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WATERSHED MASTER PLAN

Walton County Board of County Commissioners, Florida

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1.0 DEFINING THE WATERSHED PLANNING PROCESS

The watershed master planning approach is based on the concept that many water quantity and water quality problems are best addressed at the local level through the involvement of key stakeholders. As a result, the local focus helps to identify community concerns, while exploring cost-effective strategies that meet stakeholder goals and objectives.

A watershed is a large land area that directs rainfall to creeks, streams, and rivers; eventually, discharging at outfall points – such as reservoirs, bays, or Gulf of Mexico. A watershed does not follow jurisdictional boundaries. Upstream runoff from one community has potential to overwhelm systems, negatively affecting communities downstream. Both originating in southern Alabama, the Choctawhatchee River and Yellow River Watersheds flow through Walton County, Florida. These two large watersheds converge in Walton County and are made up of over 40 smaller watersheds or sub-basins.

The Federal Emergency Management Agency (FEMA) prioritizes flood risk management as an integral part of its mission. In 1968, U.S. Congress established the National Flood Insurance Program (NFIP). The NFIP is managed by FEMA and is responsible for providing flood insurance to property owners, renters, and businesses located in a designated Special Flood Hazard Area (SFHA). FEMA has minimum flood plain standards for communities participating in the NFIP. Participating communities adopt higher design standards through the Community Rating System or CRS Program. The CRS Program provides a framework to increase flood resiliency in participating communities and is designed to be used to reduce flood insurance premiums for active NFIP policy holders. The watershed master plan is a pre-requisite to gaining a Class 4 in the National Flood Insurance Program's community rating system.

Flooding is the most common and costly disaster in the United States. Floods can happen anywhere – just one inch of water can cause up to $25,000 in damage (FEMA 2019).

Flooding can impact a community's social, cultural, environmental, and economic resources; therefore, producing sound, science-based, long-term decisions to improve resiliency is critical to future prosperity and growth. According to the CRS Coordinator's Manual, "the objective of watershed master planning is to provide the communities within a watershed with a tool they can

use to make decisions that will reduce flooding from development on a watershed-wide basis." Successful watershed master plans (WMP) consist of the following activities (Association of State Floodplain Managers, 2020):

1. Evaluation of the watershed's runoff response from design storms under current and predicted future conditions;
2. Assessment of the impacts of sea level rise and climate change;
3. Identification of wetlands and other natural areas throughout the watershed;
4. Protection of natural channels;
5. Implementation of regulatory standards for new development such that peak flows and volumes are sufficiently controlled;
6. Specific mitigation recommendations to ensure that communities are resilient in the future; and
7. A dedicated funding source to implement the mitigation strategies recommended by the plan.

The United States Environmental Protection Agency (USEPA) notes six basic steps to develop and implement a watershed master plan (2013 – see Figure 1).

Figure 1. Six Steps for WMP (USEPA, 2013)

The first step is to build trust between surrounding communities to develop partnerships to focus on flood mitigation efforts. Few communities can resolve such issues alone, a watershed does not follow jurisdictional boundaries and upstream runoff from one community has potential to overwhelm systems, negatively affecting communities downstream. Further emphasizing meaningful stakeholder engagement and intergovernmental outreach to occur for a WMP to be successful. Investing time in this step will strengthen partnerships and identify common driving forces. To do this, there needs to be a series of questions developed to help guide a facilitator through the process of acquiring relevant information while simultaneously navigating the existing regulations and policies. The questions would, ideally, stimulate thought provoking dialogue into what the community and its neighbors can do and are doing in a holistic sense. After gaining inputs, the answers can be organized into a coherent set of goals, with the result being a clear path forward for watershed management. A second series of questions would be designed for the jurisdictional authorities to thoughtfully examine their previously established WMP every 5-years so that they may update their policies/actions to adapt to evolving management goals and to meet the CRS scoring criterion.

The second step in developing and implementing a WMP is to characterize the watershed. In general, there are five broad categories of data used to adequately characterize the watershed; these categories include:

- Physical and natural features – watershed boundaries, hydrology, topography, soils, climate, habitat, and wildlife.
- Land use and population characteristics – land use and land cover, existing management practices, and demographics.
- Water body and watershed conditions – water quality standards, 305 (b) report, 303 (d) list, TMDL reports, and source water assessments.
- Pollutant sources – point sources and non-point sources.
- Water body monitoring data – water quality and flow, biology, and geomorphology.

Obtaining this watershed-related information with precision can be difficult, and a balanced approach is needed to address this concern. This means collecting data on topography, channels where the water can flow, repetitive loss properties, past floods, water levels in aquifers, and more. The idea is to collect any data that might impact the movement of water that imperils

property. For this study, much of this information was generated from federal, state and local sources in a GIS format.

The third step in the WMP process involves identifying measures that are in place already to reduce impacts at various scales (watershed, regional, and local). At the watershed level, this is difficult to do because the scale of a watershed is far larger than individual neighborhoods, but development of the data for the entire watershed should include the ability to use collected data to drill down to the local level. Note that addressing local issues requires the ability to take the current data and drill down to the details. For example, this Walton County plan is a drill down of the Choctawhatchee watershed (HUC8) and within this plan, drilldown to areas of flood concern should be further undertaken.

The fourth step is to design a plan to address concerns. An inventory of existing management efforts is generally completed through the following measures:

- Review and evaluation of existing watershed data, including identification of features requiring immediate maintenance.
- Development of preliminary watershed model diagram.
- Establishment of GIS database for watershed resource features and parameter inventory through desktop and field reconnaissance.

Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated. Floodplain analysis may include the following tasks:

- Completion of the watershed resource feature and parameter inventory GIS database for the watershed using the acquired information.
- Assembly of GIS database information into a specific format for a selected computer program which predicts the watershed's response to the hydrologic cycle.
- Watershed model development, calibration, and verification
- Floodplain delineation

The fifth step in the WMP process involves implementation, where local communities participate in defining projects and solutions as well as the timing and means to fund them. This is where many watershed plans fail – the ability to fund outside a jurisdiction is fraught with many difficulties. Capital plans, bond issues, etc. are all part of the plan.

An example process that USEPA (2013) suggests for capital plans is:

1. "Inventory existing management efforts in the watershed, taking into account local priorities and institutional drivers.
2. Quantify the effectiveness of current management measures.
3. Identify new management opportunities.
4. Identify critical areas in the watershed where additional management efforts are needed.
5. Identify possible management practices.
6. Identify relative pollutant reduction efficiencies.
7. Develop screening criteria to identify opportunities and constraints.
8. Rank alternatives and develop candidate management opportunities."

The final step involves monitoring progress so that updates can be made. USEPA recognizes that the processes involved in watershed assessment, planning, and management are iterative and that targeted actions might not result in complete success during the first or second cycle. The recommendation is to include a continuous improvement plan that evaluates measurable goals and includes a 5-year window to reassess the plan to make needed adjustments in light of new data or resource availability as well as evolving regulations and CRS requirements.

1.1 Overview of the Watershed

Walton County has a total area of 1,240 square miles (3200 km2), of which 1038 square miles (2960 km2) is land, and 202 square miles (520 km2) (20.7%) is water. Walton County is located in the Pensacola/Choctawhatchee TMDL/HUC8 region of Florida (Figure 2). Incorporated communities include the City of DeFuniak Springs and Freeport and the Town of Paxton (Figure 3). The county is home to the highest natural point in Florida: Britton Hill, at 345 feet (105 m) above mean sea level. Over 75,000 people (per 2020 census data) live in Walton County (Figure 4), which is part of the Northwest Florida Water Management District.

Figure 2. TMDLs HUC8s in Florida & Walton County

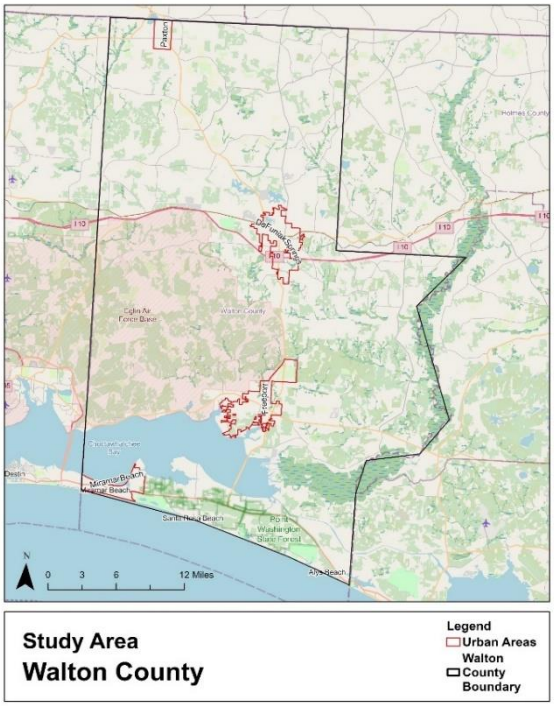


Figure 3. Incorporated Areas in Walton County, FL

Barrier islands, beaches, and tidal marshes border most of the Gulf Coast. Panhandle beaches are famous for their white 'sugar sand', composed of quartz. The County is home to 15 named coastal dune lakes along 26 miles of coastline. A Coastal Dune Lake (see Figure 5 and Figure 6) is a unique shallow body of water that shares an intermittent connection with the Gulf of Mexico, known as an outfall. The outfall provides natural flood control, that allows for fresh and saltwater exchange. Each lake's outfall and chemistry are different. Water conditions between lakes can vary greatly, from completely fresh to significantly saline.

The northern Gulf Coast is classified as humid subtropical climate which closely borders a tropical savanna climate. The summer is hot and humid, while the winter is warm and wet. Unlike central and south Florida, the area is impacted with fronts that bring precipitation all winter, making it relatively wet all year (see Figure 7). Normal annual rainfall ranges from about 55 to 67 inches per year; the average annual rainfall is generally highest in the western portion of the NWFWMD and lowest in the eastern portion (Pratt et al., 1996).

Due to its coastal location, on the Florida Panhandle, the County is vulnerable to hurricanes. Walton County has been impacted by Hurricanes Eloise (1975), Opal (1995), Earl (1998), Ivan (2004), Dennis (2005), and Michael (2018). Additionally, shallow offshore shelf formations make surge a concern for the barrier islands. King tides and tropical storm-induced rainfall are the major flood concerns. Figure 8 shows flood prone areas of the County based on modeling performed for this study.

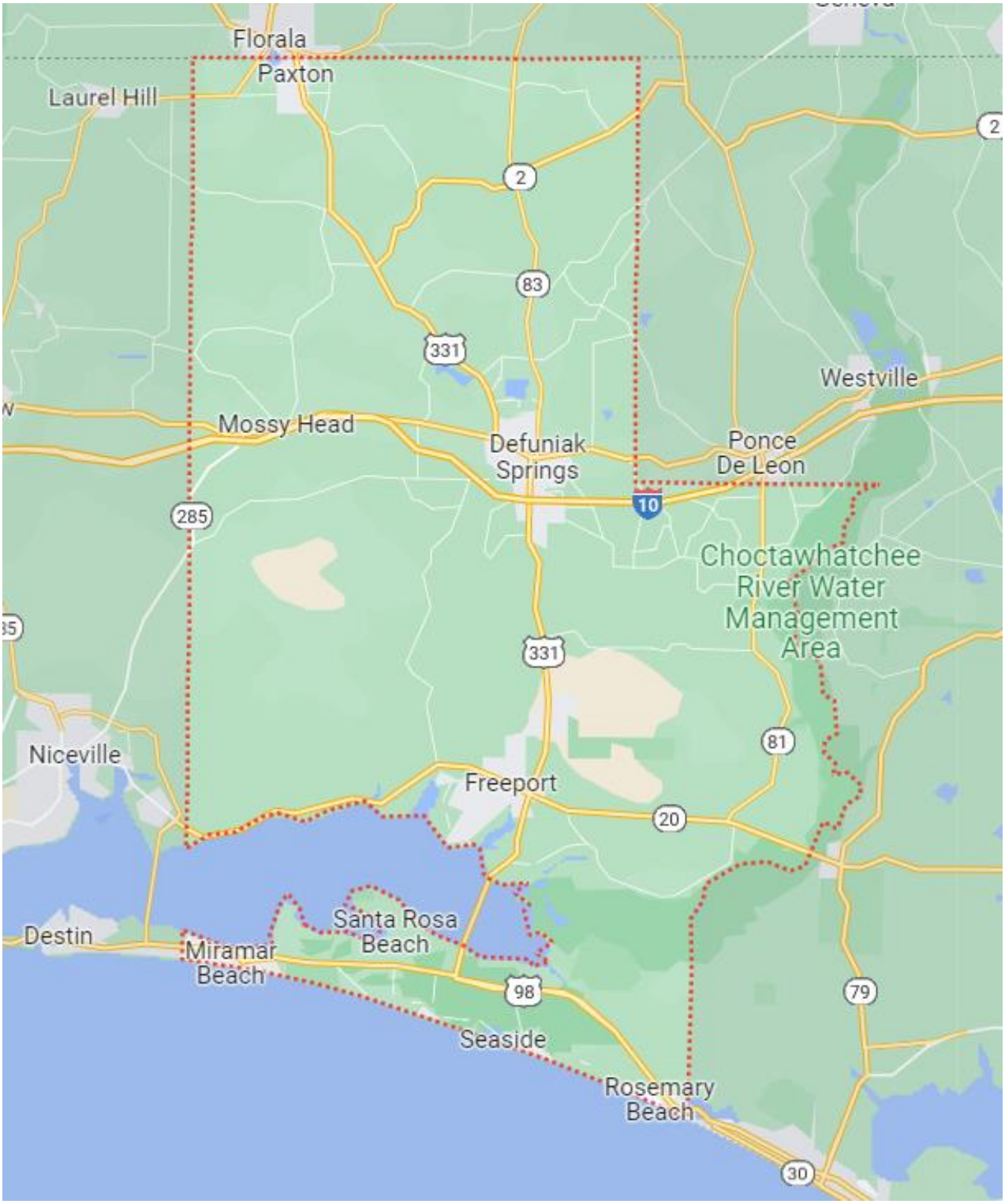


Figure 4. Walton County Map

Figure 5. Eastern Dune Lake located in South Walton

Figure 6. Dune Lake located in South Walton

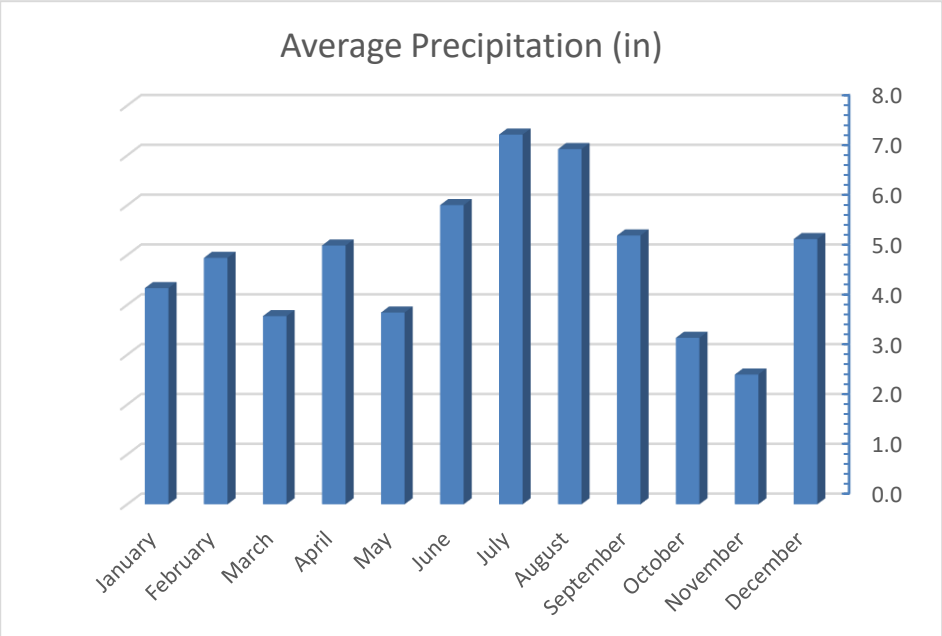


Figure 7. Walton County Average Monthly Rainfall, 2011-2013

**Note figure provided by Walton County*

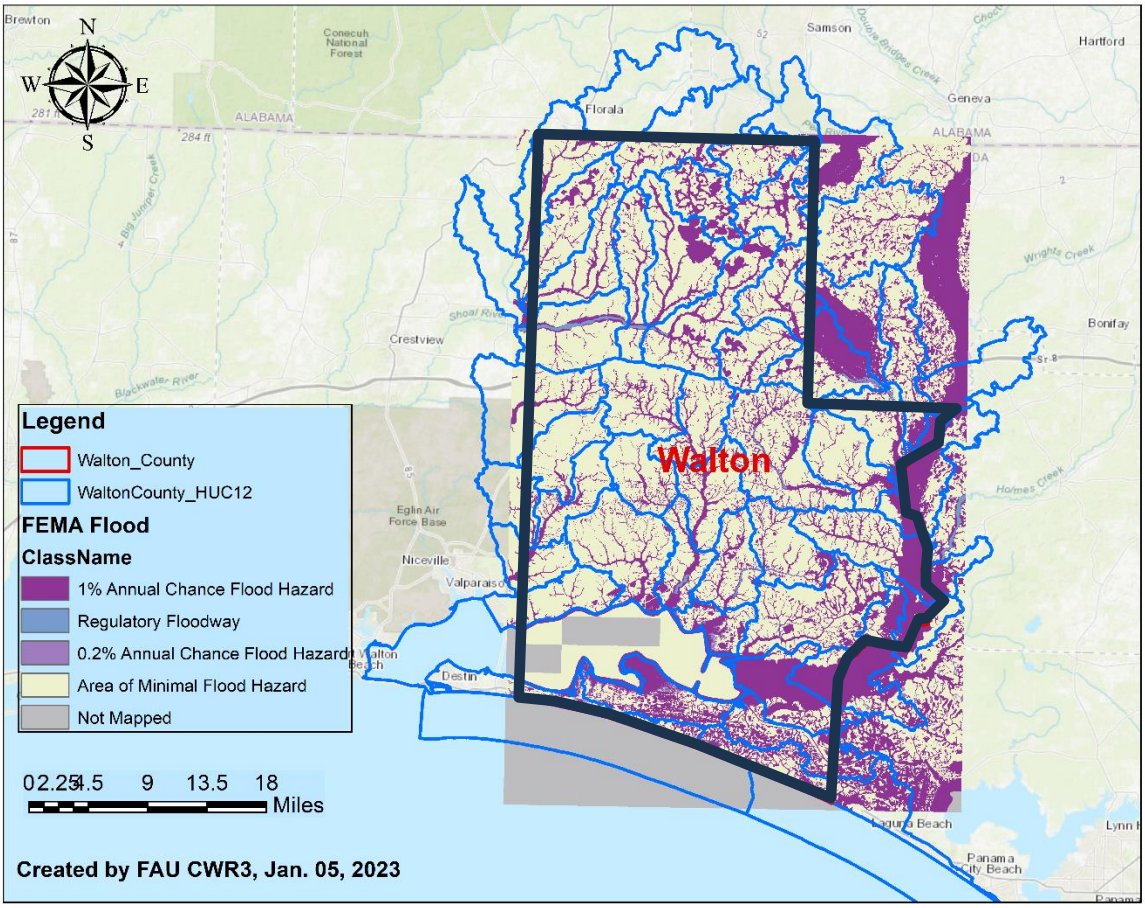


Figure 8. Locations of Flood Prone Areas Based on FAU Modeling

The Choctawhatchee Bay and River Watershed are shown in Figure 9. It is clear from this figure that there are areas beyond the County that contribute flood waters to Walton County. This extended area includes portions of Okaloosa, Washington, Bay, and Holmes Counties in north Florida, and ten counites in Southern Alabama. The primary surface water features of the watershed driving the flow of water are the upper tributaries of the Choctawhatchee River.

The region's rolling, hilly terrain more closely resembles areas within Alabama or Georgia than the peninsula of Florida. Elevations in the highlands area range from 50 to 345 feet above mean sea level. The highest point in Florida, at 345 feet at Britton Hill off County Road 285 in Paxton, near the Alabama border (smilingglobe.com, 2020). The major physiographic features include the Northern Highlands, and the Coastal Lowlands (Pratt et al., 1996).

The ground surface elevations in the watershed are lowest along the coast between 0 feet and 15 feet NAVD88. The low land elevations along the coast and shallow water table driven by the surface waters will likely contribute to flooding, which is expected to occur adjacent to the rivers and coastline. The groundwater elevations in coastal areas may be controlled drainage systems like the Mosquito control ditches, in addition to outfalls and intermittent streams.

Inland, cool freshwater springs can be seen throughout the panhandle area allowing for some recreational opportunities such as tubing, cave diving, etc.

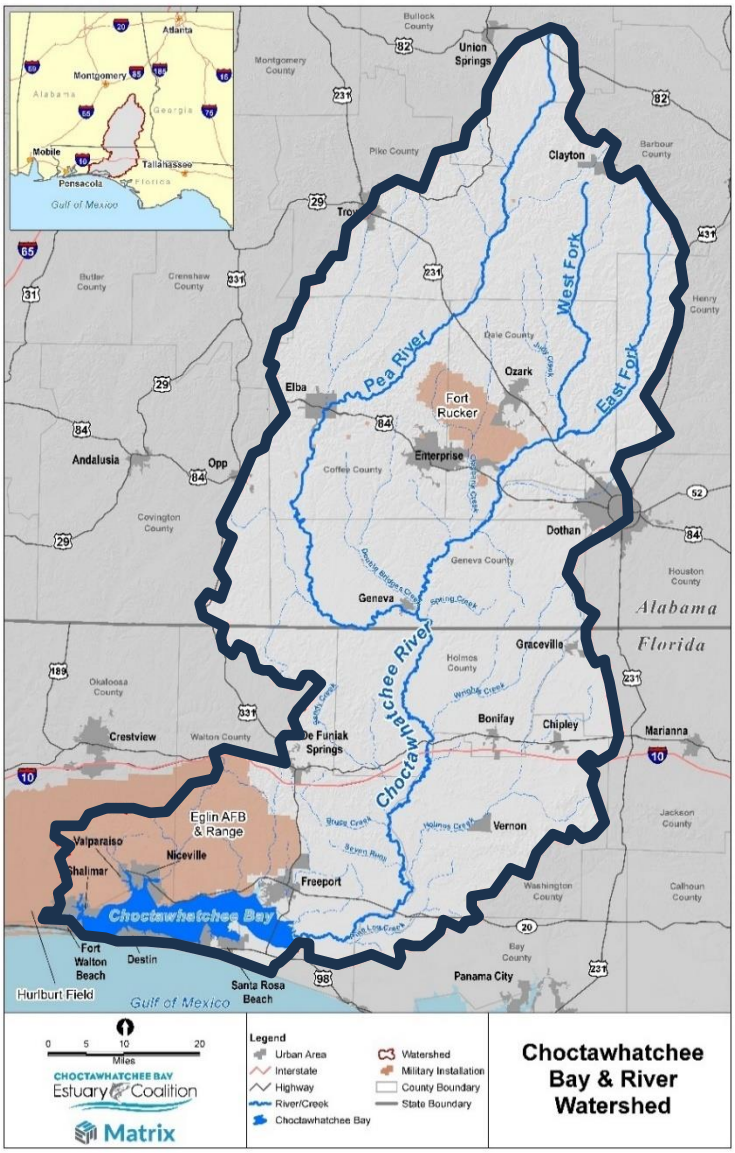


Figure 9. Choctawhatchee Watershed

1.1.1 Geomorphological Considerations

In northwest Florida, the hydrogeologic framework is divided into four groups of sediments that constitute distinct hydrogeologic systems, and each system is a compilation of lithologic beds that have similar hydrogeologic characteristics. (Pratt et al., 1996). Systems are defined by their ability to accelerate or hinder the flow of water and, thus, are not constrained by lithologic or stratigraphic boundaries. In descending order from land surface, the four systems are: Surficial Aquifer System, which includes the Sand-and-Gravel Aquifer; Intermediate System; Floridan Aquifer System; and Sub-Floridan System. In northwest Florida, the Ad Hoc Committee recognized three aquifer systems, which includes the surficial aquifer system, the intermediate aquifer system and the Floridan aquifer system, and two confining units, which includes the intermediate confining unit and the sub-Floridan confining unit. The subsurface characteristics of each system vary both laterally and with depth. The nature of the variability determines ground water availability or the degree of detention for the respective system at any given location.

Figure 10 shows the County includes multiple HUC 12s. As a result, watershed plans for each HUC will need to be developed and integrated as a part of the 452b submission. The appendices will detail each of these HUC12s.

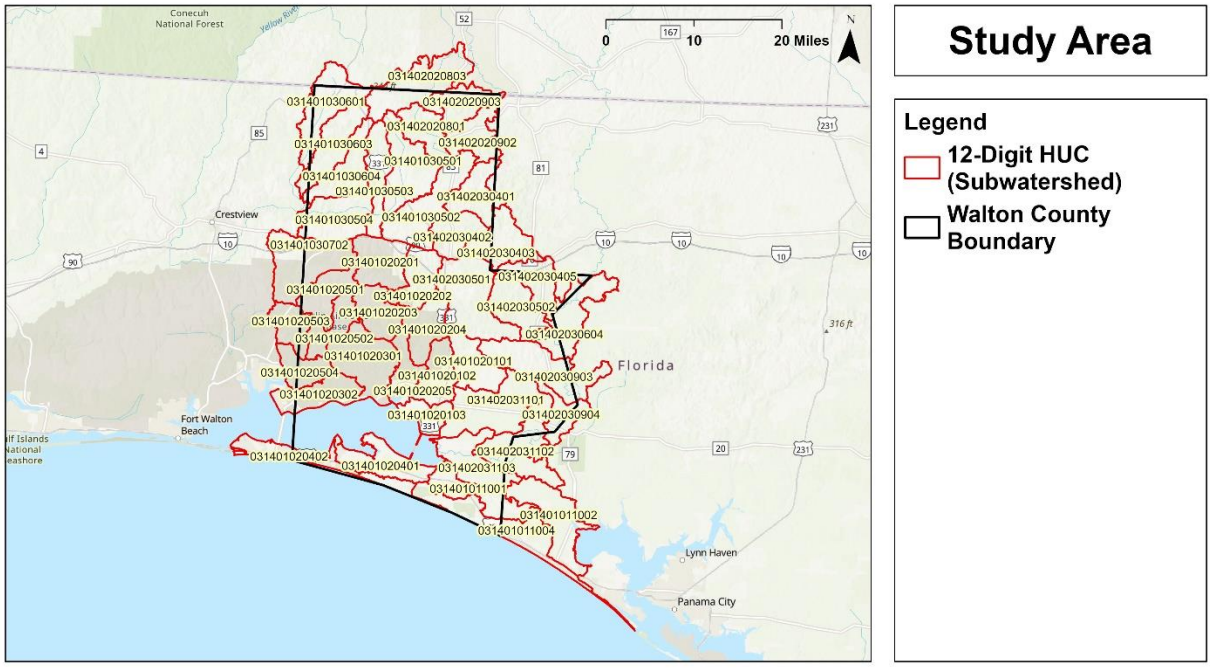


Figure 10. Map of HUC12 Watersheds in Walton County

The Choctawhatchee River and Bay watershed is within the Gulf Coastal Plain physiographic region, characterized by gently rolling hills, sharp ridges, prairies, and alluvial floodplains underlain by sand, gravel, porous limestone, chalk, marl, and clay. Within the Gulf Coastal Plain, the watershed in Florida contains three localized physiographic regions: the Western Highlands, the Gulf Coastal Lowlands, and the River Valley Lowlands (USDA 1989, 2014b; USGS 2013).

The Western Highlands span the northern watershed and extend southward to a relic escarpment approximately 30 to 40 miles south of the Alabama-Florida state line. The Western Highlands are characterized by rolling hills that consist of Pliocene-Pleistocene delta deposits (5.3 million years to 11,700 years before present), overlain by Pleistocene marine terrace deposits. The River Valley Lowlands follow the floodplain of the Choctawhatchee River and reflect Pleistocene Sea level fluctuations, including down-cutting, significant erosional features, and fluvial terraces (USDA 1989).

1.1.2 Land Use

Northern Walton County is primarily agricultural and woodlands. The southern areas are developed coastal communities. The continental shelf located in the northern Gulf of Mexico is relatively shallow near shore which increases wave action from storm events. Figure 11 represents existing land cover.

Table 1 provides the percentage of land use in Walton County versus the Choctawhatchee River Watershed. Figure 12 shows the projected future land use in the County while Figure 13 shows lands that are protected from development as conservation lands.

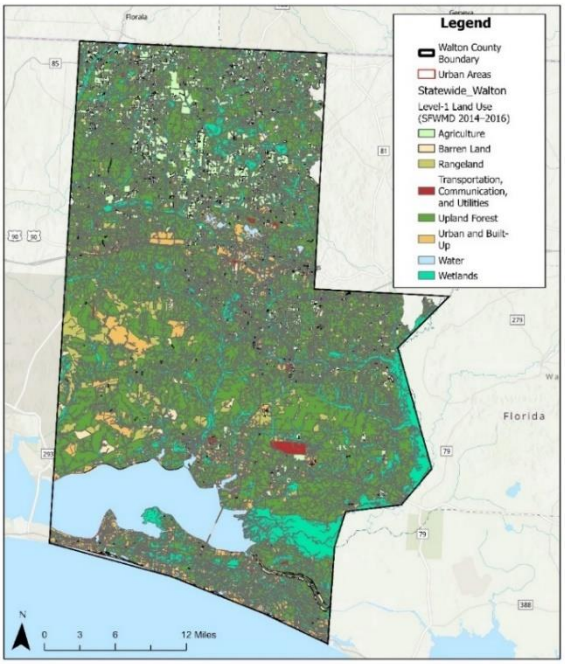


Figure 11. Current Land Use – Walton County, 2014-2016

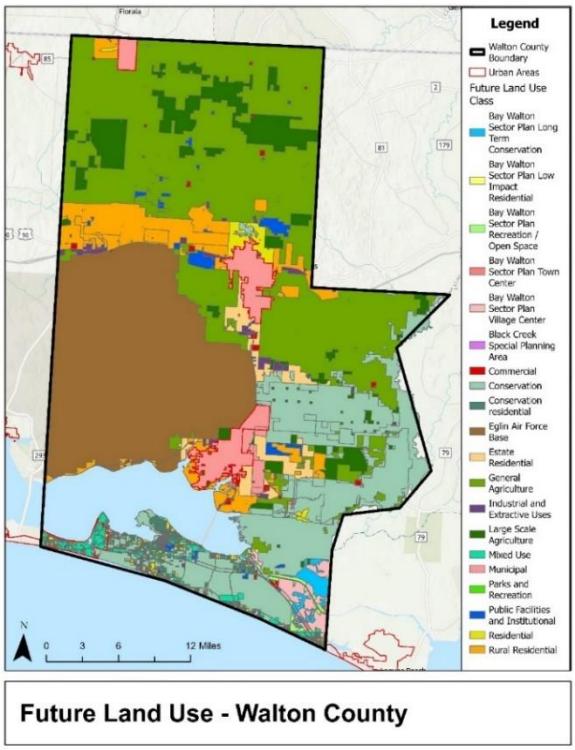
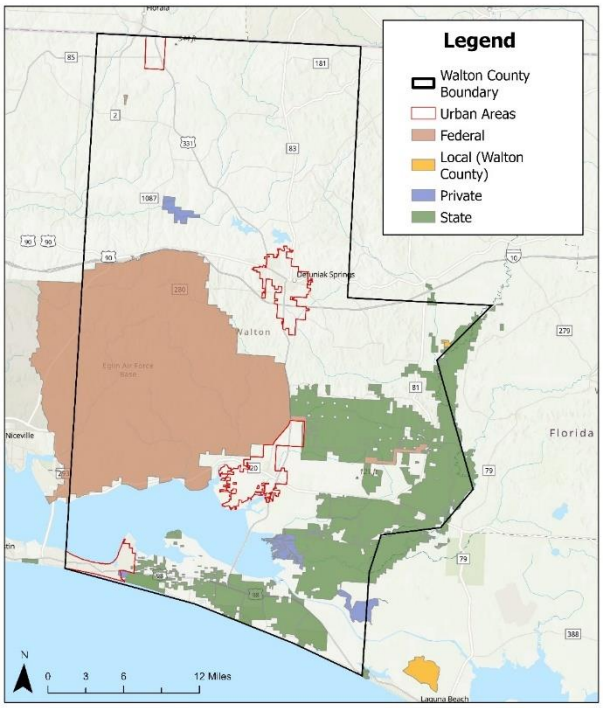


Figure 12. Future Land Use – Walton County



Conservation Lands - Walton County

Figure 13. Conservation Lands in Walton County

Table 1. Land Use in Walton County

Land use	County Percentage	Choc. Watershed Percentage
Agriculture	34.6%	1.3%
Barren Land	0.5%	2.0%
Transportation, Communication and Utilities	0.7%	-%
Upland Forests	12.5%	49.2%
Rangeland	5.6%	-%
Urban and Built Up	18.5%	9.1%
Water	11.7%	15.9%
Wetlands	15.9%	22.4%
Total	**100.0%**	**100.0%**

**Note prepared by FAU from future land use map vs. land use in entire watershed (NWFWMD 2017)*

1.1.3 Waterway Features

Numerous tributaries exist throughout both the freshwater portions of the Yellow River and Choctawhatchee watersheds and can influence overall hydrology of the river depending on rainfall and regional hydrological conditions (Figure 14).

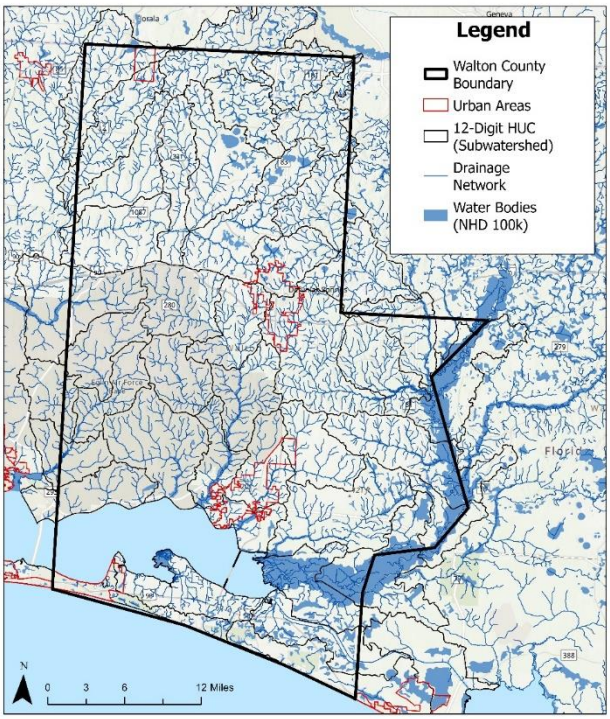


Figure 14. Regional Drainage Network

Watersheds can provide water storage and flood attenuation, groundwater recharge, regulation of discharge to receiving waters, water quality protection, cycling of energy and nutrients, erosion control, and stream bank stabilization. Therefore, an understanding of river- and stream-channel geomorphic responses to various human-caused and natural disturbances is important for effective management, conservation, and rehabilitation of rivers and streams to accommodate multiple, often conflicting, needs.

Channel changes may have implications for the protection of property and structures, water supply, navigation, and habitat. The channel-bank erosion that accompanies natural channel migration on a flood plain represents a constant threat to property and structures located in or

near the channel. Various anthropogenic and natural disturbances introduce additional instability to which rivers and streams adjust. Human-caused disturbances include reservoirs, channelization, in-channel sand and gravel extraction, and urbanization. A common natural disturbance is a flood or major storm event.

There are two major watersheds affecting the County. The largest is the Choctawhatchee. The other is the Yellow River which flows into northeastern Okaloosa County. Stream flow is critical for estimating flooding, Figure 15 and Figure 16 shows the relationship between historical rainfall and streamflow for the Choctawhatchee and the Yellow River, respectively. Such data is useful in assessing relationships between precipitation and stream flow and can be an indicator of watershed development. The figures show that the flows are highest in the summer. The flows are consistent from year to year.

A small portion of south Walton, that includes the unincorporated coastal communities of Grayton Beach, Seaside, Inlet Beach, and Watercolor, drain to West Bay, an interconnected surface water basin for the St. Andrews Bay Watershed. The St. Andrews Bay Watershed is the only major watershed located entirely within the Florida Panhandle (Figure 17).

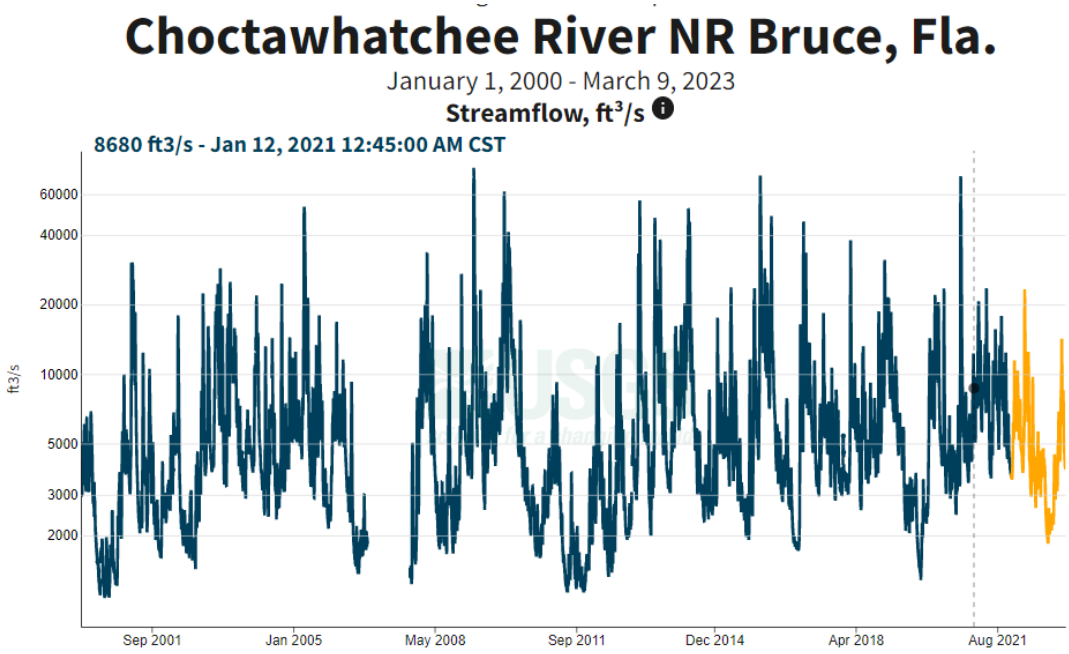


Figure 15. Stage Data for Choctawhatchee River (2000 – 2023)

(NOAA - https://waterdata.usgs.gov/monitoring-location/02366500/#parameterCode=00060&startDT=2000-01-01&endDT=2023-03-09)

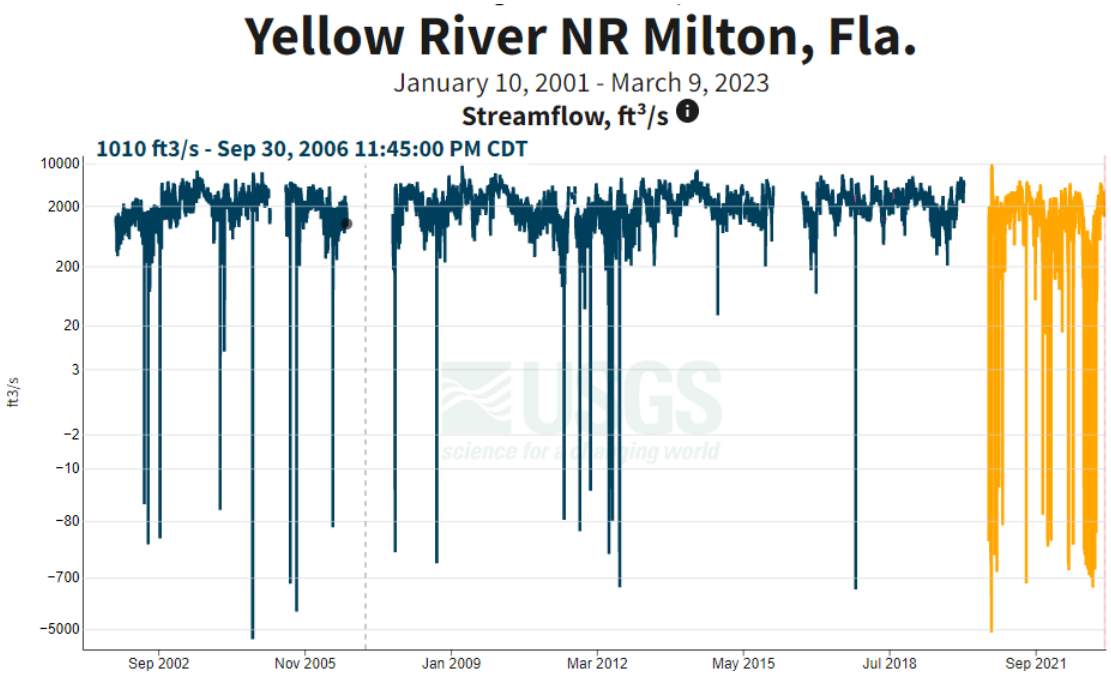


Figure 16. Stage Data for Yellow River (2001 – 2023)

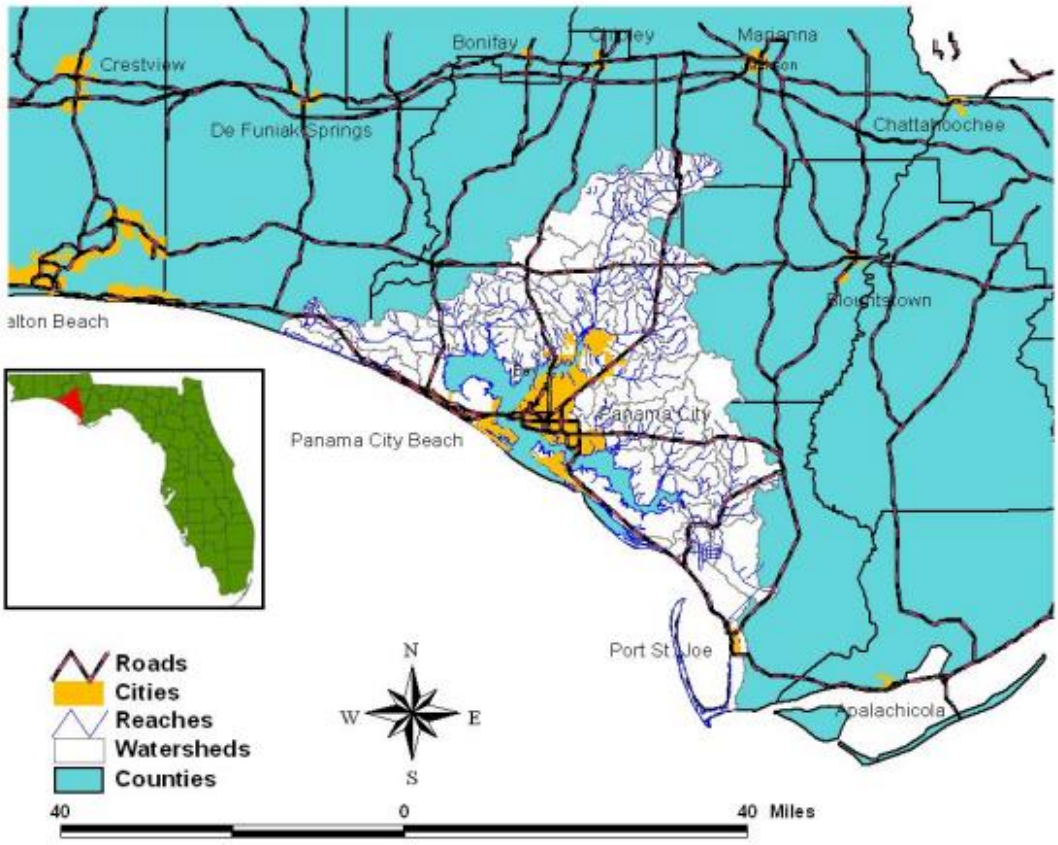


Figure 17. Location of St. Andrews Bay Watershed located in South Walton

1.1.4 Hydrologic Boundaries

Watershed master planning focuses on a large geographic area and its drainage basin. The geographic area should be clearly defined to ensure that implementing the plan will address potential flooding sources and causes of impairments that may affect water quality. One way to identify the geographic extent of the watershed master planning effort is to consult the USGS map of hydrologic units.

A hydrologic unit is part of a watershed mapping classification system showing various areas of land that can contribute surface water runoff to designated outlet points, such as lakes or stream segments (Figure 10). USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

1.1.5 Wetlands and Natural Areas

Wetlands serve many purposes, including acting as recharge areas, filters for contaminants and buffers that mitigate temperature changes in adjacent areas. Riparian habitats include those areas along waterbodies that serve as an interface between terrestrial and aquatic ecosystems. Riparian areas are important fish and wildlife habitats that promote ecological diversity and assist in mitigating or controlling NPS pollution. Riparian vegetation can be effective in removing excess nutrients and sediment from surface runoff and shallow groundwater and in shading streams to optimize light and temperature conditions for aquatic plants and animals. Riparian vegetation, especially trees, is also effective in stabilizing streambanks and slowing flood flows, resulting in reduced downstream flood peaks. Major floodplain swamps span the length of the Choctawhatchee River. Riparian wetlands and floodplains are also along other streams throughout the watershed (Figure 18). Another major palustrine wetland system is south of Choctawhatchee Bay on the Moreno Point peninsula within Walton County.

Marshes within the Choctawhatchee River and Bay watershed include both salt (brackish) marsh in the coastal reaches and freshwater emergent marsh along the Choctawhatchee River (FNAI 2010). Marsh species composition is influenced by a combination of salinity tolerance and differences in soil type, elevations, and competitive interactions. Salt marshes serve as a transition between terrestrial and marine systems. Generally, salt marshes are intertidal and develop along relatively low energy shorelines. Salt marshes in the Florida Panhandle are usually characterized by fairly homogeneous expanses of dense black needle rush (*Juncus roemerianus*). Often, they are accompanied on the water-ward side by smooth cordgrass (*Spartina alterniflora*). The Juncus and Spartina zones are distinctive and can be separated easily by elevation.

The major salt marsh on Choctawhatchee Bay is on the Live Oak Point peninsula, bordering Hogtown Bayou on the south shore of the bay. A network of mosquito control ditches, constructed during the 1960s, intersects the marsh. The marsh at Live Oak Point has been extensively altered by mosquito control ditch excavation, particularly within the northern portion of the marsh. While the ditch areas host shellfish and finfish, they also act as the terminus for stormwater conveyances that send untreated stormwater runoff into the bay. Additionally, Live Oak Point has experienced considerable erosion along its northern shoreline.

Upland communities in the watershed include mesic flatwoods, sandhill, scrub, scrubby flatwoods, upland hardwood forests, wet flatwoods, and xeric hammocks (FNAI 2010). longleaf pine forests currently occupy less than five percent of their original range, due to conversion to pine plantations, fire suppression, and other factors (Van Lear et al. 2005; USDA 2017). Natural longleaf pine forests in typically have an open canopy and an understory dominated by wiregrass (Aristida stricta). The community is ecologically diverse, supporting numerous plant and animal species.

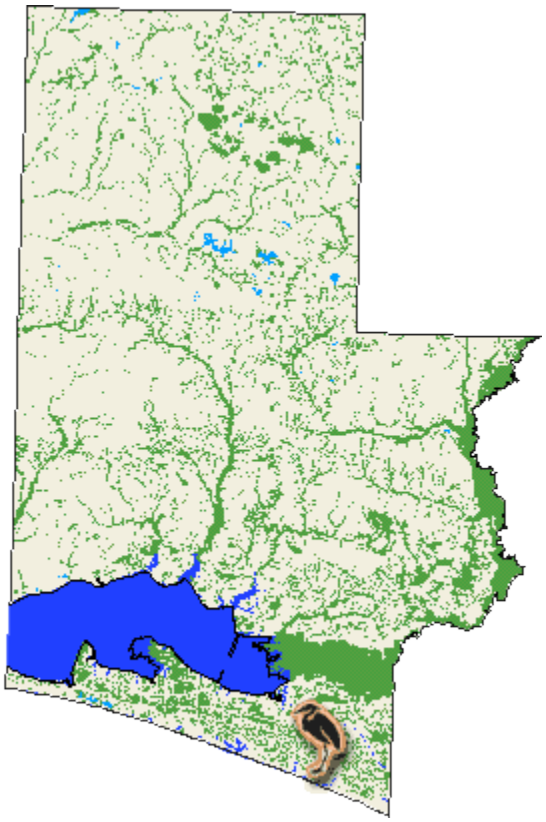


Figure 18. Wetlands in Walton County (in green, water is blue)

**Note source: https://www.fws.gov/program/national-wetlands-inventory/wetlands-mapper*

Choctawhatchee Bay can support over 5,700 acres of seagrasses (Carlson 2017) (Figure 19). Yarbro and Carlson (2016) reported that Choctawhatchee Bay seagrass coverage in 2007 was 1,915 acres, a 55% decline from 1992. The new findings estimated coverage at around 4,261 acres, an increase from previous years. Historic observations suggest that seagrass beds within

Choctawhatchee Bay are subject to shifts in coverage area, depending on complex interactions between variable factors, including water clarity, salinity fluctuation and stratification, physical disturbance, and recruitment. Two species of seagrass, shoal grass (*Halodule wrightii*) and widgeon grass (*Ruppia maritima*), are most prevalent in Choctawhatchee Bay, with shoal grass being the most common. Small amounts of turtle grass (*Thalassia testudinum*) are also present near Destin's East Pass.

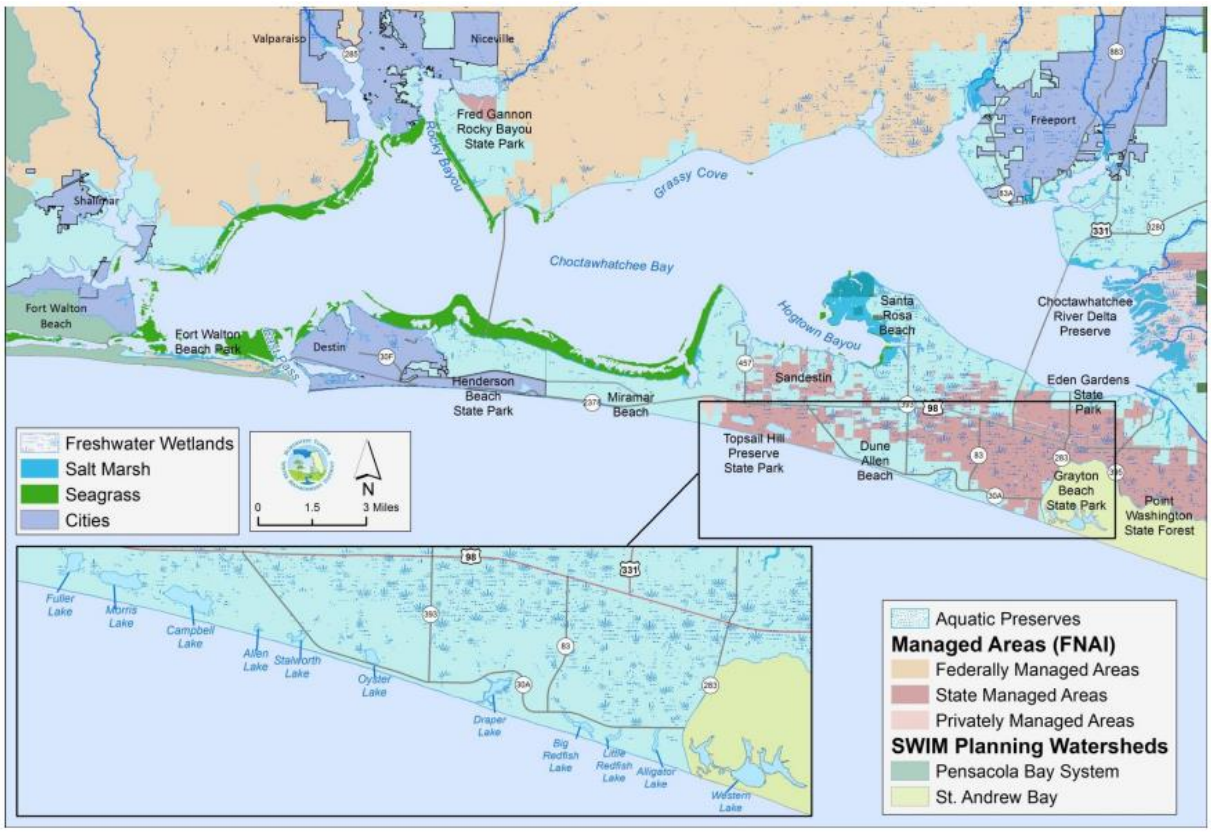


Figure 19. Managed Lands and Coastal Habitat

**Note source: NWFWMD 2017*

1.1.6 Floodplains

Floodplain identification and mapping, as shown in Figure 20, is important for flood protection of property/damage reduction. Because floodplains will flood periodically, local governments are expected to develop regulations that follow standards that make the structures/properties more resilient to flooding.

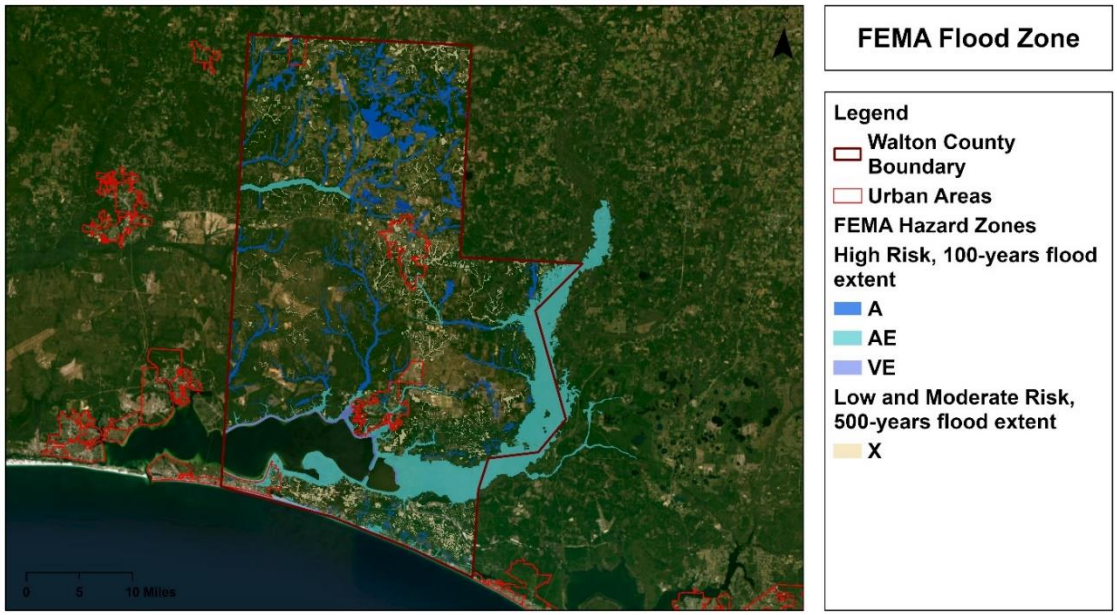


Figure 20. Walton County FEMA Flood Zone Boundaries

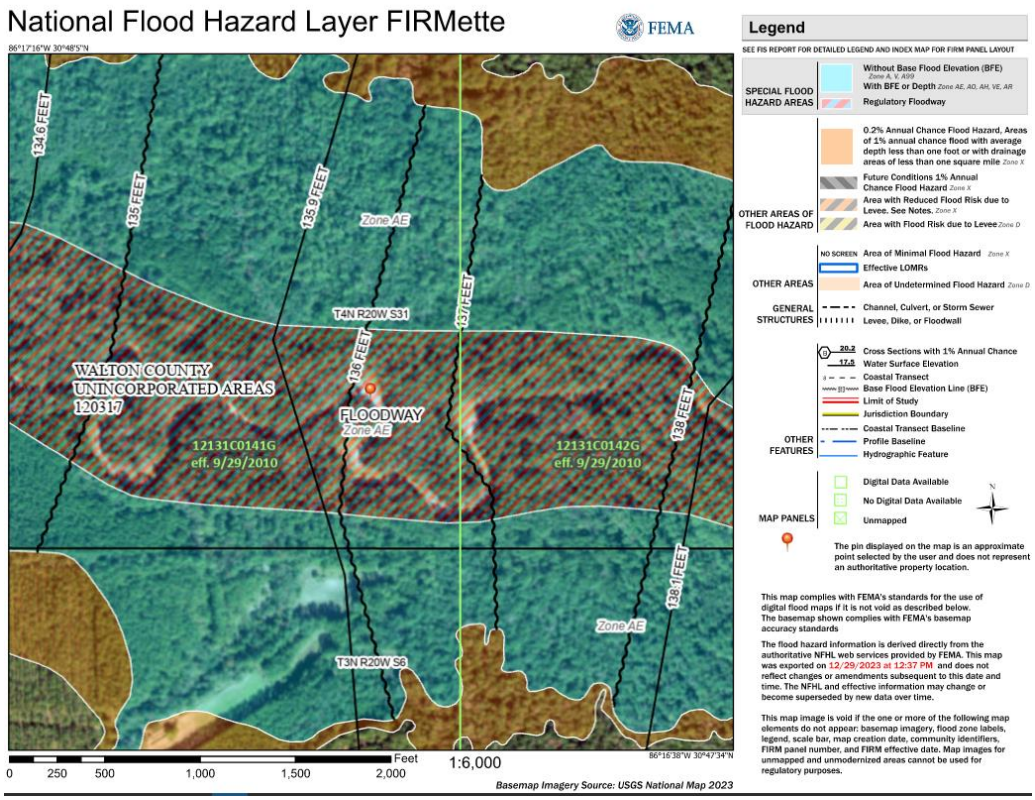


Figure 21. Walton County FEMA FIRM, (River Floodplain)

Beyond the flood plain is the flood fringe, which extends from the outer banks of the floodway to the bluff lines of a river valley. When a channel receives too much water, the excess flows over its banks and into the adjacent floodplain. Flooding that occurs along a channel is called riverine flooding (orange/blue diagonal hatched area in Figure 21). Overbank flooding occurs when downstream channels receive more than normal rain or snowmelt from their watershed. Excess water overloads the channels and flows out onto the floodplain. Overbank flooding varies with the watershed's size and terrain. One measure of a flood is the speed of its moving water (velocity). Depending on the size of the river and terrain of its floodplain, flooding can last for days and cover wide areas. In urban areas, flash flooding can occur where impervious surfaces, gutters, and storm sewers increase the speed of runoff.

1.1.7 Flow Paths and Natural Channels

ArcHydro is an available extension in ArcMap with a set of tools designed to draw the catchment drainage areas using digital elevation model (DEM). The ArcHydro function also permits the delineation of routing and sub-basins, which may need to be modeled separately. The results from the land cover, water bodies, flood routing, soil capacity, and topography are all inputs that will be used to generate flood maps. Section 1.1.1 describes the flow channels for the Choctawhatchee and Yellow River watersheds based on modeling conducted by Florida Atlantic University (FAU).

1.2 Planning Goals and Scope

To ensure that the watershed planning effort remains focused, the planning goals and scope of the effort must be clearly defined. Defining the scope and setting goals early in the planning process, will make it easier to implement and monitor the plan. The primary purpose of a watershed management plan is to guide watershed coordinators, resource managers, policy makers, and community organizations to restore and protect the quality of lakes, rivers, streams, and wetlands in each watershed. The plan is intended to be a practical tool with specific recommendations on practices to improve and sustain water quality.

The specific goals for Choctawhatchee and Yellow River watersheds in Walton County are to:

- Identify and characterize the physical and natural features of the watershed in the following categories:
    - Topographic data

- Groundwater
- Surface water/tides
- Soils data
- Land cover/land use identification including vacant land, wetlands, waterbodies, etc.
- Precipitation records
- Open space
- Impervious areas
- Waterbodies
- Natural resources
- Demographics
- Locations of stormwater infrastructure

- Identify existing plans and policies such as:
  - Source water assessments
  - Water quality management reports (TMDL implementation plans, BMAPs, SWIM Plans)
  - Flood insurance studies
  - Floodplain management plans
  - Florida “Peril of Flood” guidance
  - Comprehensive plans
  - Stormwater management policies
  - Local mitigation strategies
  - Unified land development regulations
  - Intergovernmental cooperative agreements
  - Special Watershed Restoration Plans
  - Stormwater pollution prevention plans (SWPPPs)
  - Post-disaster redevelopment plans
  - Climate adaptation action plans

- Identify:
  - Flood prone areas
  - Current and proposed watershed projects

- Local flood protection projects
- Local regulatory constraints
- Dedicated funding for projects

Table 2 shows goals related to flood protection at the watershed level.

Table 2. List of Potential Planning Goals and Solutions

Goal	Indicator	Management/Project
Increase water supply	Reduced water restrictions	Construct upstream reservoirs and store water in wetland areas to increase natural recharge
Increase intergovernmental communication	Increasing number of attendees to periodic meetings Increased number of website viewers	Coordination of projects
Reduce overbank flooding	Reduced repetitive loss claims	Improved management strategies for the river, provide restoration of oxbows, bypass flood waters to offsite reservoirs
Restore wetlands	Increased wetland species	Restore water flow, increase regulatory protection, acquire properties
Reduce flood frequency	Reduced repetitive loss claims Changes to flood maps	Improved management strategies for the river Locally, install pump stations, piping, stormwater treatment areas, and develop additional green strategies

1.3 Public Outreach

Community outreach is a major part of the watershed master planning process. The stakeholders for the basin include the county governments, the municipal governments, the water management district, utilities, agricultural and tourism interests, and environmental interests that may have more concerns associated with timing of flood releases and water quality. Public works agencies and FDOT should also be included as a part of the process because roadways are major sources of conveyance (bridges and culverts).

The goals of the watershed management plan public outreach program reflect the steps required to solicit the input of the public and build awareness of the project throughout diverse communities. Public information on the plan must be straightforward, factual, and designed to be appreciated by non-technical audiences. The goals of this plan are as follows:

- Communicate effectively with the diverse communities and stakeholders;
- Create public forums and collateral materials that provide a clear, concise and easy-to understand information to enable the public to make informed decisions about the project;
- Develop a strong list of public and regional benefits that the project will generate;
- Respond to public and stakeholder feedback in an accurate, consistent, and timely manner;
- Provide accurate, timely and comprehensive documentation on the public involvement process;
- Publish and distribute the draft environmental documents for review and also notify the public, elected officials, and other stakeholders of upcoming community meetings and public hearings;
- Create and implement a meaningful public involvement process, and evaluate the public involvement process on a regular basis; and
- Create measurable objectives tied to the milestones that are required for the successful conclusion of the project.

To facilitate community participation, there is a need to develop a database of all stakeholders (community groups, residents, local and regional business owners, labor, environmental organizations, employers, employees, academia, cultural and entertainment

attractions, emergency responders, media, surface transportation industry, policy leaders, other institutions, etc.). Then the outreach program should be applied to the stakeholders to:

- Develop corollary key messages that are consistent with the goals and objectives of the demonstration project
- Assess attitudes and perceptions among target audiences
- Identify barriers, advantages, and levels of support

The meetings must be public, and all input recorded. Each meeting should be developed with an agenda that includes:

- Community group meetings/workshop times
- Locations
- Meeting formats
- Speakers/presenters
- Content of presentation material

A website should be created to provide documentation for all meetings including:

- Agendas
- Notices/ads
- Meeting materials
- Meeting summaries
- Minutes
- Public comment logs
- Plan documents
- Materials used for the plan

Because many stakeholders cannot attend daytime meetings in person, options to provide input may include an informational webpage, virtual meetings, blogs, survey platform, electronic news outlets, and discussion boards.

Such forums must be monitored to incorporate findings into the plan. All outreach should incorporate a news media outlet, in addition to including relative information on stakeholder websites:

- Walton County (https://www.co.walton.fl.us//)
- Okaloosa County (https://myokaloosa.com//)
- City of DeFuniak Springs (https://defuniaksprings.net/)
- Town of Paxton (https://www.paxtonfl.net/)
- City of Freeport (https://www.freeportflorida.gov/)
- Bay County (https://www.co.bay.fl.us/)
- Holmes County (https://holmescountyfla.com/)
- Washington County (https://www.washingtonfl.com/)
- Covington County (http://covcounty.com/)
- Geneva County (http://genevacountyal.gov/)

A list of potential stakeholders:

- NWFWMD
- Walton County
- Okaloosa County
- City of DeFuniak Springs
- Town of Paxton
- City of Freeport
- Bay County
- Holmes County
- Covington County
- Washington County
- Geneva County
- Coffee County
- Crenshaw County
- Dale County
- Bullock County
- Macon County
- Montgomery County
- Pike County
- Barbour County

Within the community, prior FAU modeling reveals there are challenges on the barrier island portion of the County, bayfront, and along waterways within the community. Proximity to the Gulf of Mexico means that sea level rise, king tides, and storms will all affect the future condition.

1.4 Credit Criteria and Documentation

The credit criteria for Section 452.b are found in the 2017 CRS Coordinator's Manual (https://www.fema.gov/sites/default/files/documents/fema_community-rating-system_coordinators-manual_2017.pdf). There is no need to submit more than one copy of a watershed master plan or regulatory section if it can be used to document separate sub-elements. Instead, in each section clearly indicate where to find the desired criteria.

1.4.1 Elements of the CRS Section 452 criteria for watershed planning

If submitting a plan for WMP credit, the plan must indicate which of the eight sub-elements the plan meets. To this end, this section is designed to outline where the associated issues are located. Note that WMP 1 credit must be received in order to receive credit for any of the additional sub-elements. An outline of the submittal requirements for each of the eight sub-elements is listed in Table 3 below.

Table 3. Sub-Elements Submittal Requirements

Sub Elements	Submittal Requirements
WMP 1	Attach a copy of each watershed plan that has analyzed the impact of sea level rise and/or fully developed watersheds on your community during a 100-year event. To be credited, the plan must have been adopted and implemented by your community and you must have a plan to control the impacts of the 10-year event and at least the 25-year event on your community. Credit for onsite control of the 10-year event and the 25-year event or the 100-year event is an acceptable method of controlling the impacts.
WMP 2	Explain how your plan and regulations manage a 100-year event and where those requirements/ regulations are found.
WMP 3	Explain how your plan manages not only future peak flows but also the volume of runoff from new development, so that it doesn't increase over present values. A community must demonstrate that its watershed management plan and associated regulations prevent increases in peak flows at all points within its watershed(s) and downstream.
WMP 4	Explain how your plan manages the runoff from all storms up to and including the 5-day event and where to find that in the plan itself. Refer to specific regulations or standards.
WMP 5	Highlight the section of your plan that identifies existing wetlands or other natural open space areas to be preserved from development to provide natural attenuation, retention, or detention of runoff. Include the regulation that requires their preservation. For WMP 5 credit, the plan must identify these areas and there must be regulations to preserve them, a map by itself is not creditable. Note the section/page number of the plan and regulation below.

WMP 6	Highlight the section of your plan that recommends prohibiting development, alteration, or modification of existing natural stream channels. Include the regulation that implements the prohibition. For WMP 6 credit, the plan must identify these areas and there must be regulations to preserve them. (These channels may be eligible for credit under element NSP — natural shoreline protection, under Activity 420.) Note the section/page number of the plan and regulation.
WMP 7	Highlight the section of your plan that recommends that channel improvement projects use only natural or "soft" approaches rather than gabions, rip rap, concrete, or other "hard" techniques. Include a copy of the regulation or the design standards that implement the regulation. For WMP 7 credit, the plan must recommend these techniques and there must be regulations to require them. Note the section/page number of the plan and regulation.
WMP 8	The section requires a copy of the ordinance establishing the source of dedicated funding to implement the watershed master plan and a copy of recent expenditures. This is discussed further in section 3.6.

1.4.2 Conclusion on Points

If submitting to the CRS program, the conclusion of this report is that the County can earn points towards its CRS rating while meeting the Class 4 pre-requisite.

2.0 WATERSHED CHARACTERIZATION

Despite historical water management conflicts and periodic disruptions, Northwest Florida will remain a desirable place to live, so the interconnectedness of water bodies will require a more integrated solution to resolve water quantity and quality issues. Making thoughtful, long-term decisions will be important because infrastructure and development typically have an expected life cycle of at least 50 years or more. It is important to create a planning framework to protect vulnerable infrastructure through a long-term plan. While uncertainties in the scale, timing and location of climate change impacts can make decision-making difficult, response strategies can be effective if planning is initiated early. Because vulnerability can never be estimated with 100% accuracy, the conventional approach should be replaced or supplemented with one that recognizes the importance of building resiliency, which requires data. Among the datasets to acquire are the following:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, etc.
- Basin delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (3-day / 25-year, 1-day /10-year, and 1-day / 100-year storm events to achieve Class 4 in the CRS Manual). In developed areas many sources of data are already available – the key is putting the key datasets in a format that can be queried for screening to identify the priority areas of the watershed.

Table 4 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

Table 4. List of Datasets Used in Analysis

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		607M bytes, raster images	Native
Groundwater	FL_GW	NWFWD	Florida, Excel	Daily, 1980-2020	216 M bytes, excel	Native
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	107G bytes, both vector and raster	FAU Processed
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	20G bytes, raster	Native

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Dataset size and Format	Native or FAU Processed dataset
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14 _Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 4) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

From the perspective of the water management district, there is a district plan that notes that "significant challenges continue to affect water quality, natural systems, and the public benefits provided by watershed resources and by individual waterbodies. One of the defining characteristics of the coastal reaches of the Choctawhatchee River and Bay watershed has been growth and development. Population in the Florida portion of the watershed has increased significantly over the last several decades: from approximately 134,556 in 1990 to 187,962 in 2010, a nearly 40 percent increase over 20 years. Population over the next twenty years (2010-2030) is projected to increase by perhaps 23 percent, with continuing changes in land use and increasing demands on wastewater and stormwater management systems. These changes require continuing cooperative efforts on the part of the state, regional and local governments, and the communities they serve."

The riverine systems are subject to the Surface Water Improvement and Management plans developed pursuant to the SWIM Act, enacted by the Florida Legislature in 1987 and amended in 1989 through sections 373.451-373.459, Florida Statutes (F.S.). Through this Act, the Legislature recognized threats to the quality and function of the state's surface water resources. Watershed protection and management requires coordination of complementary programs among jurisdictions, agencies, and stakeholders, including local, state, and federal governments, nongovernmental organizations, and private citizens. The SWIM program addresses watershed priorities by identifying management options and supporting cooperative project implementation. Surface Water Improvement and Management plans integrate complementary programs and activities to protect and restore watershed resources and functions. They are also designed to address water quality and natural systems challenges. The SWIM plans for the Yellow and Choctawhatchee River Watersheds were updated in 2017 as part of funding allocated to local counties through the Resources and Ecosystem Sustainability, Tourist, Opportunities, and Revived Economies of the Gulf Coast Act, also known as RESTORE.

2.1 Surface Topography

In a flood risk assessment, the ground surface elevation is an important consideration as low-lying land areas are often highly vulnerable to flooding. assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. To meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 3 m × 3 m LiDAR tiles were kriged to create a topographic map of the watershed (Figure 22). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016. The LiDAR DEM products used in this study have a horizontal resolution of three meters and a vertical accuracy between 22 centimeters and 30 centimeters. This dataset covers nearly all areas in the watershed. Further processing of the data involved mosaicking into a seamless ground elevation surface, projecting into the NAD 1983 UTM Zone 17N coordinate system and converting vertical units from meters to feet.

Topography is a key parameter that influences many of the processes involved in flood risk. Note the LiDAR shows an area north of the basin that is relatively high, but it drains south toward the Gulf of Mexico.

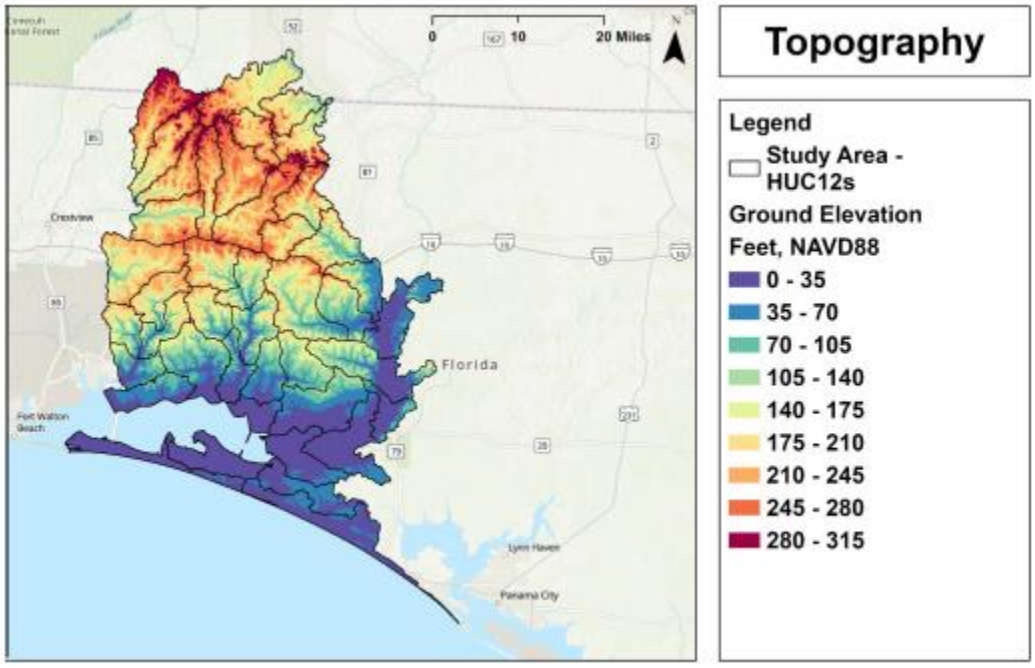


Figure 22. Topography of Walton County – NAVD88 (2016 flight, processed by FAU)

**Note this represents areas outside the basin.*

2.2 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. While the native soil (Section 2.4) and topography (Section 2.1) create an environment that is highly permeable and capable of infiltrating significant percolation of the water into the soil, changes in land use have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition.

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th percentile surface of the groundwater table elevation for mapping purposes. All daily mean surface water level observations on the common date were gathered from monitoring stations in the DBHYDRO database. Many stations are located along canals and rivers, which assists in determining the water levels across open and connected surface water bodies. As shown on the map in Figure 23 there are sixteen groundwater stations. Most are found in the southern reaches of the County. Surface water stations are more extensive due to the number of streams in the area.

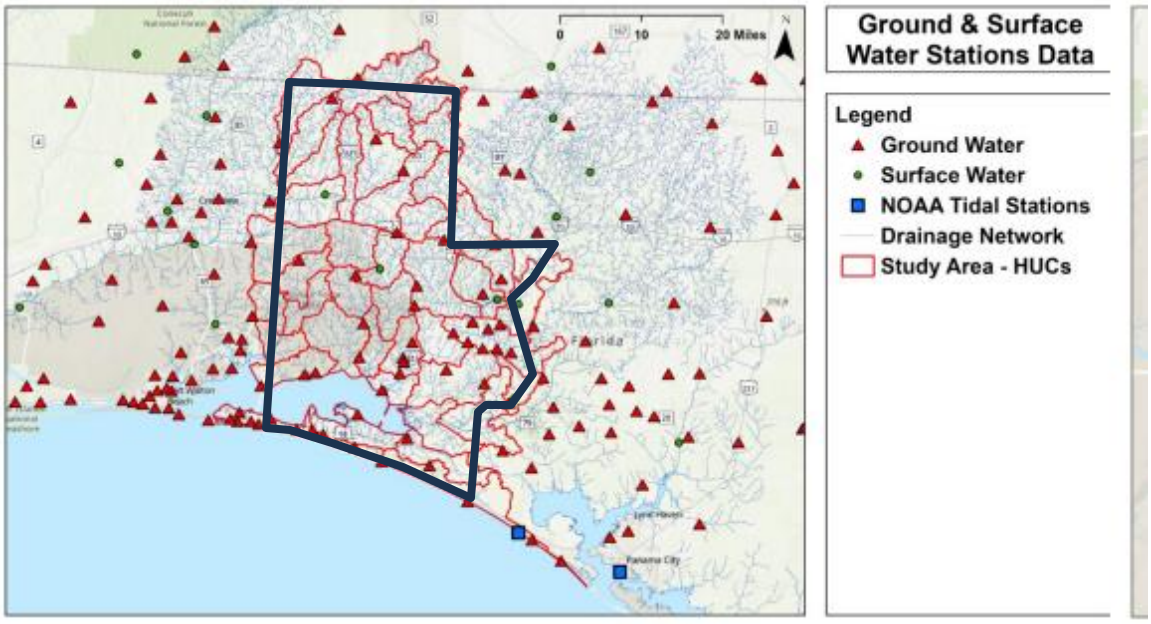


Figure 23. Ground and Surface Water Stations Maintained in Walton County (FAU, 2023)

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date of 09/27/2013 was chosen. Figure 24 shows the tidal stations maintained by NOAA in Florida. The Panama City and Pensacola tide stations were used for this exercise.

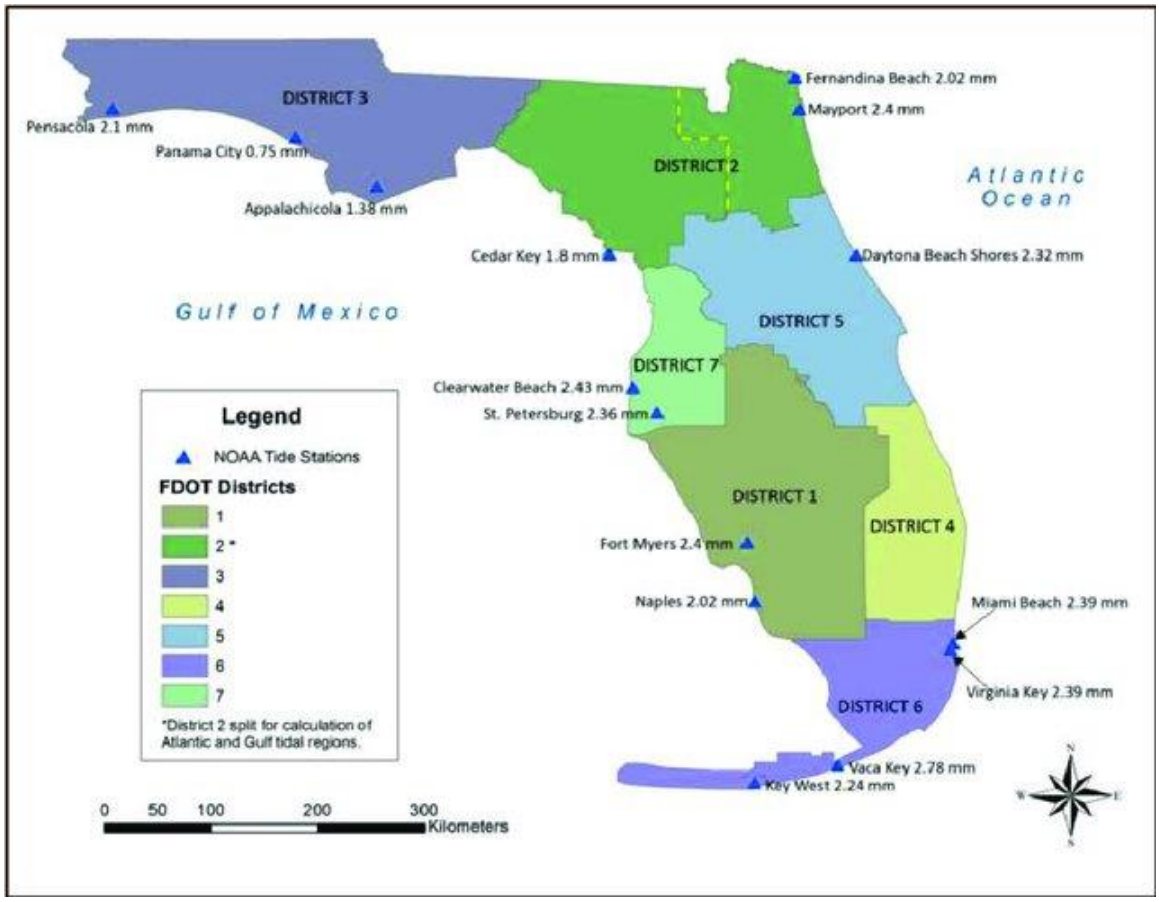


Figure 24. Locations of Tidal Stations Maintained by NOAA in FDOT Districts

(https://www.researchgate.net/publication/330637496_Sea_Level_Rise_Projection_Needs_Capacities_and_Alternative_Approaches_Sea_Level_Rise_Projection_Needs_Capacities_and_Alternative_Approaches/figures?lo=1)

2.3 Groundwater

There are a series of aquifers that underlie Walton County although none of them are very prolific. The water table aquifer is the Citronelle Formation which is widespread in the Gulf Coastal Plain. The formation was named by Matson (1916) as a result of its location near Citronelle, Alabama. The Citronelle Formation grades laterally, through a broad facies transition, into the Miccosukee Formation of the eastern Florida panhandle. Coe (1979) investigated the Citronelle Formation in portions of the western Florida panhandle. The Citronelle Formation is a siliciclastic, deltaic deposit that is lithologically similar to, and time equivalent with, the Cypresshead Formation and, at least in part, the Long Key Formation (Cunningham et al., 1998) of the peninsula. In the western panhandle, some of the sediments mapped as Citronelle Formation may be reworked Citronelle. The lithologies are the same and there are few fossils present to document a possible younger

age. The Citronelle Formation consists of gray to orange, often mottled, unconsolidated to poorly consolidated, very fine to very coarse, poorly sorted, clean to clayey sands. It contains significant amounts of clay, silt and gravel which may occur as beds and lenses and may vary considerably over short distances. Limonite nodules and limonite-cemented beds are common. Marine fossils are rare but fossil pollen, plant remains, and occasional vertebrates are found. Much of the Citronelle Formation is highly permeable.

The Citronelle Formation is the first unit encountered at the surface (Figure 25). Quaternary alluvium has accumulated in some of the major river valleys and Miocene formations are exposed in deeply incised river and stream valleys in the eastern portion of the study area.

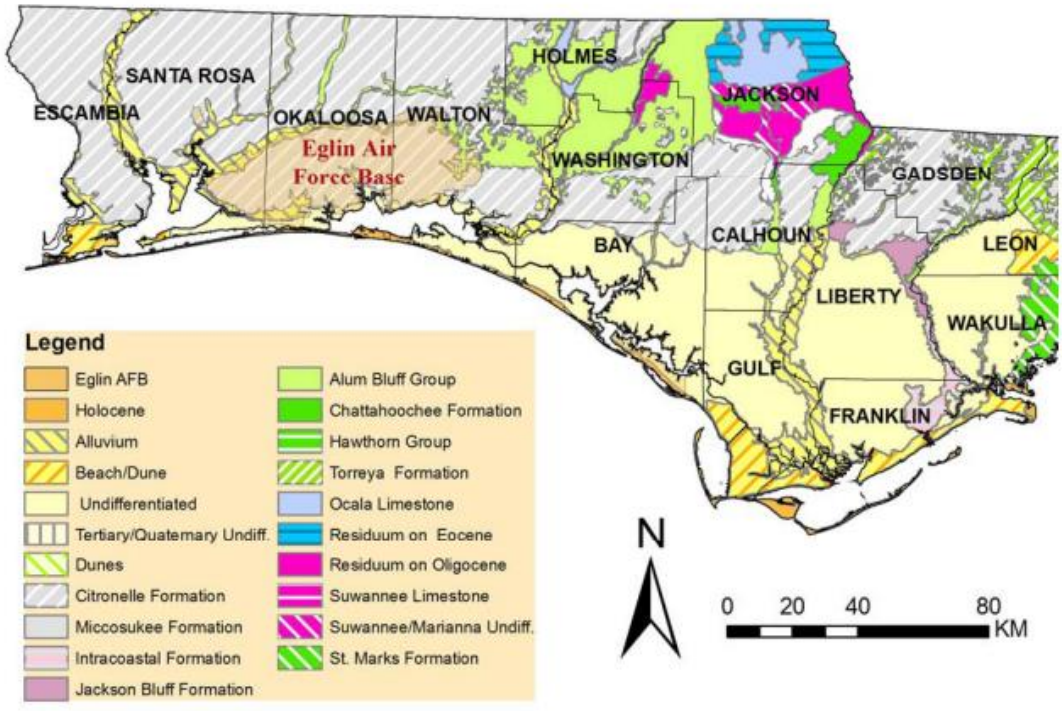


Figure 25. Geological Map of Citronelle Formation

Throughout Florida, the coastal condition is characterized by direct interaction between groundwater and surface water near the coast. The land has relatively flat terrain (refer to Figure 22 in Section 2.1), and coastal groundwater elevation is controlled by canals, rivers, and tides.

Bloetscher et al. (2012) found that the groundwater table elevation would seek high tide as opposed to average tides for a boundary condition.

Once a common time period is determined across the majority of wells, canal data can be gathered for that common date (and two days prior in the event the canals were deliberately lowered). Data is obtained from the SFWMD DBHYDRO site for surface waters. Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. Using water levels in the groundwater and canals, the only remaining boundary was the Gulf of Mexico. The tide issue is resolved by using the common date for high tide. As a result, surficial wells were noted across the area (refer to Figure 25), and in conjunction with the surface water stations, were used to krige a groundwater surface layer for the basin (Figure 26).

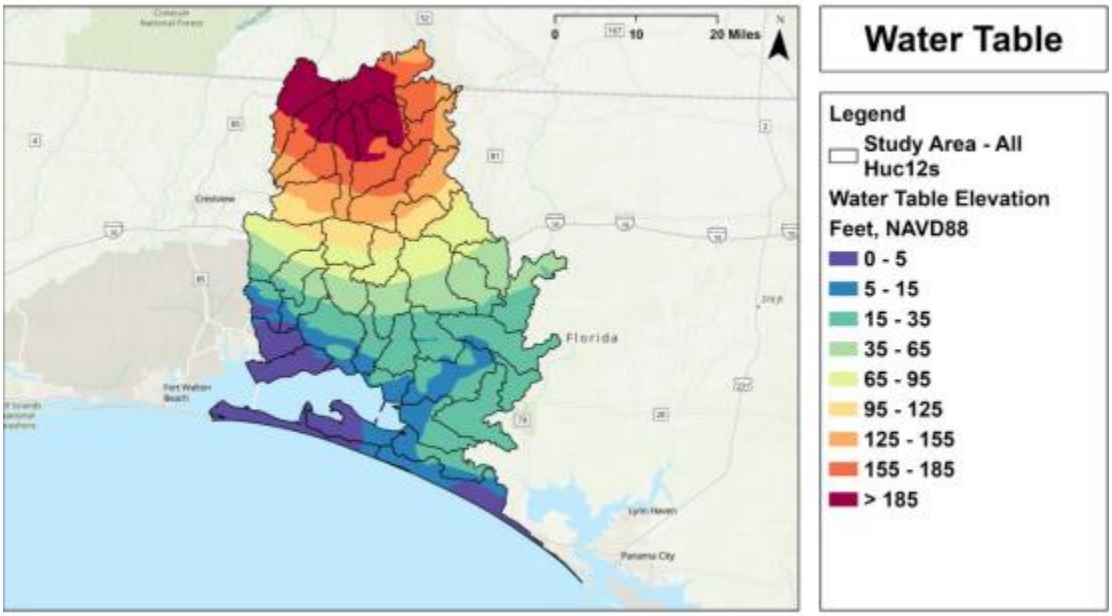


Figure 26. Groundwater Table for Walton County

**Note created by Kriging – elevation NAVD88 (FAU, 2023)*

2.4 Soils

While low land elevations and high groundwater table elevations influence flooding, the soil storage capacity will also greatly influence the watershed's vulnerability to flooding. Open surface

water bodies and frequently inundated land will be unable to store additional water during a rainfall event. Hence, when mapping the soil storage capacity across the watershed, these areas were set to zero storage capacity as there is no capacity for these areas to store additional water. These areas were delineated from statewide land use land cover datasets and were used in the calculation of soil storage capacity. Flooding is likely to occur near open surface water bodies and areas such as wetlands, swamps, and marshes.

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soils are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory, 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in Figure 27.

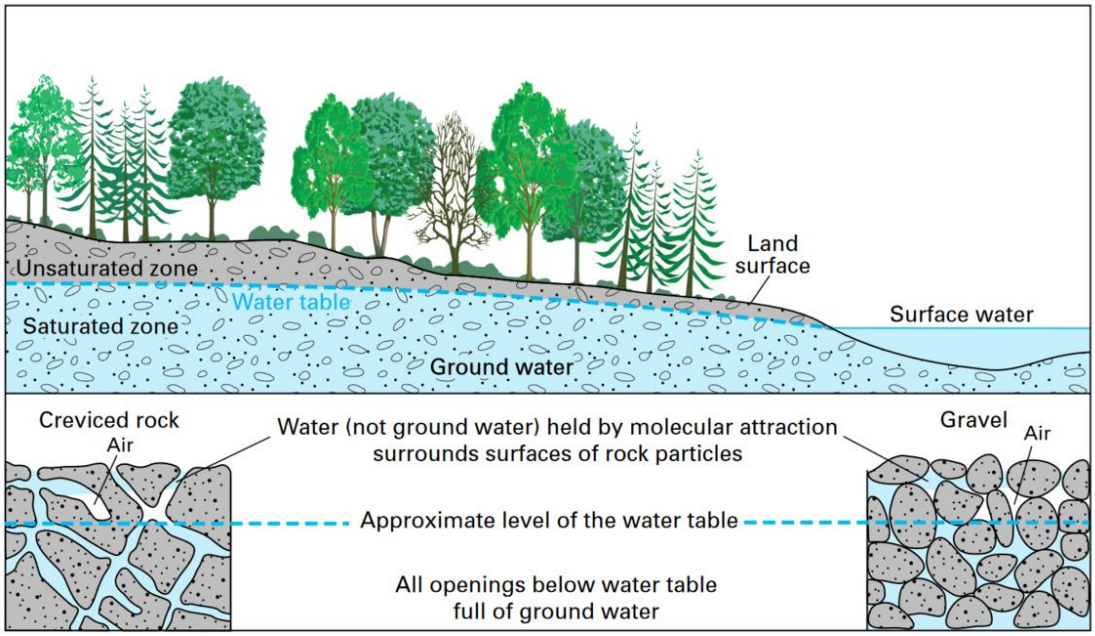


Figure 27. Subsurface Voids in the Unsaturated Zone (USGS, 2020)

The unsaturated zone is the portion of the subsurface above the groundwater table that contains soil and rock, and air and water in subsurface voids as shown in Figure 28. This zone affects the rate at which the aquifer gets recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the ground water table rising to the surface and the surplus rainfall becomes runoff.

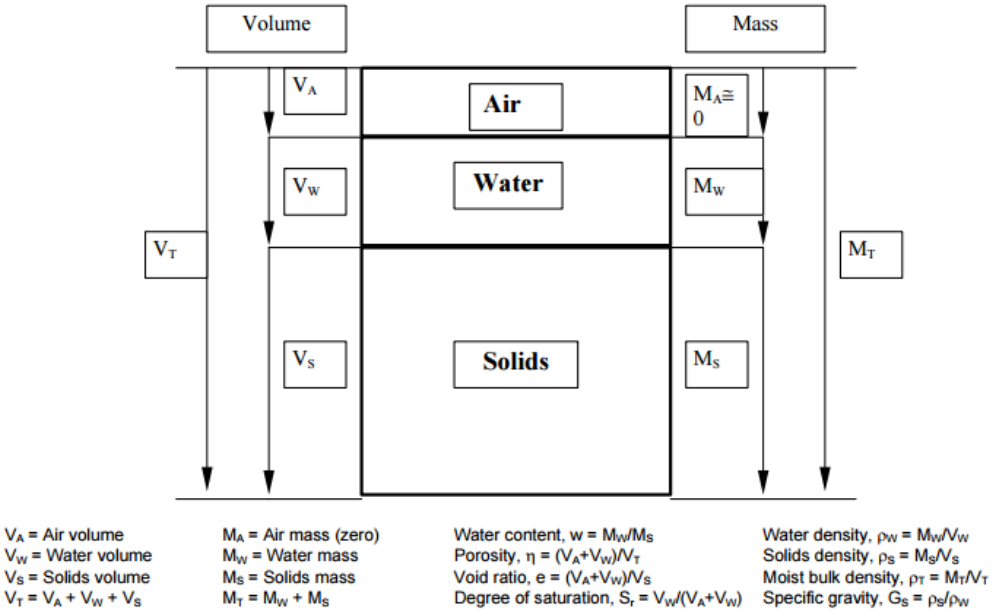


Figure 28. Saturated Zone Soil Phase Diagram (Gregory et al., 1998)

Soils data is available from United States Department of Agriculture (USDA) or other agencies is available in the form of maps that can be incorporated as a GIS layer. FAU chose to use the Gridded SSURGO (gSSURGO) dataset from USDA, which is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). Figure 29 shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

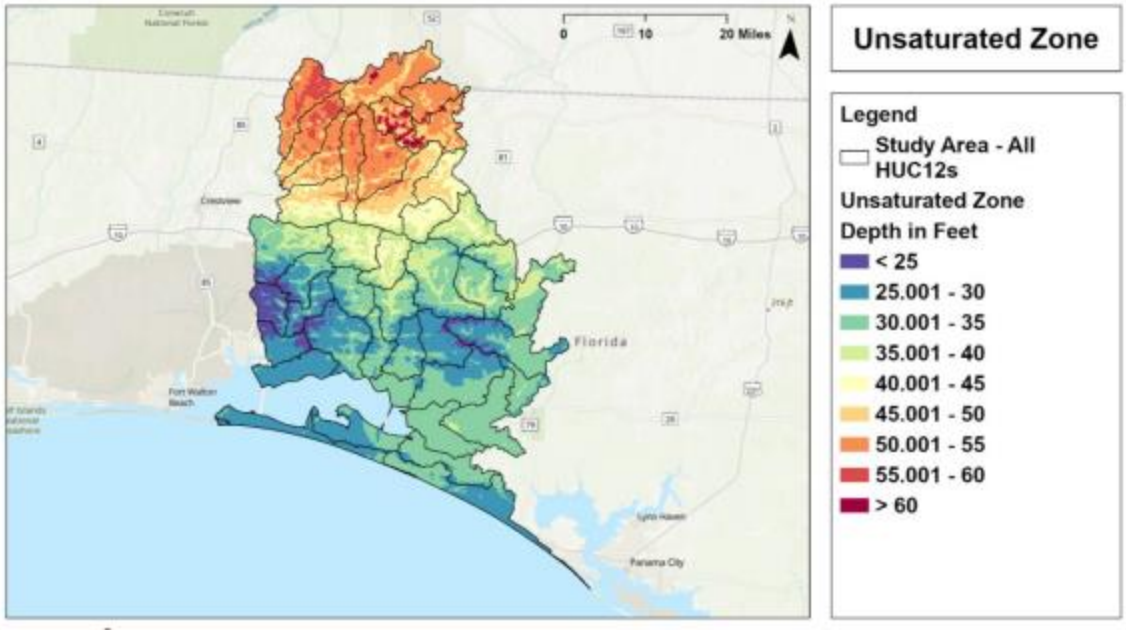


Figure 29. Unsaturated Zone Map for Walton County (FAU, 2023)

The available water storage from USDA derived for the soil layer (0-150 cm) statewide is shown in Figure 30, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. The "no data area" is mainly due to a land cover by water body or wetland. As a result of applying this layer (Figure 31), the estimated soil storage capacity can be illustrated (Figure 32). Much of the basin has very limited soil storage capacity.

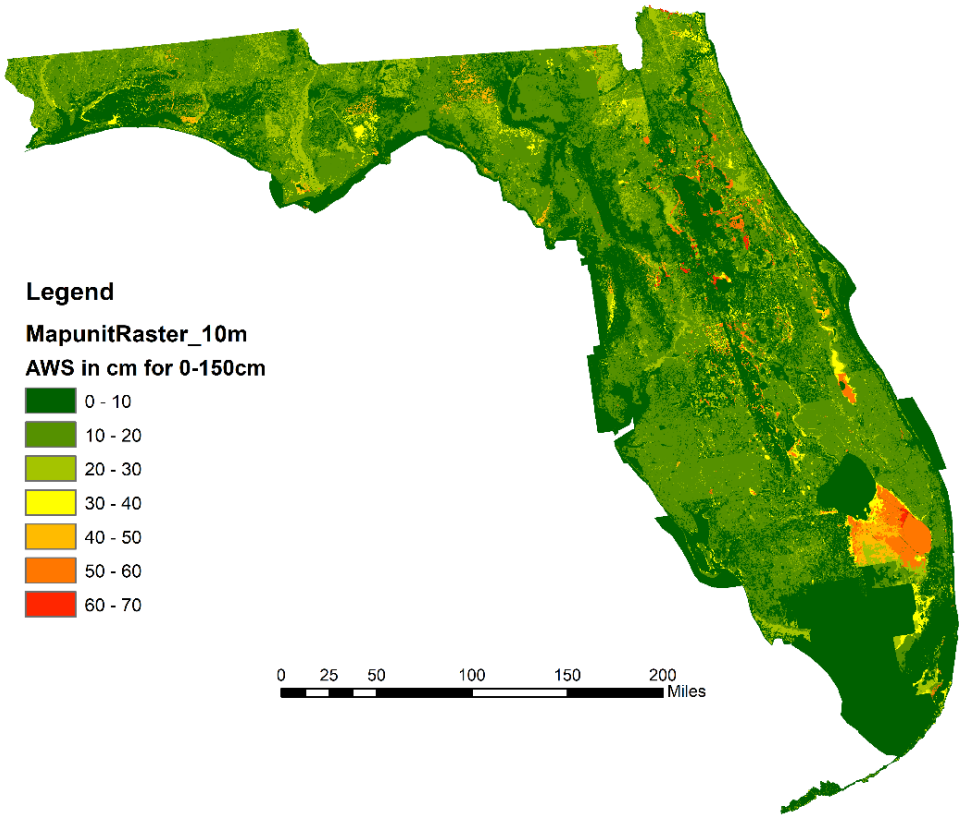


Figure 30. Available Water Storage for State of Florida (FAU, gSSURGO Soil Database)

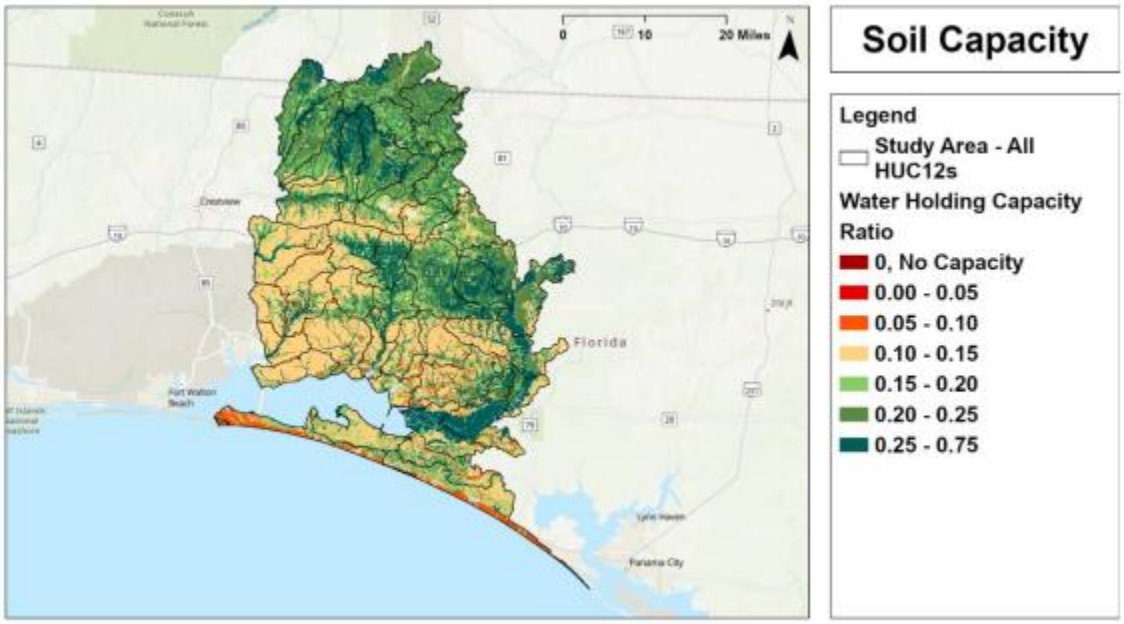


Figure 31. Soil Capacity (inches) for Walton County (FAU, 2023)

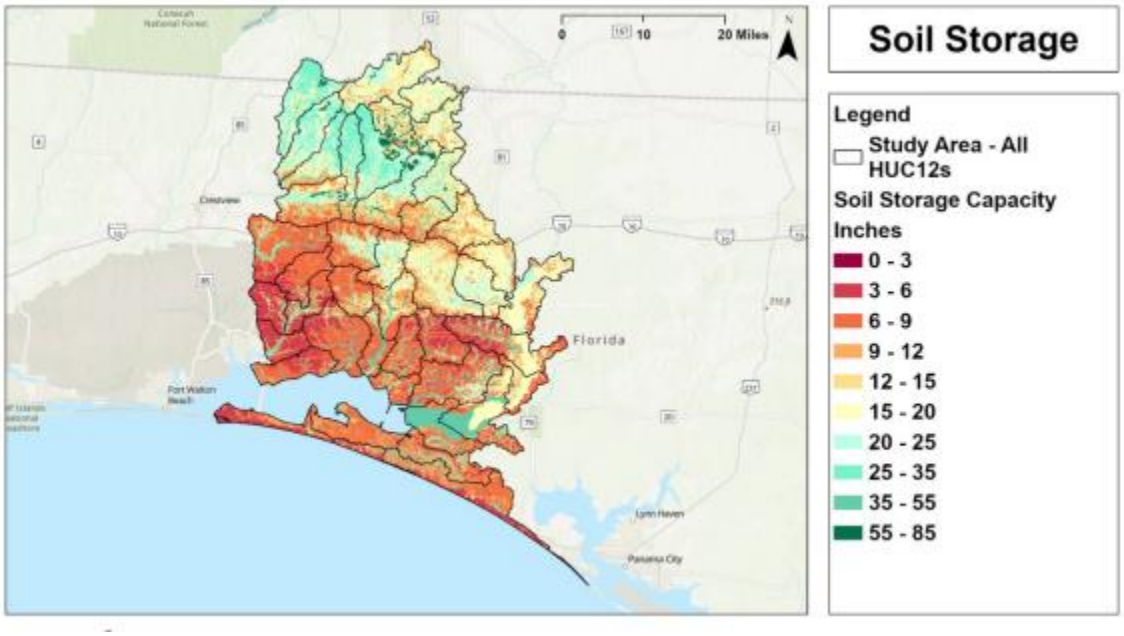


Figure 32. Water Holding Capacity (ratio) for Walton County (FAU, 2023)

2.5 Land Cover

The U.S. Geological Survey (USGS) produces the NLCD of nationwide data on land cover at a 30 m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016. Figure 12 was used for land use.

2.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day, 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 33 shows the 3-day, 25-year rainfall map based on the NOAA Atlas 14 dataset for the Walton County. This is one of four design storms used in the overall analysis. The others are 1-day / 5-year, 1-day / 10-year, and 1-day / 100-year events (Figure 34, Figure 35 and Figure 36).

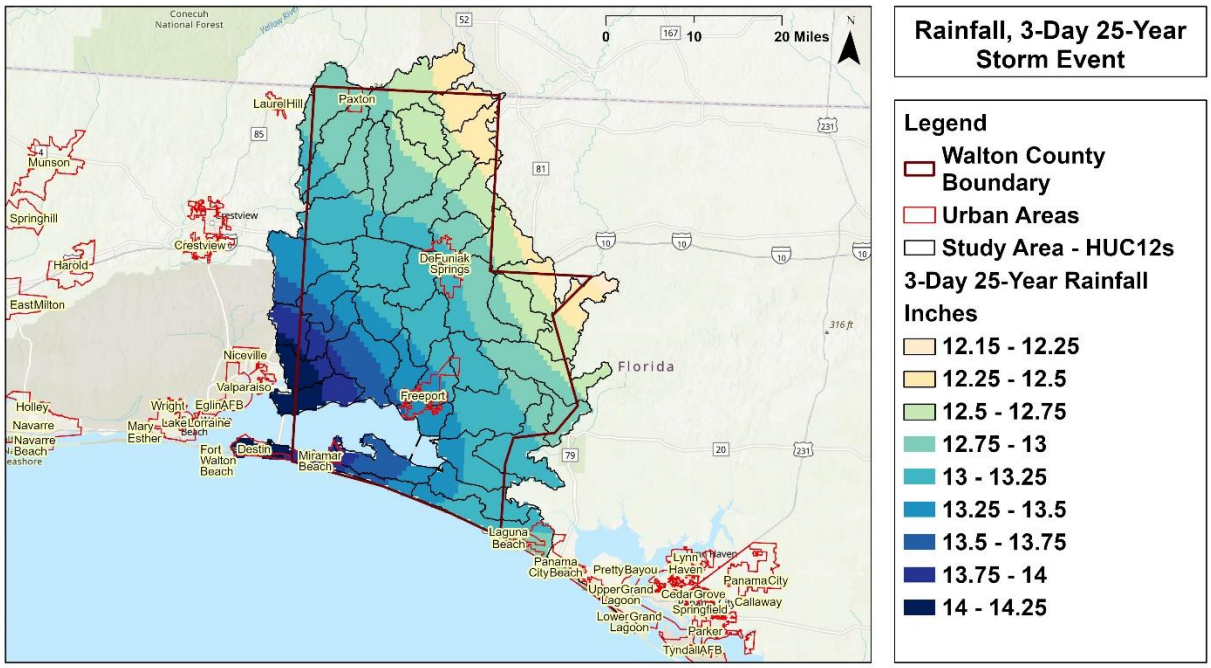


Figure 33. County-wide Rainfall Distribution 3-day, 25-year Storm (FAU, 2023)

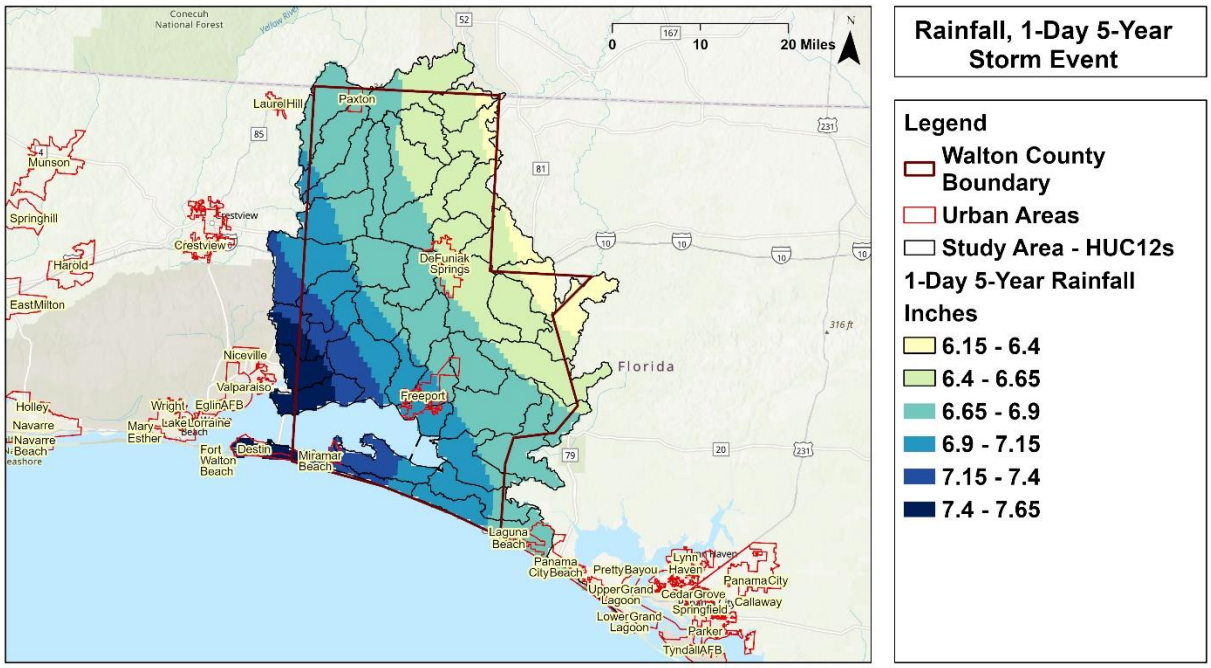


Figure 34. County-wide Rainfall Distribution 1-day, 5-year Storm (FAU, 2023)

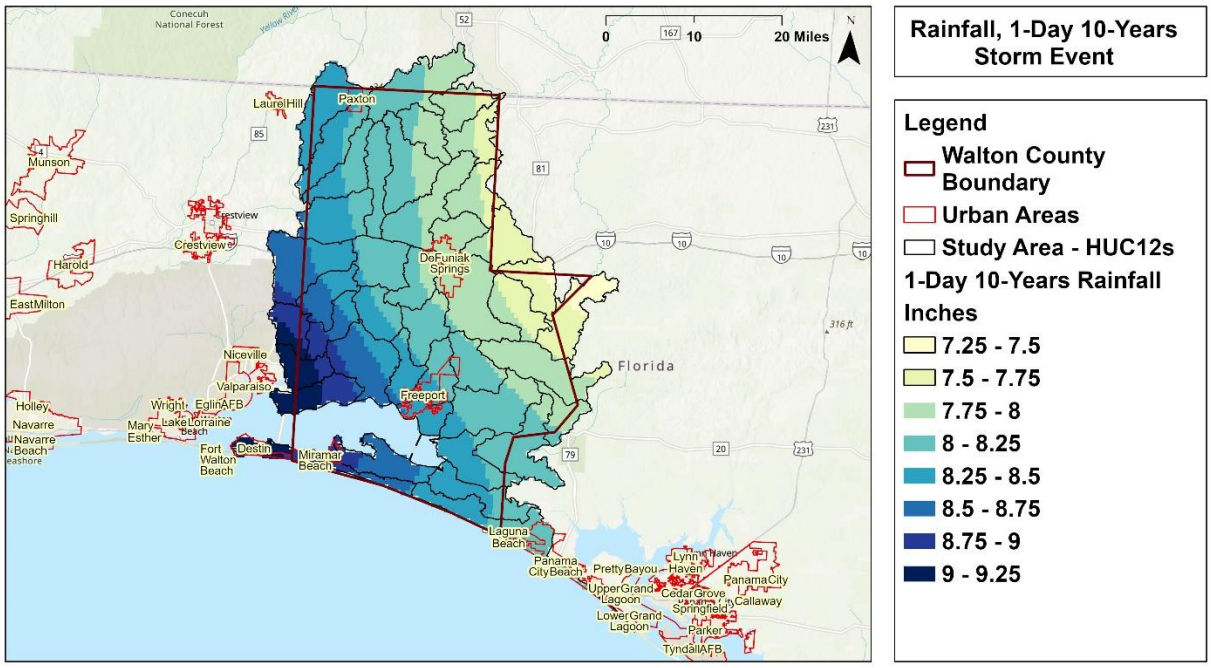


Figure 35. County-wide Rainfall Distribution 1-day, 10-year Storm (FAU, 2023)

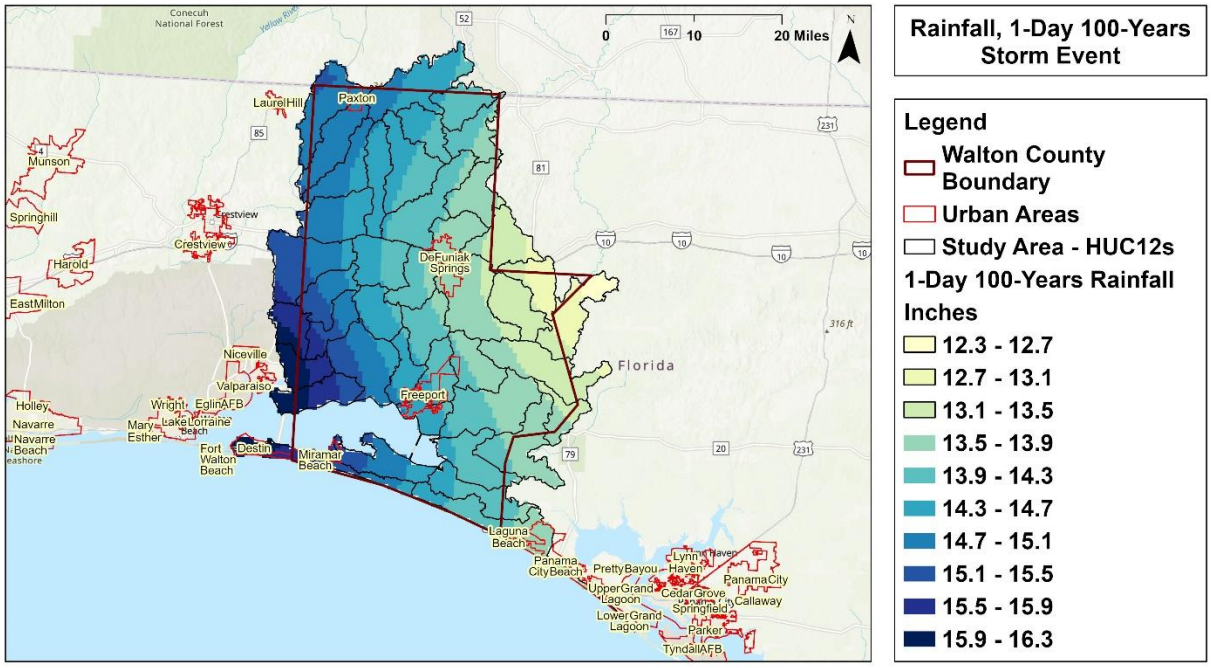


Figure 36. County-wide Rainfall Distribution 1-day, 100-year Storm (FAU, 2023)

2.7 Open Space

Open space is defined as areas that are exempted from development. Generally, it means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and bodies of water that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is land throughout the Choctawhatchee watershed that has been protected via acquisition by federal, state, or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. These are primarily shown on the conservation maps noted in Section 1.1.4. Agricultural land and other land cover will come from the land cover map (see Section 2.5). Added to this will be the waterbodies discussed in Section 2.9, which serve a related condition to open space.

2.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate the ground, it runs off faster. Faster runoff means that peak flows to water bodies and storm sewers occur faster, and with a higher peak. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than areas that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30 m resolution with a 16-class legend based on a modified Anderson Level II classification system. The database is designed to provide cyclical updates of United States land cover and associated changes. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change and enables monitoring and trend assessments. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. Figure 37 shows the impervious areas derived from the NLCD2016.

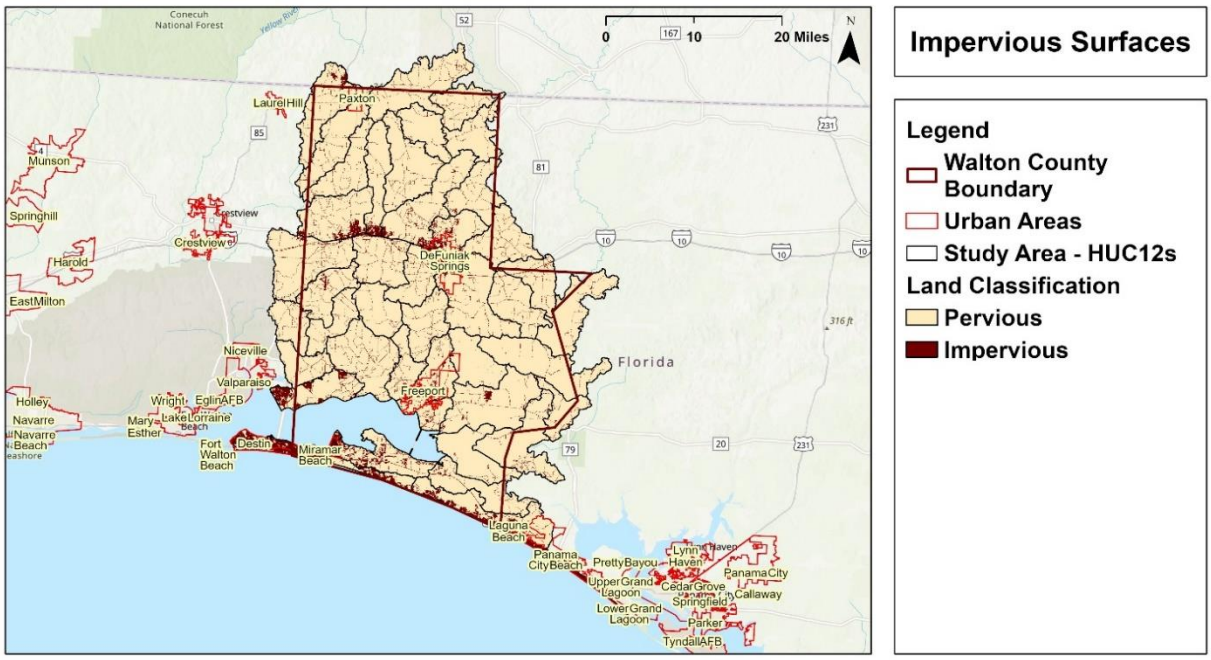


Figure 37. Impervious Areas Derived from NLCD2016 (FAU, 2023)

2.9 Waterbodies

Since much of the property in the study area is agricultural land or wetlands, waterbodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (Figure 38). Note that tiny waterbodies may be missing from the maps. Soils were discussed previously in Section 2.4.

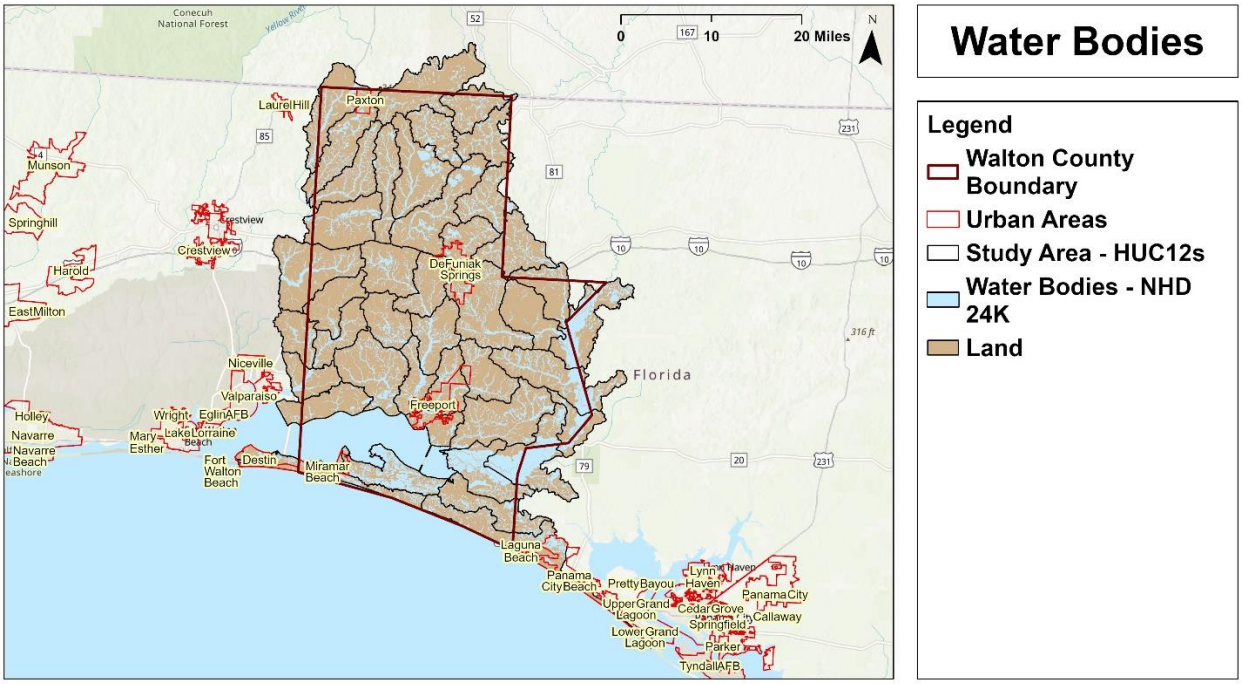


Figure 38. Surface Water Located in Walton County (FAU, 2023)

2.10 Natural Resources

Understanding the watershed's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones.

USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, at the watershed level, this data can

be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers. Much of this information is primarily covered in Section 1.1 and earlier parts of this chapter and will not be repeated here.

2.11 Demographics

Demographics data is important for determining several key indicators for watershed level master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the watershed, Table 5 outlines population and racial composition demographics by County and its neighbors.

Table 5. Demographics and Housing Characteristics for Walton County (US Census, 2020)

Demographic Parameter	Walton County	Bay County	Washington County	Holmes County	Okaloosa County
Area	893 mi^2	1033 mi^2	616 mi^2	489 mi^2	1028 mi^2
Population	75,305	175,216	25,318	16,766	146,271
No. of Households	150,345	73,536	9,073	7,187	79,235
White	80.5%	73.3%	77.0	85.3%	69.1%
Black, African American	4.4%	10.2%	12.8%	6.1%	8.9%
American Indian, Native	0.6%	0.45%	0.8%	6.1%	0.4%
Asian	1.2%	2.3%	0.5%	2.0%	3.1%
Other Race	0.4%	0.5%	0.45%	0.1%	0.8%
Two or More Races	4.7%	5.5%	4.8%	3.8%	7.0%
Hispanic or Latino (Regardless of Race)	8.2%	7.9%	3.6%	3.5%	10.7%

2.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, or the ocean. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the

amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and may be completely lacking in others. The quality and amount of data available may vary from jurisdiction to jurisdiction; some communities use GIS or other software, while others rely on paper maps or as-built surveys. The condition of the assets may be lacking, and the maintenance history may not be available. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County does not have all publicly maintained stormwater infrastructure catalogued in its GIS system. Figure 39 shows the drainage structures located in Miramar Beach.

2.13 Data Gaps

Data gaps for the watershed include – mapping existing stormwater infrastructure and maintenance records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the watershed level and 2) community hotspots. The regional infrastructure overwhelms the impacts of local infrastructure at the watershed analysis level. An assessment of neighborhood level vulnerability will require a complete list of existing stormwater infrastructure and maintenance records.

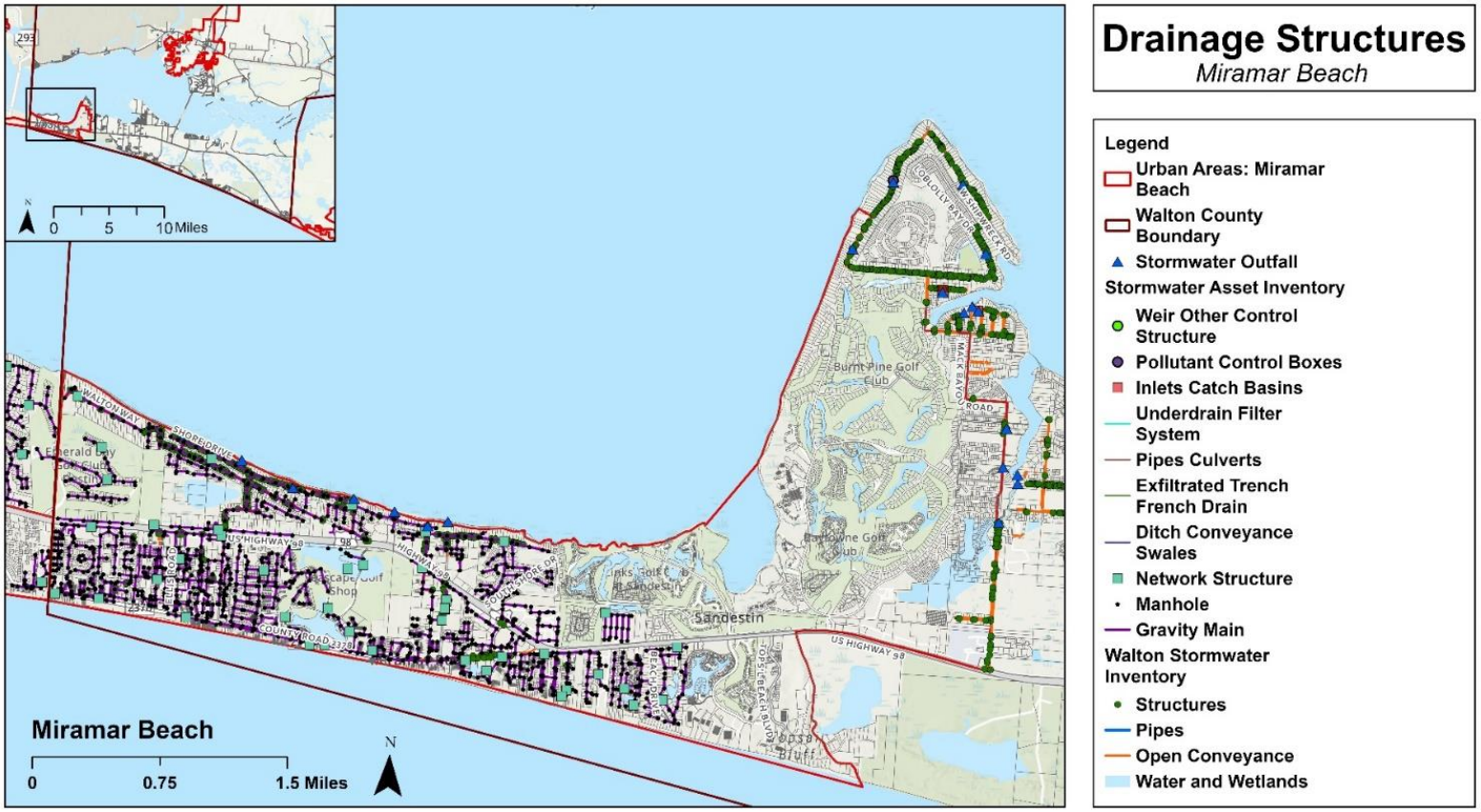


Figure 39. Location of Stormwater Infrastructure in Miramar Beach

3.0 POLICY FRAMEWORK

A Watershed Master Plan should be cognizant of all applicable policy guidelines, ordinances, and public policies that relate to water management within the study area. In this section, the planning documents available for the HUC12 sub watersheds that affect Walton County are discussed as they relate to watershed master plan. Ultimately the goal Is that there is harmony among the plans, regulations, and implementation of flood reduction efforts in adjoining jurisdictions.

3.1 Existing Regulations

It is important that the watershed master plan identify the control actions, management practices, and regulations as well as the agencies that have authority and jurisdiction, as applicable to the study area. The universe of existing regulations includes federal, state, tribal, regional, and local rules. The following section summarizes them. Note that for this watershed, the primary regulations are established by the Florida Department of Environmental Protection and the Northwest Florida Water Management District.

3.1.1 Federal Regulations

The federal and state rules have been interconnected since the 1980s with delegation of enforcement and administration of the major environmental protection rules to the states. In response to increased flood damage, the escalating costs of disaster relief for taxpayers, and the lack of affordable flood insurance, Congress enacted the National Flood Insurance Act (NFIA) in 1968 (Public Law Number 90-448, 82 Stat. 572 (August 1, 1968). Codified, as amended, at 42 U.S.C. §4001), which established the National Flood Insurance Program (NFIP). Property located in a flood area where the community participates in the NFIP is subject to the NFIA's requirements.

Flood insurance compliance requirements for federally regulated financial institutions began in 1973, when Congress enacted the Flood Disaster Protection Act of 1973 (FDPA - Public Law Number 93-234, 87 Stat. 975.). Section 102(b) of the FDPA amended the NFIA to require the Board of Governors of the Federal Reserve System (Board), the Federal Deposit Insurance Corporation (FDIC), the Office of the Comptroller of the Currency (OCC), and the National Credit

Union Administration (NCUA) to issue regulations directing lending institutions under their supervision not to make, increase, extend, or renew any loan secured by improved real estate or mobile homes located, or to be located, in a Special Flood Hazard Area (SFHA) where flood insurance is available under the NFIP unless the building or mobile home and any personal property securing the loan are covered by flood insurance for the term of the loan.

Congress subsequently enacted the National Flood Insurance Reform Act of 1994 (Reform Act - Title V of the Riegle Community Development and Regulatory Improvement Act of 1994, Public Law Number 103-325 (September 23, 1994), which made comprehensive changes to the NFIA and FDPA. The changes include obligating lenders to escrow all premiums and fees for flood insurance required under the NFIA. In part because the NFIP incurred large deficits from paying claims for major floods, Congress enacted the Biggert-Waters Flood Insurance Reform Act of 2012 (BWA) to ensure the NFIP's fiscal stability and for other purposes. To make the program self-sustaining, the BWA phased out both subsidized rates, which apply to approximately 20% of policyholders (Pub. L. No. 112-141, 126 Stat. 916 (2012). The BWA also directed FEMA to implement full-risk pricing for all policies.

Discharging into surface waters is one of the oldest methods of disposing of waste from the point of generation. Downstream, reduction of the waste occurs due to dilution and natural degradation processes. Given sufficient treatment prior to discharge, these mutual processes work to reduce the waste to relatively minimal levels. Failure to treat adequately will overload the natural attenuation ability of the waterbody, resulting in noticeable pollution. As a result of major issues with pollution in the 1960s, Congress passed the Clean Water Act (CWA). The preamble for the CWA is as follows:

> "The objective of this act is to restore and maintain the chemical physical and biological integrity of the Nation's waters…"

Congress further stated that the discharge of pollutants in toxic amounts must be prohibited. As a result, the Clean Water Act regulates surface discharges to fresh waters, ocean discharges by wastewater plants, disposal of concentrated process waters from water plants (such as concentrate from membrane facilities), and disposal of residuals (sludge).

Legislation was first directed to wastewater because discharging to a stream or surface waterbody made it the source water for downstream communities. Hence, if wastewater could be treated before it was discharged into the rivers, this might reduce the amount of treatment necessary for drinking water. Thus, the focus was primarily on wastewater treatment plants. At the same time, there were a variety of other issues that were addressed such as the attempt to reuse wastewater for beneficial uses like irrigation, to deal with industrial pretreatment so that metals and other contaminants that would disrupt the wastewater treatment process would not be discharged to the sewer system as well as the idea that stormwater might contribute to overflows. Implicit is that stormwater and agricultural runoff issues may affect potable water supplies and are potentially subject to regulation.

Since 1990, the focus has shifted from wastewater (mostly addressed) to agricultural and urban nonpoint source stormwater runoff (nutrients) which account for about half the pollution loadings that originally existed in these waterways. Because agriculture is so expansive and difficult to regulate, USEPA developed MS4 and other permitting systems to address runoff. Runoff continues to be a regulatory challenge at the federal level, so much of the enforcement has been delegated to the states and regional/local governments. In Florida, the state has delegated much of this effort to FDEP and the water management districts.

3.1.2 Dredge, Fill and Changes to Channels – Mixed State, Local and Federal Jurisdiction

USACOE has rules associated with federal works that apply to dredging, and other activities on navigable waters or wetlands. Such changes require permits from the Corps unless delegated to the states. In Florida, dredging and filling in the surface waters has been regulated since the early 1970s. This program was established under Chapter 403, F.S., to protect our surface waters from degradation caused by the loss of wetlands and from pollution caused by construction activities.

Any activity on or over wetlands and other surface waters (dredging and filling) is regulated by the department and five water management districts (Northwest Florida, Suwannee River, St. Johns River, Southwest Florida, and South Florida) through the Environmental Resources Permitting program. The ERP replaced the older the dredge and fill permit program by combining it with the management and storage of surface water (MSSW) permit program of the districts, creating a new environmental resource permit (ERP) program under Part IV of Chapter 373 of

the Florida Statutes. The Chapter 403 rules apply only within the limits of the Northwest Florida Water Management District (NWFWMD), and for certain grandfathered activities in the rest of the state. The ERP program is in effect throughout the state. The ERP program regulates dredging and filling in all wetlands and other surface waters, and also regulates the aspects of the MSSW program such as water quantity (flooding) and water quality (stormwater) in both wetlands and uplands.

Dredging and filling also is regulated by the federal government under a separate program administered by the U.S. Army Corps of Engineers. The process is initiated by submitting a joint (interagency) application to the department or to one of the above water management districts. Processing such permits involves evaluation of individual, project-specific applications in what can be considered three steps: 1) pre-application consultation (for major projects), 2) project review, and 3) decision-making. Per the USACE website (https://www.lrl.usace.army.mil/Portals/64/docs/regulatory/Permitting/PermittingProcessInformation.pdf), the process for the general permit is as follows:

1. A pre-application consultation is recommended.
2. The applicant submits ENG Form 4345 and plans electronically or to the appropriate USACOE regulatory office.
3. USACOE notifies the applicant if additional information is required to complete the application.
4. A public notice is issued within 15 days of receipt of a complete application to solicit comments from the public, adjacent property owners, interested groups and individuals, local agencies, state agencies, and Federal agencies.
5. The public notice comment period is 15-30 days, depending upon nature of activity.
6. USACOE provides the applicant an opportunity to respond to comments received in response to the public notice.
7. USACOE considers all comments and the applicant’s responses to those comments, including any proposed modifications of the project.
8. A public hearing is held, if necessary.
9. USACOE conducts a public interest review evaluation and, if necessary, a section 404(b)(1) guidelines evaluation.

10. USACOE makes a decision on the permit application and explains its decision in a decision document. This decision document may include an environmental assessment or environmental impact statement, a statement of findings or record of decision, a Section 404(b)(1) guidelines evaluation (if necessary), and a public interest review evaluation.
11. If USACOE issues the permit, a copy is sent to the applicant for signature, otherwise an explanation of permit denial is sent.
12. If the applicant refuses to sign the permit because he or she does not agree with the conditions in the permit, or if the permit is denied, the applicant can request an administrative appeal of the permit decision.

Pre-application consultation is suggested to provide for informal discussions about a proposed activity. This invaluable feedback gives the applicant insight into the viability of alternatives available to accomplish the project goal and provides opportunities to discuss measures for reducing impacts and to inform the applicant of the factors USACOE must consider in its decision-making process.

The following general criteria are considered in evaluating all applications (https://www.lrl.usace.army.mil/Portals/64/docs/regulatory/Permitting/PermittingProcessInformation.pdf):

1. Relevant extent of public and private need for the proposed work.
2. Where unresolved conflicts of resource use exist, the practicability of using reasonable alternative locations and methods to accomplish the objective of the proposed structure or work.
3. The extent and permanence of the beneficial and/or detrimental effects the proposed structure or work is likely to have on public and private uses to which the area is suited.

The public interest review involves an analysis of the foreseeable impacts the proposed work would have on public interest factors, such as navigation, general environmental concerns, wetlands, economics, fish and wildlife values, land use, floodplain values, and the needs and welfare of the people. The permit decision document includes a discussion of the environmental impacts of the project, the findings of the public interest review process, and any special evaluation required by the type of activity, such as determining compliance with the Section

404(b)(1) guidelines. Because every project is subject to regulations and permitting requirements, preparing a comprehensive up-to-date list may be problematic. Therefore, it is recommended to conduct pre-application meetings with the pertinent regulatory agencies (USACE, FDEP, WMDs, and the counties) to identify the appropriate permits and guidelines for regulatory compliance.

3.1.3 State Regulations

In addition to the dredge and fill/MSSW program described in the prior section, the Florida Legislature enacted the Florida Watershed Restoration Act (FWRA) in 1999 to protect Florida's water resources from excessive pollution loading. It focuses on the Total Maximum Daily Load (TMDL) program that is required by the federal Clean Water Act and discusses specifics of how this program should be implemented in Florida. It does not address water quantity directly.

3.1.3.1 Water Quality Management Reports (TMDL/BMAP/SWIM Plans)

A TMDL is the total amount of pollution discharge from all sources that a waterbody can assimilate and still meet water quality standards. This value is typically represented in lb/year allocations. For more information on water quality standards, consult Surface Water Quality Standards - Chapter 62-302. The TMDL program protects state waters by coordinating the control of pollution from point sources (i.e., sources discharging through a discrete conveyance, such as a pipe, as well as urban stormwater conveyance outfalls) and nonpoint sources (i.e., sources contributing to pollution caused by rainfall moving over and through the ground).

Waterbodies that do not meet water quality standards are identified as "impaired," and implementation plans must be developed describing how the point and nonpoint sources of pollution will meet their discharge allocations. This implementation plan is referred to as Basin Management Action Plan (BMAP). FDEP identified the following basic steps for the TMDL program (the bulleted list below is a direct quotation from the website at http://www.dep.state.fl.us/water/tmdl/):

- Access the quality of surface waters—Are water quality standards being met?
- Determine which waters are impaired or are not meeting water quality standards for particular pollutants?
- Establish and adopt, by rule, a TMDL for each impaired water for the pollutants of concern.

- Develop, with extensive local stakeholder input, Basin Management Action Plans (BMAPs)
- Implement the strategies and actions of BMAPs.
- Measure the effectiveness of BMAPs, both continuously at the local level and through a formal re-evaluation every five years
- Adapt BMAPs to local conditions by changing the plan and changing the actions if things are not working.
- Reassess the quality of surface waters continuously.

FDEP is the lead agency in establishing TMDLs and for enforcing the FWRA when addressing point source and nonagricultural nonpoint source pollution, while the Florida Department of Agriculture and Consumer Affairs (FDACS) is the lead agency for enforcing the FWRA when it comes to agricultural nonpoint source pollution. FDEP is required to coordinate with the water management districts, FDACS, soil and water conservation districts, environmental groups, regulated parties, and local stakeholders during all phases of the TMDL process, which includes:

- Development of a TMDL assessment. The assessment methodology for determining those waters that are impaired should be adopted by the FDEP by rule. The methodology should include determination of what information is required for the TMDL assessment, the acceptable methods of data collection, and analysis and quality control requirements. Recall that impaired waters are those that fail to meet the water quality standards assigned to them based on designated uses. If waterbodies are determined to be impaired, the FDEP must establish a TMDL.
- Development of an approved list of waterbodies or segments for which TMDLs will be applied, including a priority ranking and schedule for analyzing such waters.
- Calculation and implementation of TMDLs, accounting for seasonal variations and including a margin of safety to reflect uncertainties about pollution loading effects on water quality. A TMDL should be allocated among pollution sources in a reasonable and equitable manner (accounting for the availability of treatment technologies, existing treatment levels, and the costs/benefits of achieving allocation).

FDEP in coordination with the water management districts may develop a BMAP to achieve the TMDL. BMAPs can include such strategies as construction of regional treatment systems or

voluntary trading of water quality credits. BMAPs should include water quality improvement milestones, and the progress with achieving these milestones should be evaluated every five years. FDEP can implement TMDLs under existing water quality protection programs, such as:

- Permitting and other existing regulatory programs, such as water-quality-based effluent limitations.
- Non-regulatory and incentive-based programs, such as cost-share, best management practices, and public education.
- Trading of water quality credits or other agreements.
- Public works, including capital facilities.
- Land acquisition

Section 303(d) of the Clean Water Act allows USEPA to assist states, territories, and authorized tribes in the process of listing out any and all impaired waters and develop plans to address each of their respective TMDLs. FDEP checks the quality of watersheds across the State of Florida and determines if they are with an acceptable TMDL of pollutants (Figure 40). A TMDL is the restoration goal of a specific watershed. A TMDL has been adopted in Walton Count for Turkey Creek as shown on Figure 41.

Turkey Creek is located in the Pensacola Bay Basin in north central Walton County. Turkey Creek is a Class III waterbody, with a designated use of recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife" per FDEP's website. This waterbody was verified as impaired for fecal coliform, and therefore was included on the Verified List of impaired waters for the Pensacola Bay Basin that was adopted by Secretarial Order in November 2010. The TMDL establishes the allowable fecal coliform loading to Turkey Creek that would restore the waterbody so that it meets its applicable water quality criterion for fecal coliform. The creek, which is approximately 11 miles long, flows from north to south and empties into the Shoal River (Figure 41). The watershed is rural, mainly covered by upland forest, wetlands, and pasture. Additional information about the hydrology and geology of this area is available in the Water Quality Status Report for the Pensacola Bay Basin. The Department used the IWR to assess water quality impairments in the Turkey Creek watershed and has verified that this waterbody segment is impaired for fecal coliform bacteria. The verified impairment was based on the observation that 5 out of 25 fecal coliform samples collected during the verified period (January 1, 2003, through

June 30, 2010) exceeded the applicable fecal water quality criterion (Rule 62-302, F.A.C). Table 6 outlines the Turkey Creek TMDLs.

Figure 40. TMDL Basins and Planning Units in Northwest Florida (FAU, 2023)

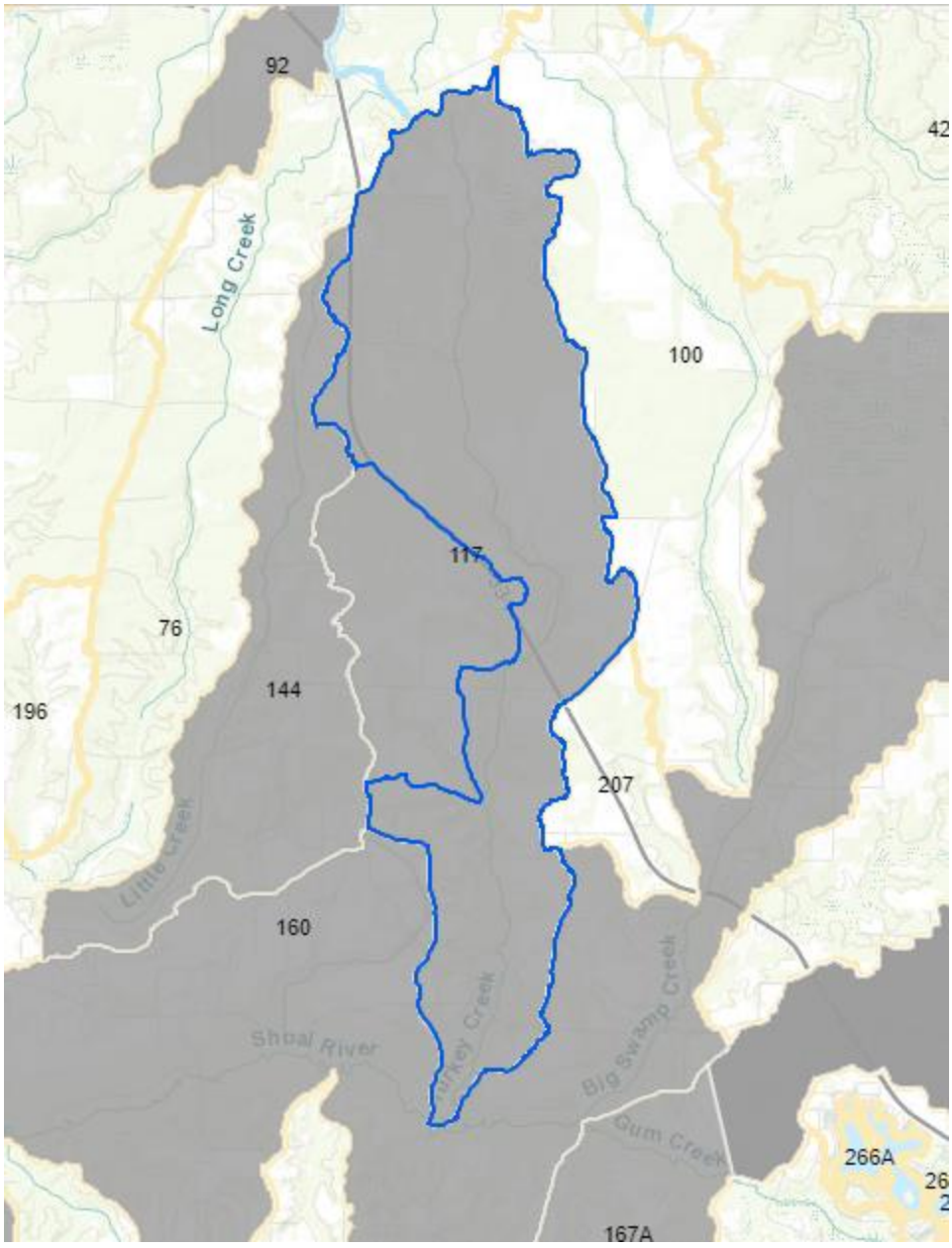


Figure 41. Turkey Creek Sub-watershed in Walton County (empties to Shoal Creek)

(https://fdep.maps.arcgis.com/home/webmap/viewer.html?webmap=1b4f1bf4c9c3481fb2864a415fbeca77)

Table 6. TMDL Data for Fecal Coliforms in Turkey Creek

Parameter	Fecal Coliform
Total number of samples	25
IWR-required number of exceedances for the Verified List	5
Number of observed exceedances	5
Number of observed nonexceedances	20
Number of seasons during which samples were collected	4
Highest observation (counts/100mL)	1,800
Lowest observation (counts/100mL)	70
Median observation (counts/100mL)	148
Mean observation (counts/100mL)	359
FINAL ASSESSMENT	**Impaired**

(http://publicfiles.dep.state.fl.us/DEAR/DEARweb/TMDL/Final_TMDL/gp4/turkey-creek-fecaltmdl_117.pdf)

Accurately quantifying the fecal coliform loadings from nonpoint sources requires identifying nonpoint source categories, locating the sources, determining the intensity and frequency at which these sources create high fecal coliform loadings, and specifying the relative contributions from these sources. There are no NPDES-permitted facilities located or that discharge within the Turkey Creek watershed. There are no NPDES municipal separate storm sewer systems (MS4s) covering the Turkey Creek watershed. Runoff from agriculture could be another source, in addition to failed septic tanks and pet feces. During the wet weather period, rainfall washes off coliform bacteria that have built up on the land surface under dry conditions, resulting in the wet weather exceedances (Figure 42). The fact that fecal coliforms increase during rainy months confirms that all three of these sources are possible. Near the sampling stations where fecal coliform exceedances were observed, there are improved pasturelands, suggesting agriculture as the source of the fecal coliforms. A fecal coliform reduction of 73% is needed from nonpoint sources in the Turkey Creek watershed.

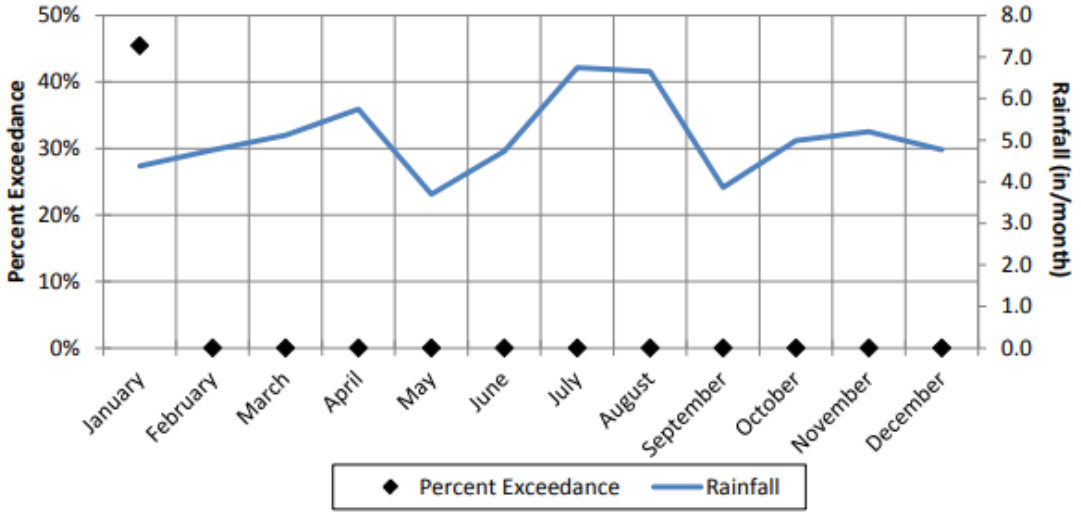


Figure 42. Rainfall as it Relates to Fecal Coliform Counts

**Note Source: http://publicfiles.dep.state.fl.us/DEAR/DEARweb/TMDL/Final_TMDL/gp4/turkey-creek-fecaltmdl_117.pdf*

Therefore, all the load reduction goes to the load allocation for nonpoint sources. Numeric criteria for bacterial quality are expressed in terms of fecal coliform bacteria concentration. The water quality criterion for the protection of Class III waters, as established by Rule 62-302, F.A.C., states the following: Fecal Coliform Bacteria: The most probable number (MPN) or membrane filter (MF) counts per 100 mL of fecal coliform bacteria shall not exceed a monthly average of 200, nor exceed 400 in 10 percent of the samples, nor exceed 800 on any one day. The criterion states that “monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30-day period.”

3.1.3.2 NPDES

The Environmental Protection Agency's (EPA) National Pollutant Discharge Elimination System (NPDES) is the means by which discharges to waters of the state or nation are regulated. NPDES permits are issued, and the results monitored to prevent degradation of water bodies.

After converting wastewater system to NPDES permits, about 50% of pollutants remained. Stormwater and nonpoint runoff account for this loading. As a result, focus turned to stormwater

since often pipes are easier to permit and monitor. The NPDES Stormwater Program regulates point source discharges from three potential sources: Municipal Separate Storm Sewer Systems (MS4s), construction activities and industrial activities. The NPDES Stormwater Program in Tallahassee is responsible for the development, administration and compliance of rules and policy to minimize and prevent pollutants in stormwater discharges. In turn, local governments are tasked with the implementation of an aggressive stormwater program that controls stormwater pollution to the maximum extent practicable.

A municipal separate storm sewer system (MS4) is a publicly owned conveyance or system of conveyances (i.e., ditches, curbs, catch basins, underground pipes, etc.) designed or used for collecting or conveying stormwater and that discharges to surface waters of the state. Examples of MS4 operators include, but are not limited to, municipalities, counties, community development districts, universities, military bases, or federal correctional facilities. Operators of large, medium, and regulated small MS4s are required to obtain NPDES permit coverage to discharge to waters of the state. As implemented by Chapter 62-624, F.A.C., Phase I addresses discharges of stormwater runoff from "medium" and "large" MS4s (i.e., those MS4s located in areas with populations of 100,000 or greater). Walton County participates in a County-wide MS4 program that will be discussed under County regulations in 3.1.4.1. As a result, regulation is with the County and NWFWMD.

3.1.4 Regional Regulations

Regional regulations, aside from dredge and fill as discussed in Section 3.1.2, fall under the purview of the NWFWMD. The first applicable set of regulations relates to stormwater. The stormwater rule is a technology-based rule that relies upon four key components:

1. A performance standard or goal for the minimum level of treatment.
2. Design criteria for best management practices (BMPs) that will achieve the performance standard.
3. A rebuttable presumption that discharges from a stormwater management system designed in accordance with the BMP design criteria will not cause harm to water resources.

4. Periodic review and updating of BMP design criteria as more information becomes available to increase their effectiveness in removing pollutants.

Florida's stormwater rules were developed to meet a performance standard of reducing the average annual post-development stormwater pollutant loading of Total Suspended Solids (TSS) by 80%, or by 95% for stormwater discharges directly into Outstanding Florida Waters. This level of treatment was selected for two reasons:

1. To establish equitability in treatment requirements between point and nonpoint sources of pollution. The minimum level of treatment for domestic wastewater point sources was "secondary treatment" which equated to an 80% reduction in TSS.
2. The costs of stormwater treatment greatly increased as the level of treatment rose above 80%.

In 1990, in response to legislation, the department developed and implemented the State Water Resource Implementation Rule (originally known as the State Water Policy rule). This rule sets forth the broad guidelines for the implementation of Florida's stormwater program and describes the roles of DEP, the water management districts and local governments.

The rule provides that one of the primary goals of the program is to maintain, to the degree possible, during and after construction and development, the predevelopment stormwater characteristics of a site. The rule also provides a specific minimum performance standard for stormwater treatment systems: to remove 80% of the post-development average annual stormwater pollutant loading of pollutants "that cause or contribute to violations of water quality standards."

The Environmental Resource Permitting (ERP) program regulates almost all changes to the landscape that affect surface water flows. Changes to the landscape include clearing, grading, construction of structures, filling, and dredging, whether the work occurs in uplands, wetlands, or other surface waters (including wetlands and waters that are isolated). The program addresses impacts to resources caused by dredging and filling in wetlands and other surface waters, as well as stormwater runoff quality (stormwater treatment) and quantity (preventing flooding of other

properties, slowing down flow, and draining of surface and ground waters) issued by FDEP, he NWFWMD or a delegated local agency for work that affects surface water flows.

There are two volumes. Volume 1 applies statewide. Volume 1 applied to facilities that are designed and constructed or implemented to control discharges which are necessitated by rainfall events, incorporating methods to collect, convey, store, absorb, inhibit, treat, use, or reuse water to prevent or reduce flooding, over-drainage, environmental degradation, and water pollution or otherwise affect the quantity and quality of discharges from the system.

Volume applies to a specific water management district. Volume II generally is not applicable to projects that generate no more than an incidental amount of stormwater runoff, such as:

- Dredging and filling to construct such things as most “stand-alone” seawalls, docks and “in water” types of activities, such as channel dredging. This would not include dredging and filling in wetlands or other surface waters to construct such things as bridges or culverted road crossings, parking areas, building sites, or land fill which may or may not contain structures;
- Pervious (e.g., slatted decking) piers that do not convey vehicular traffic.
- An overwater pier, dock, or a similar structure located in a deepwater port subject to subsection 373.406(12), F.S. This would not include activities landside of a wharf bulkhead at a port facility;
- Construction of an individual, single-family residence, duplex, triplex, or quadruplex dwelling unit that is not part of a larger plan of development;
- “Stand-alone” dredging, including maintenance dredging; or
- Activities that do not add new impervious surfaces, such as the installation of overland and buried electric and communication transmission and distribution lines.

In order to obtain an Environmental Resource Permit to construct an individual, private single-family home involving some impacts to wetlands, an applicant must provide reasonable assurance that the project: 1. eliminates and reduces impacts to wetlands as much as possible 2. won’t cause or contribute to flooding (water quantity), 3. will maintain pre-development drainage flows as much as possible, AND 4. won’t contribute to water pollution (water quality). Efforts to

minimize and redirect stormwater runoff to grassed or landscaped areas should be shown on the plans to the extent possible.

As a result, stormwater management systems in the County are regulated by NWFWMD and the Florida Department of Environmental Protection via the Environmental Resource Permit Applicant's Handbook Volume II (Design and Performance Standards Including Basin Design and Criteria) For Use Within The Geographic Limits Of The Northwest Florida Water Management District. The volume was created to assist persons in understanding and applying the rules, procedures, standards, and criteria implementing the environmental resource permit (ERP) program under Part IV of Chapter 373 of the Florida Statutes (F.S.). More specifically, it provides specific, detailed design and performance methodologies designed to meet the water quality and quantity requirements of stormwater management systems. It also will assist persons who are designing activities to comply with the general permit in Section 403.814(12), F.S. District-specific appendices for regionally specific criteria applicable to such things as Sensitive Karst areas are included as well.

With respect to wetlands, impacts are to be minimized. Discussion about encroachment into the floodplain, is not discussed in the volume. Treatment is required for offsite discharge to many categories of waters. Treatment that is part of retention/detention must provide for: 1) the first inch of runoff from the developed project, or the total runoff of 2.5 inches times the percentage of imperviousness, whichever is greater; or 2) dry detention volume must be provided equal to 75% of the above amounts computed for wet detention; or 3) retention volume shall be provided equal to 50% of the above amounts computed for wet detention. Projects having greater than 40% impervious area and which discharge directly into receiving waters are required to provide at least one-half inch of dry detention or retention pretreatment as part of the required retention/detention. The major point is that added volumetric loadings are not permitted in most circumstances.

3.1.4.1 Flood Protection

The NWFWMD promotes flood protection using non-structural techniques, which include acquiring and maintaining floodplains, regulatory activities, and providing technical expertise to local governments and state and federal agencies for flood protection programs.

In December 2002, the District took responsibility for modernizing flood hazard maps into a digital format for the 16 counties of Northwest Florida through a Cooperating Technical Partner agreement with the Federal Emergency Management Agency (FEMA). As a result of this partnership and associated efforts, all of the panhandle now has digital flood insurance rate maps (DFIRMs).

FEMA has also initiated the Risk Mapping, Assessment, and Planning (Risk MAP) program, which includes collaboration with state and local agencies – including the District – to deliver quality data to increase public awareness of and support for actions that reduce flood-related risks. The general goal of the program is to foster informed risk management decisions and actions that mitigate flood risk through a consistent approach to assessing potential vulnerability and losses.

The NWFWMD is partnering with FEMA and other agencies to provide local communities with the tools and resources for managing, assessing, and planning for development and construction in flood prone areas to save lives and protect property.

3.1.4.2 Minimum Flows and Levels.

One major challenge associated with water supply planning is finding the balance between meeting public water supply needs while maintaining the healthy natural systems essential to Florida's economy and quality of life. Two ways that water managers ensure that water resources and associated ecological systems are protected are through the implementation of MFLs.

In the establishment of MFLs, water management districts are required to use the “best available information.” In accordance with Rule 62-40.473, Florida Administrative Code, and Section 373.0421, Florida Statutes, the District must consider natural seasonal fluctuations in water flows or levels, non-consumptive uses, structural alterations, and ten environmental values (referred to as Water Resource Values or WRVs), when developing the minimum flows. These (WRVs) include:

1. Recreation in and on the water;
2. Fish and wildlife habitats and the passage of fish;
3. Estuarine Resources;
4. Transfer of detrital material;

5. Maintenance of freshwater storage and supply;
6. Aesthetic and scenic attributes;
7. Filtration and absorption of nutrients and other pollutants;
8. Sediment loads;
9. Water quality; and,
10. Navigation.

The completion of an MFL Technical Assessment is a complex process which takes multiple years to complete (Figure 43). Once a waterbody is placed on the Priority List, extensive data collection is performed involving the collection of water levels, flows, water quality, physical information describing the system, and ecological data such as the presence of listed species and habitat types. These data are then used to determine appropriate WRV metrics. These metrics are quantifiable measures that relate WRVs to changes in flow or water levels. Hydrologic models capable of simulating changes in water levels and flows under different environmental and withdrawal conditions are developed. These models are then used to determine the flow(s) or level(s) of water required in a waterbody to ensure that significant harm to water resources and ecology is not caused by consumptive uses.

Although significant harm is not specifically defined in statute, an allowable 15 percent reduction in WRV metrics has been implemented as the protection standard for multiple MFLs throughout Florida, recognizing that additional data collection and long-term research to confirm or refine this threshold for MFL assessments in Florida would be beneficial.

Following the completion of the draft Technical Assessment, the work is subjected to a scientific peer review where established experts review the data, assumptions, and analysis completed by the NWFWMD. Public involvement is integral and generally occurs throughout the duration of an MFL project, including opportunities to review the data and the technical assessment. Once finalized, the MFL Technical Assessment is then used to help establish the MFL criteria for the waterbody. The criteria are used to develop formal rule language, which must then be adopted and included in Florida Administrative Code Chapter 40A-8. Figure 43 shows the process.

At the time of rule adoption, water management districts are required to develop and implement a recovery strategy when a system is currently not meeting MFL criteria or a prevention strategy

if the MFL is expected to not be met during the following 20 years based on projected withdrawals. Prevention/recovery strategies may include water conservation measures and additional water supply or water resource development projects. Currently, no prevention or recovery strategies are required for any NWFWMD waterbodies with established minimum flows.

MFL implementation follows an adaptive management approach, with MFLs periodically reviewed and reevaluated by the NWFWMD to reflect new data and information. As new data and information become available regarding the definition of or threshold for significant harm, the NWFWMD will consider this information in future MFL re-evaluations.

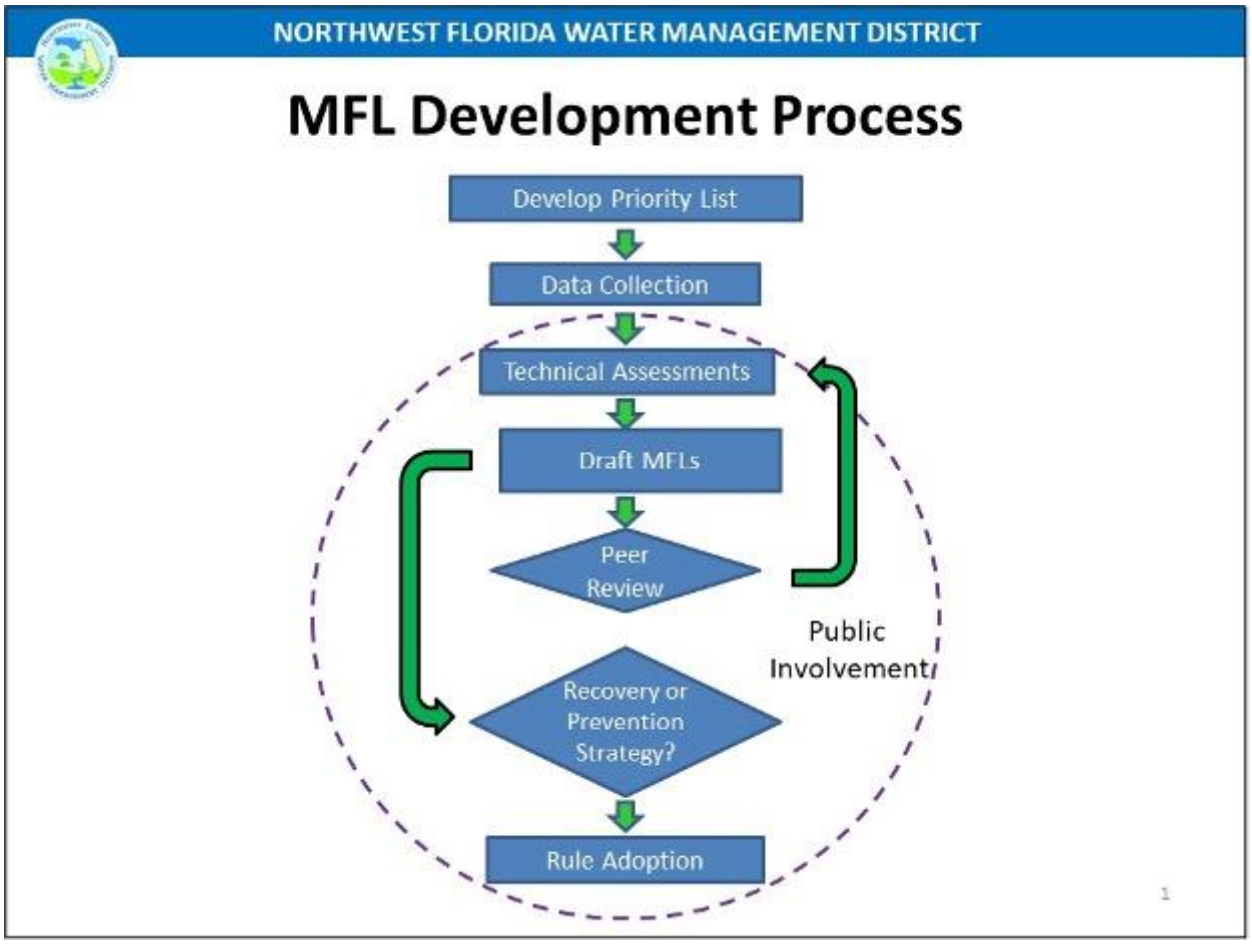


Figure 43. MFL Development process

Water Management Districts in Florida are required to establish Minimum Flows and Minimum Water Levels (MFLs) for selected waterbodies within their boundaries under Section 373.042 (1),

Florida Statutes. Minimum Flows and Minimum Water Levels are defined as the limit beyond which further withdrawals would be significantly harmful to the water resources or the ecology of the area. MFLs are not used for offsetting the effects of drought, sea level rise, precipitation patterns, or any other effects unrelated to the impacts of consumptive withdrawals.

Minimum Flows and Minimum Water Levels are established for priority waterbodies within the boundaries of each water management district. These waterbodies are listed on each District's MFL Priority List and Schedule which is submitted to and approved by the Florida Department of Environmental Protection annually. Waterbodies included on the MFL Priority List include:

1. Outstanding Florida Springs, as defined in Section 373.802, Florida Statutes. Minimum flows are required to be established for the District's Outstanding Florida Springs by July 1, 2026. There are three Outstanding Florida Springs located within the District boundaries: Wakulla Spring, Jackson Blue Spring, and the Gainer Spring Group.
2. Second magnitude springs discharging between 10 and 100 cubic feet per second (cfs) of water located on state-owned lands purchased for conservation purposes, unless the District submits a report to the Department of Environmental Protection demonstrating that adverse impacts from consumptive uses are not currently occurring nor reasonably expected to occur within the next 20 years.
3. Waterbodies (including springs, lakes, rivers, streams, and aquifers) determined to be at risk for significant harm due to consumptive withdrawals.

The purpose of establishing Minimum Flows and Levels (MFLs) is to avoid diversions of water that would cause significant harm to the water resources or ecology of an area. The Florida Legislature has mandated that all water management districts establish MFLs for surface waters and aquifers within their jurisdiction. Section 373.042(1) defines the minimum flow as "the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area." It further defines the minimum level as the "level of ground water in an aquifer and the level of surface water at which further withdrawals would be harmful to the water resources of the area." The NWFWMD is further directed to use the best available information in establishing a minimum flow or a minimum level. The overall purpose of Chapter 373 is to ensure the sustainability of water resources of the state (Section 373.016, F.S.). MFLs play one part in this framework. Section 373.0421 requires that once the MFL technical criteria have been established, the water

management districts develop a prevention or recovery strategy for those waterbodies that are expected to exceed the proposed criteria. It is possible that the proposed MFL criteria cannot be achieved immediately because of the lack of adequate regional storage.

MFLs and Reservations are adopted in accordance with the district's MFL and Reservation Priority List and Schedule, submitted annually to the department for approval. As a result, each year, Florida's five water management districts must submit a priority list and schedule for the establishment of MFLs within their region to the Florida Department of Environmental Protection for review and approval. The priority list for the NWFWMD is shown in Table 7.

Figure 44 shows the location of priority water bodies in the NWFWMD jurisdiction. None are in Walton County. As a result, MFLs are not a current regulatory consideration in Walton County.

Table 7. NWFWMD Minimum Flows and Levels Priority List (2022)

Waterbody Name	Waterbody Type[3]	County(s)	Technical Assessment Complete	Anticipated Rule Adoption
Jackson Blue Spring	Spring-1	Jackson	2024	2025
Gainer Spring Group	Spring-1	Bay	2024	2025
Sylvan Spring Group	Spring-2	Bay	2024	2025
Williford Spring Group	Spring-2	Washington	2024	2025
Coastal Floridan Aquifer	Aquifer	Bay	2026	2027

(https://nwfwater.com/water-resources/minimum-flows-minimum-water-levels/)

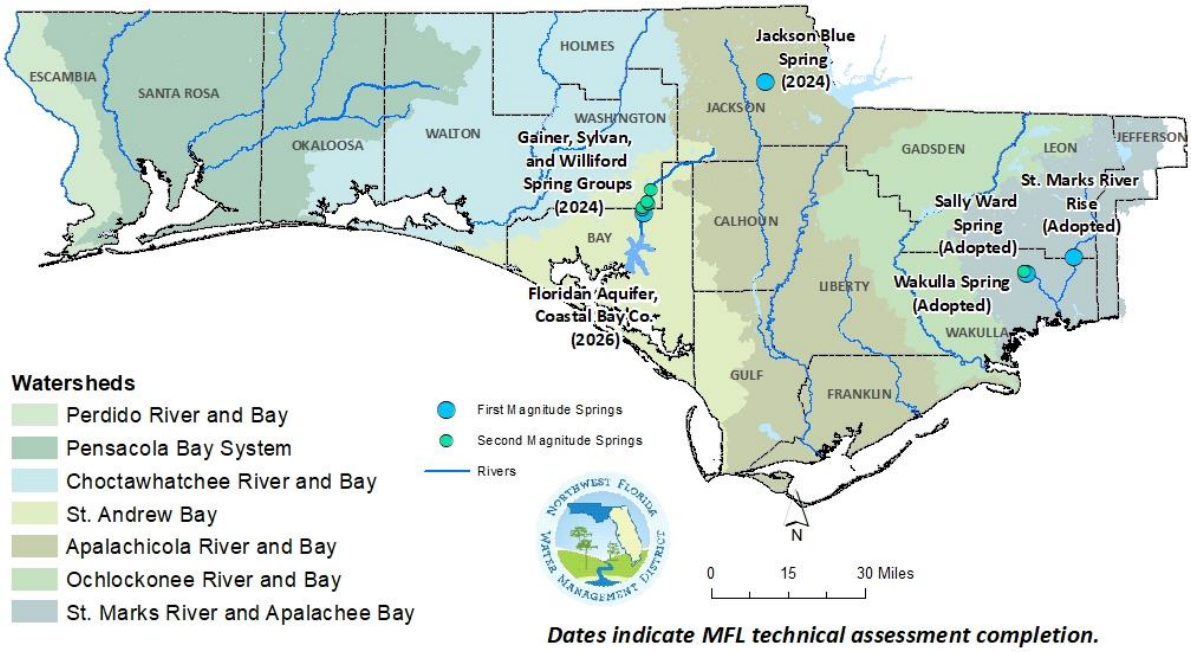


Figure 44. Location of Established and 2022 Northwest Florida Water Management District Minimum Flows and Levels Priority List Water Bodies

(https://nwfwater.com/water-resources/minimum-flows-minimum-water-levels/)

3.1.5 Local Regulations/Comprehensive Plans

In 1985, the Florida legislature approved the Growth Management Act, which guided community development in the state until 2010. However, many communities still conduct planning activities as if the Growth Management Act was still in place. As a result, comprehensive plans are still available in most communities (some may be dated, but the information is still useful).

Comprehensive plans are official public documents that have been adopted by a local government as a policy to guide decisions regarding development in the community. A comprehensive plan serves as a blueprint for future commercial and residential land uses, while outlining requirements for conservation, and cultural and recreational amenities. It is important to note that a comprehensive plan and zoning are two separate tools used in conjunction with one another. A comprehensive plan acts in a guiding role and provides recommendations on

how land should be utilized, whereas zoning regulates land uses as outlined in the jurisdiction's Comprehensive Plan.

3.1.5.1 Walton County Comprehensive Plan

The Walton County Comprehensive plan includes verbiage on stormwater. Full document found here: https://www.co.walton.fl.us/68/Comprehensive-Plan

A summary of the information within this document is as follows:

OBJECTIVE L-1.1 is designed:

> "To establish the maximum residential densities and nonresidential intensities for Future Land Use Map Categories which shall be spatially distributed in accordance with Planning Areas in Walton County," but noting that "each Future Land Use Map category may be less per the density requirements of the implementing zoning district, development standards of the Land Development Code, or other environmental / stormwater management policies and regulations."

Policy BW-1.7.12] notes that

> "Stormwater facilities shall be designed to treat rainfall runoff for water quality and attenuate rainfall runoff for discharge quantity in accordance with the standards below. Those standards note that "Runoff from development shall be treated prior to discharge to the level of treatment for the treatment type as required by state law and as contained in the applicable state ERP Applicant's Handbook or EMA Stormwater Criteria Manual."

Policy BW-1.7.11 notes that

> "Stormwater management facilities serving development within the Bay-Walton Sector Plan shall be designed to manage and treat stormwater runoff as follows. (A) Water Quality: Runoff from development shall be treated prior to discharge to the level of treatment for the treatment type as required by state law and as contained in the applicable state ERP Applicant's Handbook or EMA Stormwater Criteria Manual."

> "(B) Flood Attenuation: Runoff from development shall be attenuated prior to discharge such that the post-development discharge for the critical duration event does not exceed the pre-development discharge for the same event during a 25-year frequency storm for watersheds with positive discharge or, for watersheds without a positive discharge, the post-development discharge and volume for the critical duration event does not exceed the pre-development discharge and volume for the same event during a 100-year frequency storm except, discharges to tidally influence waters shall not require attenuation."
>
> "(I) Stormwater management systems may be designed to discharge pre-treated stormwater into preserved wetlands in such a way as to maintain and/or enhance their current hydrology."

Hence the 25-year storm event is the design storm.

3.1.5.1.1 Ordinances and Policies

Walton County has an adopted floodplain management ordinance adopted in 2014 (https://www.co.walton.fl.us/DocumentCenter/View/8902/SignedCertified_Adopted_Ord?bidId=). This ordinance states:

> "The purposes of this ordinance and the flood load and flood resistant construction requirements of the Florida Building Code are to establish minimum requirements to safeguard the public health, safety, and general welfare and to minimize public and private losses due to flooding through regulation of development in flood hazard areas."
>
> 4.05.04C states:
> "C. Applications and permits. The Floodplain Administrator, in coordination with other pertinent offices of the community, shall: 1. Review applications and plans to determine whether proposed new development will be located in flood hazard areas; 2. Review applications for modification of any existing development in flood hazard areas for compliance with the requirements of this ordinance; 3. Interpret

flood hazard area boundaries where such interpretation is necessary to determine the exact location of boundaries; a person contesting the determination shall have the opportunity to appeal the interpretation; 4. Provide available flood elevation and flood hazard information; 5. Determine whether additional flood hazard data shall be obtained from other sources or shall be developed by an applicant; 6. Review applications to determine whether proposed development will be reasonably safe from flooding; 7. Issue floodplain development permits or approvals for development other than buildings and structures that are subject to the Florida Building Code, including buildings, structures and facilities exempt from the Florida Building Code, when compliance with this ordinance is demonstrated, or disapprove the same in the event of noncompliance; and REVISED Model FPM Ordinance & Code Amendments: Zones A & V (1/7/14) 10 8. Coordinate with and provide comments to the Building Official to assure that applications. plan reviews. and inspections for buildings and structures in flood hazard areas comply with the applicable provisions of this ordinance."

4.05.04D states that

> "For applications for building permits to improve buildings and structures. including alterations. movement. enlargement. replacement, repair. change of occupancy. additions. rehabilitations. renovations, substantial improvements, repairs of substantial damage, and any other improvement of or work on such buildings and structures, the Floodplain Administrator, in coordination with the Building Official. shall:
>
> 1. Estimate the market value, or require the applicant to obtain an appraisal of the market value prepared by a qualified independent appraiser, of the building or structure before the start of construction of the proposed work; in the case of repair, the market value of the building or structure shall be the market value before the damage occurred and before any repairs are made;
> 2. Compare the cost to perform the improvement, the cost to repair a damaged building to its pre-damaged condition, or the combined costs of improvements and repairs, if applicable, to the market value of the building or structure;

3. Determine and document whether the proposed work constitutes substantial improvement or repair of substantial damage; the determination requires evaluation of previous permits issued for improvements and repairs as specified in the definition of "substantial improvement"; for proposed work to repair damage caused by flooding, the determination requires evaluation of previous permits issued to repair flood-related damage as specified in the definition of "substantial damage"; and

4. Notify the applicant if it is determined that the work constitutes substantial improvement or repair of substantial damage and that compliance with the flood resistant construction requirements of the Florida Building Code and this ordinance is required."

Section 4.05.06 SITE PLANS AND CONSTRUCTION DOCUMENTS says:

"A. Information for development in flood hazard areas. The site plan or construction documents for any development subject to the requirements of this ordinance shall be drawn to scale and shall include, as applicable to the proposed development:

1. Delineation of flood hazard areas. floodway boundaries and flood zone(s}. base flood elevation(s), and ground elevations if necessary for review of the proposed development.

2. Where base flood elevations, or floodway data are not included on the FIRM or in the Flood Insurance Study, they shall be established in accordance with Section 4.05.06(B)(2) or (3) of this ordinance.

3. Where the parcel on which the proposed development will take place will have more than 50 lots or is larger than 5 acres and the base flood elevations are not included on the FIRM or in the Flood Insurance Study. such elevations shall be established in accordance with Section 4.05.06(B}(1} of this ordinance.

4. Location of the proposed activity and proposed structures, and locations of existing buildings and structures; in coastal high hazard areas. new buildings shall be located landward of the reach of mean high tide.

5. Location. extent. amount. and proposed final grades of any filling, grading. or excavation.

6. Where the placement of fill is proposed, the amount. type. and source of fill material; compaction specifications; a description of the intended purpose of the fill areas; and evidence that the proposed fill areas are the minimum necessary to achieve the intended purpose.
7. Delineation of the Coastal Construction Control Line or notation that the site is seaward of the coastal construction control line. if applicable.
8. Extent of any proposed alteration of sand dunes or mangrove stands. provided such alteration is approved by the Florida Department of Environmental Protection.
9. Existing and proposed alignment of any proposed alteration of a watercourse."

"Section 4.05.11 SUBDIVISIONS
A. Minimum requirements. Subdivision proposals, including proposals for manufactured home parks and subdivisions, shall be reviewed to determine that:

1. Such proposals are consistent with the need to minimize flood damage and will be reasonably safe from flooding…"

Section R322.3.2 states:
1.1. All buildings and structures erected within coastal high-hazard areas shall be elevated so that the lowest portion of all structural members supporting the lowest floor, with the exception of mat or raft foundations, piling. pile caps. columns, grade beams and bracing, is:

1.1. Located at or above the base flood elevation plus 1 foot or the design flood elevation. whichever is higher, if the lowest horizontal structural member is oriented parallel to the direction of wave approach, where parallel shall mean less than or equal to 20 degrees (0.35 rad) I t from the direction of approach, or
1.2 Located at the base flood elevation plus 2 feet, 1 foot (305 mm) or the design flood elevation, whichever is higher, if the lowest horizontal structural member is oriented perpendicular to the direction of wave approach, where perpendicular shall mean greater than 20 degrees (0.35 rad) from the direction of approach.
1.3 Basement floors that are below grade on all sides are prohibited."

This ordinance was updated in 2021 to update rules on manufactured and mobile homes among other changes (https://www.co.walton.fl.us/DocumentCenter/View/40615/Floodplain-Management-Ordinance-2021-31).

3.1.5.1.2 Stormwater Map

In order to meet the requirements of the NPDES Permit for the County, Walton County has developed and implemented a Stormwater Management Program that consists of Best Management Practices (BMPs) to protect our local waterways. BMP's have been implemented by Walton County to address the following areas: Public Education and Outreach, Public Involvement and Participation, Illicit Discharge Detection and Elimination, Construction Site Runoff Control, Post Construction Stormwater Management and Pollution Prevention and Good Housekeeping.

The Walton County Stormwater Department has created and maintains a map of all MS4 features in unincorporated Walton County using GPS to record points in a Geographic Information System. The map is used to help locate structures for inspections and maintenance.

The staff pursues best management practices (BMPs) to improve the stormwater system. Among the BMP'S they perform are:

- Inspect 20% of detention ponds a year from our inventory.
- Investigate and resolve all illicit discharge complaints report.
- Maintain all county owned detention facilities.
- Screen 20% of outfalls annually for pollutants.
- Inspect 20% of stormwater structures annually and maintain all stormwater structures on County right of way.
- Train employees on good practices related to pollutants.

The County notes three streams in the urbanized area of Walton County where they are actively trying to identify and eliminate the sources leading to the impairment of these streams. The impaired waters are the following along with the impairment:

- Big Flat Creek from Loganville City Limits to Highway 138: Fecal Coliform
- Little Haynes Creek from Loganville City Limits to Centerhill Church Road: Fecal Coliform
- Tributary to Little Haynes Creek from headwaters to Chandler Haulk Road: Bio F Impacted fish community.

In addition, the County pursues Illicit discharges. Some examples of an illicit discharges are sewage or septic, used motor oil, or sediment going into a storm drain or stream. We encourage the citizens of Walton County to report anything that they suspect of being an illicit discharge to the Walton County Stormwater Department for further investigation.

3.1.5.1.3 Floodplain Management

(https://www.co.walton.fl.us/696/Floodplain-Management)

Walton County participates in the Community Rating System (CRS). Their website notes that "flood insurance premium rates are discounted to reflect the reduced flood risk from the community's efforts that address three main goals:

1. Reduce and avoid flood damage to insurable property
2. Strengthen and support the NFIP
3. Foster comprehensive floodplain management

Beginning October 1, 2018 – Walton County holds a Class 6 CRS rating. This classification provides a 20% discount on new or renewing flood insurance policies for all SFHA properties.

3.1.5.2 DeFuniak Springs Comprehensive Plan

(https://www.defuniaksprings.net/DocumentCenter/View/19056/Updated-1-25-23-DeFuniak-Springs-Final-Comprehensive-Plan_Oct_2010)

The DeFuniak Springs comprehensive plan includes:

> Policy 1.1.5 states that "The land development regulations shall include requirements for the provision of stormwater management facilities by developers

sufficient to meet the level of service adopted in the stormwater management sub-element of the plan."

Policy 1.1.11 (1) (6) states "The areas of particular concern in this regard are in identified wetland areas, in 100-Year floodplains, and in stormwater management areas. Development may not exceed 10% impervious area and may include boardwalks, docks, and other recreation related structures."

Policy 1.5.5 states that "The City shall encourage the use of Low Impact Development techniques, such as rain gardens and ecologically enhanced stormwater basins."

An entire section is devoted to stormwater:

"STORMWATER MANAGEMENT GOAL 1: PROVISION OF AN ENVIRONMENTALLY SAFE AND EFFICIENT STORMWATER MANAGEMENT SYSTEM.

Objective 1.1: The City will complete a preliminary assessment of drainage issues within the planning period to identify any drainage facility deficiencies and develop cost estimates for City of DeFuniak Springs 4-3 2025 Comprehensive Plan: Infrastructure Element inclusion in the Capital Improvement Program (CIP). Construction of any needed facilities will be prioritized in the CIP.

Policy 1.1.1: The City will continue to enforce the stormwater management provisions of its Land Development Code.

Policy 1.1.2: The City will amend the Capital Improvements Element to include system improvements, funding sources and timing of stormwater management facility projects, based on the assessment committed to in Objective 1.1.

Policy 1.1.3: The City will continue to enforce a minimum city-wide water quality level of service standard that require stormwater facilities which provide retention,

or detention with filtration, of the runoff from the first one inch of rainfall; or, as an option for projects with drainage areas less than 100 acres, facilities which provide for retention, or detention with filtration, of the first one-half inch of runoff or provide for the discharge of stormwater equal to pre-development levels, whichever is greater.

Policy 1.1.4: The City will continue to enforce a minimum city-wide water quantity level of service that requires stormwater facilities which attenuate the 24-hour, 25 -year storm event while limiting discharge to pre-development levels or to the capacity of the receiving water. It shall be assumed that the capacity of the receiving water will allow for discharges equal to predevelopment levels or the first inch of rainfall, whichever is greater, unless an engineering analysis using professionally accepted methodologies demonstrates that a differing discharge rate should be used. In requiring a lesser rate of discharge, the burden of analysis shall be the responsibility of the developer. Upon completion of the drainage assessment, the stormwater management regulations shall be re-evaluated. If a more or less stringent level of service is dictated, then this Plan shall be modified to conform to the needed level of service.

Policy 1.1.5: The City will continue to monitor compliance with the Florida Department of Environmental Protection's and the Northwest Florida Water Management District's stormwater management requirements.

Objective 1.2: Stormwater management regulations will continue to be included in the City's Land Development Code.

Policy 1.2.1: Stormwater management regulations will prohibit the alteration of existing drainage features unless such alterations will not create adverse impacts in the form of decreased performance for upstream and downstream areas. The evaluation of adverse impacts shall be by acceptable engineering methodologies and shall consider storage volume, conveyance capacity, water quality, and maintenance.

Policy 1.2.2: Stormwater management regulations will:

1. Require that new developments provide stormwater management systems which meet the water quality and quantity levels of service defined in Stormwater Management Policies 1.1.3 and 1.1.4. This requirement shall not be imposed on any single-family dwelling unit, duplex, triplex, or quadruplex provided it is not part of a larger common plan of development or sale. City of DeFuniak Springs 4-4 2025 Comprehensive Plan: Infrastructure Element
2. Require that appropriate stormwater engineering, design and construction standards for on-site systems are provided and utilized.
3. Require that erosion and sediment controls are used during development.
4. Require that periodic inspection and maintenance of on-site systems is provided by the owner, unless the system is accepted by the city for maintenance; and,
5. Provide for requirements for buffer zones adjacent to natural drainage features to be developed; and,
6. Provide for new commercial, industrial, public, and residential developments to integrate their stormwater management systems into their project's landscaping, open space, or recreational areas and to require the maintenance of 10% of the building lot's native vegetation in order to absorb stormwater runoff; and,
7. Include provisions to prevent the creation of breeding areas for disease-carrying vectors, such as mosquitoes."

The plan notes that "City-wide water quantity level of service that requires stormwater facilities which attenuate the 24-hour, 25-year storm event while limiting discharge to pre-development levels or to the capacity of the receiving water."

In addition, Policy 1.3.2 states that "Existing and future developments directly benefitting from storm water management improvements shall bear a proportionate cost of stormwater facility capital improvements. Cost may be collected through a stormwater utility or developer provision of stormwater facility."

3.1.5.3 Bay County Comprehensive Plan

(https://www.baycountyfl.gov/322/Comprehensive-Planning)

Bay County's comprehensive plan has a sub-element devoted to stormwater management. The stated goals are:

"The goals of the Board relative to drainage and stormwater management are: reduce or eliminate existing flooding problems and prevent future flooding problems; protect surface waters from contamination and sedimentation caused by stormwater runoff; provide special protection for potable water sources; correct known deficiencies in the existing stormwater control network; prevent future problems by regulating the development and use of land, and; to promote and further the established policies and laws of the state relative to stormwater management and flood damage prevention"

It references a Master Storm Drainage Plan, Stormwater Strategic Plan and a Cartegraph based stormwater management system. For the purposes of =design, Policy 5#.7.2.7(b) states that

> "For purposes of flood attenuation all development projects shall be designed and constructed so as to accommodate at a minimum the 25-year critical duration storm event as outlined in the FDOT Drainage Manual or the 100-year critical duration storm event in identified critical basins."

The Master Storm Drainage Plan was first developed in 1997 (https://www.co.bay.fl.us/DocumentCenter/View/4258/Exhibit-1-Appendix-1-Master-Storm-Drainage-Plan-Volume-I-and-II?bidId=). Planned Programs 1. Regulatory Requirements 2. Data Assessment (system mapping., water quality) 3. Best Management Practices (structural and non-structural) 4. Level of Services, Comprehensive Plan and Ordinance Review 5. Problem Area Identification and Prioritization 6. Stormwater Facilities Operation and Maintenance. By 2017 the County had completed 6 detailed sub basin master plans for the six highest ranked basins: Bayou George, Grand Lagoon, Bear Creek, Panama City, Mill Bayou and Upper Econfina Creek. Connection to NFIP guidance was inferred. To date, the County has completed in excess of $11 million in construction that covers for 33 capital projects.

The current infrastructure includes:

- 70 miles of outfall ditches
- Over 800 miles of roadside ditches/swales
- 51 bridges
- 84 box culverts
- 80.5 miles of pipes
- 9,301 inlets, headwalls, mitered ends
- 125 treatment facilities
- 51 Beach Outfalls (19 County owned)

Recommended levels of services are shown in Table 8.

Table 8. Recommended Water Quantity Levels of Service

FLOOD PROTECTION GOALS AND CLASSES						
Structure/Facility	**10-Year, Critical**	**LOS Class**	**25-Year, Critical**	**LOS Class**	**100-Year, Critical**	**LOS Class**
Houses/Buildings	<FFE[1]	D	<FFE	D	<FFE	D
Evacuation Routes[2]	½W[3]	B	<0.5 ft	B	<1.0 ft	B
	½W	B	<0.5 ft	B	<1.0 ft	B
Arterial Roads[4]	<0.5 ft	C	<0.75	D	<1.5 ft	N/A
Other Roads[5]						

(1) Peak flood stages less than the first floor elevation (FFE) based on available data.

(2) Evacuation routes as defined by the county.

(3) Flooding limited to each side of the road such that ½ of the roadway width (W) or one travel lane width is not flooded.

(4) Roads with four or more travel lanes, or roads that are the only access to a respective area/development (secondary evacuation routes).

(5) Other roads that are not critical for evacuation, but that will be used to estimate encroachment on FFEs.

(https://www.co.bay.fl.us/DocumentCenter/View/4258/Exhibit-1-Appendix-1-Master-Storm-Drainage-Plan-Volume-I-and-II?bidId=)

3.1.5.4 Holmes County Comprehensive Plan

(https://holmescountyfla.com/wp-content/uploads/Holmes-County-LDR_2009.pdf)

This plan was updated in 2021 https://holmesclerk.com/uploads/2022/08/ordinance-21-04.pdf).

They adopted the Florida Building code in 2023 (https://holmesclerk.com/uploads/2023/02/ordinance-23-01.pdf).

Ordinance 92-1 is the land development code (https://holmesclerk.com/uploads/2022/03/ordinance-no-92-01.pdf). However, while noting it involved “Regulating areas subject to seasonal and periodic flooding and providing for drainage and stormwater management;” there is no further mention in the ordinance.

The 2009 update notes section 6.03.00 which discusses stormwater management (https://holmescountyfla.com/wp-content/uploads/Holmes-County-LDR_2009.pdf) :

> 6.03.01 Purpose The purpose of this Section is to protect the surface water, groundwater, and other natural resources by ensuring that the stormwater runoff peak discharge rates, volumes and pollutant loadings are managed to minimize the adverse impacts of erosion, sedimentation, flooding, and water pollution.
>
> 6.03.02 Relationship to other Stormwater Management Requirements In addition to meeting the requirements of this Code, the design and performance of all stormwater management systems shall comply with Chapter 17-25, Florida Administrative Code. In all cases, the strictest of the applicable standards shall apply. The County will condition final development orders to restrict the commencement of development activity until all applicable stormwater permits from the Florida Department of Environmental Regulation have been issued.
>
> B. Design Standards 1. The design standards set forth in Section 17-25.025, Florida Administrative Code, shall be used in the design and construction of stormwater management facilities.

Otherwise, there is limited information. Stormwater appears to be a Road and Bridge responsibility.

3.1.5.5 Okaloosa County Comprehensive Plan

(https://myokaloosa.com/sites/default/files/doc/dept/growth_mgmt/comp_plan/CH-2.6%20stormwater.pdf)

Okaloosa County's comprehensive plan includes the following guidelines, which are similar to Walton County and the other neighboring communities:

> "Policy 1.2 The development and adoption of a comprehensive Stormwater Master Plan for Okaloosa County shall be completed in its entirety or in phases in

compliance with NPDES requirements. This plan will include an inventory of existing facilities and shall recommend needed stormwater management improvements, analyze the adopted level of service standards, and recommend alternative standards if necessary.

Policy 2.3 The LOS standards for stormwater management shall be: a. Single-Family Detached Residential Subdivisions: Post development runoff shall not exceed the pre-development runoff rate for a twenty-five (25)-year storm event, up to and including an event with a twenty-four (24)-hour duration; b. All Other Development: The first one (1) inch of runoff from the property shall be retained on the site of the development and post development runoff shall not exceed the pre-development runoff rate for a twenty-five (25)-year storm event, up to and including an event with a twenty-four (24)-hour duration; and c. A “pop off” shall be provided for stormwater runoff beyond the above requirements. The developers must provide a pop off to an outfall with adequate capacity to handle additional stormwater runoff and must document that the pop off to the outfall has been authorized by the owner of the outfall system. If no pop off is available, the stormwater storage facility shall be designed with a minimum capacity to retain a storm event of one hundred (100)-year frequency up to and including a twenty-four (24)-hour duration for post development.

Policy 2.4 The level of service standard for stormwater management on county roads shall be Level II (capacity maximum): Street gutter systems are flowing full however ten to twelve feet of the road crown is not submerged, and traffic can move at a slightly reduced speed. Stormwater swales and ditches are full with water overflowing the tops Stormwater Management 2.6.2 and edges in some locations. Water may be ponded eight (8) to ten (10) feet onto private property and yards. Inlets and culverts are flowing full to overfull slightly backing up water at entrances.”

The County’s stormwater division is responsible for the operation and maintenance of all stormwater systems that are within the unincorporated areas of the County. The County stormwater system is classified as an MS4.

The County has an illicit discharge ordinance (https://myokaloosa.com/sites/default/files/users/pwuser/ordinance11-16_0.pdf).

3.2 10-year, 25-year and 100-yr and 5-day events

Figure 47 to Figure 50 show the 1-day, 5-, 10-, and 100-yr storm events and the 3-day, 25-year storm events to comply with. The 3-day, 25-year event and the 1-day, 100-year event yielded similar results. The 100-year event exceeds the guidance criteria to use at least the 25-year event; however, Appendix AR illustrates the 25-Year, 1-Day storm modeling results for information purposes. In the coastal area, flooding from king tides and storm events is a greater consideration than rainfall.

3.3 Peak Flows and Volumes

Figure 15 and Figure 16 in Section 1.1.3 show the flow volumes for the rivers.

3.4 Minimum Flows and Levels

See Section 3.1.4.2. There are no MFLs in Walton County.

3.5 Available Policy Documents

Note that watershed master plans are distinctly different than a variety of other plans developed for different purposes including water quality and TMDL plans, local mitigation strategy plans, flood insurance studies, floodplain management plans, stormwater master plans, local ordinances, and CRS plans. For example, a County's Local Mitigation Strategy (LMS) details all of the possible hazards that the incorporated and unincorporated areas need to be concerned about. These possible hazards are identified and rated on the potential for damage based on previous hazards of similar type. LMS follows the FEMA hazard mitigation definitions in an attempt to address issues that will reduce or eliminate exposure to hazard impacts.

While the flood hazard event section of the County's LMS relates directly to CRS activity 510, there are still more aspects of the LMS that can be used for WMPs. These reports are only produced at the County level but are adopted through resolutions into a municipal ordinance. Section 322 of the Disaster Mitigation Act of 2000 specifically addresses mitigation planning and requires state and local governments to prepare multi-hazard mitigation plans (and their

resubmission every five years to stay eligible) as a precondition for receiving FEMA mitigation project grants and non-emergency assistance.

The Walton County Local Mitigation Strategy Working Group prepared the most recent LMS update by working collaboratively utilizing the Smartsheet application. The LMS identifies that the community as vulnerable to many types of natural hazards (i.e., hurricanes, flooding, wildfire). As a result, the Sub-recipient has serious challenges regarding:

- Fires – a major issue this past spring in neighboring Bay County. Fires result from a lack of timely rainfall – mostly in the mid-spring period of the year. While fires damage property, they also remove vegetation that might help reduce coastal flood migration.
- Coastal erosion - Coastal erosion is the removal of land or beach or dune sediments by wave action, tidal currents, wave currents, or drainage. Waves generated by coastal storms or hurricanes cause coastal erosion, which may take the form of long-term losses of sediment and rocks, or merely in the temporary redistribution of coastal sediments. Erosion in one location may result in accretion elsewhere. Vulnerability can impact the quality of life through damage to buildings, roads/bridges, and infrastructure (lifeline systems). Over wash occurs when waves and storm surge overtop dunes and transport sand landward. Over wash is likely at these locations because of increased water levels at the shoreline.
- Flooding - Flooding has been the most frequent occurrence in Walton County over the past 100 years. Walton County residents can experience flooding from two sources, and they can occur at the same time:

    - Coastal flooding and erosion triggered by tropical storms and hurricanes.
    - Riverine flooding, which is intense and abundant rainfall into our river, streams, channels, and numerous low-lying areas. The extent of a flood is generally measured in water levels and amount of damage done. Walton County is highly subject to riverine flooding due to heavy rains.

- Coastal storms are typically associated with hurricanes and or other tropical depressions and storms that may impact Walton County. The difference between the vulnerabilities

and impacts of coastal storms and hurricanes is separated by the severity of the event are extensive risks.

- Hurricanes are large cyclonic storms with counter-clockwise winds of 74 mph or greater based upon the Saffir-Simpson Hurricane Wind Scale. Coastal areas that receive the full force of hurricane winds and storm surge sustain the most damage. Since hurricanes dissipate quite rapidly to less than hurricane strength after they make landfall, inland areas typically receive less catastrophic damage. Inland damage is usually in the form of flooding associated with the exceptionally heavy rains commonly associated with the remaining storm system. Hurricanes would cause the greatest impact to the jurisdictions of Walton County; thus, mitigation efforts are focused on hurricanes and include the mitigation efforts associated with coastal storms and wind events.

The Subrecipient has prior studies that drill down in some areas of the community. Primarily the Subrecipient's goals will be to:

- Identify flood prone areas under the modeling scenarios.
- Identify solutions to the flooding that is created by the flood modeling.

3.5.1 Stormwater Master Plans

No dedicated stormwater master plans were found for the jurisdictions located for Walton County. As a result, master planning, especially in areas where flooding is a potential issue, will be noted in the capital plan.

Note that currently Walton County stormwater regulations are addressed through their Comprehensive Plan. Other communities, such as the Town of Santa Rosa and the neighborhood of Driftwood Estates, have been said to have stormwater plans but access to these documents has not been obtained.

Stormwater master plans were found for Okaloosa County (https://myokaloosa.com/sites/default/files/users/pwuser/Final%20Master%20Plan2.pdf). Bay County has 6 plans for localized areas, but they are not web accessible.

3.5.2 Flood Insurance Study

“A Flood Insurance Study (FIS) is a compilation and presentation of flood risk data for specific watercourses, lakes, and coastal flood hazard areas within a community. The FIS report contains detailed flood elevation data in flood profiles and data tables” (FEMA, 2020). FIS are encouraged by FEMA and commonly used to present flood risk data for specific waterbodies, lakes, and coastal flood hazard areas within a community.

All counties that take part in the NFIP should have access to a FIS for their respective county. FIS are valuable in understanding what the analysis and data expected of a WMP may look like. It is important to remember that flood elevations shown on the FIRMs are primarily intended for flood insurance rating purposes, developed from historical data. WMPs seek to bridge historical data with future projections (NFIP, 2017).

Walton County has an FIS as noted in Figure 45.

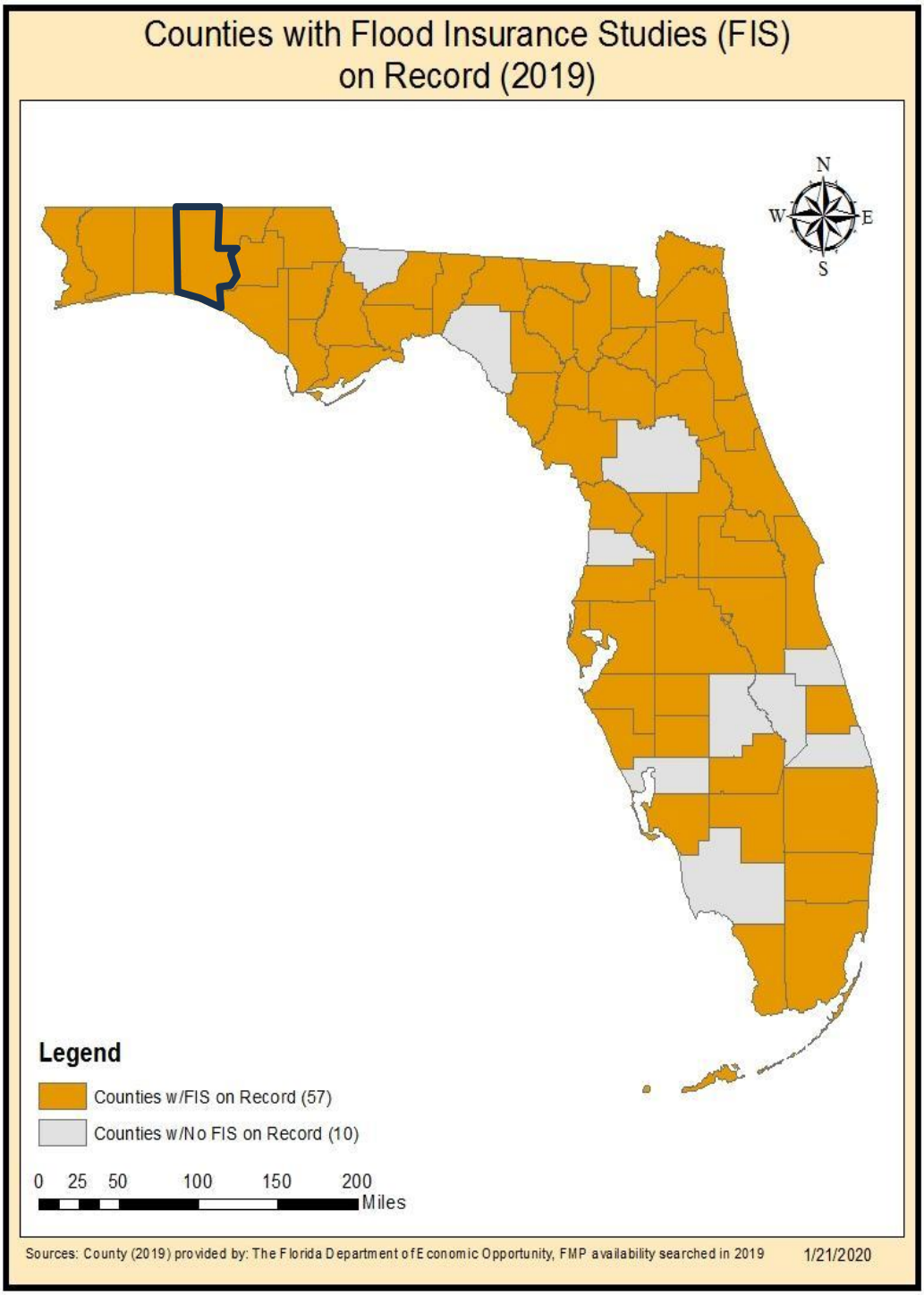


Figure 45. Counties with Flood Insurance Studies

**Note Walton County has an FIS.*

3.5.3 Stormwater Pollution Prevention Plans (SWPPPs)

Stormwater Pollution Prevention Plans (SWPPPs) identify primary sources of stormwater pollution at construction sites, best practices to reduce stormwater discharge from construction sites, and procedures to comply with construction permits. As part of the Clean Water Act, it is required that nearly all construction site operators engaged in clearing, grading, and excavating activities that disturb one acre or more, including smaller sites in a larger common plan of development or sale, must obtain a National Pollutant Discharge Elimination System (NPDES) permit for their stormwater discharges. Understanding the requirements of the SWPPP and the NPDES are helpful in addressing parts of a WMP with regards to stormwater and runoff management. No specific plan exists in the watershed outside of references to the local comprehensive plans, master plans and other policy documents.

3.5.4 Post-Disaster Redevelopment Plan

Some communities may decide to formalize a Post-Disaster Redevelopment Plan to facilitate long-term recovery following a disaster. A community's Post-Disaster Redevelopment Plan can address issues relating to the identification of key roles, personnel, and agencies for future land use and zoning of areas damaged by disasters. Key sections of Post-Disaster Redevelopment Plans that should be considered when developing a WMP are as follows:

- Mapping Hazard Risks. Aligns the need for geospatial hazard analysis and mapping efforts, which leads to more informed policy recommendations post-disaster.
- Protecting or Restoring Natural Areas. Focuses on the redevelopment process taking place in areas that are less sensitive to development, leaving areas more prone to disaster and allowing them to serve as a buffer or other mitigating effect.
- Funding through Capital Improvement Programs. The identification of funding can assist a community to implement well-managed growth and redevelopment.

3.5.5 Climate Adaptation Action Plan (CAAP)

The adaptation chapter of Florida's Climate Adaptation Action Plan (CAAP) is one that contains a series of 28 varying goals with strategies that work towards addressing the impacts of climate. There is no climate action plan for Walton County.

3.6 Dedicated Funding Sources

Funding for stormwater improvement projects can come from various sources. Some can come from accumulating funds from stormwater fees. Borrowing of funds for implementation projects can be accomplished at low interest rates from the State Revolving Fund (SRF) loan program that finances the cost of construction of publicly owned water, wastewater, and stormwater facilities. Authority for the program is found in Chapters 62-622, 62-503 and 62-504 of the Florida Administrative Code. FDEP is charged with implementing the program. Generally, any local government entity is eligible to apply for SRF loans.

The concepts of Municipal Services Benefit Units (MSBUs), Municipal Services Taxing Units (MSTUs), a stormwater utility, or other funding option are available in the greater watershed. These are available to all municipalities. The use of stormwater utility fees or assessments as a dedicated funding source is available, but neither has taken advantage of this option. Walton County should consider establishing some form of stormwater utility assessment to help funding their specific flood control needs.

4.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

4.1 Historical and Existing Challenges

Challenges that face Walton County regarding stormwater management include high water table, regularly occurring extreme storm events, stormwater runoff impacts to wetlands, coastal erosion, aging and/or inadequate stormwater conveyance infrastructure, and data gaps including a lack of comprehensive stormwater infrastructure inventory and lack of formal Stormwater Master Plan documents for Walton County communities.

4.1.1 Existing Management Efforts in the Watershed

The entire basin is controlled by the NWFMWD and USACE with the intent of reducing flooding within the water management district boundaries. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential as discussed in Chapter 3. Most of the major projects to date have been driven by the NWFWMD.

4.2 Vulnerability Maps

4.2.1 Screening Tool

The screening tool utilizes data from various sources, as described in Chapter 2 of this document. The design storm was the 3-day, 25-year storm, which is the standard used by SFWMD for flood

management. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models.

Figure 46 shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

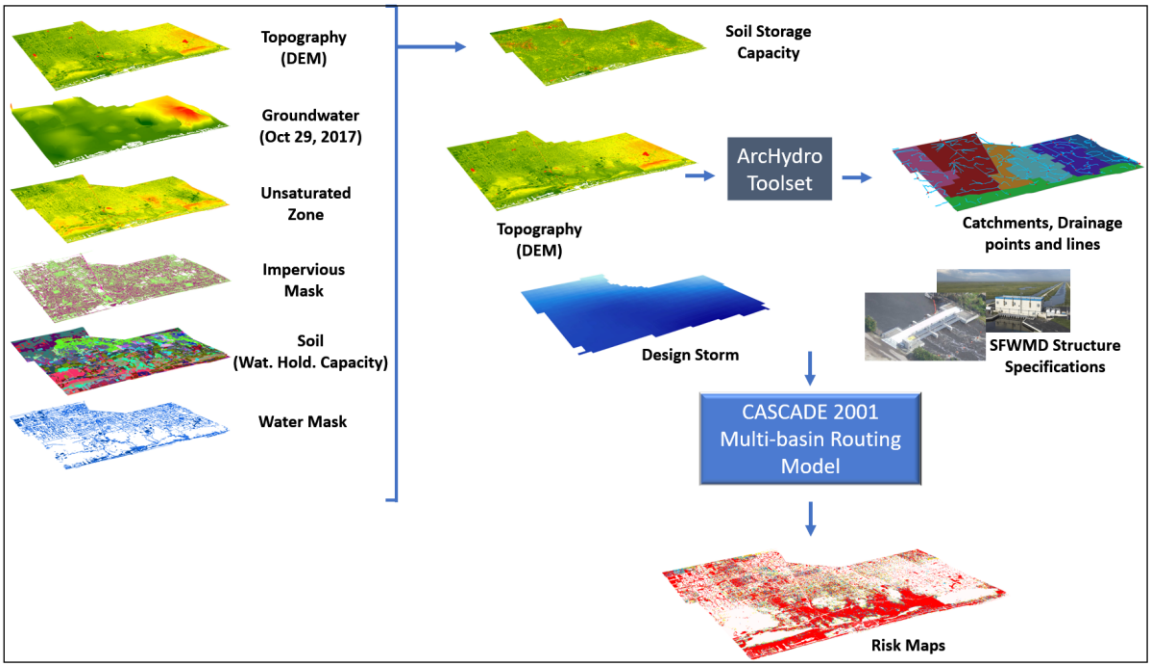


Figure 46. Screening tool methodology for creating flood risk maps

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The program creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial ground water stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

Note Chapter 2 outlined each of the layers used for modeling. The Appendices outline each HUC 12 that affects the County (there are 42 of them). The output from the model is an elevation surface that can be used to develop flood maps for the study area. The figures in Chapter 4 are a mosaic of these results that can be used for public discussion. The appendices are what NFIP will be interested in.

4.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in

combination with soils, vegetation and percent impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate the flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on “VALUE = 1” query are extracted using Extract by Attributes tool. Then the Batch Project tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using Add Field for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the Merge tool. Next, Zonal Statistics as Table is used to calculate the SUM of flooded values (1) within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the Join Field tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using Export Table to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use Calculate Field in the attribute table along with the following Python expression (replacing the respective field name): “0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!”.

Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the “percent-flooded” columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created

to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.1 of this document.

The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99.

Figure 47 shows the predicted flooding after the 3-day, 25-year storm event compared to the repetitive loss property maps superimposed to the GIS platform as a separate layer with the repetitive loss map. They compare favorably. The lighter blue areas represent land that floods, while the dark blue areas are classified as wetlands, lakes, rivers, streams, and other waterbodies.

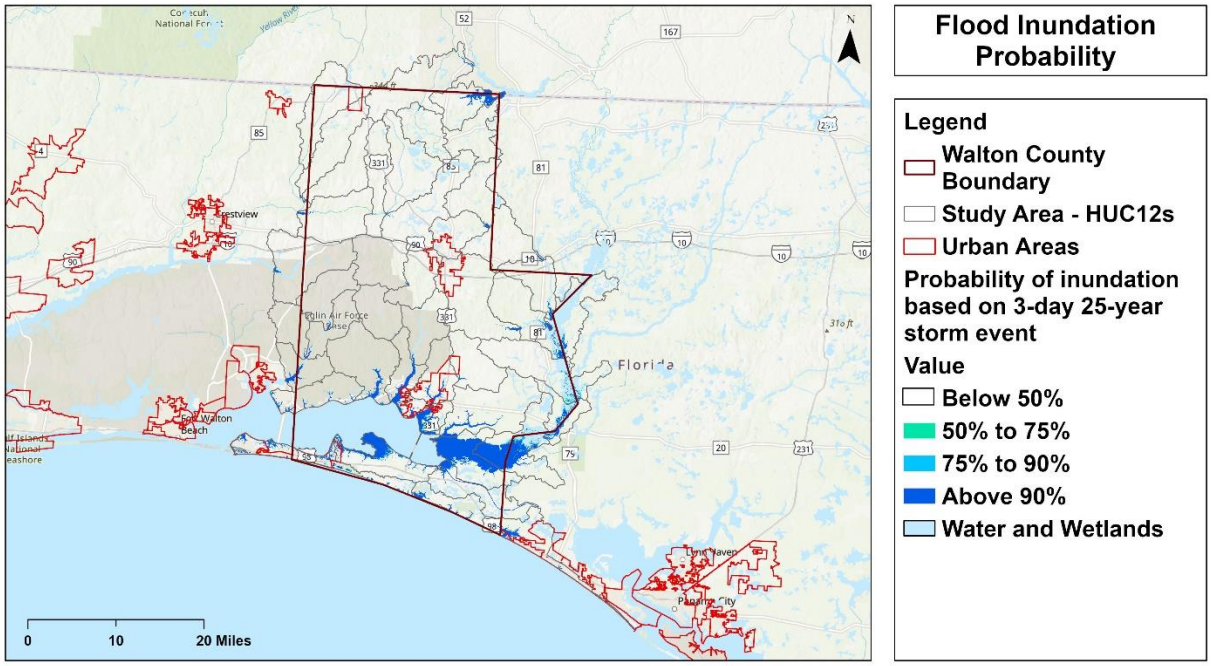


Figure 47. Flooded areas during a 3-day, 25-year storm in the Walton County (FAU, 2023)

The spatial distribution of probabilities of flooding during the 1-day, 5-year storm event is shown in Figure 48. Likewise, the 1-day, 10-year storm event is shown in Figure 49, and the 1-day, 100-year storm event is shown in Figure 50. Note that just because a property is predicted to flood does not mean it always floods.

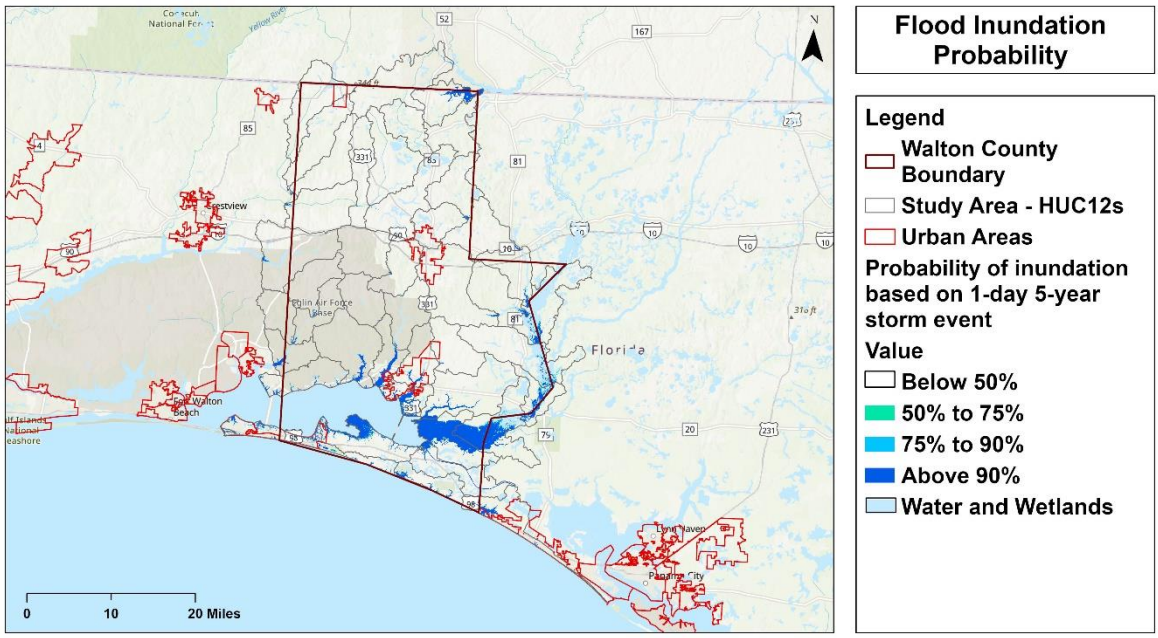


Figure 48. Probability of flood risk map for Walton County for the 1-day, 5-year storm event (FAU, 2023)

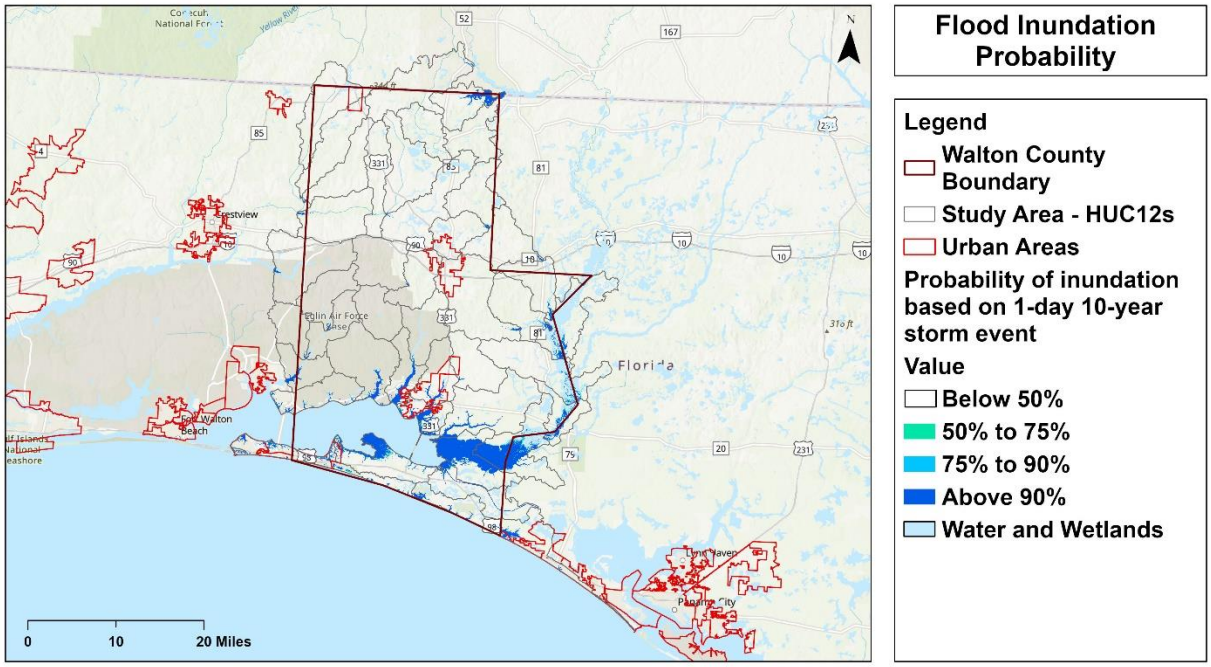


Figure 49. Probability of flood risk map for Walton County for the 1-day, 10-year storm event (FAU, 2023)

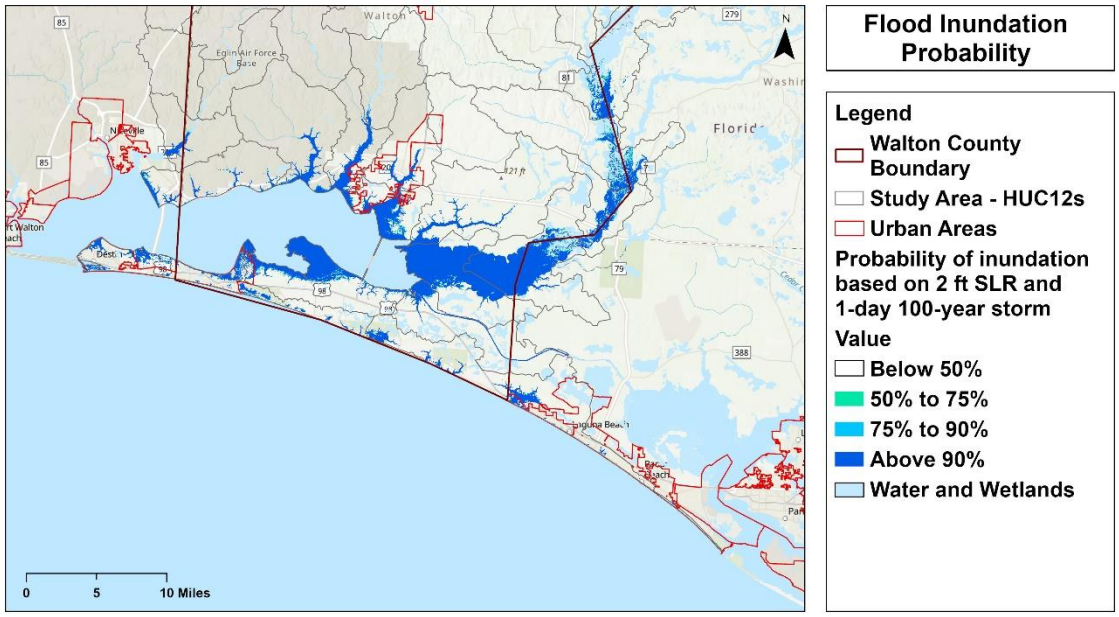


Figure 50. Probability of flood risk map for Walton County for the 1-day, 100-year flood event (FAU,2023)

4.3 Critical Target Areas Identification

By modeling the County's flood response to storm events and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas that are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool should first be applied at the sub watershed level to provide an initial risk assessment focused on the hydrologic response to a specified rainfall event given the unique characteristics and features of the watershed. For example, characteristics of the County's sub watersheds are incorporated to represent possible driving factors of flooding in the region such as low ground surface elevations, a high groundwater table, low soil storage capacity, and heavy rains. At this scale, flooding generally occurs around large waterbodies, namely the Gulf of Mexico (downstream), is a major concern. Each of the HUC12s that involve the coastal waters was modeled for sea level rise at 1, 2, 3, 4, and 5 ft for each storm event. It's these long-term storm events that are NFIP's major concern. Figure 51 to Figure 70 represent those results. Note that the critical blue areas will be further modeled, and solutions investigated for Chapter 5.

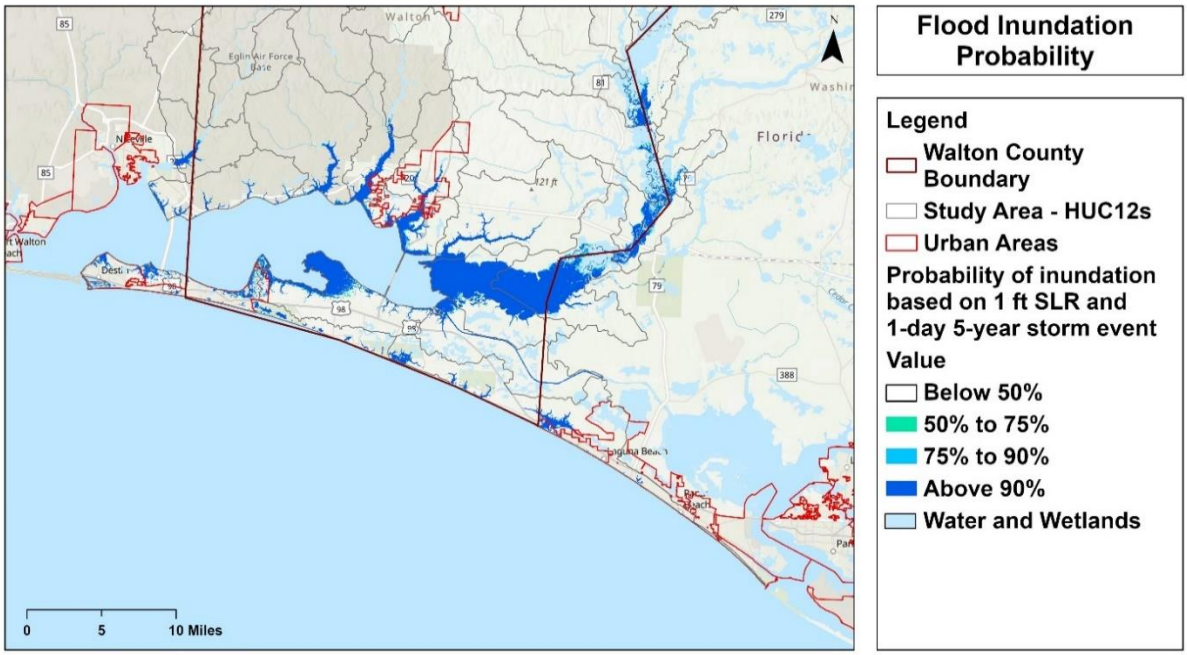


Figure 51. Probability of flood risk map for Walton County for the 1-day, 5-year flood event with 1 ft SLR (FAU, 2023)

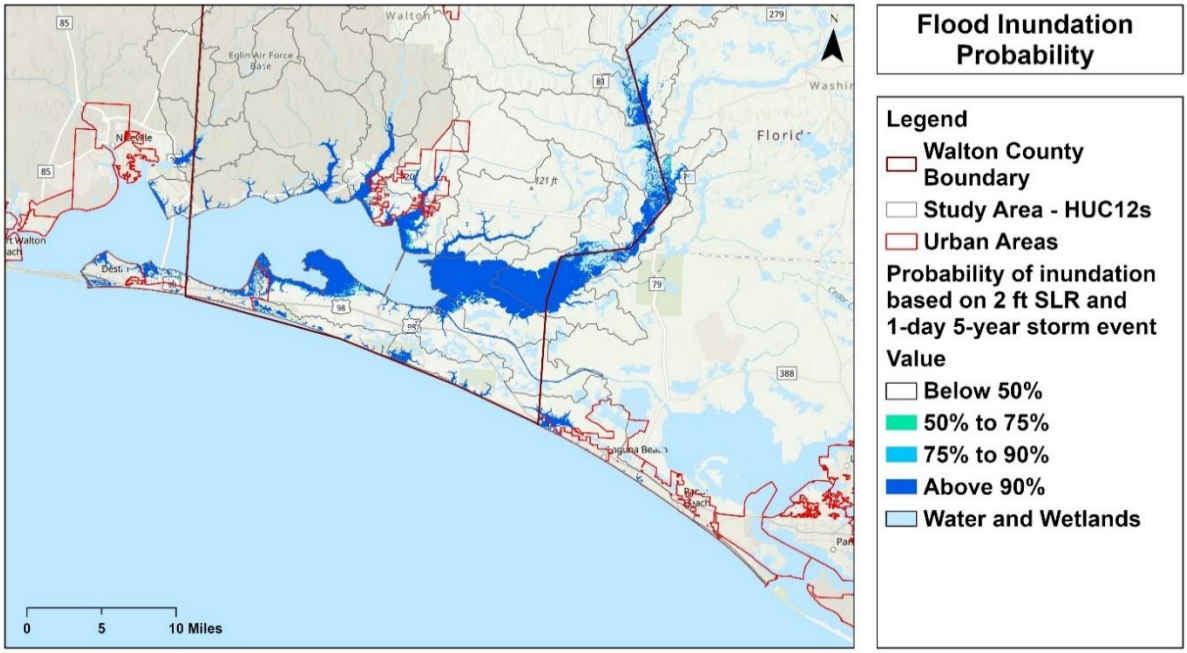


Figure 52. Probability of flood risk map for Walton County for the 1-day, 5-year flood event with 2 ft SLR (FAU, 2023)

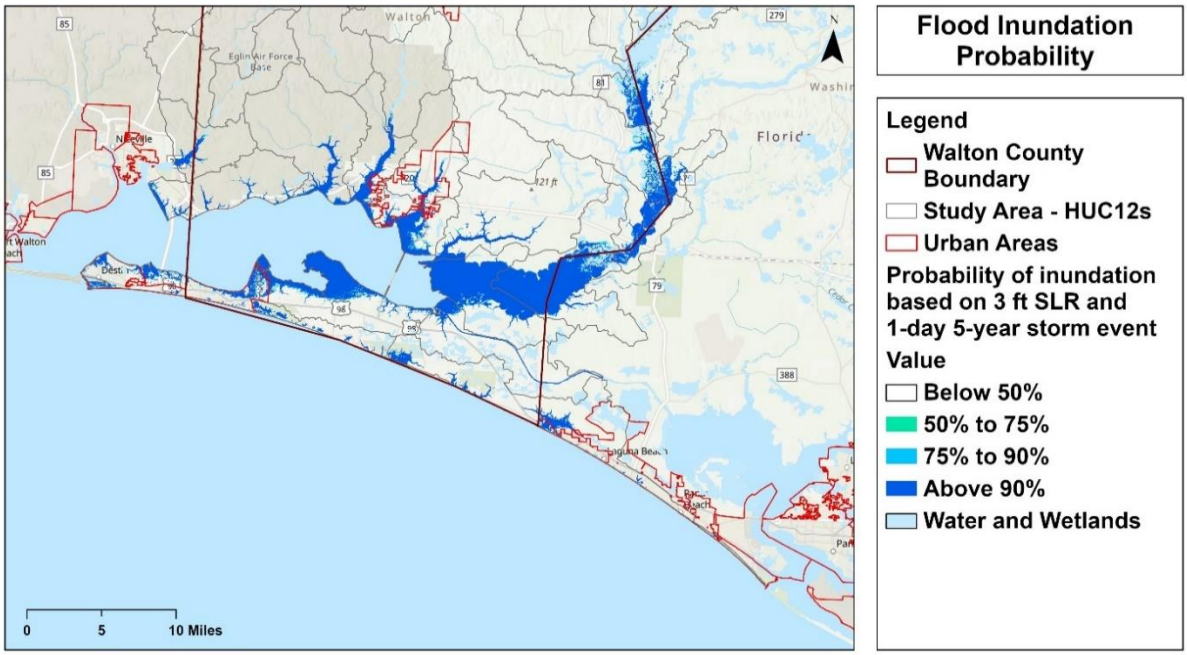


Figure 53. Probability of flood risk map for Walton County for the 1-day, 5-year flood event with 3 ft SLR (FAU, 2023)

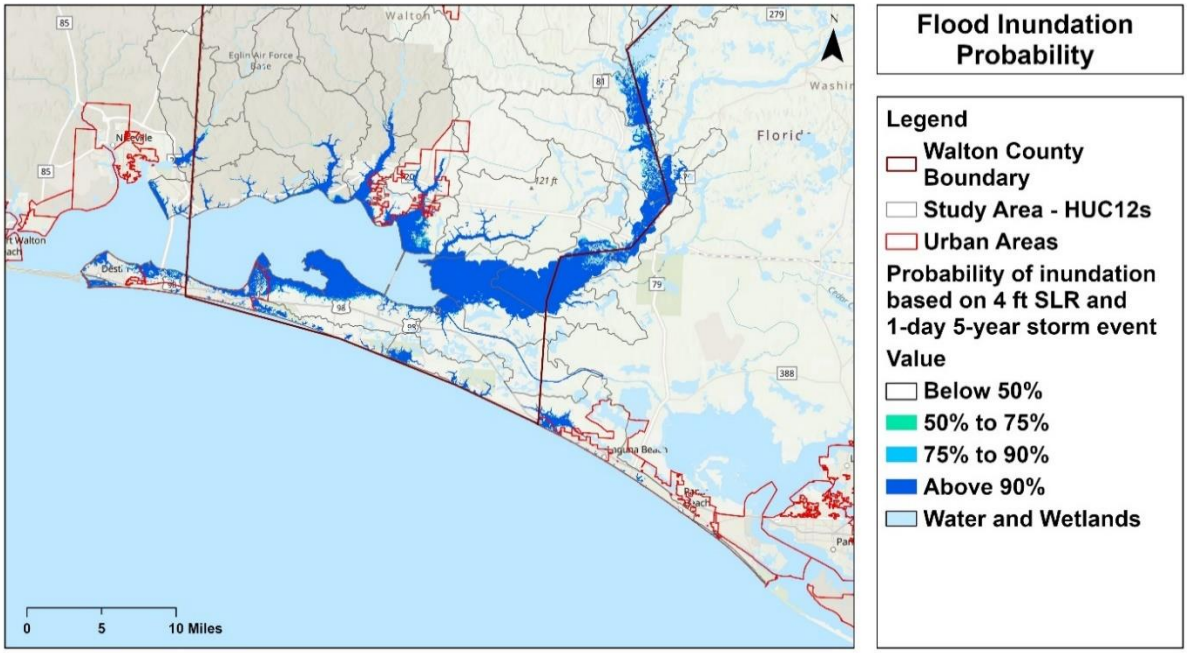


Figure 54. Probability of flood risk map for Walton County for the 1-day, 5-year flood event with 4 ft SLR (FAU, 2023)

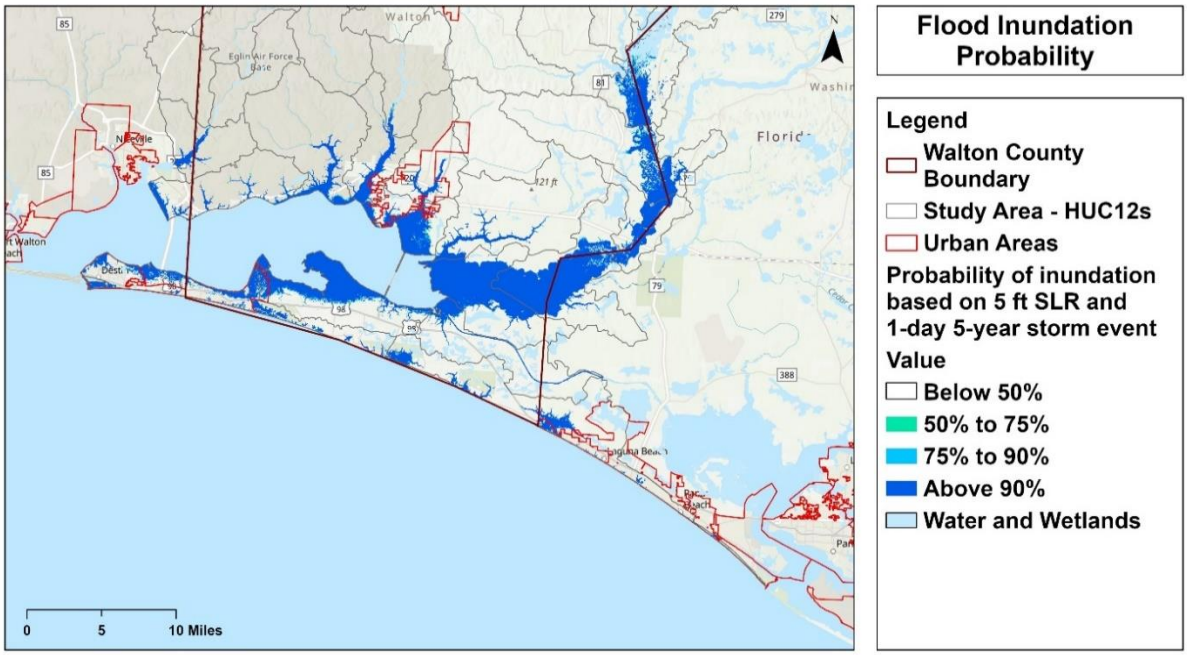


Figure 55. Probability of flood risk map for Walton County for the 1-day, 5-year flood event with 5 ft SLR (FAU, 2023)

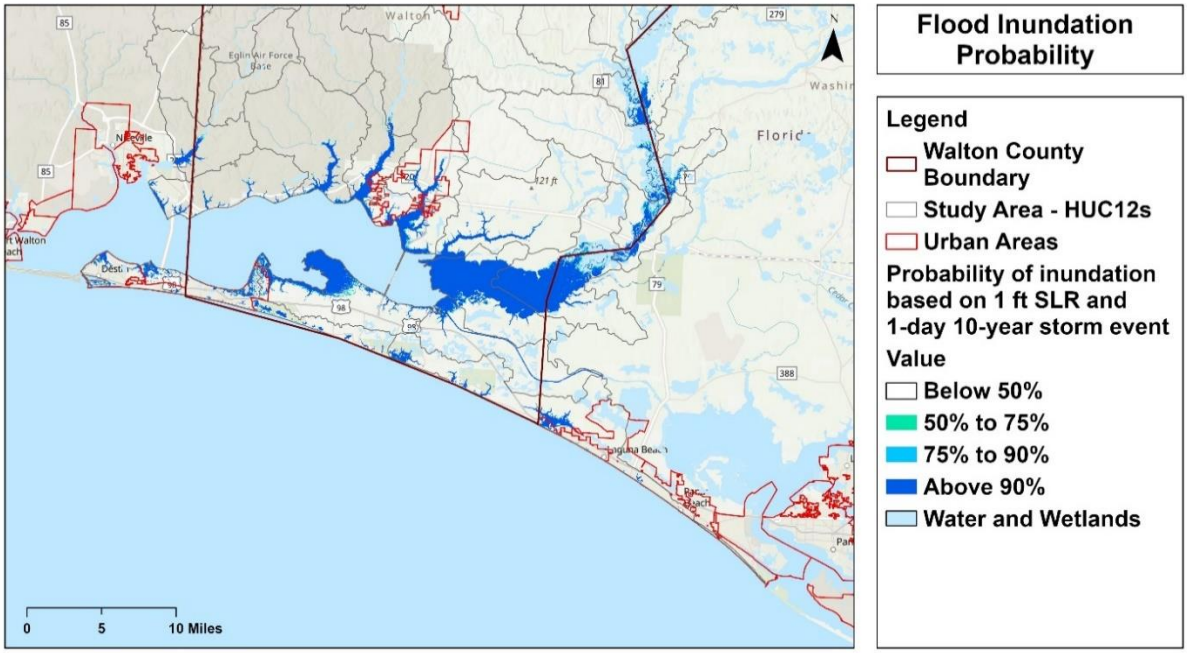


Figure 56. Probability of flood risk map for Walton County for the 1-day, 10-year flood event with 1 ft SLR (FAU, 2023)

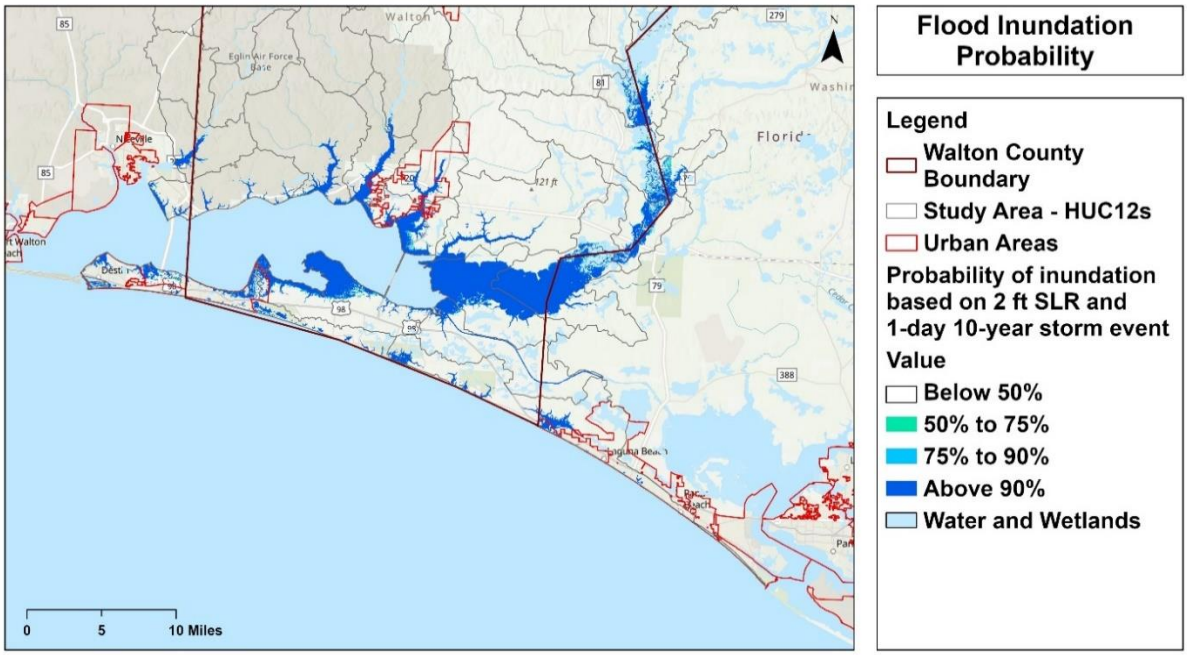


Figure 57. Probability of flood risk map for Walton County for the 1-day, 10-year flood event with 2 ft SLR (FAU, 2023)

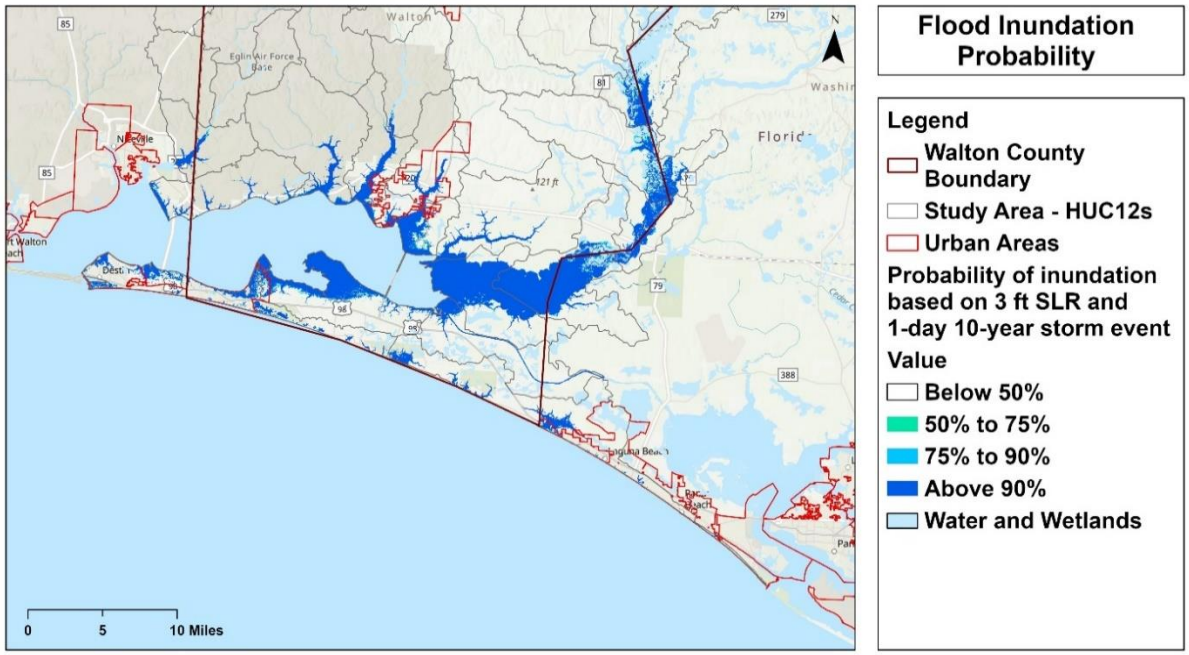


Figure 58. Probability of flood risk map for Walton County for the 1-day, 10-year flood event with 3 ft SLR (FAU, 2023)

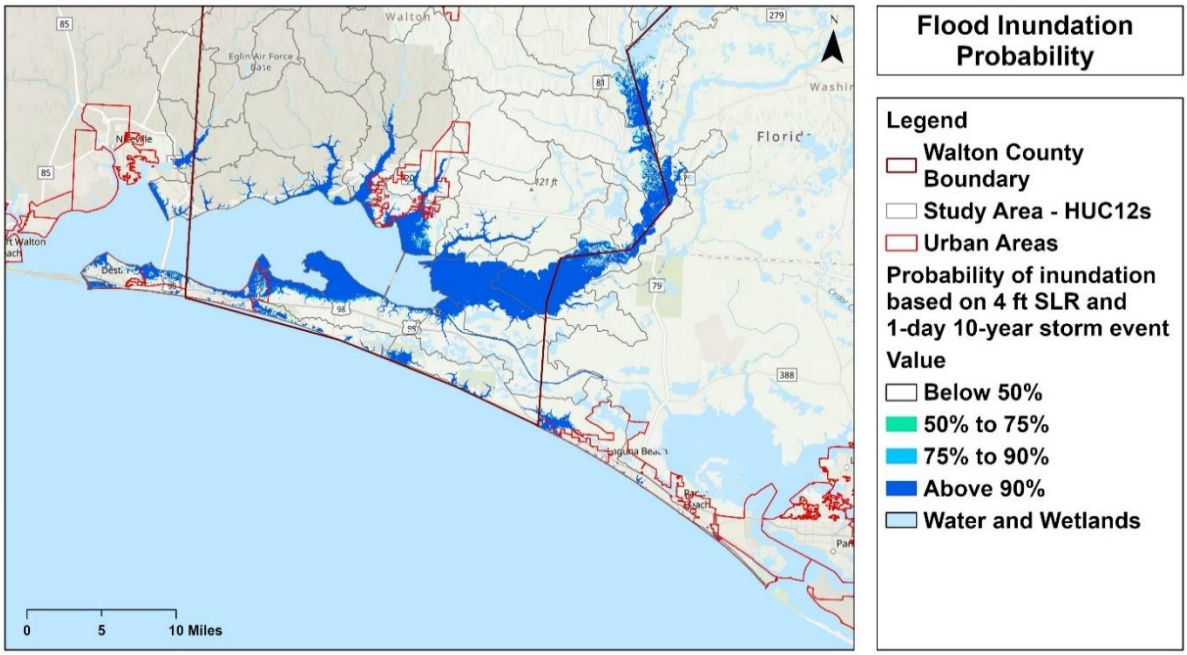


Figure 59. Probability of flood risk map for Walton County for the 1-day, 10-year flood event with 4 ft SLR (FAU, 2023)

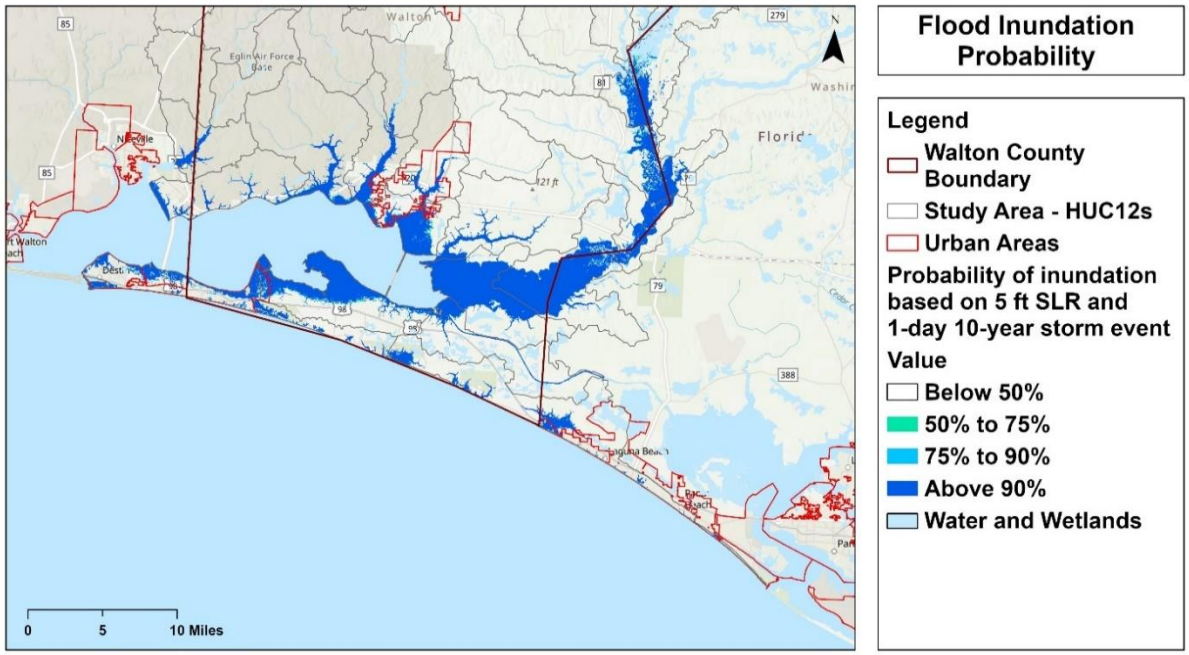


Figure 60. Probability of flood risk map for Walton County for the 1-day, 10-year flood event with 5 ft SLR (FAU, 2023)

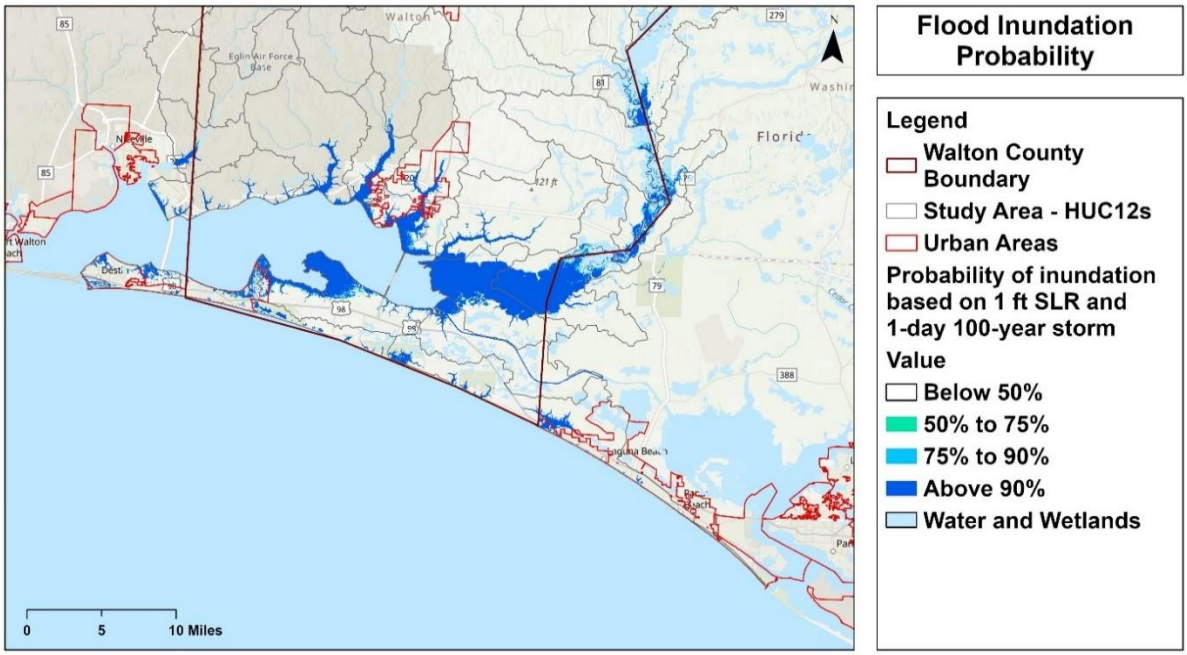


Figure 61. Probability of flood risk map for Walton County for the 1-day, 100-year flood event with 1 ft SLR (FAU, 2023)

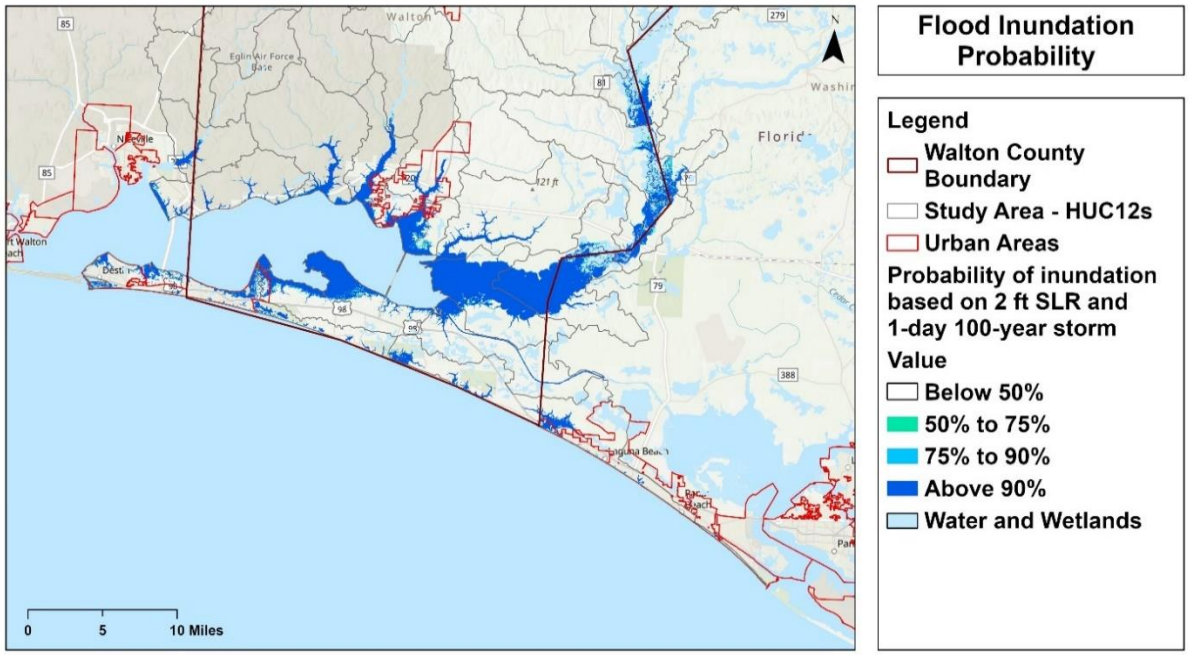


Figure 62. Probability of flood risk map for Walton County for the 1-day, 100-year flood event with 2 ft SLR (FAU, 2023)

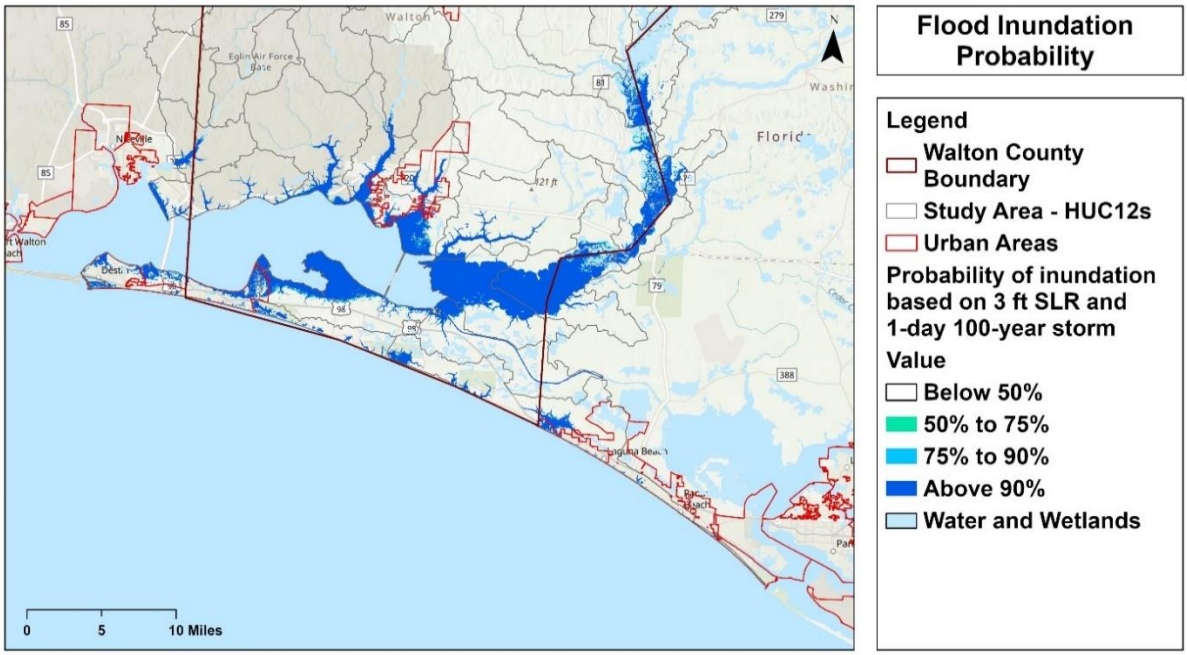


Figure 63. Probability of flood risk map for Walton County for the 1-day, 100-year flood event with 3 ft SLR (FAU, 2023)

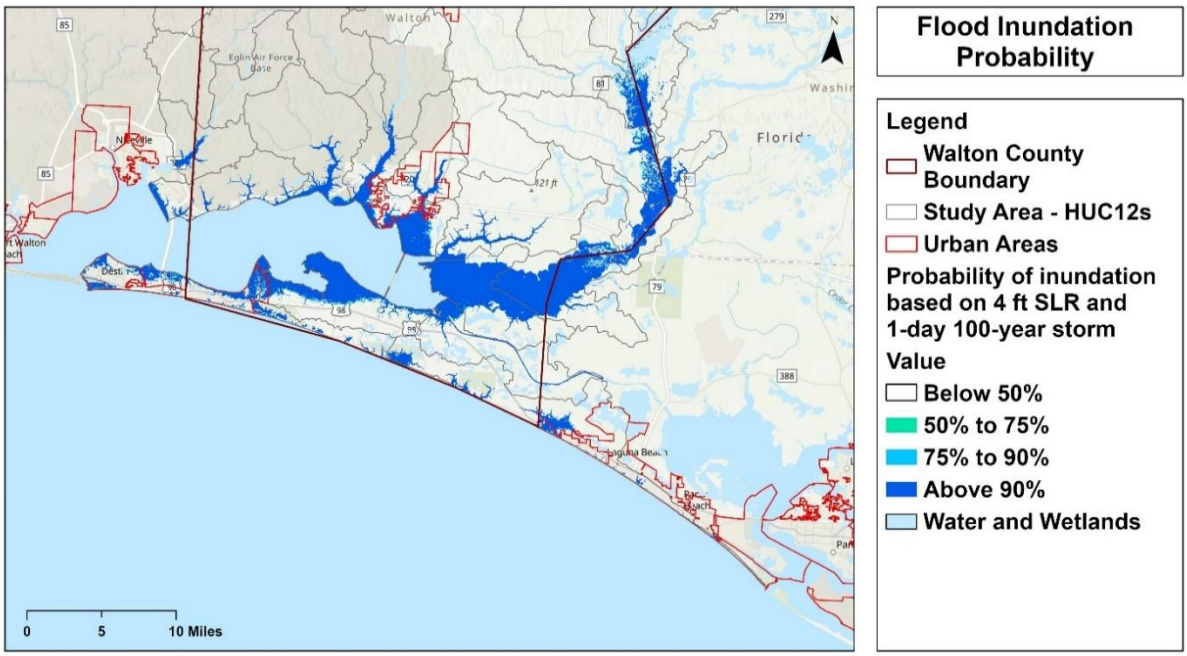


Figure 64. Probability of flood risk map for Walton County for the 1-day, 100-year flood event with 4 ft SLR (FAU, 2023)

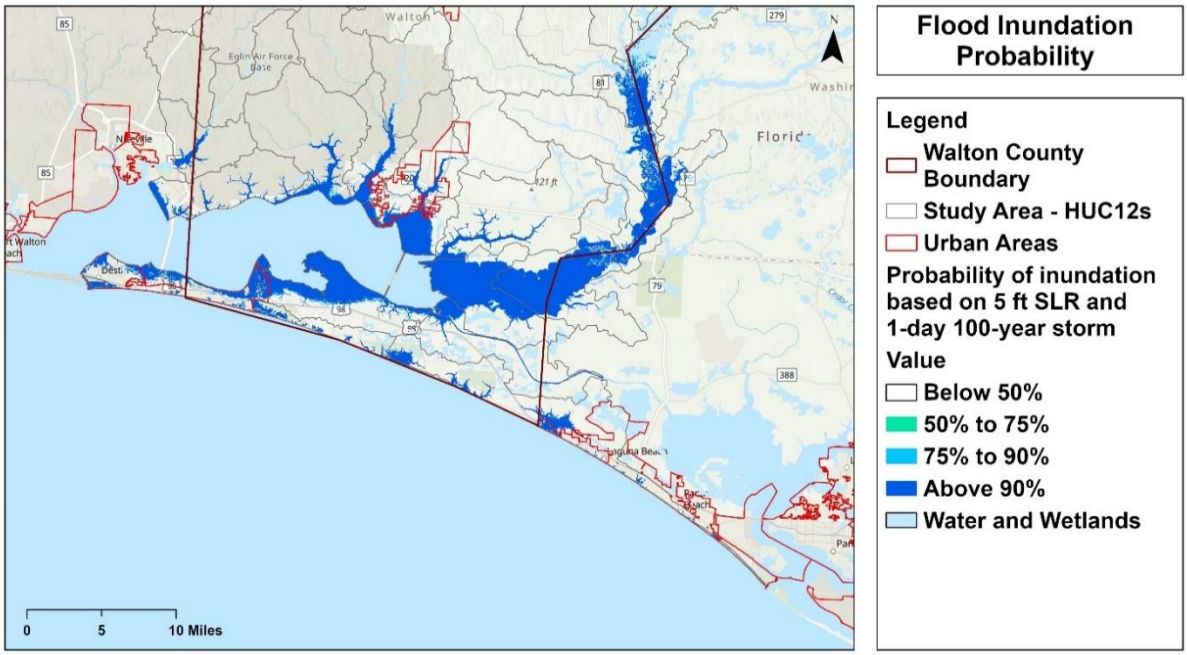


Figure 65. Probability of flood risk map for Walton County for the 1-day, 100-year flood event with 5 ft SLR (FAU, 2023)

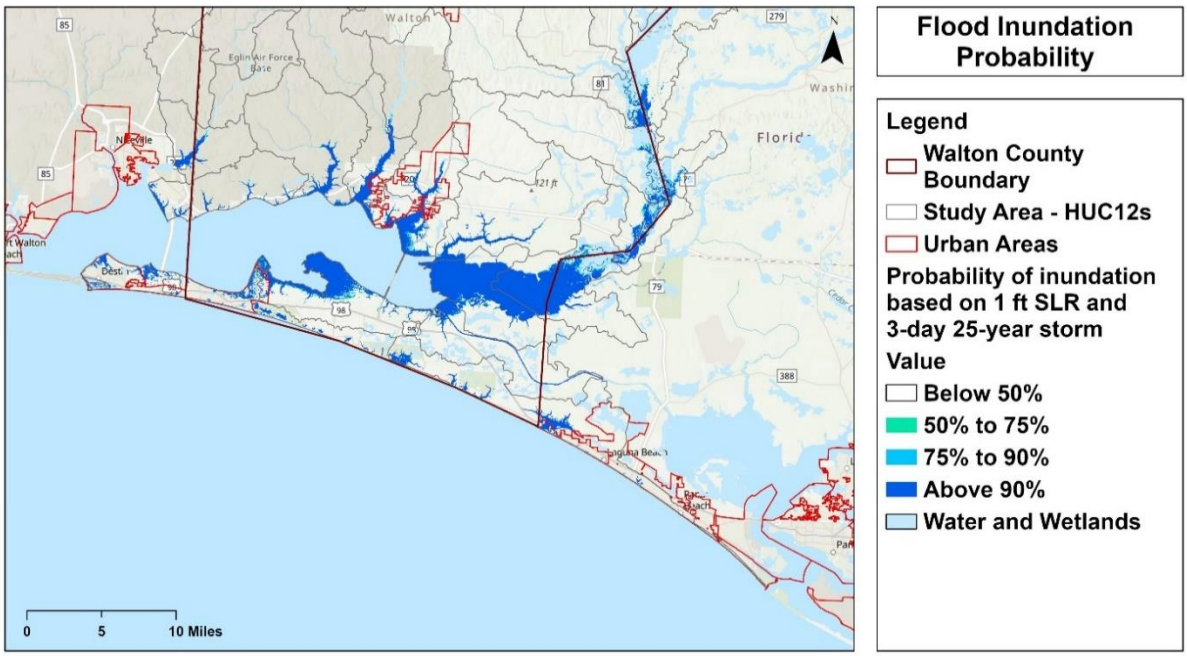


Figure 66. Probability of flood risk map for Walton County for the 3-day, 25-year flood event with 1 ft SLR (FAU, 2023)

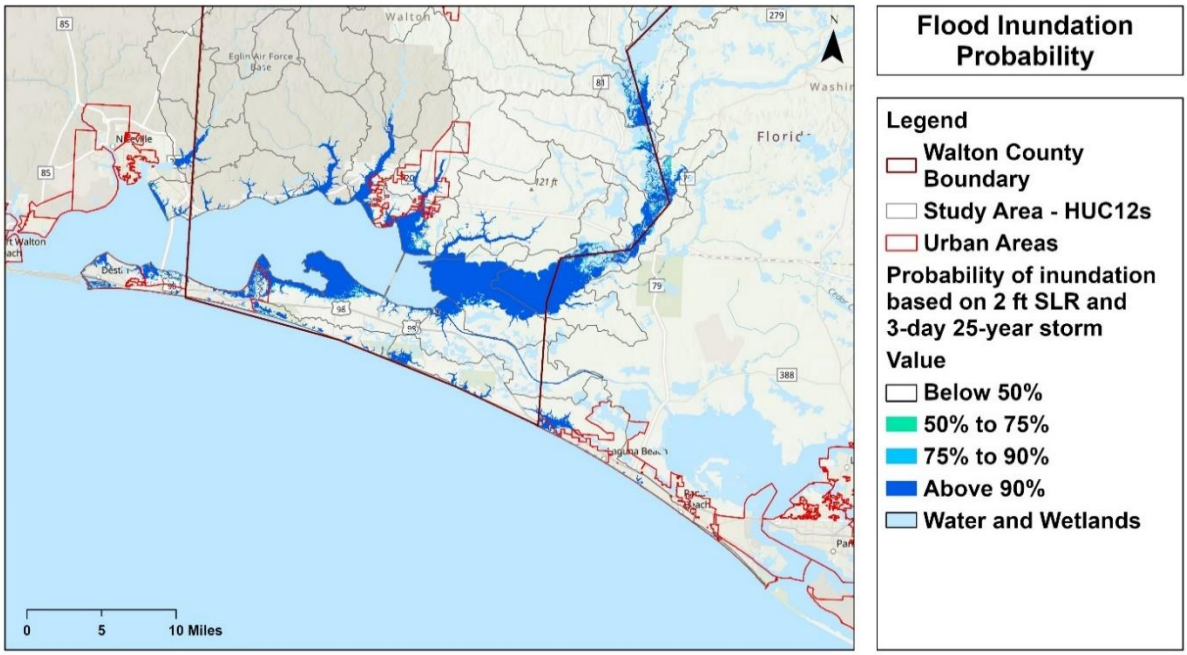


Figure 67. Probability of flood risk map for Walton County for the 3-day, 25-year flood event with 2 ft SLR (FAU, 2023)

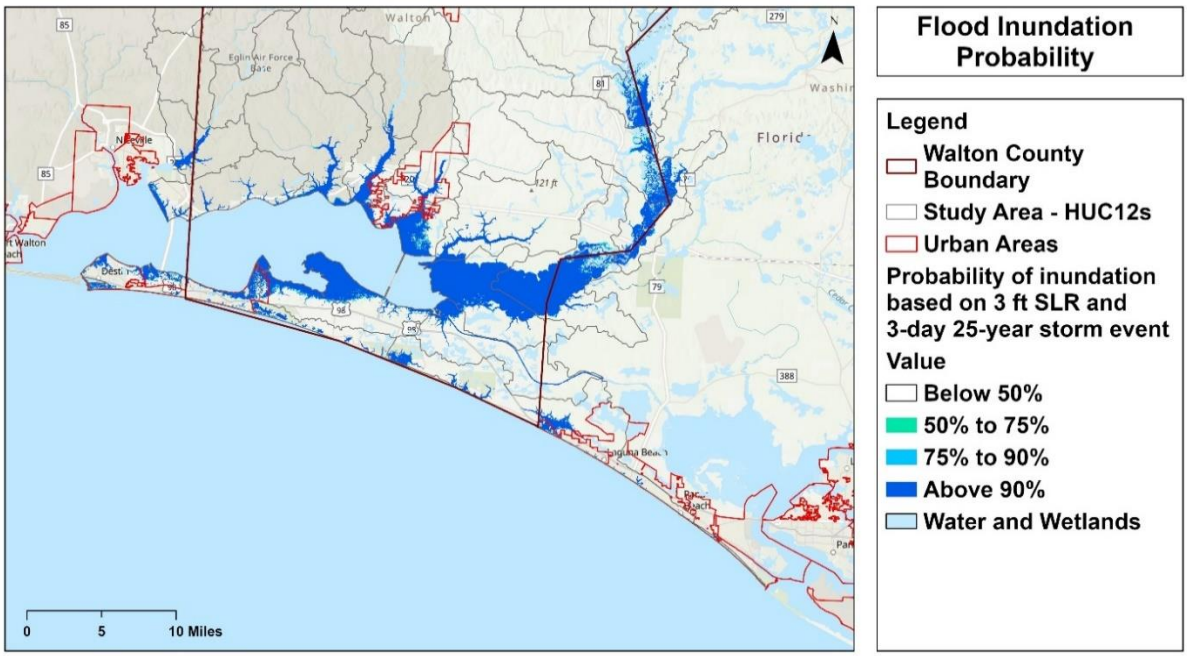


Figure 68. Probability of flood risk map for Walton County for the 3-day, 25-year flood event with 3 ft SLR (FAU, 2023)

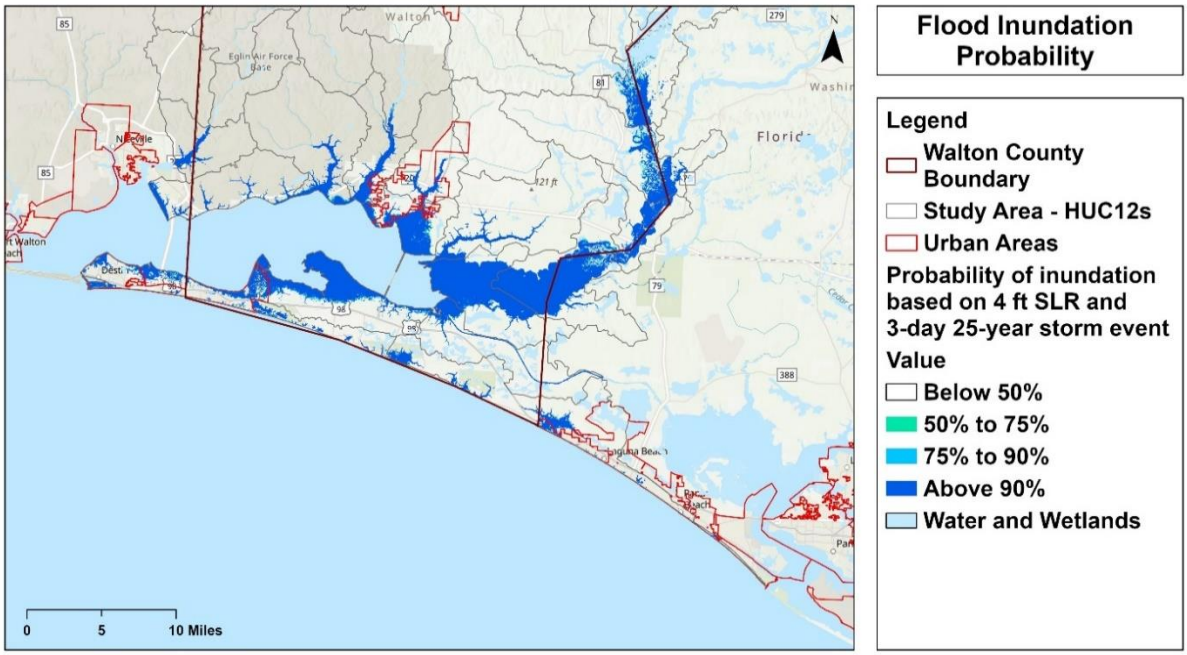


Figure 69. Probability of flood risk map for Walton County for the 3-day, 25-year flood event with 4 ft SLR (FAU, 2023)

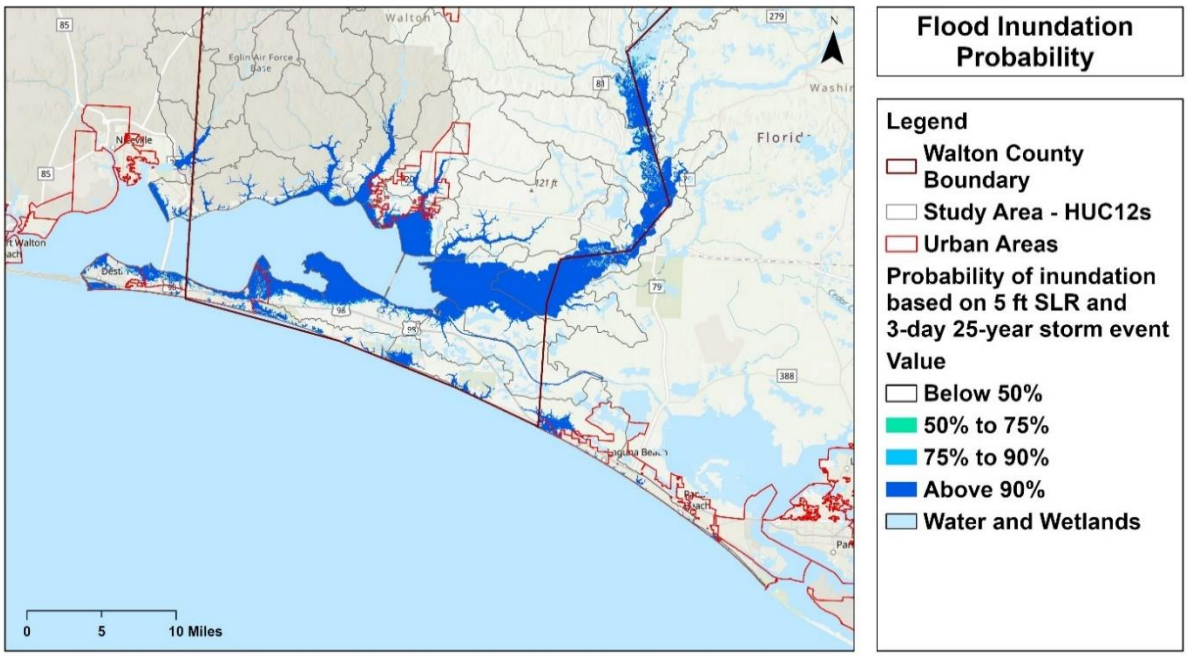


Figure 70. Probability of flood risk map for Walton County for the 3-day, 25-year event with 5 ft SLR (FAU, 2023)

However, to prioritize funding for future mitigation and planning efforts at the local level, it is necessary to identify areas of concern within the sub watershed that are highly susceptible to flooding. As expected, these susceptible areas tend to be those near waterbodies and/or the beach. Figure 71 to Figure 75 show modeling results for communities under SLR projects with 1-day, 100-year storm events for areas near waterbodies, while Figure 76 to Figure 80 show the results for areas associated with the beach communities.

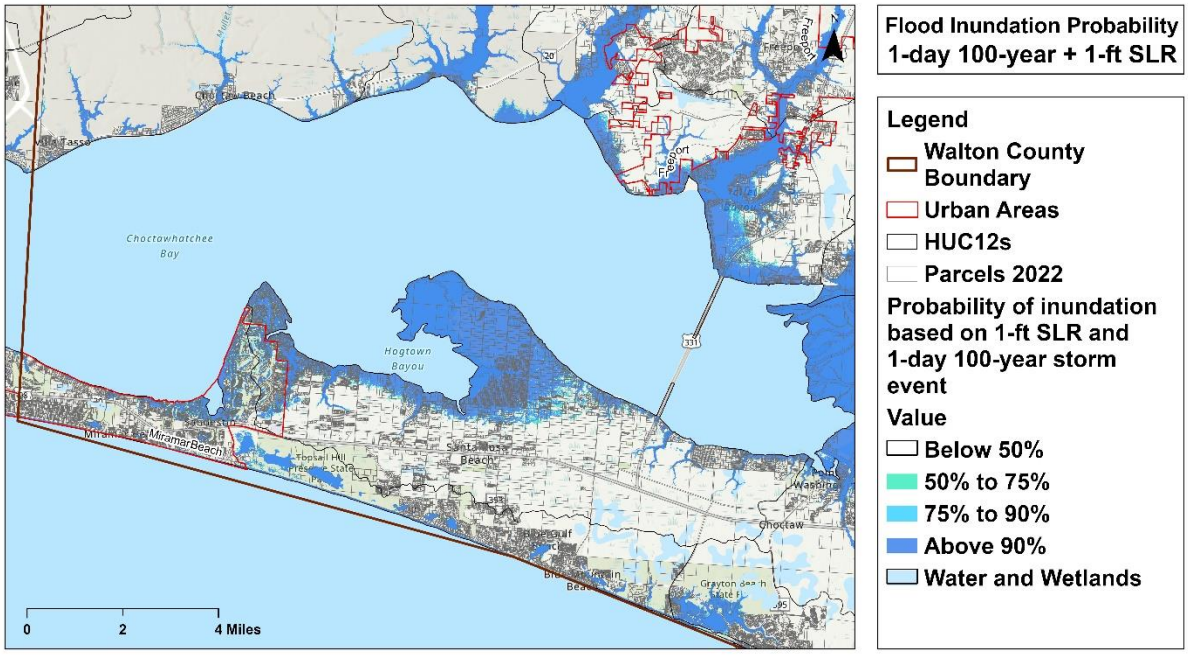


Figure 71. Probability of flood risk map for along the water in Walton County for the 1-day, 100-year flood event with 1 ft SLR (FAU, 2023)

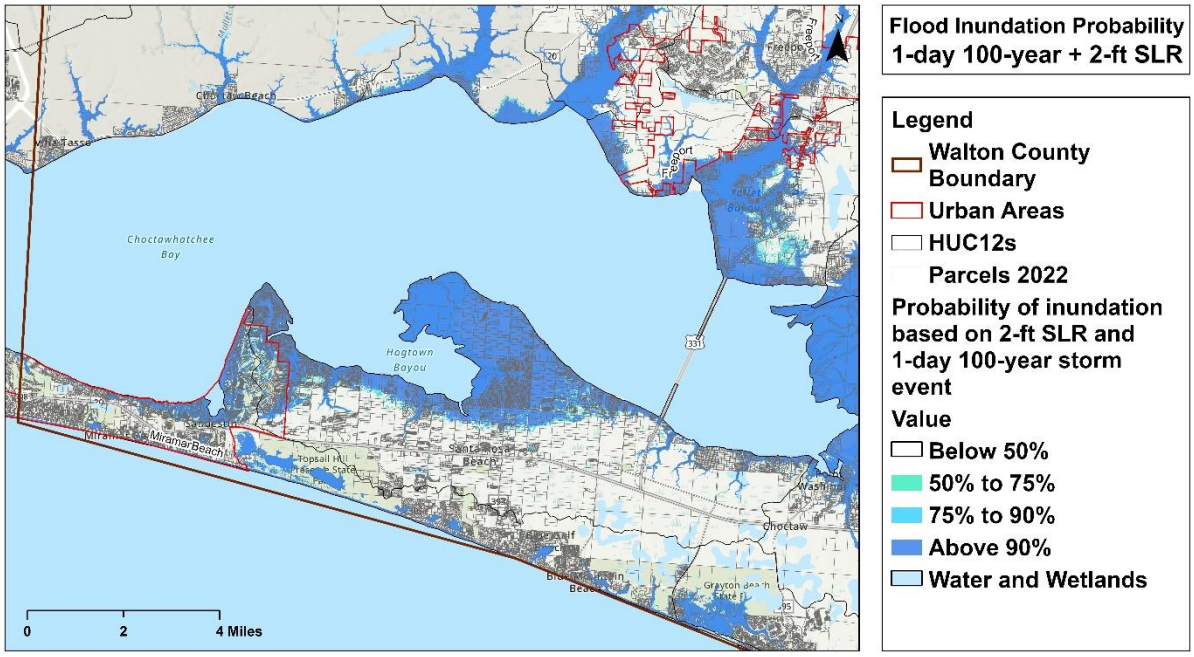


Figure 72. Probability of flood risk map for along the water in Walton County for the 1-day, 100-year flood event with 2 ft SLR (FAU, 2023)

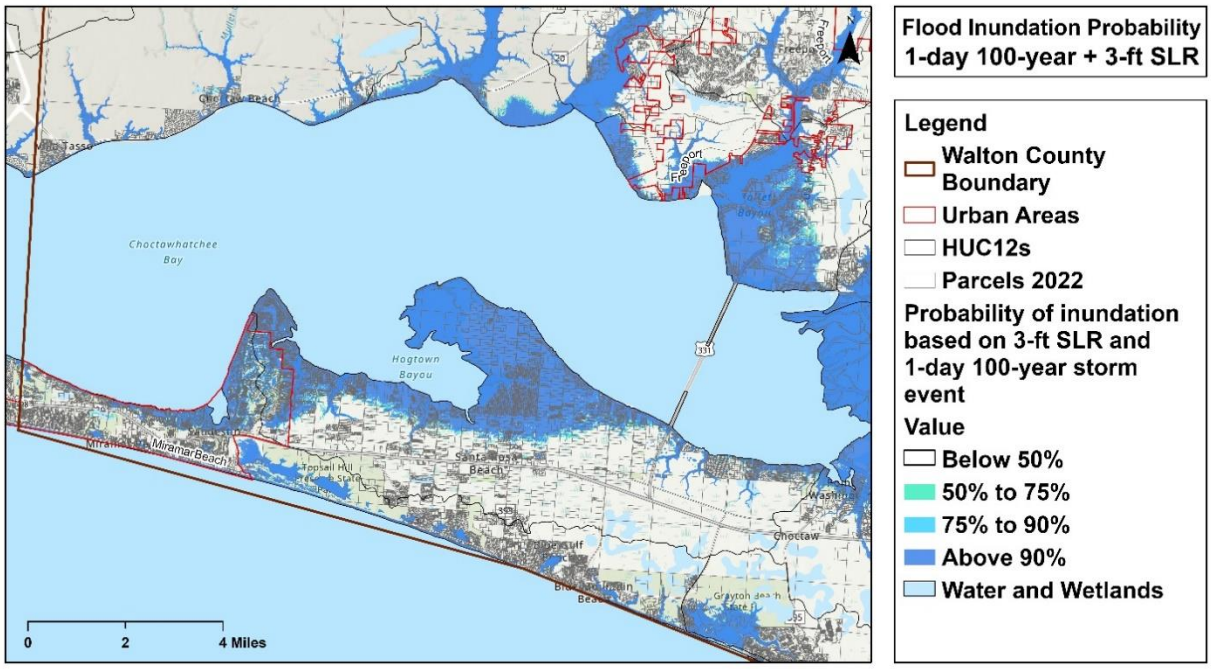


Figure 73. Probability of flood risk map for along the water in Walton County for the 1-day, 100-year flood event with 3 ft SLR (FAU, 2023)

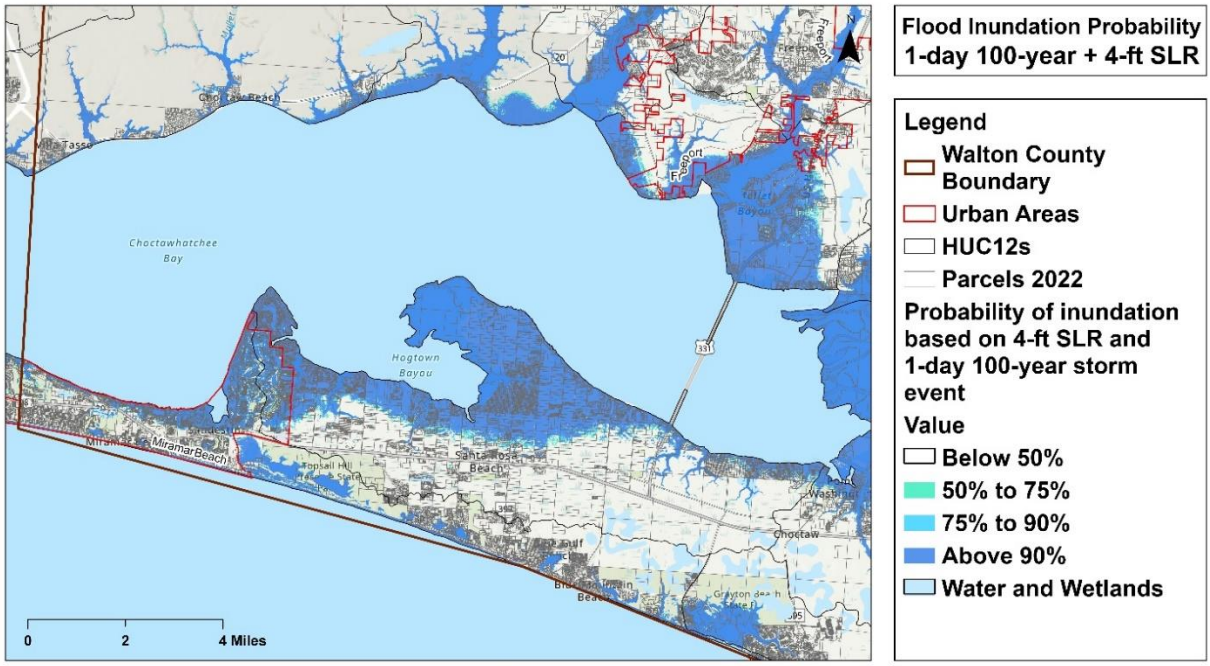


Figure 74. Probability of flood risk map for along the water in Walton County for the 1-day, 100-year flood event with 4 ft SLR (FAU, 2023)

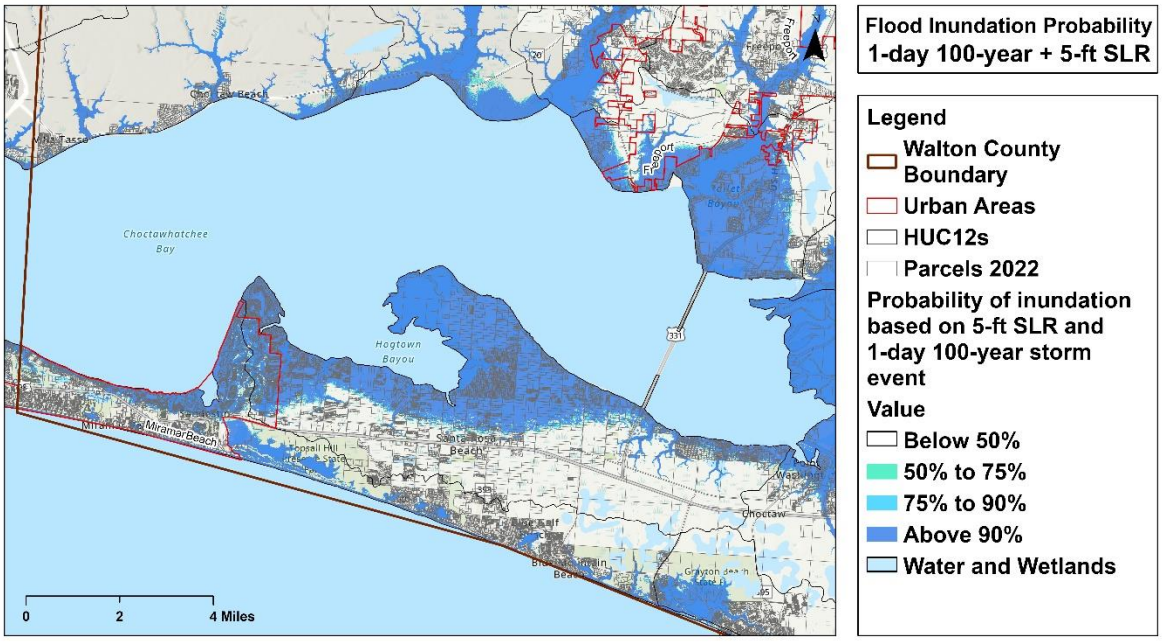


Figure 75. Probability of flood risk map for along the water in Walton County for the 1-day, 100-year flood event with 5 ft SLR (FAU, 2023)

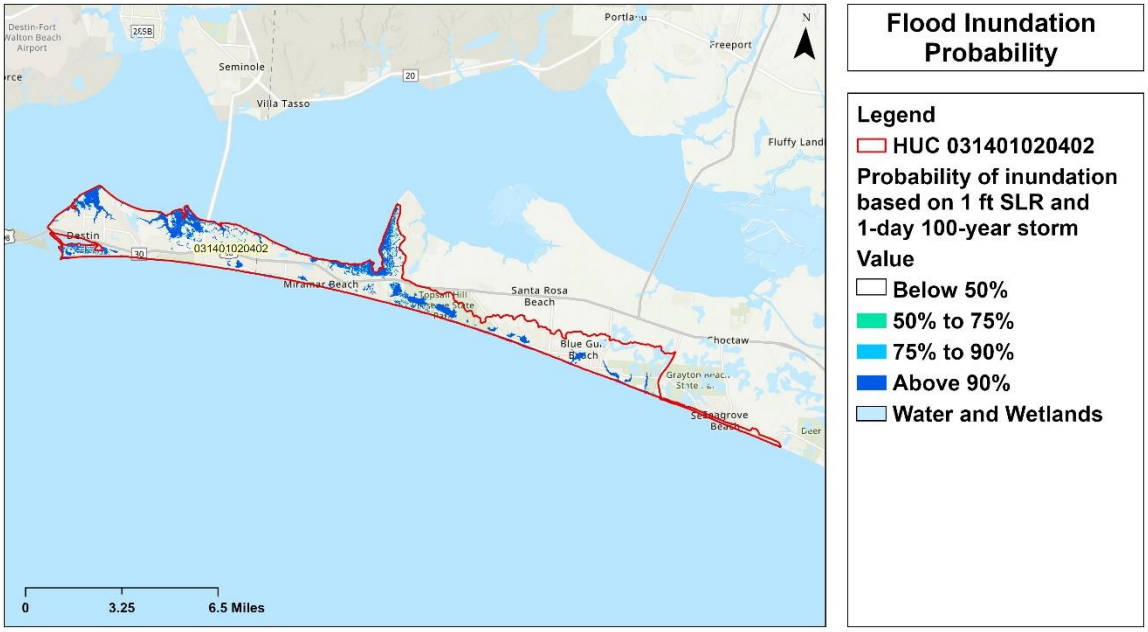


Figure 76. Probability of flood risk map for along the beach in Walton County for the 1-day, 100-year flood event with 1 ft SLR (FAU, 2023)

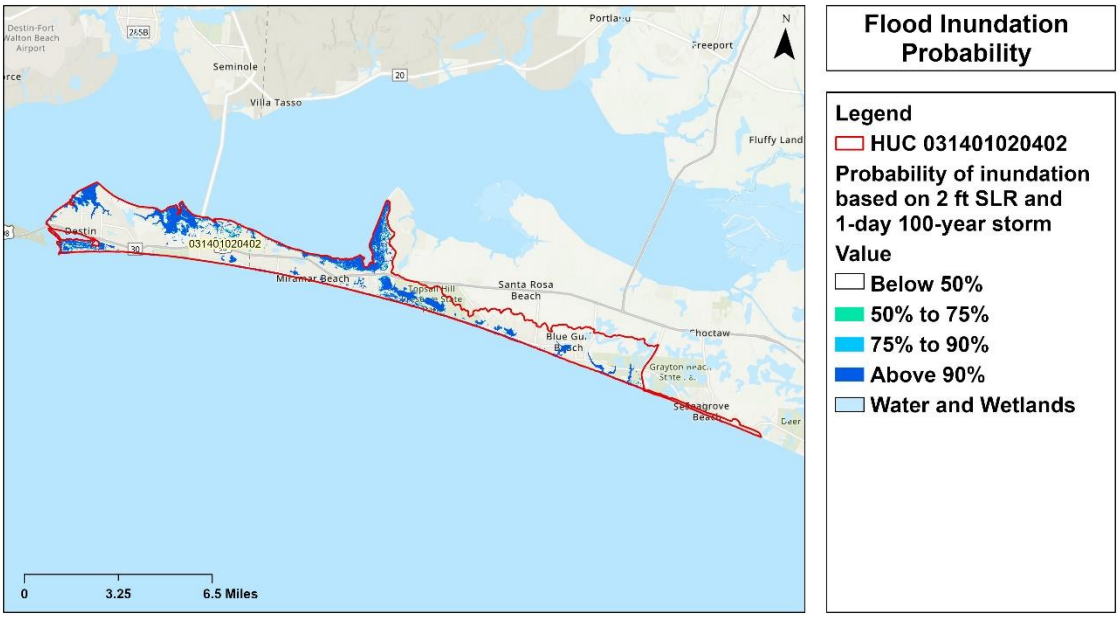


Figure 77. Probability of flood risk map for along the beach in Walton County for the 1-day, 100-year flood event with 2 ft SLR (FAU, 2023)

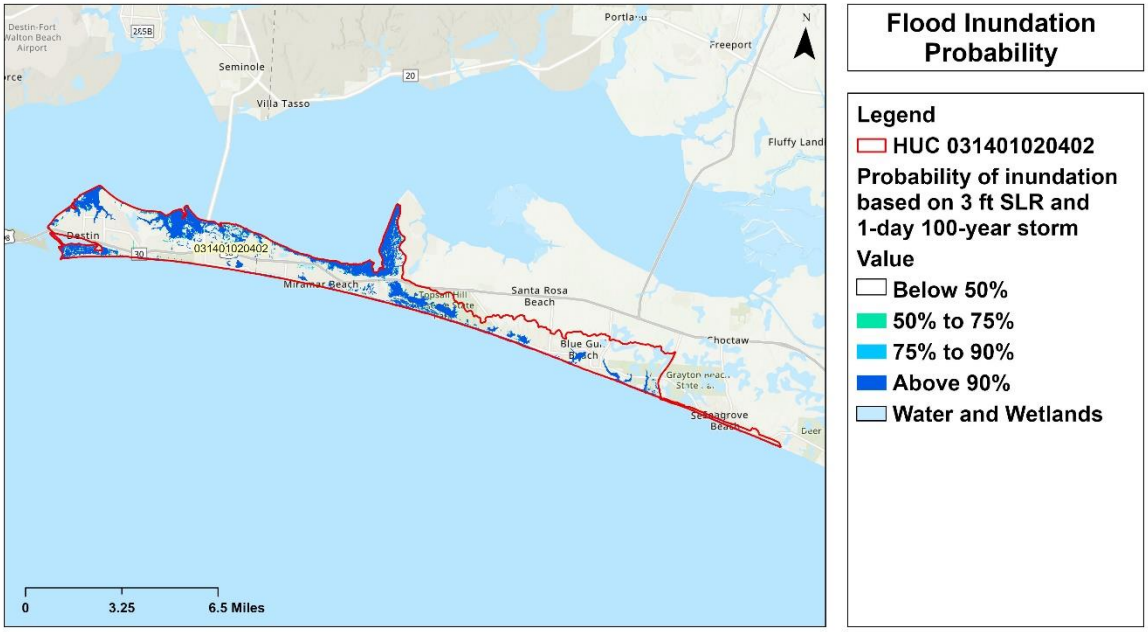


Figure 78. Probability of flood risk map for along the beach in Walton County for the 1-day, 100-year flood event with 3 ft SLR (FAU, 2023)

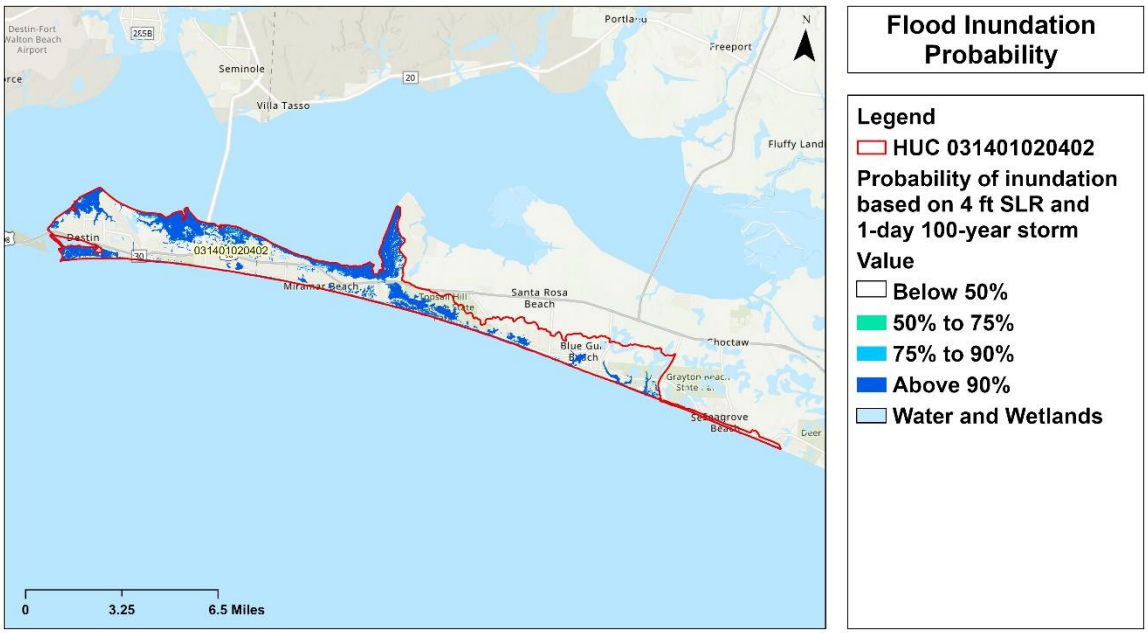


Figure 79. Probability of flood risk map for along the beach in Walton County for the 1-day, 100-year flood event with 4 ft SLR (FAU, 2023)

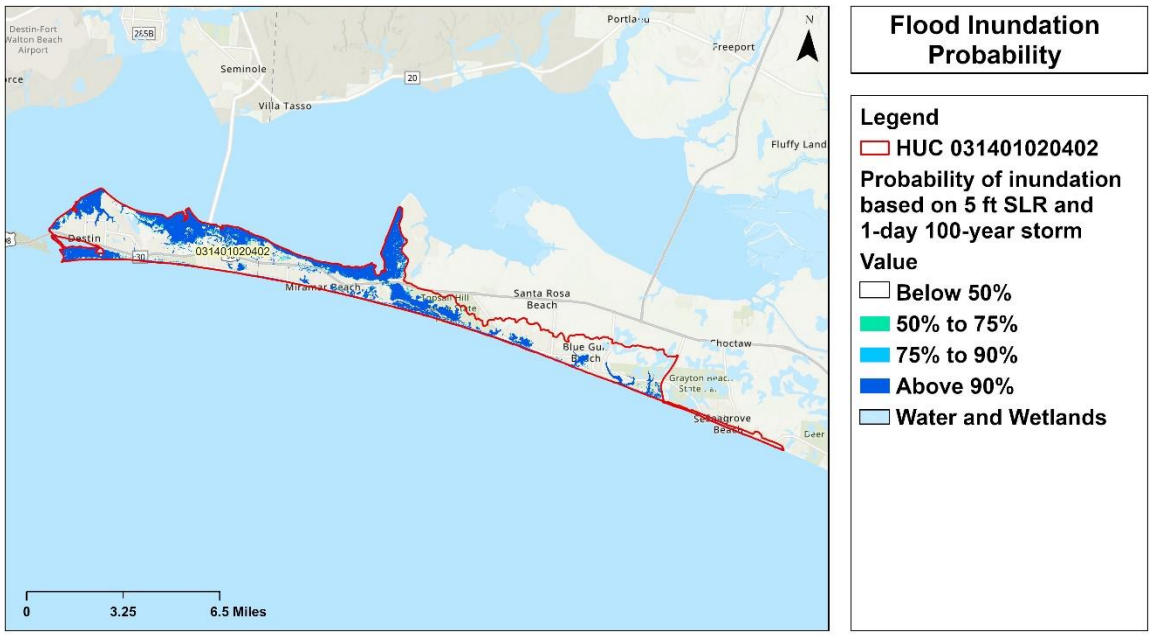


Figure 80. Probability of flood risk map for along the beach in Walton County for the 1-day, 100-year flood event with 5 ft SLR (FAU, 2023)

Understanding localized flooding conditions is crucial for developing strategies to protect vulnerable communities and infrastructure. A closer look at the flood risk maps provides additional drill down perspectives, increasing the displayed level of detail.

4.4 Future Challenges of Sea Level Rise and Climate Change

Global observations from satellites and long-term data collection have made it possible to document and analyze patterns in the Earth's climate. Scientific analysis of the impact of these changes has helped to improve the understanding of future flood hazard driving forces and long-term impacts on human activities and watershed master planning (http://www.research.noaa.gov/climate/t_observing.html). Examples of impacts are rising global average air and ocean temperatures, increased and earlier snow and ice melt, shorter subtropical rainy seasons, shifted seasons, sea level rise and greater variations in temperature and precipitation (IPCC, 2013; Freas et al., 2008; Marshall et al., 2004; Bloetscher et al., 2010). Marshall et al. (2004) specifically focused on the Florida peninsula to predict changes in rainfall

and warmer temperatures but interspersed lower low temperatures due to the potential loss of wetlands.

Figure 81 shows the accumulated precipitation average prior to 1973 versus 1994. Marshall et al. (2004) state that "because sea breezes are driven primarily by contrasting thermal properties between the land and adjacent ocean, it is possible that alterations in the nature of land cover of the peninsula have had impacts on the physical characteristics of these circulations." Their modeling suggests that land use changes have reduced total rainfall by 12% since 1900, probably as a result of the loss of wetlands. This confirms the finding of Pielke (1999) who reported that "development has exacerbated their severity since landscape changes over south Florida have already appeared to have reduced average summer rainfall by as much as 11%" (Pielke, 1999). Future changes in climate will add to the existing impacts, at a time when the population of the state is expected to nearly double by 2030. Additional research and high-resolution climate modeling for the Florida peninsula and local jurisdictions is needed to help guide long-term plans like WMPs.

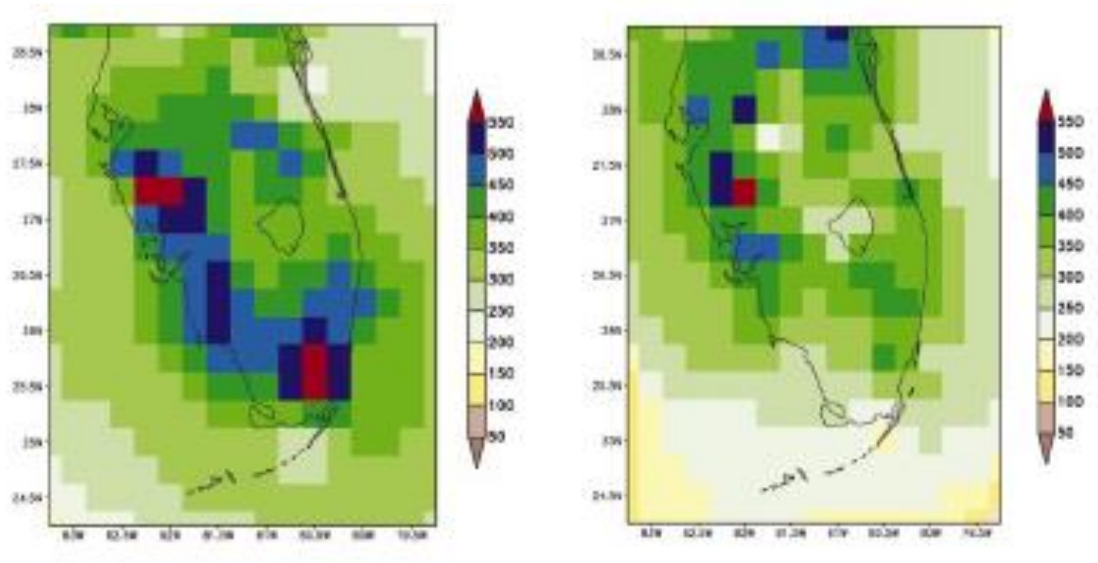


Figure 81. Accumulated precipitation 1973 (left) and 1994 (right) (Marshall et al., 2004)

Marshall et al. (2004) report that "while there is a great deal of spatial variability in these values, the results show that daytime maximum generally increased with the use of the 1993 land cover." When converted to heat flux, Marshall et al. (2004) noted that "the latent heat flux difference exhibits a consistent decrease of nearly 10% of the grid-average pre-1900 value." Figure 82 shows the change in average rainfall and the change in average temperature from 1924 to 2000.

Note the reversed trend (higher temperatures and lower rainfall), which means groundwater inputs are reduced (Marshall et al., 2004) leading to the conclusion that land use changes (loss of wetlands) contribute to the higher variability of temperature.

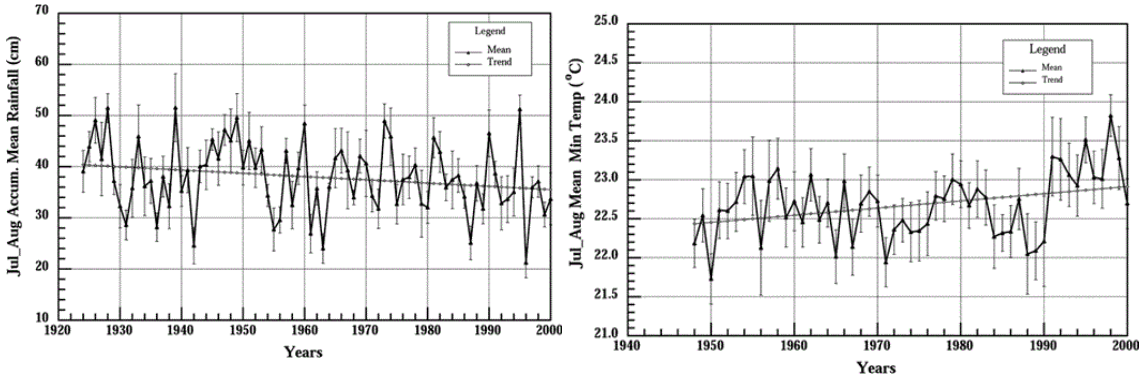


Figure 82. Change in average rainfall and change in average temp 1924 to 2000

**Note the reversed trend, which means groundwater input variability is lessened (Marshall et al., 2004)*

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3.9 feet according to the NOAA intermediate high sea level rise scenario. However, this much of the county is not coastal and is therefore not really impacted directly by sea level rise.

5.0 INVENTORY OF POTENTIAL SOLUTIONS

Once watershed master planning assessments are made and strategies (both adaptive and hardening) are identified and evaluated, decisions must be made to implement priority projects. At the center of these planning efforts, there should also exist the provision for an adequate drainage system, designed to accommodate an increased volume of water and/or increased peak flows.

5.1 Risk and Vulnerability

The screening tool modeling exercise from Section 4.2.2 identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. The major regional issues in the greater watershed are capital projects associated with the NWFWMD plans for controlling discharges that impact the ecosystem at the west end of the watershed. Hence regional water management districts and USACOE projects have higher priority due to the larger area served. All other improvements are distinctly local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer/communication utilities, public safety, hospitals, schools, power)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Table 9 outlines the Department of Revenue (DOR) codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e., wealthy neighborhoods with few older, poor-health individuals would have a lower priority than at-risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes

were evaluated based on a scale of 1 to 6, where 1 is the most vulnerable and 6 is the least vulnerable.

Table 9. Department of Revenue (DOR) land use codes

DOR (use code)	Description	Priority	Delineator
000	Vacant Residential	6	
001	Single Family Residential	Depends	Value, Age, Income
002	Mobile Homes	4	
003	Multi-Family >9 units	4	
004	Residential Condo	Depends	Value, Age, Income
007	Misc. Residential	5	
008	Multi-Family <10	4	
009	Residential Common Area	6	
010	Vacant Commercial	6	
011	One-Story Stores	3	
012	Mixed Use Store	4	
013	Department Store	3	
014	Supermarket	2	
015	Regional Shopping Center	3	
016	Community Shopping Center	3	
017	Office Non-Professional	3	
018	Service Multi-Story	3	
019	Professional Services Building	3	
020	Terminals	3	
021	Restaurant	3	
022	Drive-in	5	
023	Financial	2	
026	Laundry	3	
027	Service Station	3	
028	Mobile Home Sales, Parking Lot, Mobile Home Parks	5	
031	Drive-in Theater	5	
032	Auditoriums/Indoor Theaters	5	
033	Bar	5	
034	Skating Rinks, Poolhalls, Bowling Alleys	5	
035	Tourist Attractions	5	
038	Golf Course	6	

DOR (use code)	Description	Priority	Delineator
039	Hotel	3	
040	Vacant Industrial	6	
041	Light Manufacturing	4	
048	Warehouse Distribution	5	
049	Open Storage	6	
052	Cropland	6	
063	Grazing Land	6	
066	Orchard	6	
067	Poultry	6	
069	Ornamentals	6	
070	Vacant without Features	6	
071	Church	5	
072	Private School	3	
073	Private Hospital	1	
074	Home for the Aged	4	
075	Orphanage	4	
076	Cemetery	6	
077	Club, Hall	5	
078	Convalescent Homes	4	
080	Vacant Government	6	
082	Military, Forest, Parks	6	
083	Public School	2	
084	Public College	2	
086	County	Depends	Utilities, Arterial =1
087	State	Depends	Arterial = 1
088	Federal	6	
089	Municipal	1	
091	Utility	Depends	Water/Wastewater Treatment Plants, Public Safety = 1
094	Right of Way	Depends	Florida Department of Transportation (FDOT), Arterial = 1
095	Submerged, lakes	6	
096	Sewage Disposal	1	
099	Other Non-Agricultural Acreage	6	

Figure 83 shows the application of these DOR codes to properties throughout the County. Note some areas appear over-represented as a result of the means to map (priority areas get greater weight. The drilldowns define actual property priorities more clearly. Having identified the vulnerable properties in Section 4.2.2 by determining the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percentage of the parcel that would flood during that event. The percentage is converted to a 6-point scale as the Flood Risk Factor, as follows:

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

Now we assign 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example:

1 × 25% + 6 × 75% = 4.75

Figure 84 shows the items in Figure 83 for Tiers 1-3 overlaid on the 1-day,100-year 5 ft sea level rise flood map in Chapter 4. Figure 85 shows the flood and property consequence factors together in one figure. As a result, efforts in the County should be geared toward protecting the projects with the highest priority scores. From the outreach discussions in Chapter 6, these areas can be prioritized.

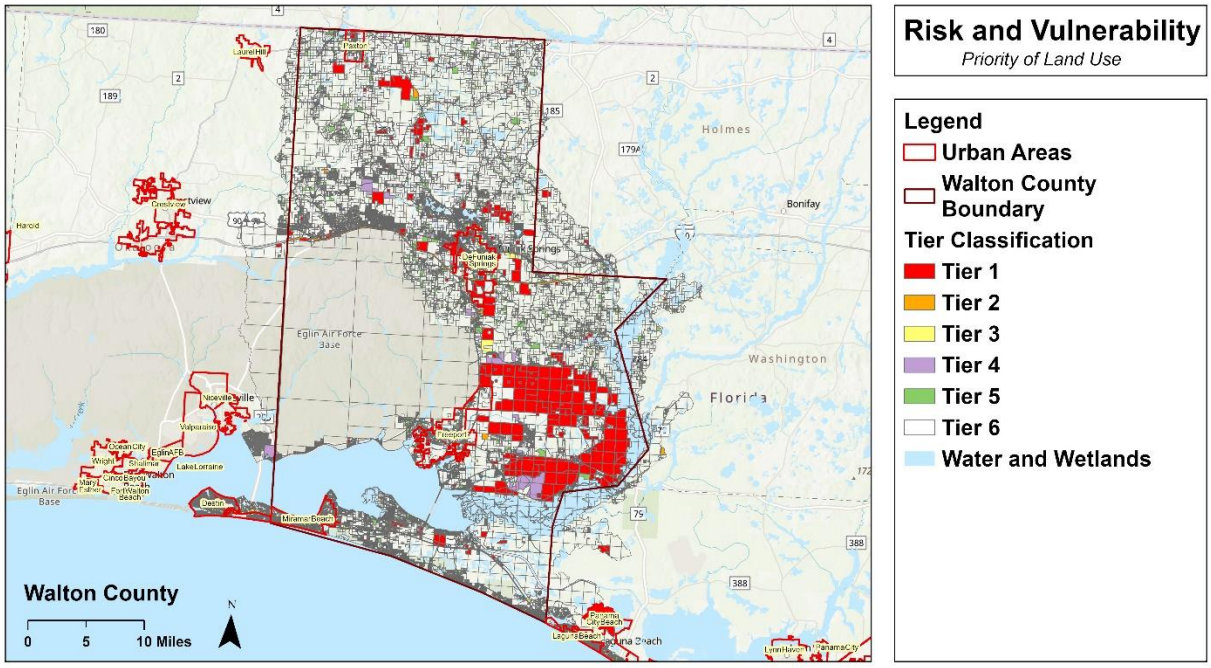


Figure 83. Priority Land Use Tiers (Property Consequence Factor) Map

**Note tiers from Table 9 based on land use from the Walton County Property Appraiser's office*

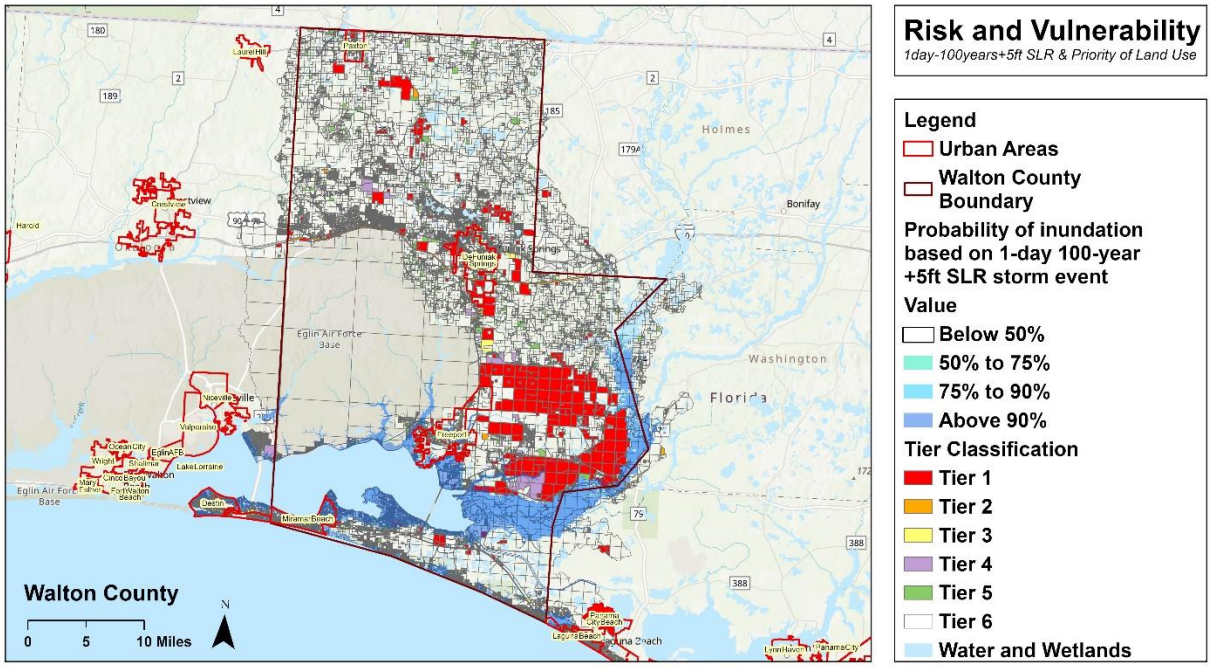


Figure 84. 1-day, 100-year 5 ft Sea level rise flood map and property consequence factors together on one map

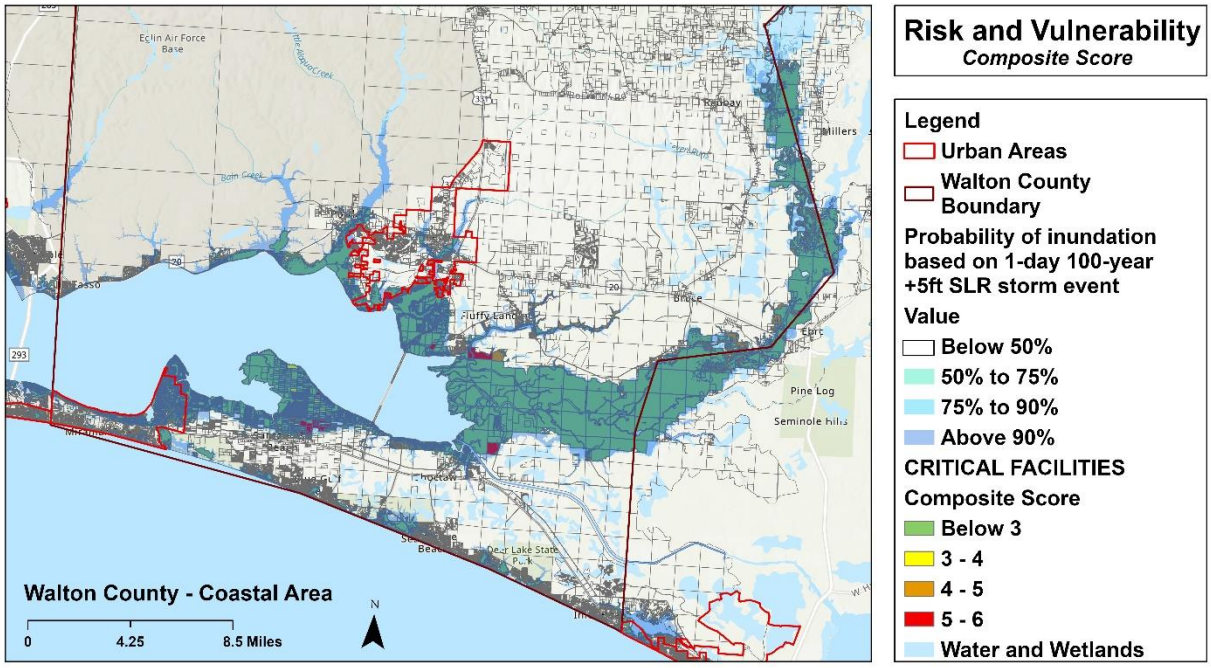


Figure 85. Flood and property consequence factors together

5.2 Drilldown to Flood-prone areas

The process of identifying potential mitigation measures to implement begins with narrowing down the feasible engineering alternatives using threshold criteria and quantifiable selection criteria that include measures of effectiveness, cost, and added benefit to the community. The toolbox describes a variety of strategies that could be used to improve potential flood management conditions. They are community-specific and require significant engineering and planning to determine the most efficient configuration to achieve the community's goals. Hard infrastructure such as streets, storm drains, sea walls and the like, are usually the first systems to be impacted because they are built at lower elevations than the finished floor of structures. In addition, many infrastructure systems are located within the roadways (water, sewer, stormwater, power, phone, cable tv, internet, etc.). At present, most roadway base courses are installed above the water table. If the base stays dry, the roadway surface will remain stable. However, when the water levels rise and the base is saturated, the roadway can deteriorate.

Catastrophic flooding should be expected during the 1-day / 10-year, 3-day / 25-year, and 1-day / 100-year storm events if there is nowhere for the runoff to go. The community must decide the protection levels as outlined in Chapter 3. The vulnerability of infrastructure will require the design of more resistant and adaptive infrastructure and network systems. This will, in turn, involve the development of new performance measures to assess the ability of infrastructure systems to withstand flood events and to enhance resilience standards and guidelines for the design and construction of facilities. Specifically, considerations include retrofitting, rehabilitation, and, in some cases, the relocation of facilities to accommodate sea-level rise impacts. As they are related, groundwater is, similarly, expected to have a significant impact on flooding in these low-lying areas because of the loss of soil storage capacity. Evapotranspiration in low-lying areas with high groundwater will become more important which is why ecologically based stormwater management that employs natural native vegetation will become more important over time in certain communities.

The figures in Chapter 4 indicate much of South Walton is at risk. Discussions with the County staff included identifying challenges and solutions within this area (Figure 86). The low lying, and low sloped, nature of these areas are a major contributor to local flooding – all water drains to coastal waters and the topography of the island permits very limited areas to store water, and those that can are very shallow.

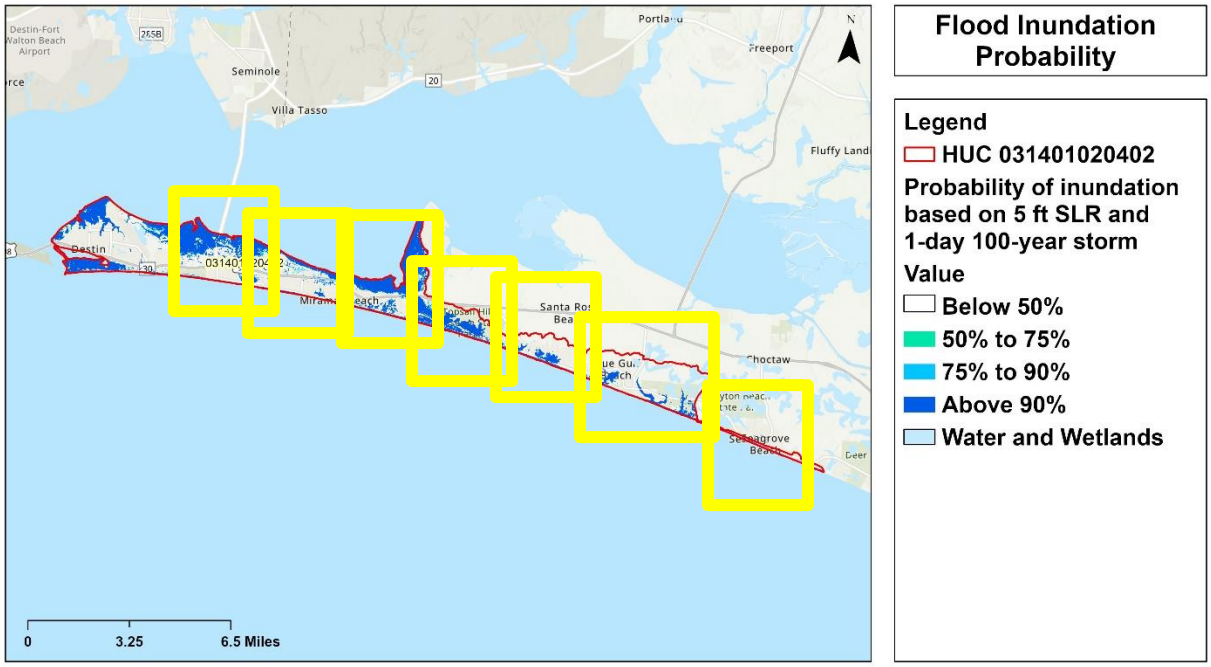


Figure 86. Priority Areas for County Staff

Figure 87 shows the aerial of the west end of the beachside communities for Miramar Beach. Figure 88 shows the priority of land uses. Figure 89 shows the vulnerability scores for the area (flooding and land use scores). At 0 ft sea level rise, the edges (sea walls) are the most consistently at risk with some limited areas of potential flooding to the adjacent streets, beach, and bay (Figure 90). When the sea level rises, the edges (sea walls) and streets are the most consistently at risk. The condos on the Gulf Coast beach edge are flooded as the beach will have migrated inland (Figure 91). On the bay side, the condos are flooded – sea walls and pumping stations may be able to improve flooding in this area although any lack of consistency will frustrate efforts to reduce flooding. Road bases will fail faster as a result of being saturated.

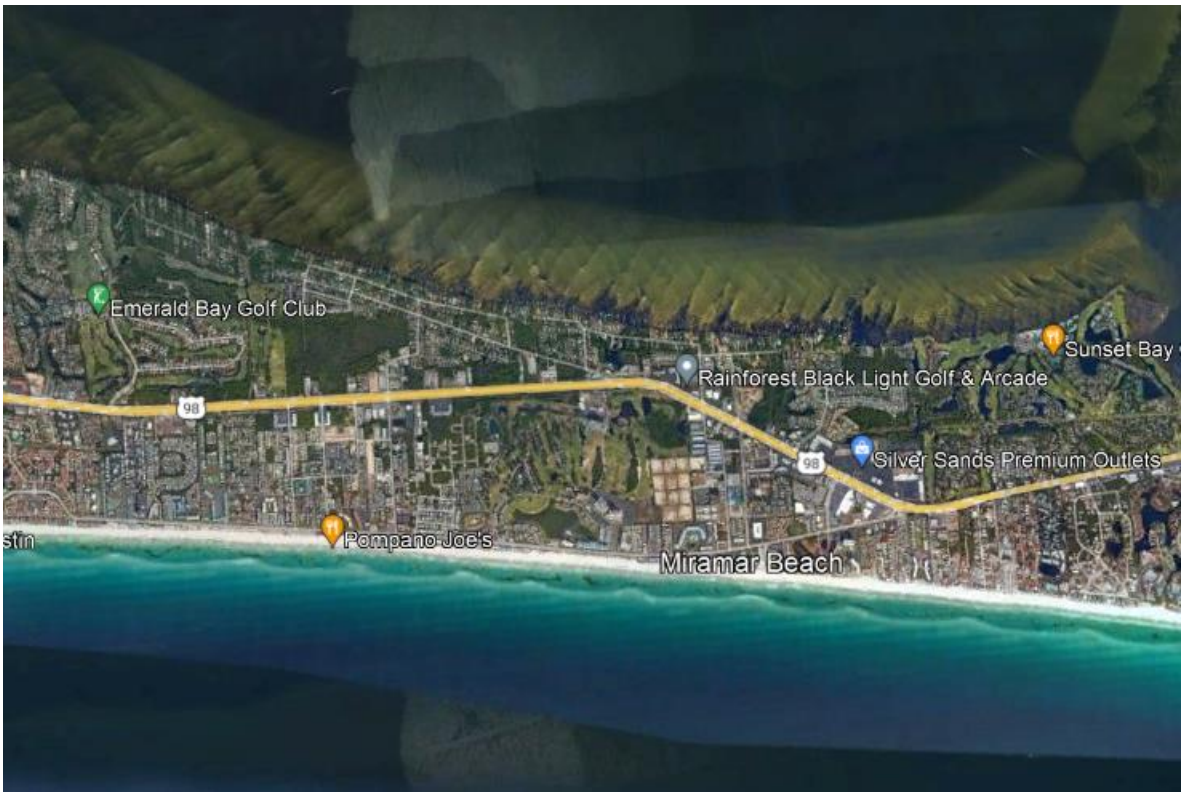


Figure 87. Aerial view of the Miramar Beach/west end area

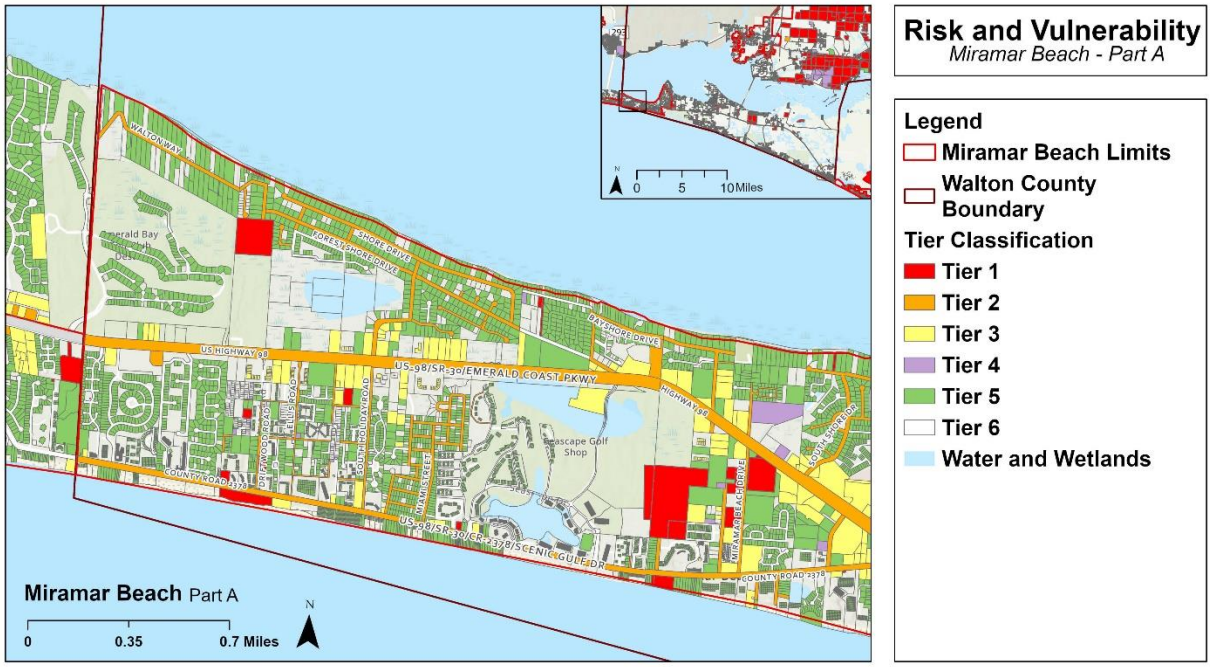


Figure 88. Identification of Critical Land uses for the Miramar Beach/west end area (FAU, 2023)

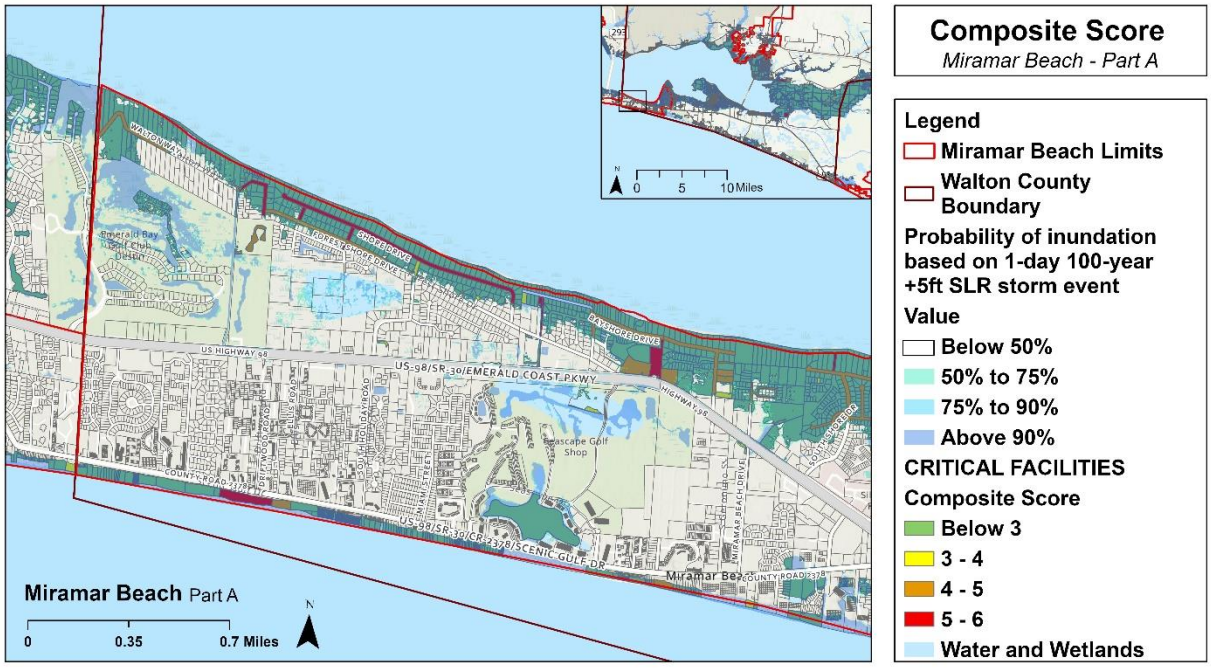


Figure 89. Identification of vulnerability scores for the Miramar Beach/west end area (FAU, 2023)

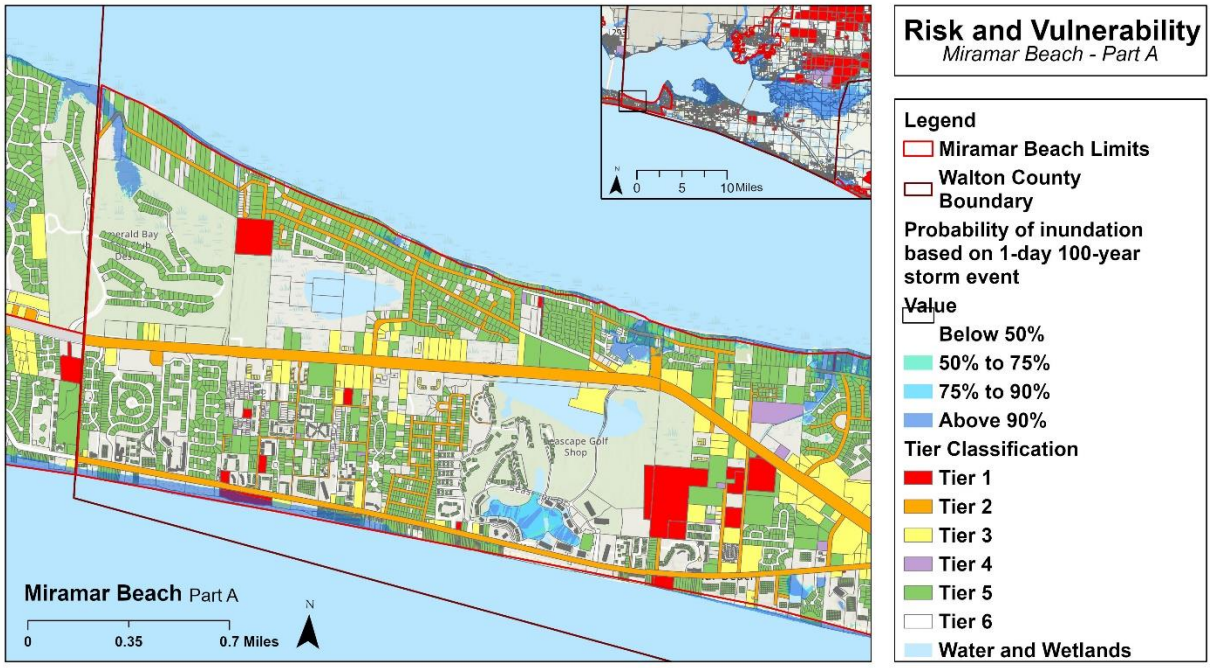


Figure 90. Miramar Beach/west end area for 0 ft SLR and 1-day, 100-year event (FAU, 2023)

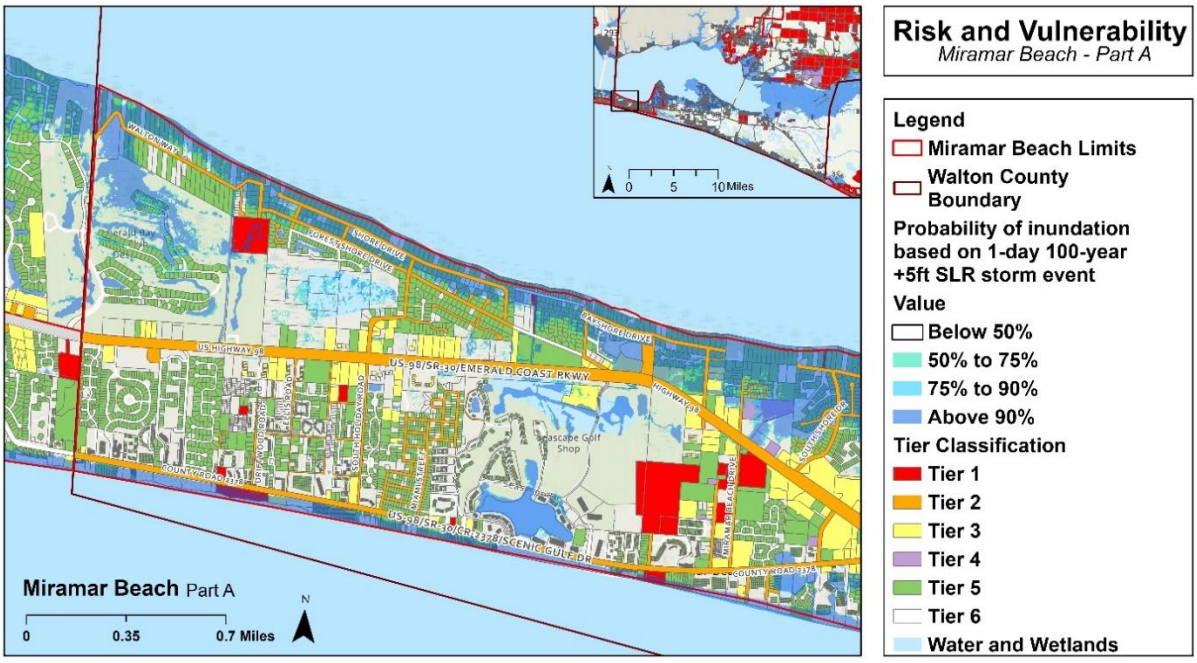


Figure 91. Miramar Beach/west end area for 5 ft SLR and 1-day 100-year event (FAU, 2023)

Figure 92 shows the aerial of the area immediately to the east of the Miramar Beach/west end area – Sacred Oaks. Figure 93 shows the priority of land uses. Figure 94 shows the vulnerability scores for the area (flooding and land use scores). At 0 ft sea level rise, the edges (sea walls) are the most consistently at risk with some limited areas of potential street flooding (Figure 95). When the sea level rises, the edges (sea walls) and streets are the most consistently at risk. The condos on the Gulf Coast beach edge are flooded as the beach will have migrated inland (see Figure 96). The ponds will flood in rainstorms (that is part of the intent). On the bay side, the golf course and surrounding properties are flooded – sea walls and pumping stations may be able to improve flooding in this area although any lack of consistency across this area of the island will frustrate efforts to reduce flooding. Like the Miramar Beach/west end area, policy issues with respect to sea walls and backflow devices are needed where appropriate. Natural areas will benefit the community, but structural improvements may be needed as sea level rises. Road bases will fail faster.

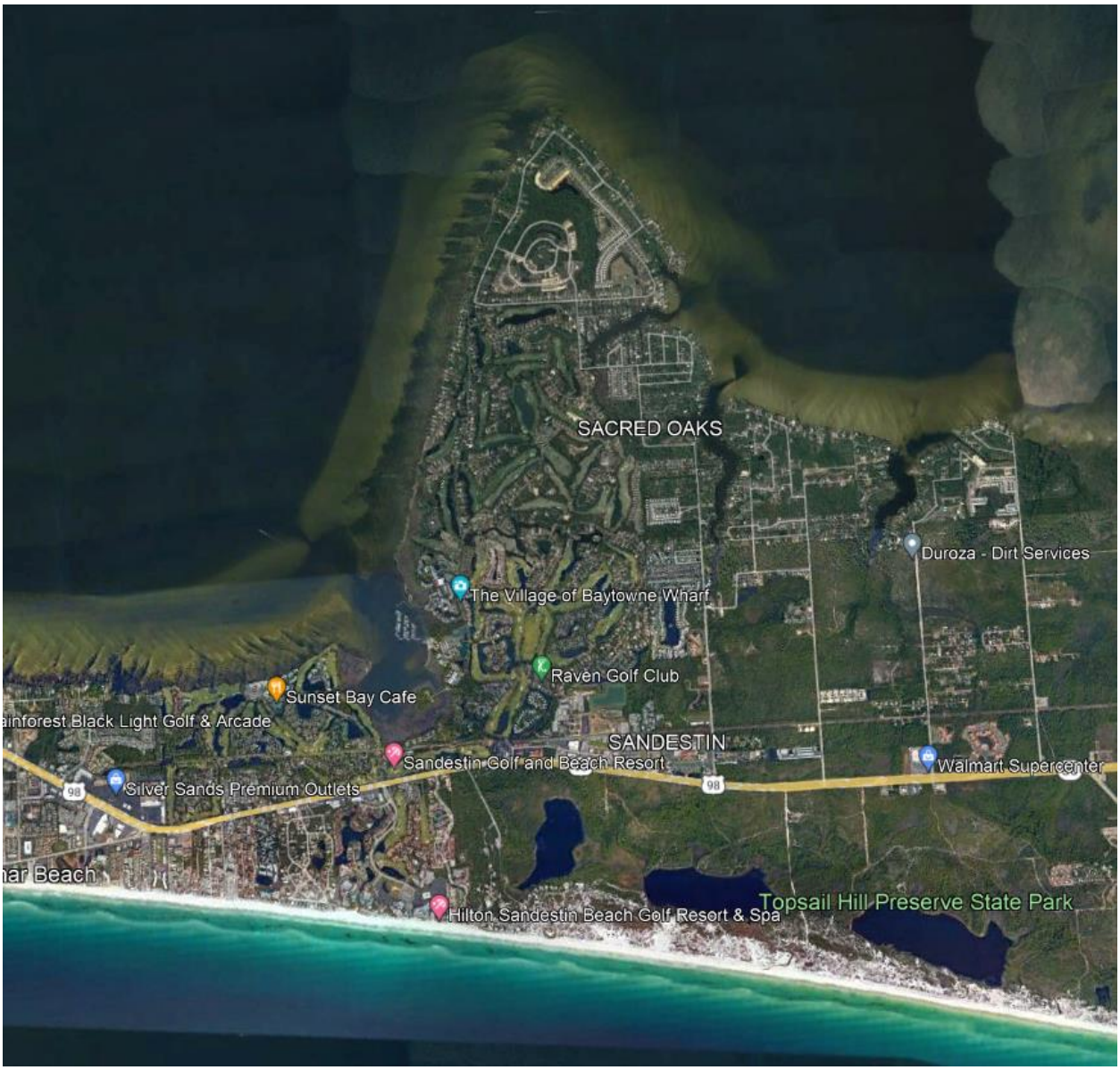


Figure 92. Aerial for Sacred Oaks area

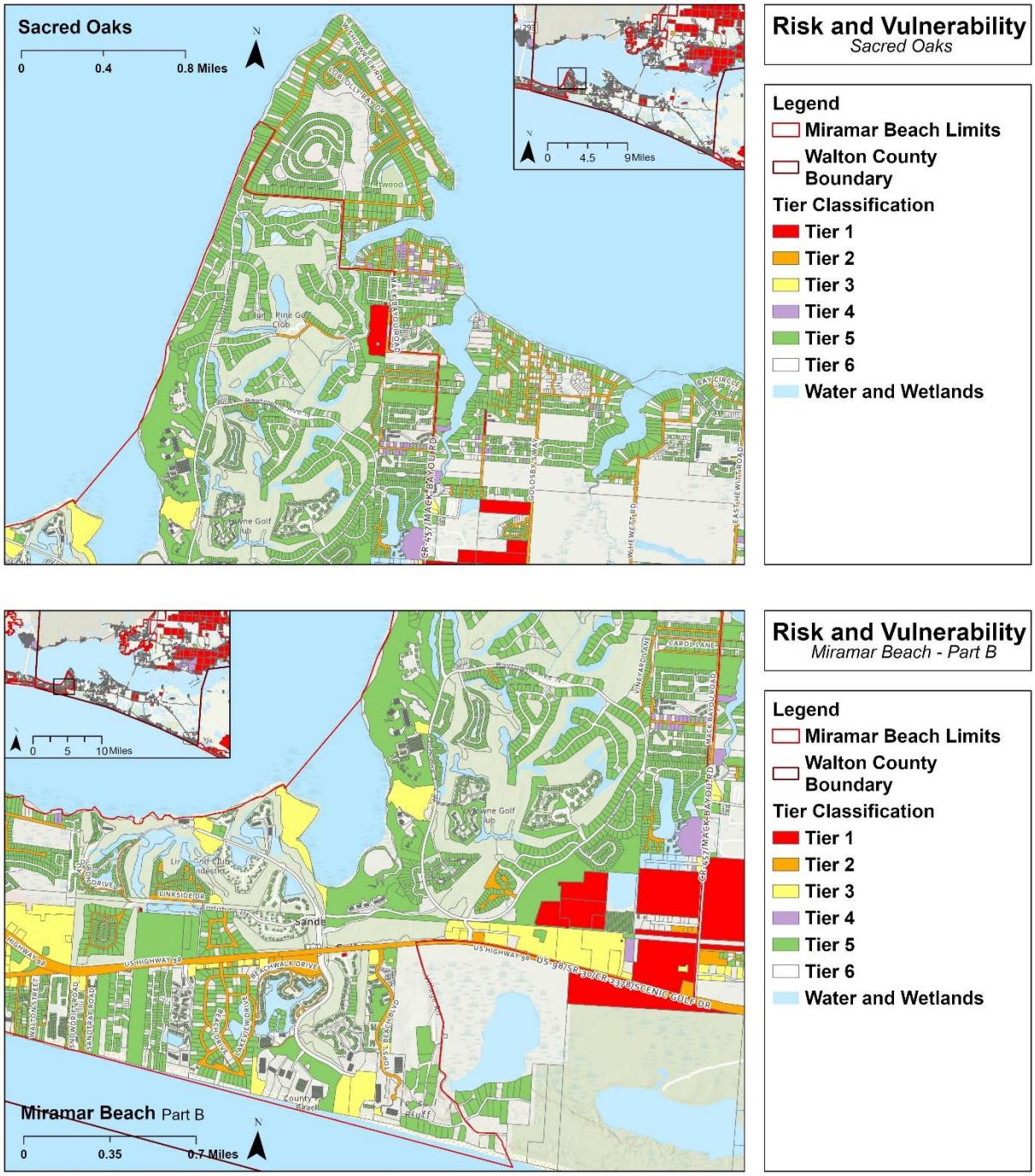


Figure 93. Identification of Critical Land uses for Sacred Oaks area (FAU, 2023)

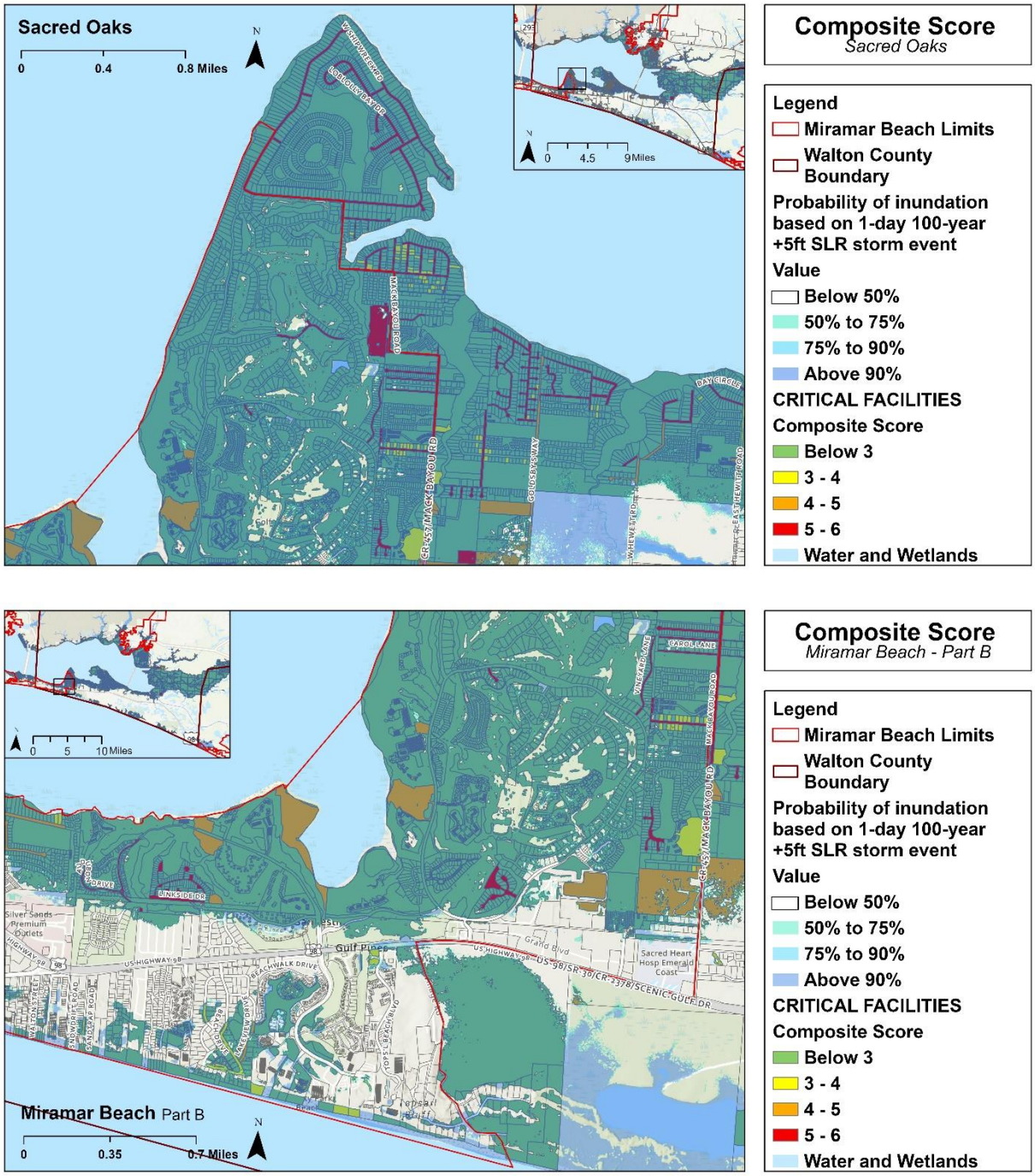


Figure 94. Identification of vulnerability scores for the Sacred Oaks area (FAU, 2023)

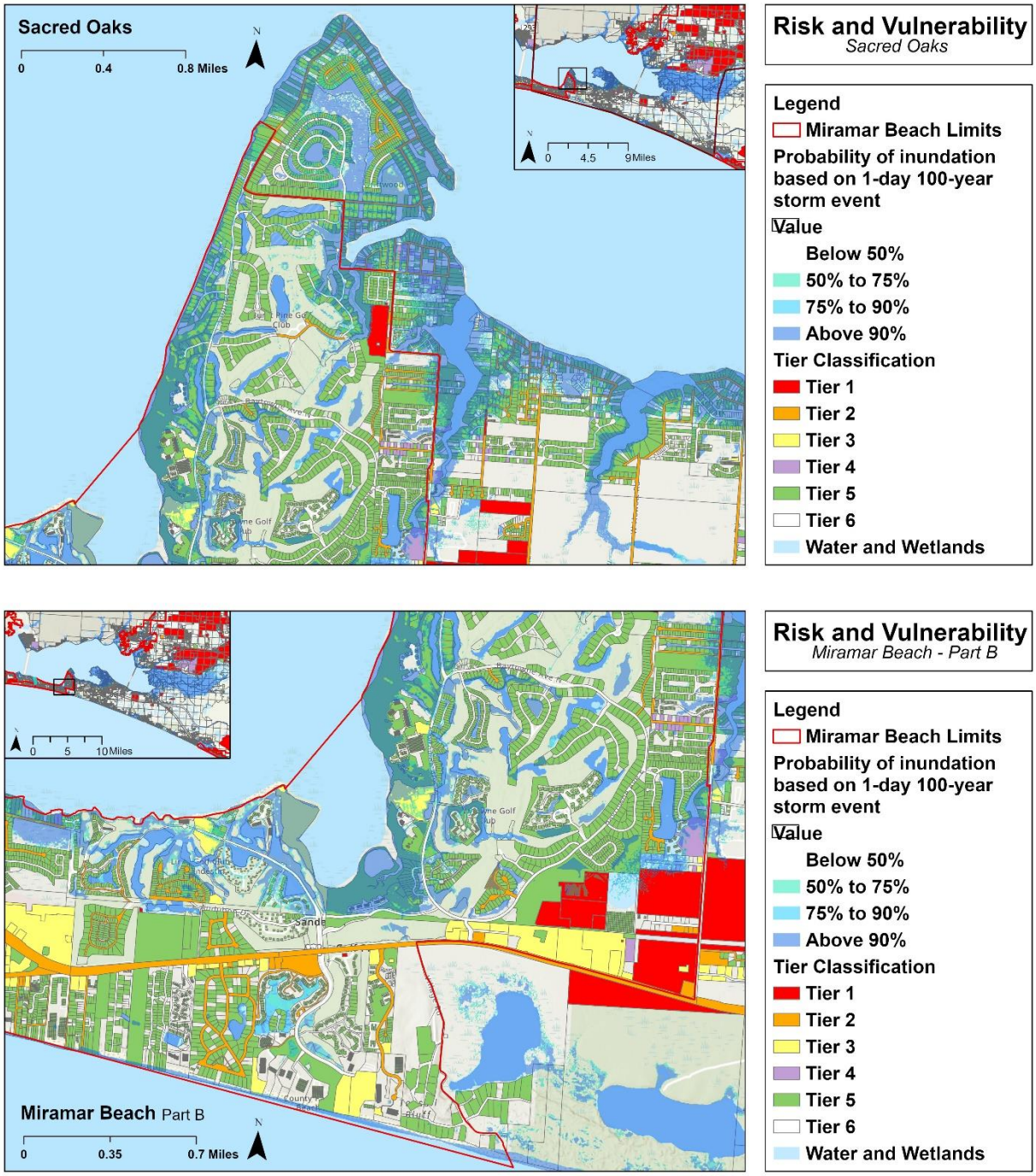


Figure 95. Sacred Oaks area (north and south sides in the two figures) for 0 ft SLR and 1-day, 100-year event (FAU, 2023)

**Note the edges (sea walls) are the most consistently at risk with some limited areas of potential street flooding.*

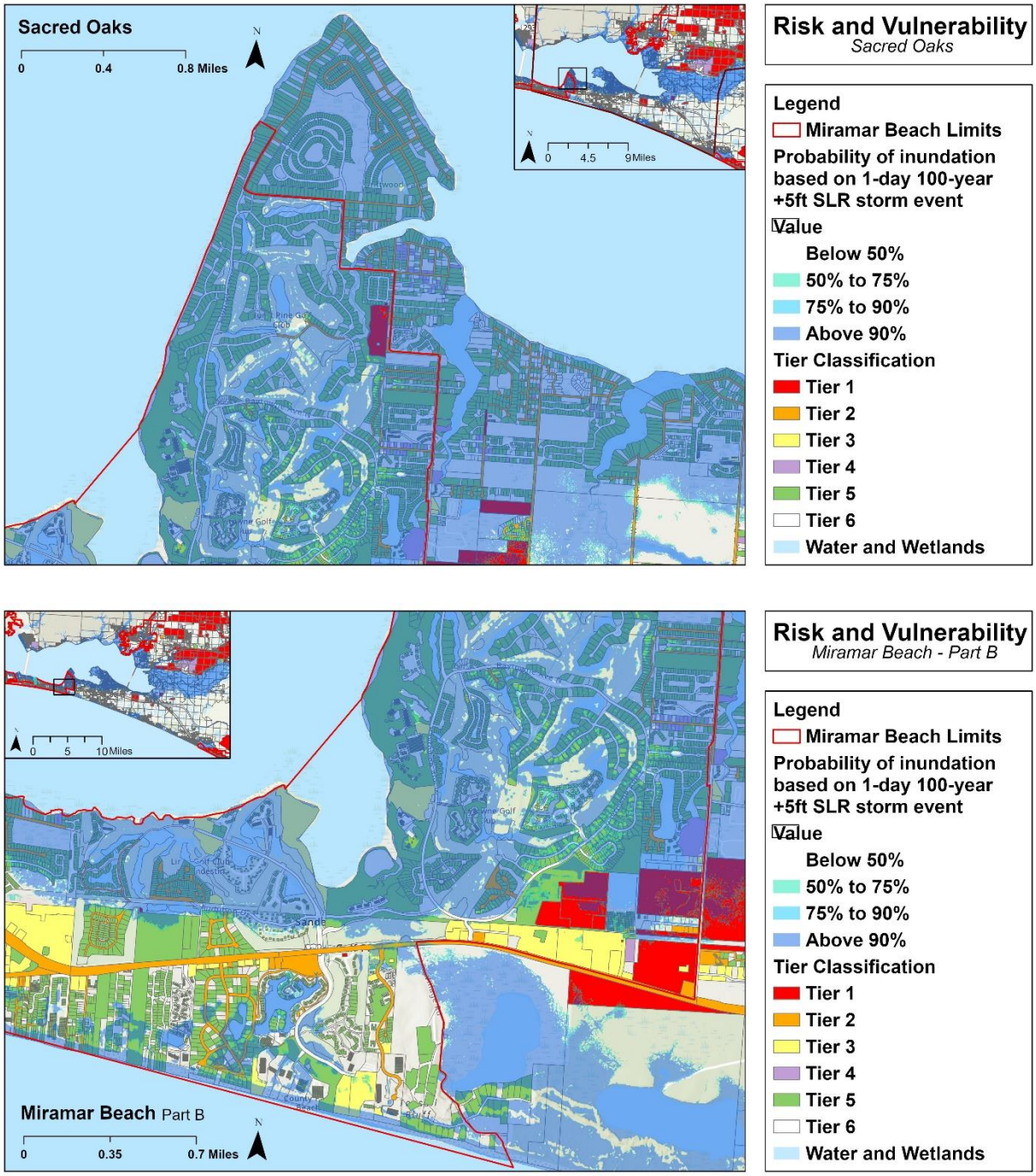


Figure 96. Sacred Oaks area (north and south sides in the two figures) for 5 ft SLR and 1-day, 100-year event (FAU, 2023)

Figure 97 shows the aerial of the middle section of Miramar Beach.
Figure 98 shows the critical land use scores for the middle section of Miramar Beach. Figure 99 shows the vulnerability scores for the area. At 0 ft sea level rise, the edges (sea walls) are the most consistently at risk with some limited areas of potential street flooding (see Figure 100). The condos on the Gulf Coast beach edge are flooded a bit as the beach will have migrated inland (see Figure 101). The ponds will flood in rainstorms (that is part of the intent). On the bay side, the golf course and surrounding properties are flooded – pumping stations may be able to improve flooding in this area although any lack of consistency will frustrate efforts to reduce flooding. Policy issues with respect to pumping should be considered for critical areas like hospitals and utilities, while other new developments should be advised to elevate higher. New roads should also be built at a higher elevation to allow for emergency access. Road base failure due to being saturated along the beach was identified as an issue by County staff.

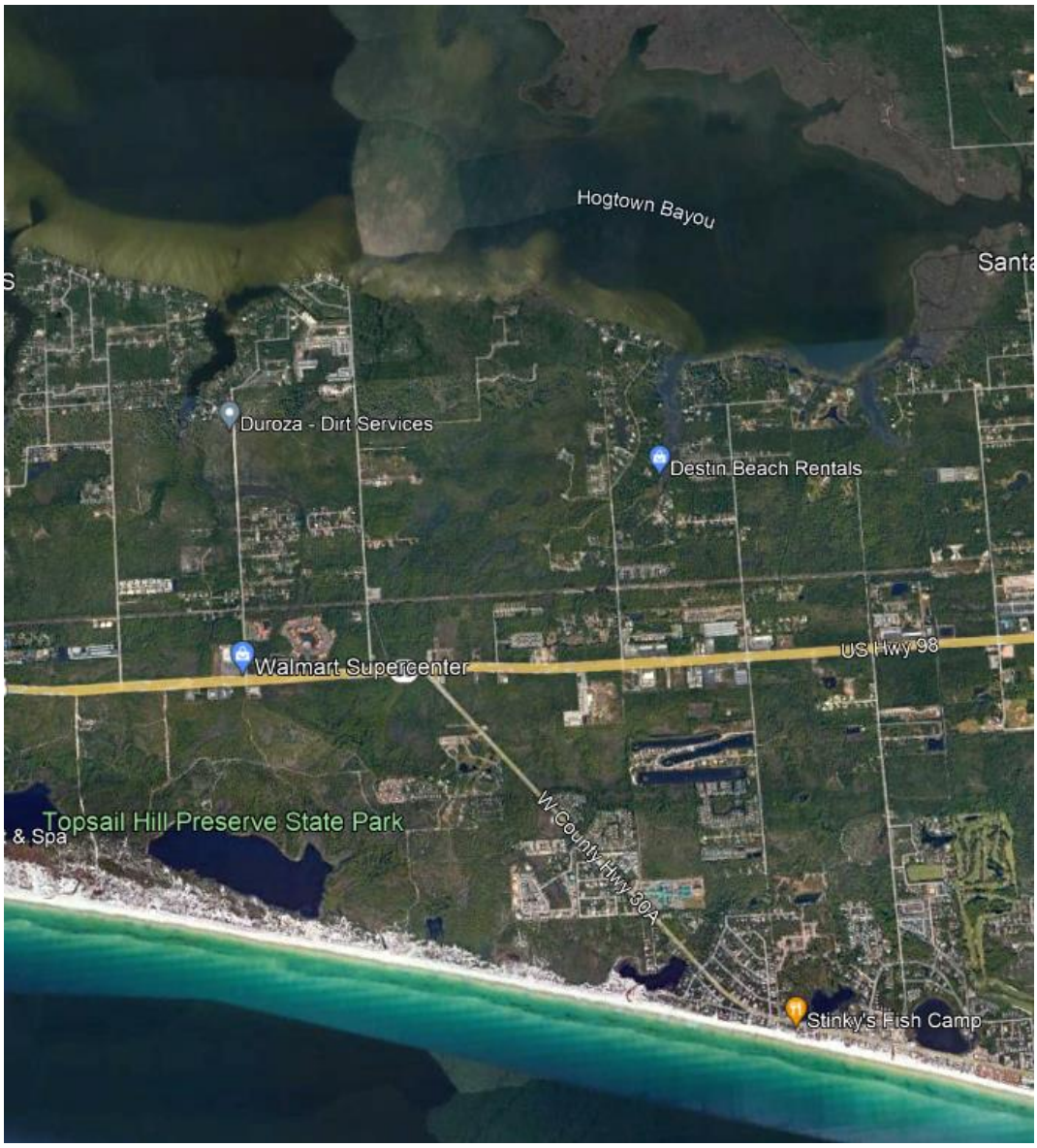


Figure 97. Middle section of Miramar Beach aerial – golf course community

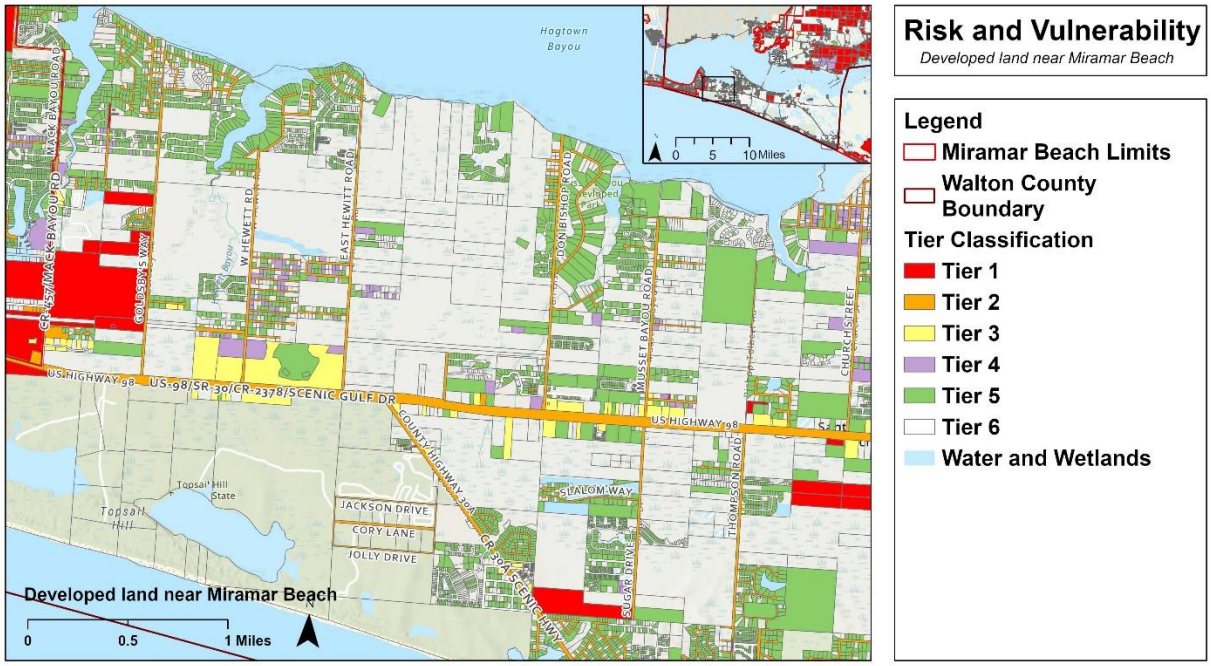


Figure 98. Identification of Critical Land uses for the Middle section of Miramar Beach (FAU, 2023)

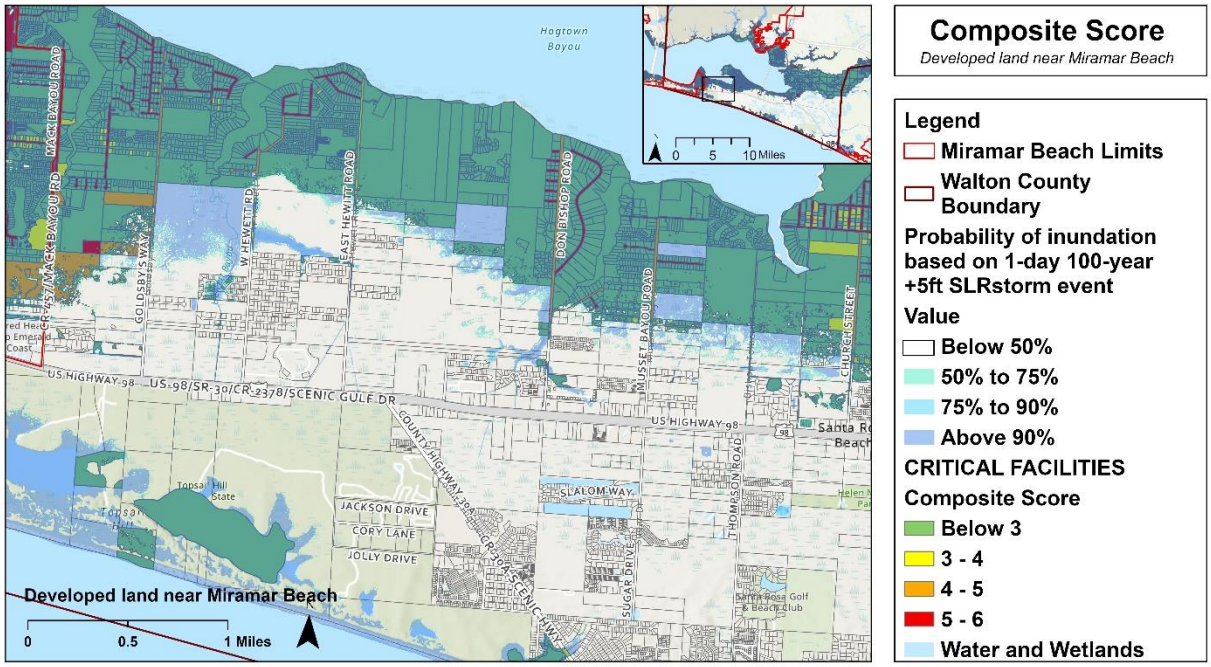


Figure 99. Identification of vulnerability scores for the Middle section of Miramar Beach (FAU, 2023)

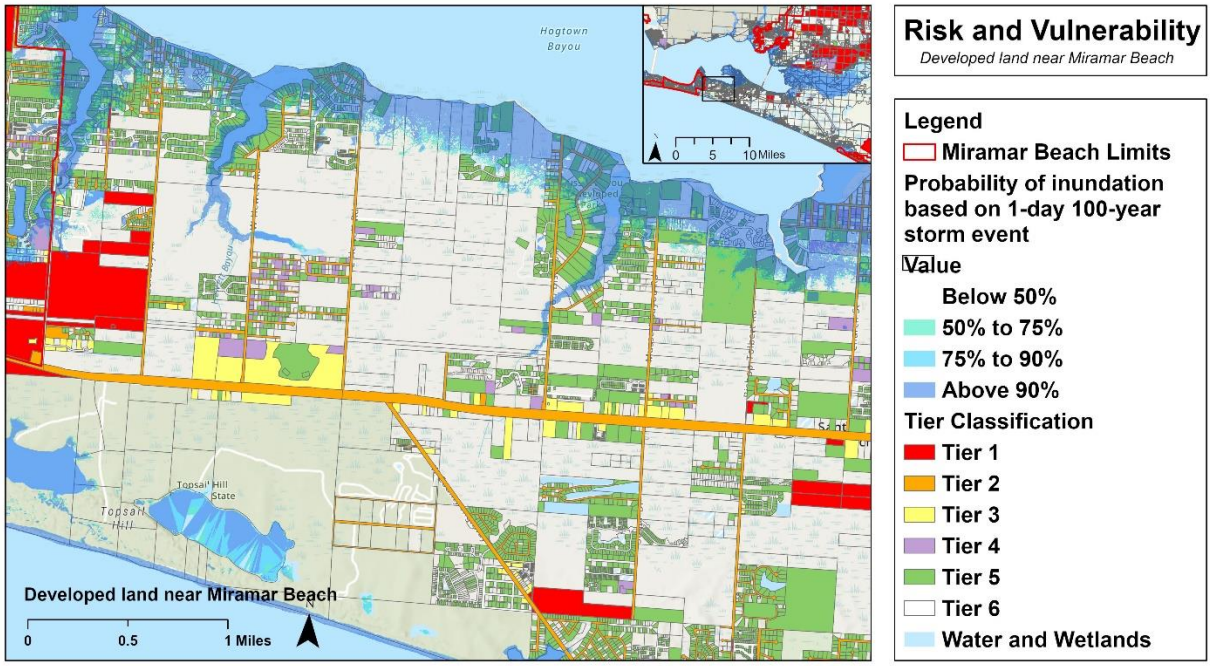


Figure 100. Middle section of Miramar Beach limits (central island) for 0 ft SLR and 1-day, 100-year event (FAU, 2023)

**Note the bay side is the most consistently at risk.*

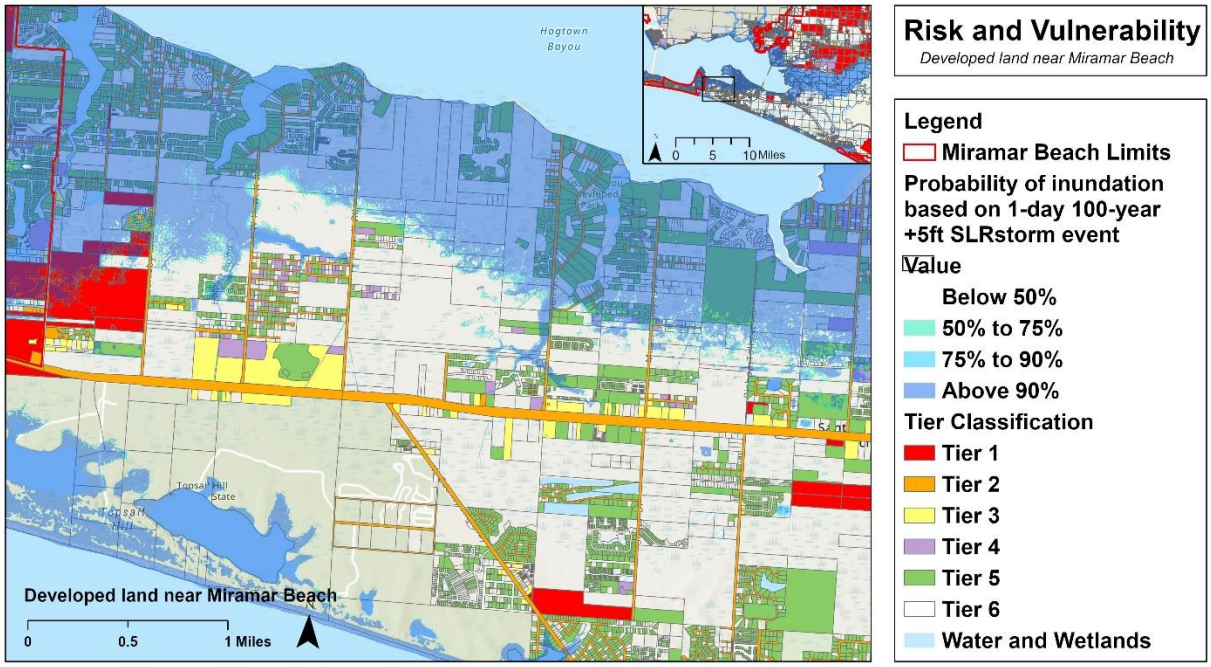


Figure 101. Middle section of Miramar Beach limits (central island) for 5 ft SLR and 1-day, 100-year event (FAU, 2023)

Note the bay side is more at risk.

Figure 102 shows the aerial of an area on the central part of the beachfront. Figure 103 shows the priority of land uses. Figure 104 shows the vulnerability scores for the area (flooding and land use scores). At 0 ft sea level rise, the potential for beach flooding is present but limited (Figure 105). At 5 ft sea level rise, the potential for beach flooding is present but still limited (Figure 106). There is no bayside in this area.

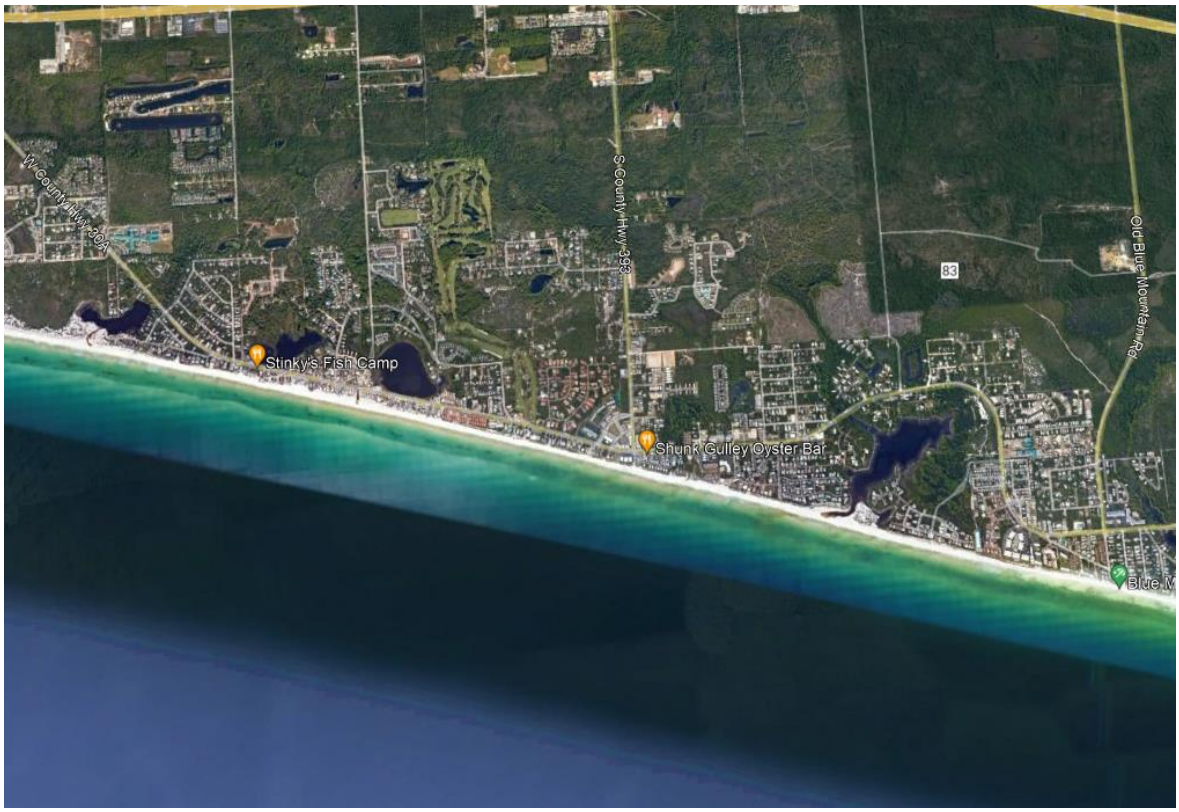


Figure 102. Aerial Map of central part of the beachfront

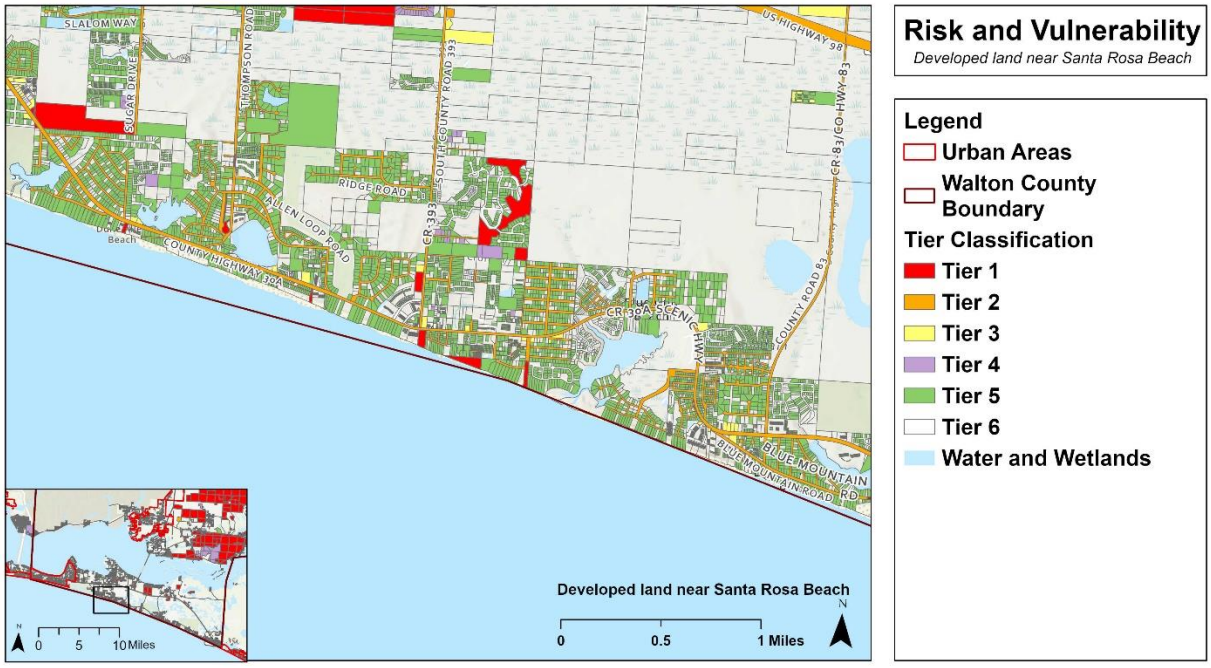


Figure 103. Identification of Critical Land uses for central part of the beachfront (FAU, 2023)

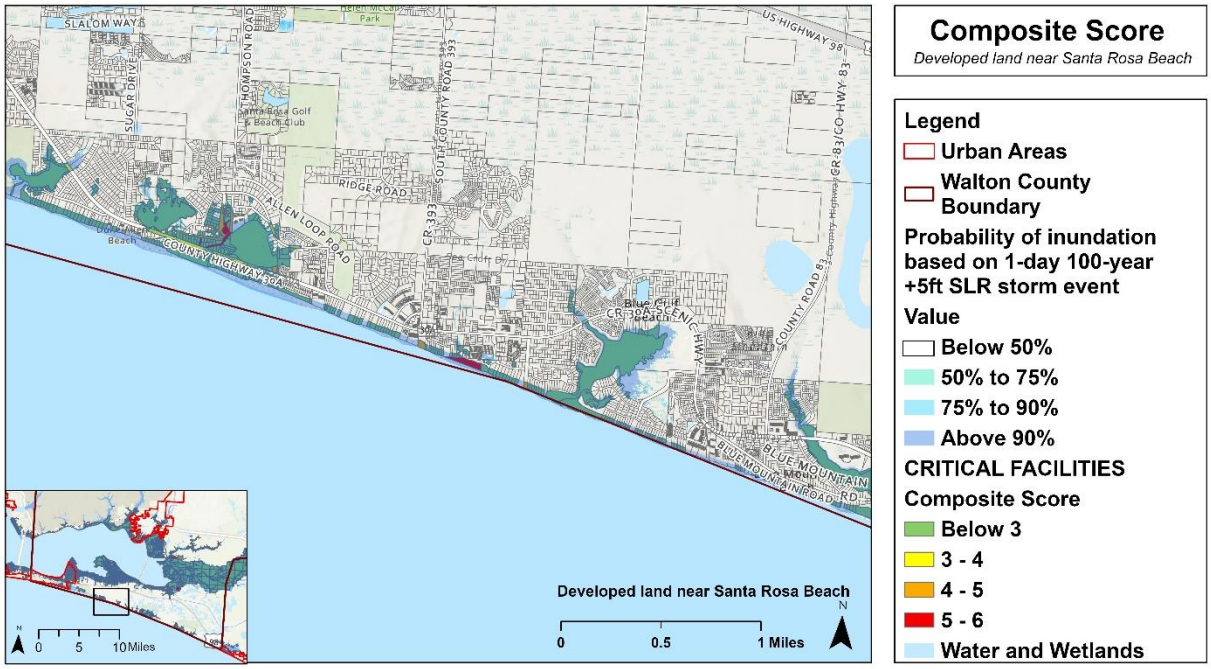


Figure 104. Identification of vulnerability scores for the central part of the beachfront (FAU, 2023)

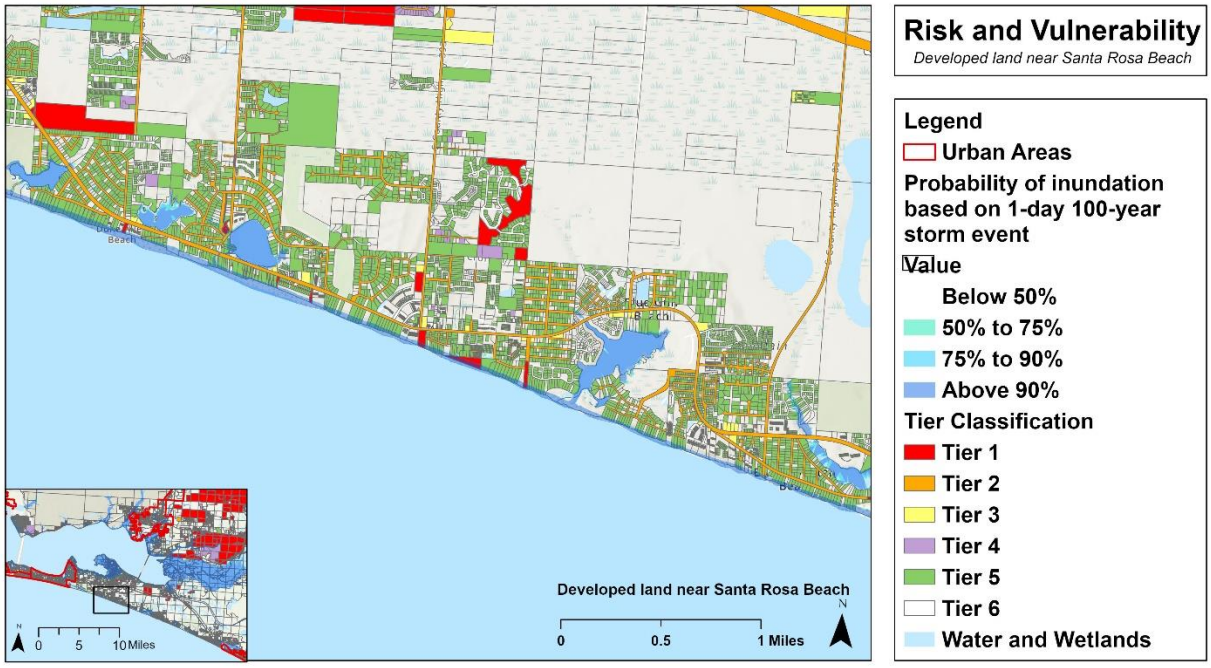


Figure 105. Central part of the beachfront for 0 ft SLR and 1-day, 100-year event (FAU, 2023)

**Note there is limited flooding.*

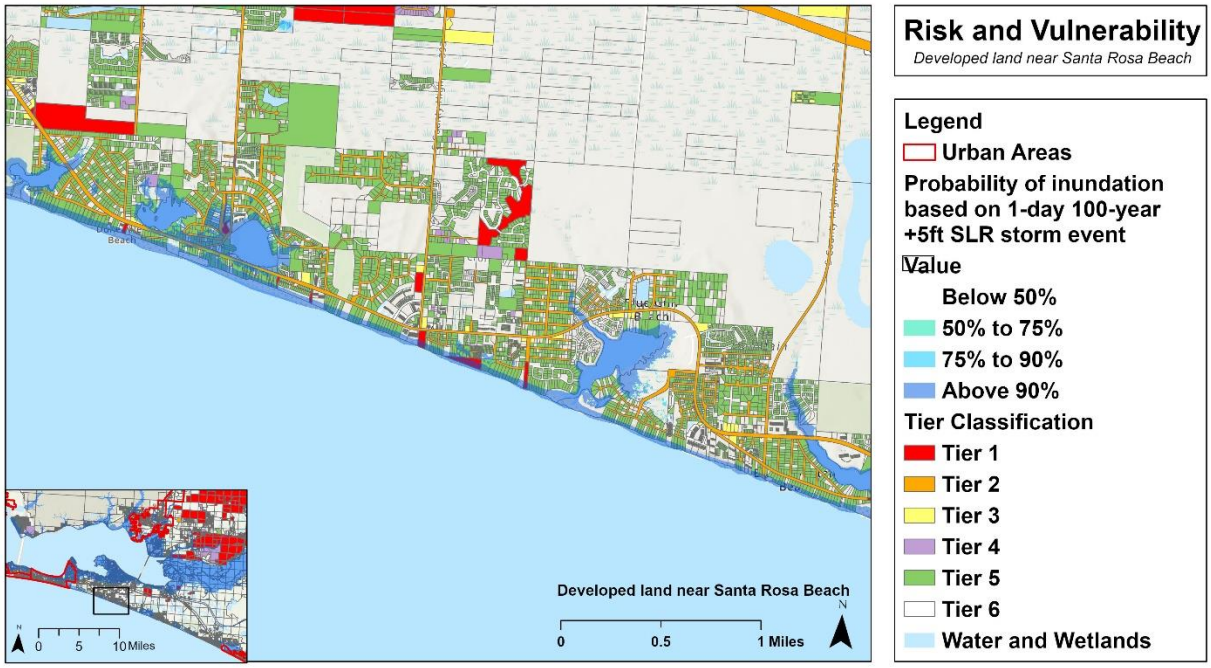


Figure 106. Central part of the beachfront for 5 ft SLR and 1-day, 100-year (FAU, 2023)

**Note there is still limited flooding.*

Figure 107 shows the aerial of an area on the eastern end of the beachfront. Figure 108 shows the priority of land uses. Figure 109 shows the vulnerability scores for the area (flooding and land use scores). At zero feet of SLR, minor beachfront flooding may exist (Figure 110). At 5 feet of SLR, the water bodies on the coast flood, but property impacts appear limited (Figure 111).

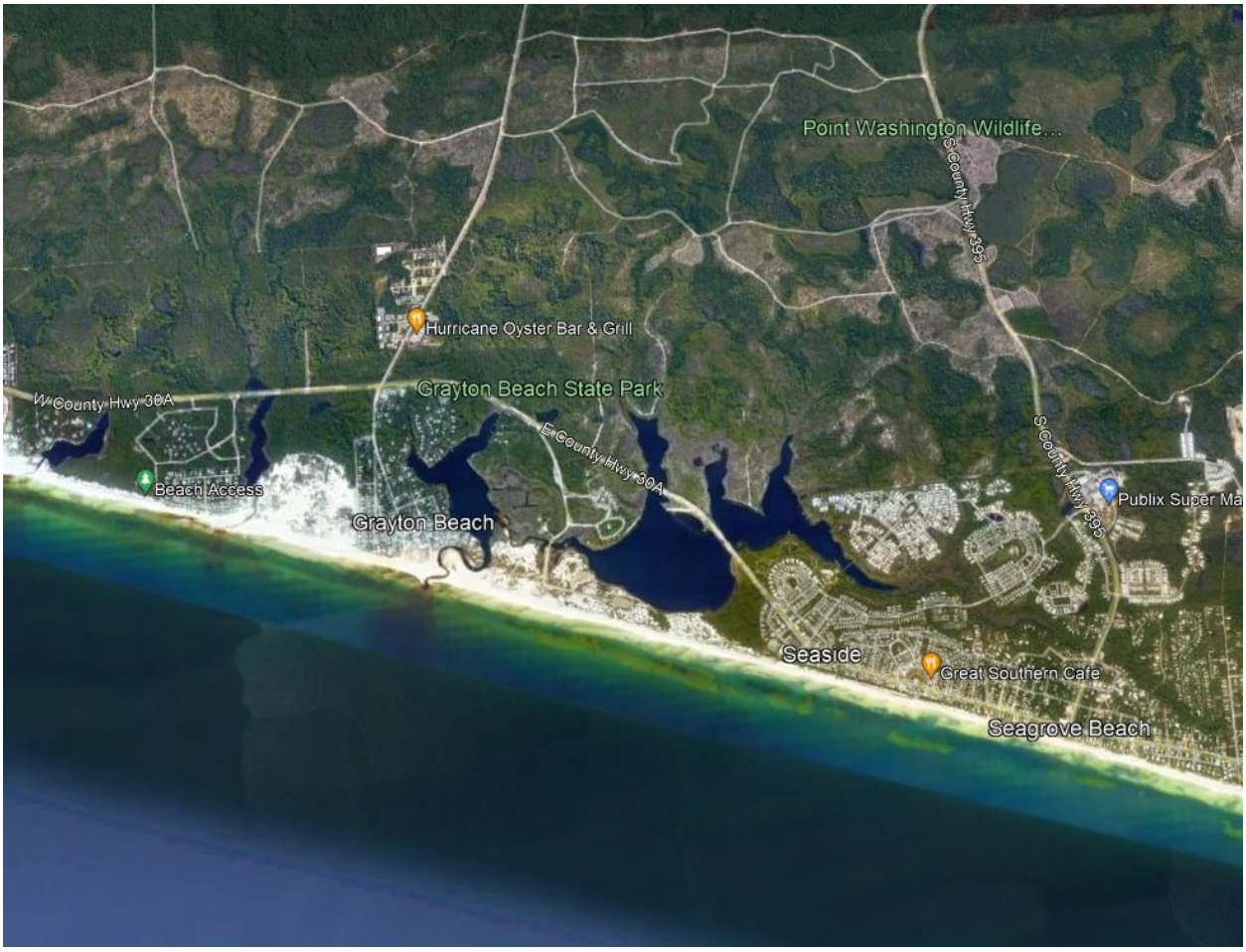


Figure 107. East end of the beachfront aerial map

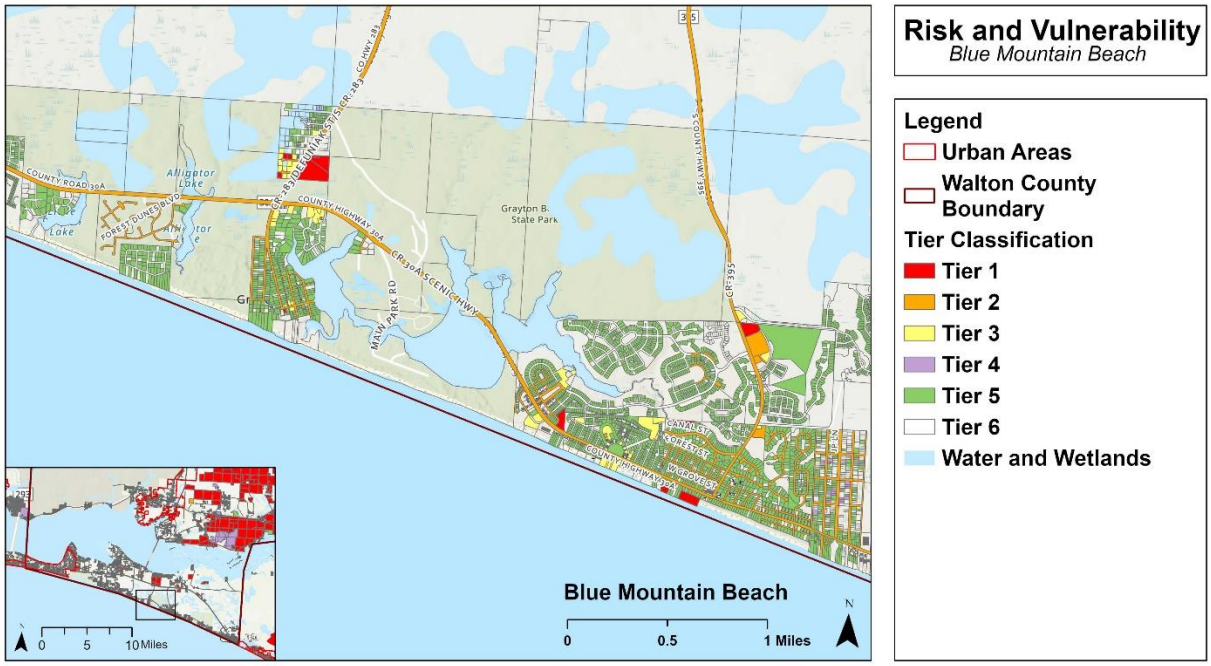


Figure 108. Identification of Critical Land uses for East end of the beachfront (FAU, 2023)

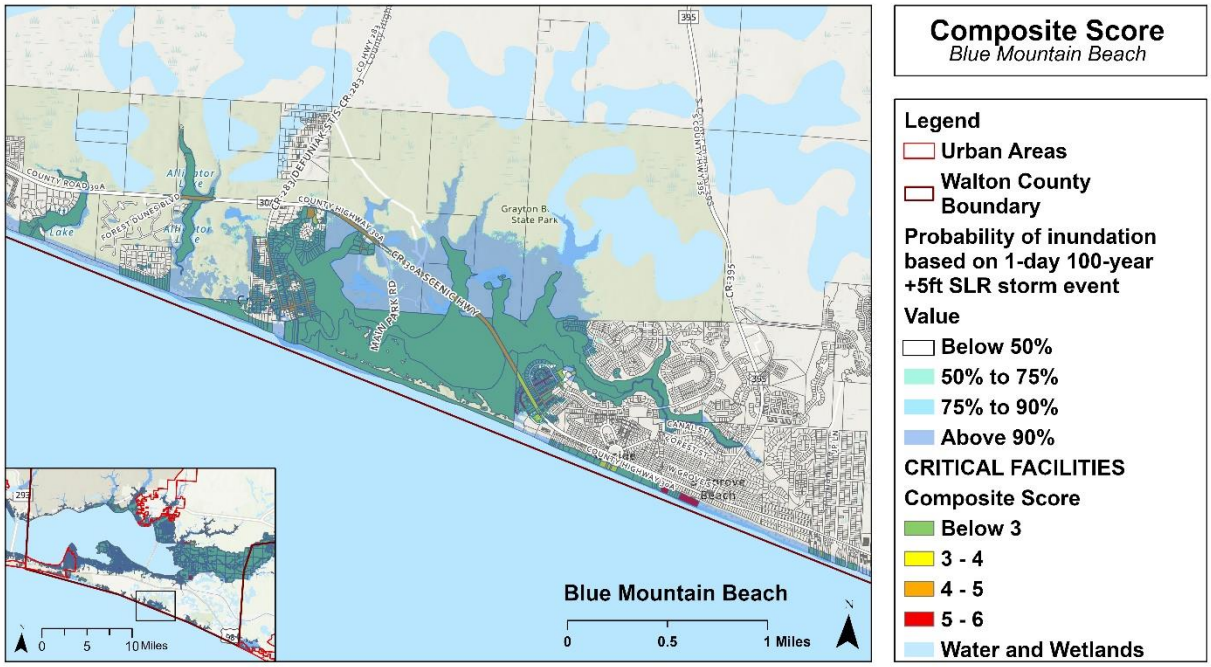


Figure 109. Identification of vulnerability scores for the East end of the beachfront (FAU, 2023)

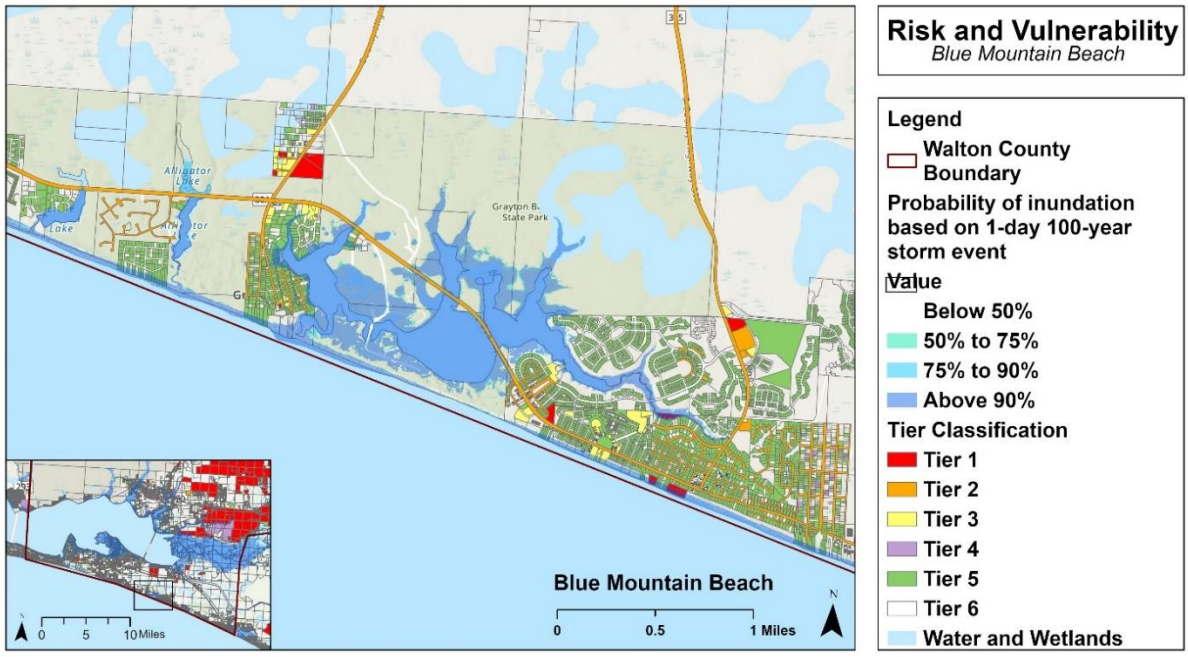


Figure 110. East end of the beachfront with 0 ft SLR and 1-day, 100-year event (FAU, 2023)

**Note minor beachfront flooding may exist.*

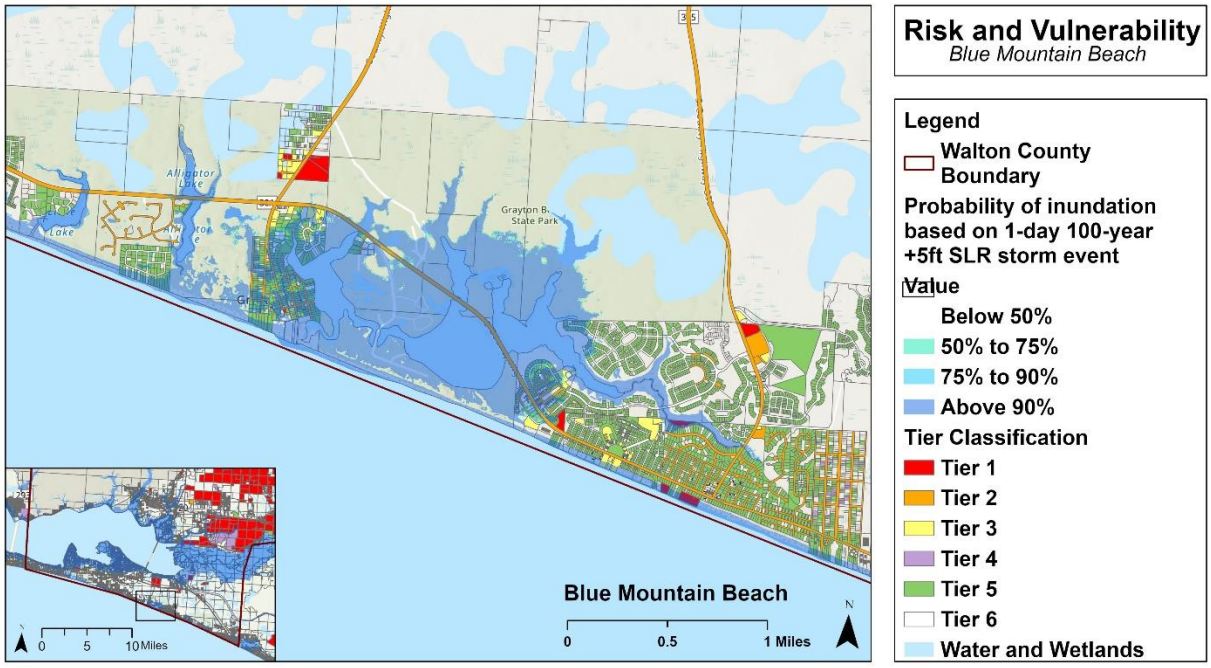


Figure 111. East end of the beachfront with 5 ft SLR and 1-day, 100-year event (FAU, 2023)

**Note coastal waterways flood.*

Figure 112 shows the aerial of an area of Seacrest. Figure 113 shows the priority of land uses. Figure 114 shows the vulnerability scores for the area (flooding and land use scores). At zero feet of SLR (Figure 115), minor beachfront flooding may exist. At 5 feet of SLR (Figure 116), the water bodies on the coast flood, but property impacts appear limited.

Figure 112. Seacrest Aerial Map

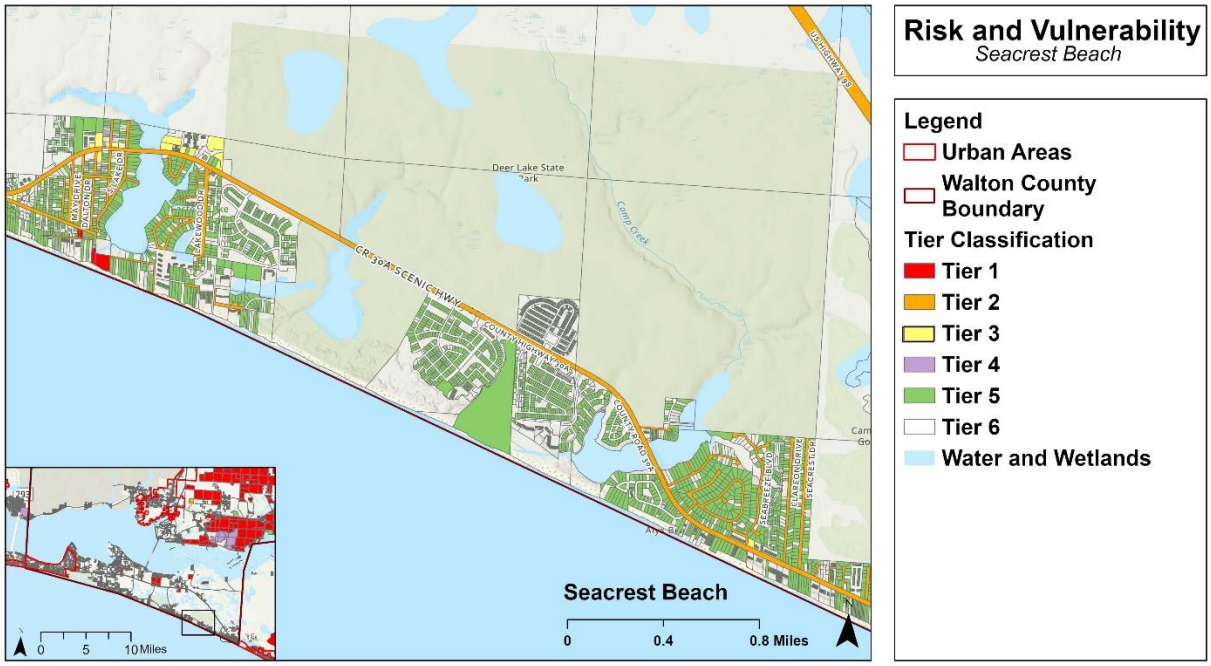


Figure 113. Identification of Critical Land uses for the Seacrest area (FAU, 2023)

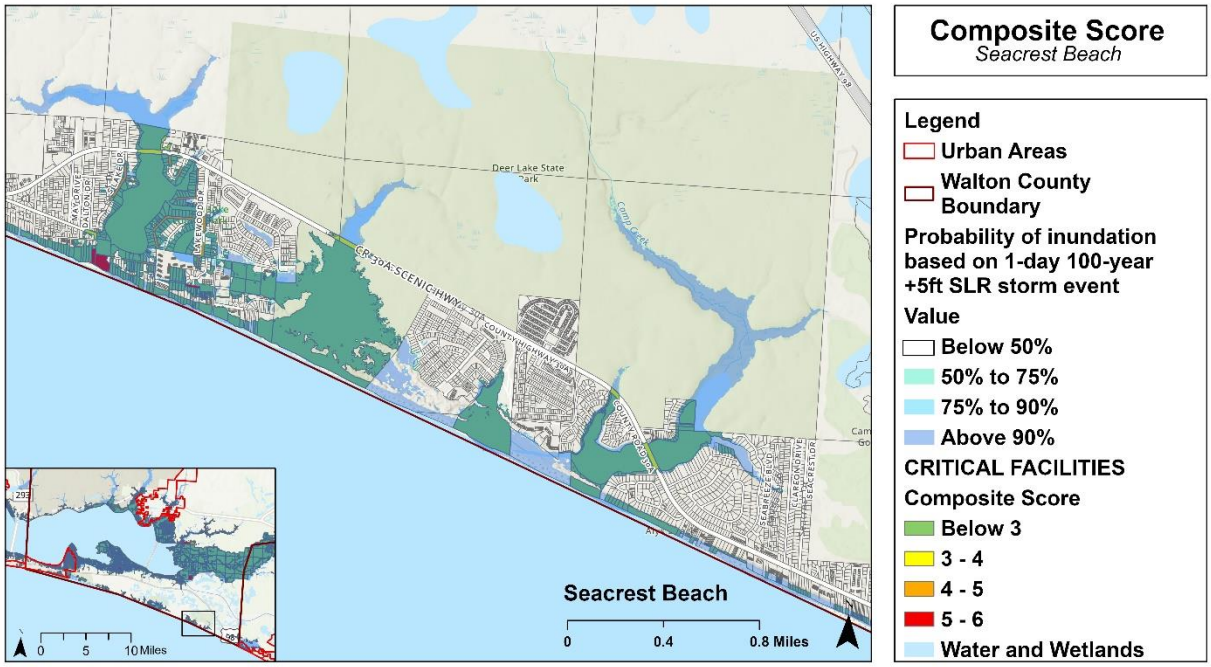


Figure 114. Identification of vulnerability scores for the Seacrest area (FAU, 2023)

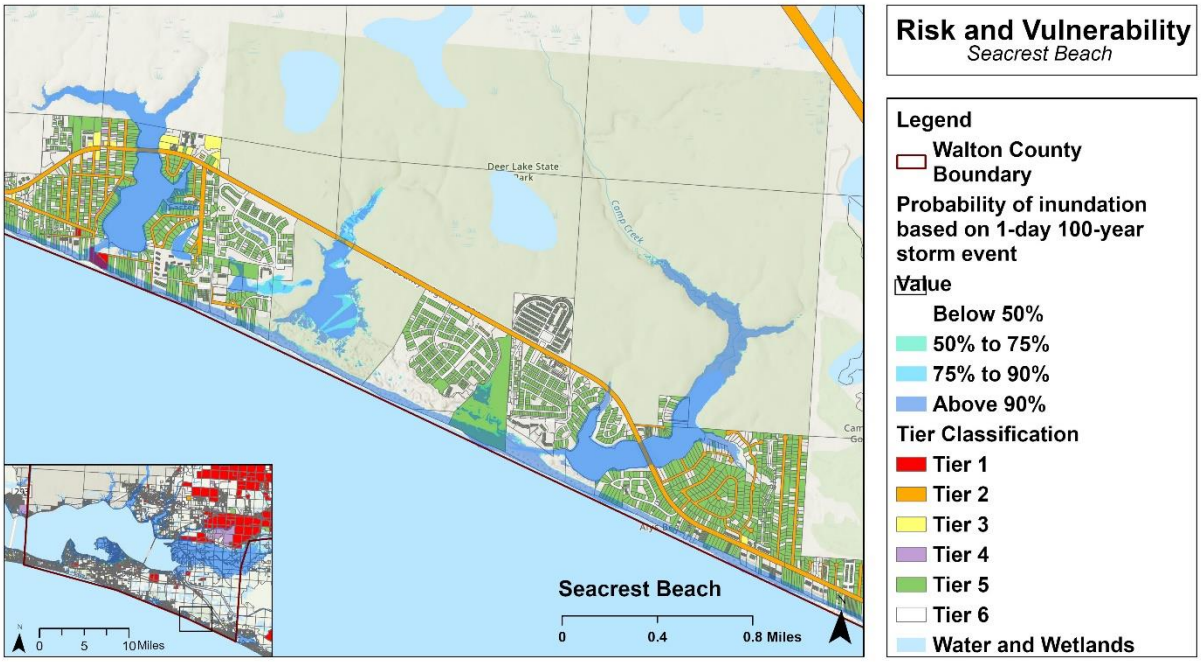


Figure 115. Seacrest at 0 ft SLR and 1-day, 100-year event (FAU, 2023)

**Minor beachfront flooding may exist.*

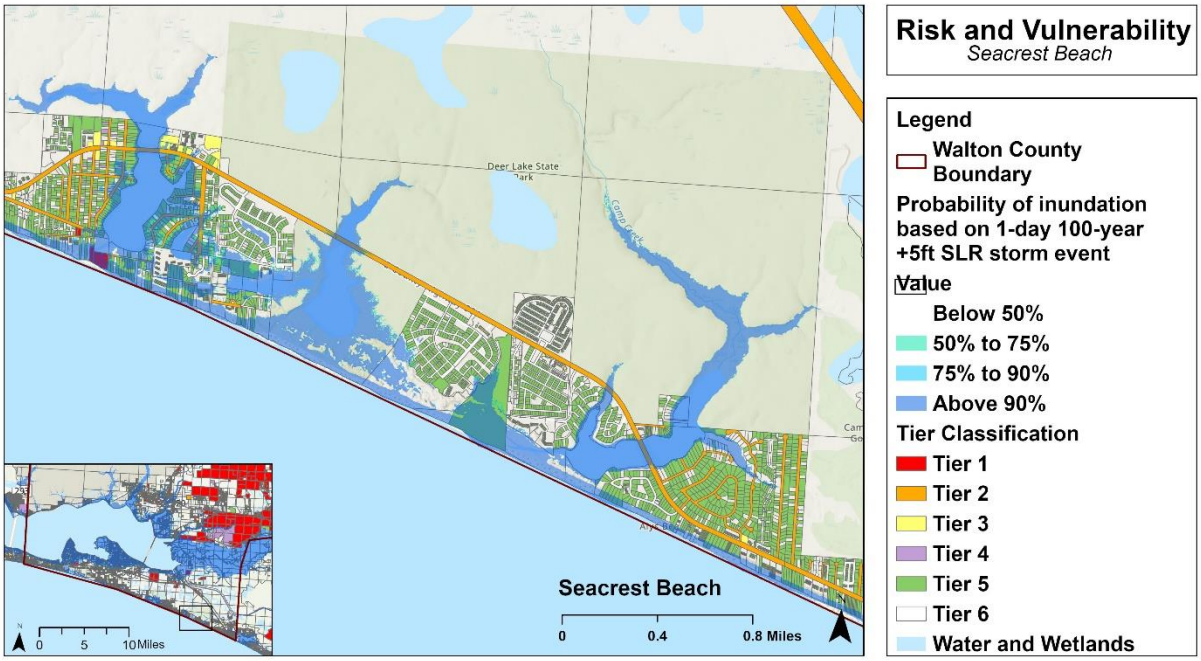


Figure 116. Seacrest at 5 ft SLR and 1-day, 100-year event (FAU, 2023)

**Note coastal waterways flood.*

The outreach meetings suggested a couple of specific neighborhoods for further investigation as a reuse of their tendency to flood. These areas are on the beachfront and further drill into areas discussed already. The first is the Peachtree Creek area. Figure 117 shows the current tiers of land use. The major concern is flooding at the canal entering the bay (see vulnerability map in Figure 118). The Highway 98 bridge structure is located in Zone X and has flooded on four separate occasions per residents. Figure 119 shows the flooding on the 1-day, 100-year flood while Figure 120 shows the 1-day, 100-year event with 5 feet of sea level rise. The model confirms the potential for flooding along the water bodies leading to the bay, properties fronting the bay, and the bridge on Highway 98, but little property is actually impacted.

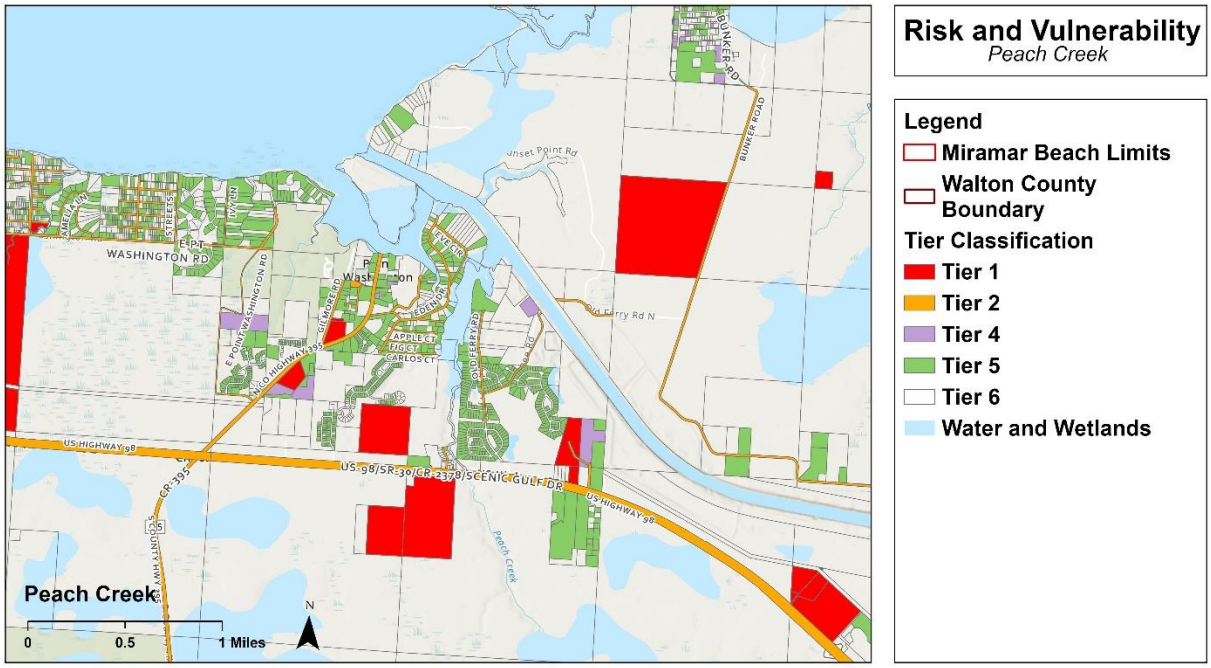


Figure 117. Identification of Critical Land uses for the Peachtree area (FAU, 2023)

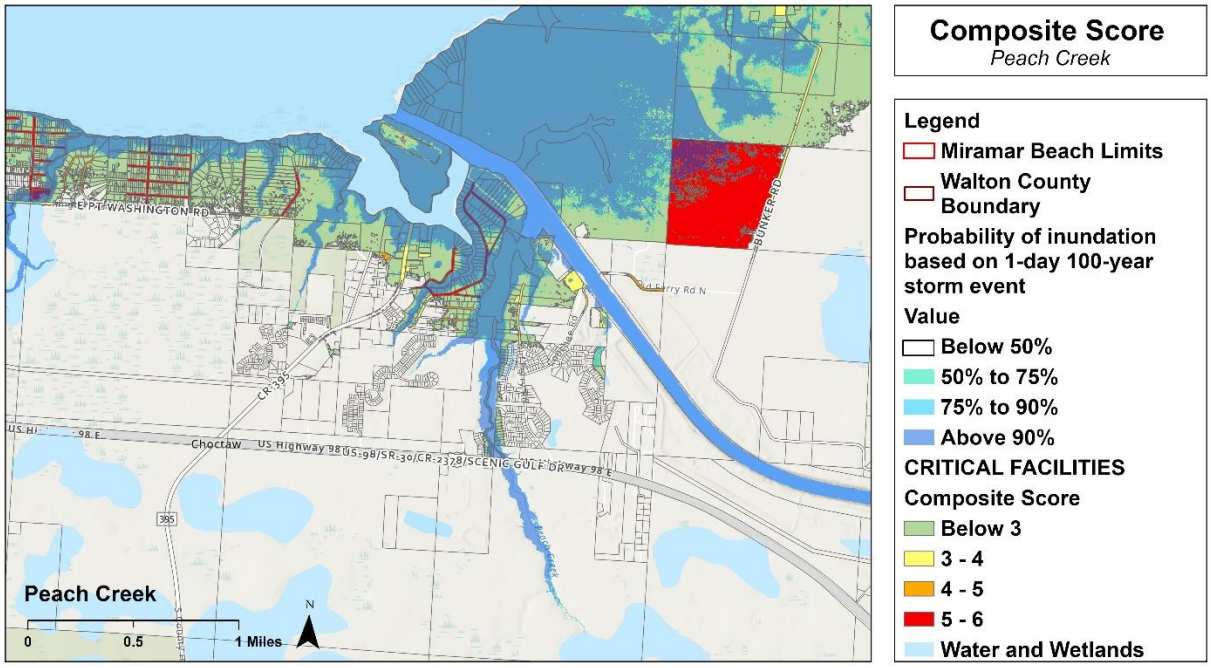


Figure 118. Vulnerability map of properties facilities Peachtree Creek at 0 ft SLR and 1-day, 100-year event (FAU, 2023)

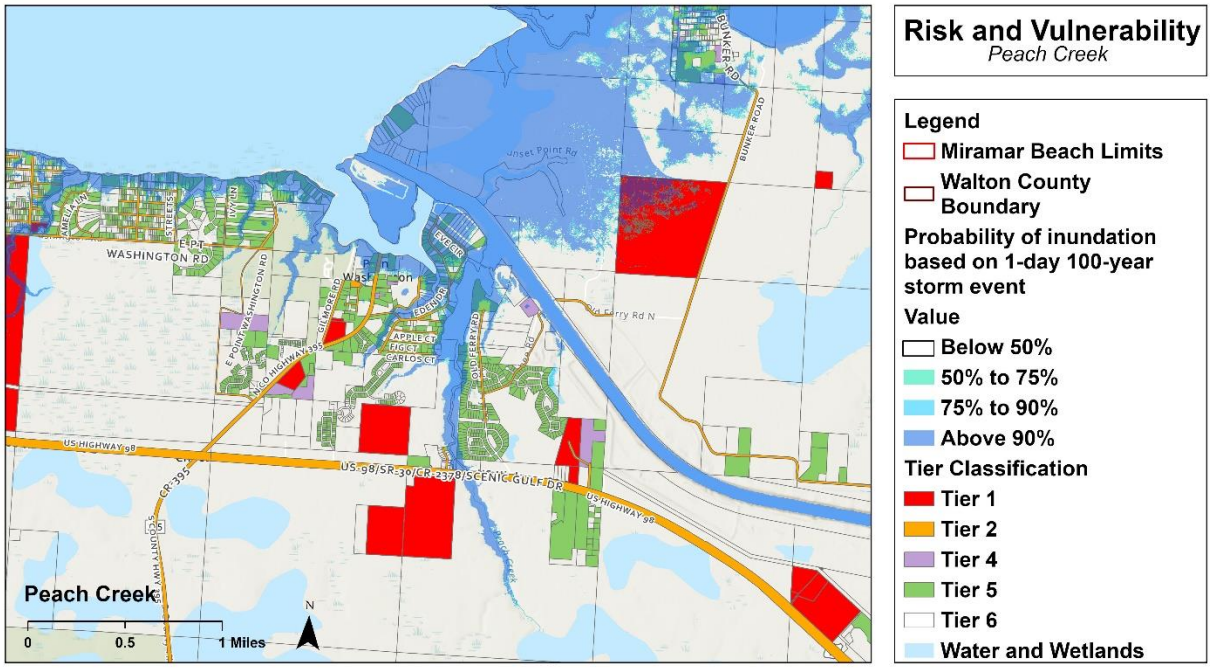


Figure 119. Peachtree Creek at 0 ft SLR and 1-day, 100-year event (FAU, 2023)

**Note flooding occurs along the water bodies leading to the bay and the bridge on Highway 98*

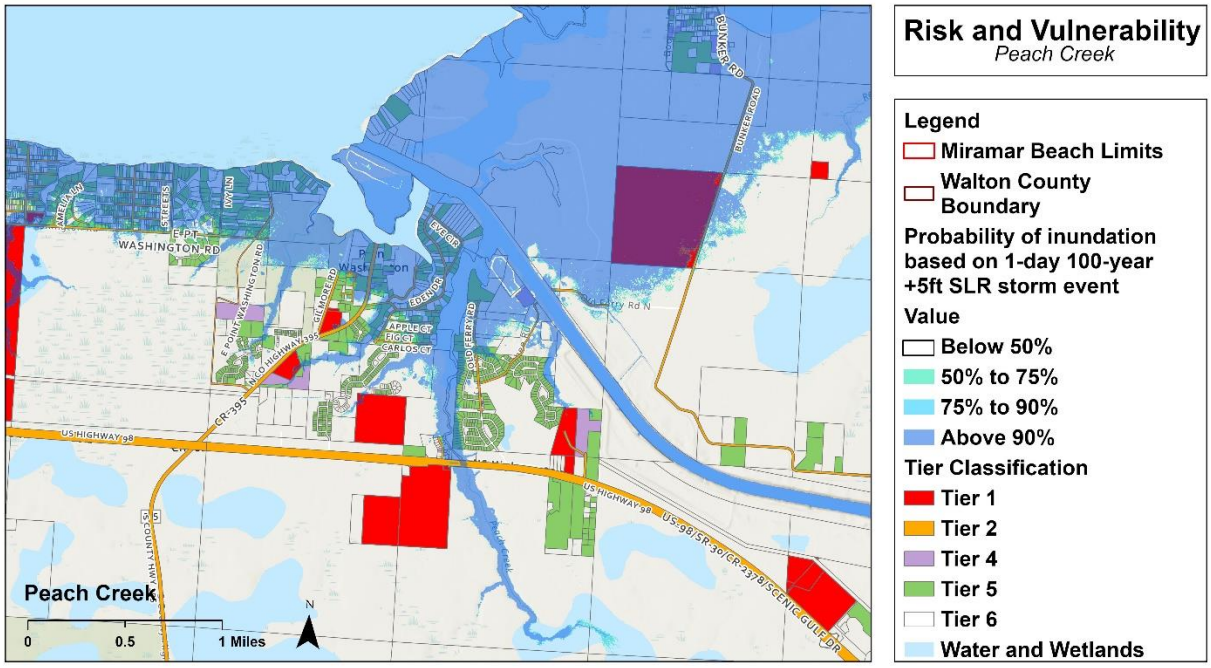


Figure 120. Peachtree Creek at 5 ft SLR and 1-day, 100-year event (FAU, 2023)

**Note flooding occurs along the water bodies leading to the bay, properties fronting on the bay and the bridge on Highway 98.*

The second area is Longleaf Circle. Figure 121 shows the current tiers of land use. Figure 122 shows the land use tiers superimposed over the flood maps. Figure 123 shows the flooding on the 1-day, 100-year storm event while Figure 124 shows the flooding on the 1-day, 100-year flood with 5 feet of sea level rise. Because the area is not on the Gulf or the bay, flooding is in waterways. However, these waterways are adjacent to some residential uses. As a result, some flooding occurs today which is worsened in the future.

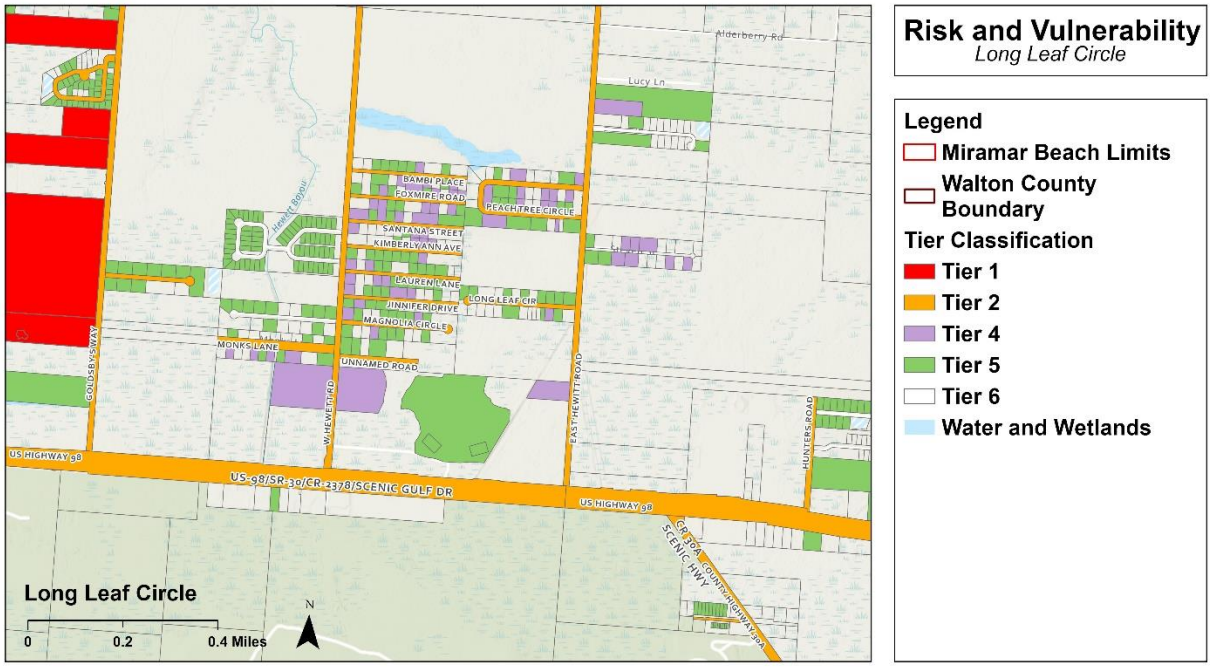


Figure 121. Land Use classification at Longleaf Circle (FAU, 2023)

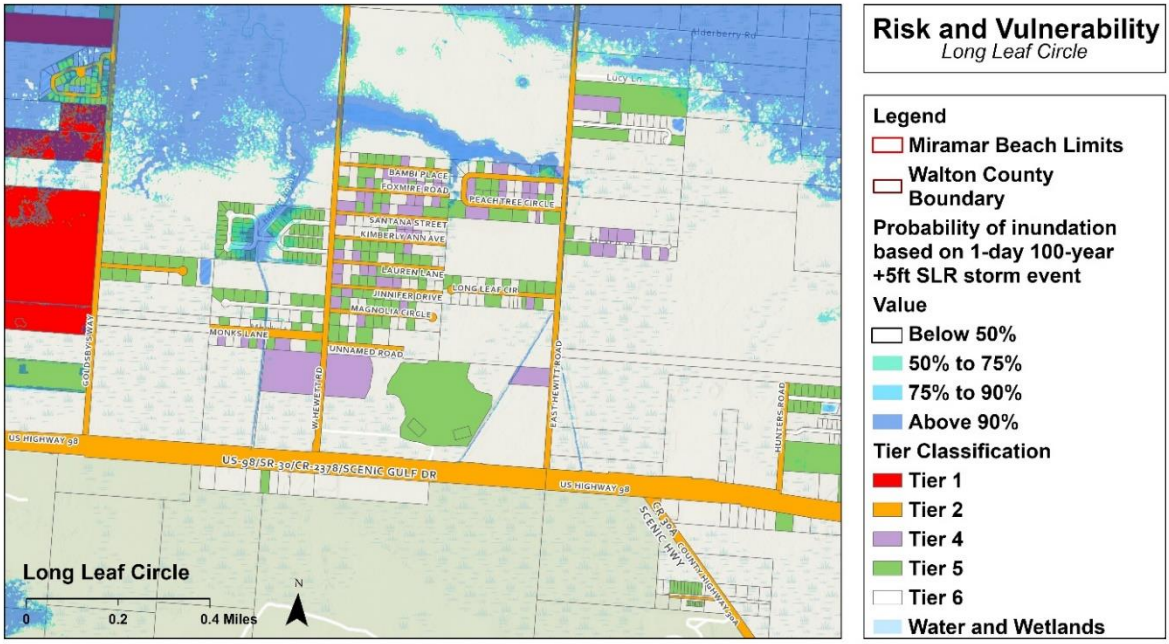


Figure 122. Land Use Flood Map Overlay for Long Leaf Circle (FAU, 2023)

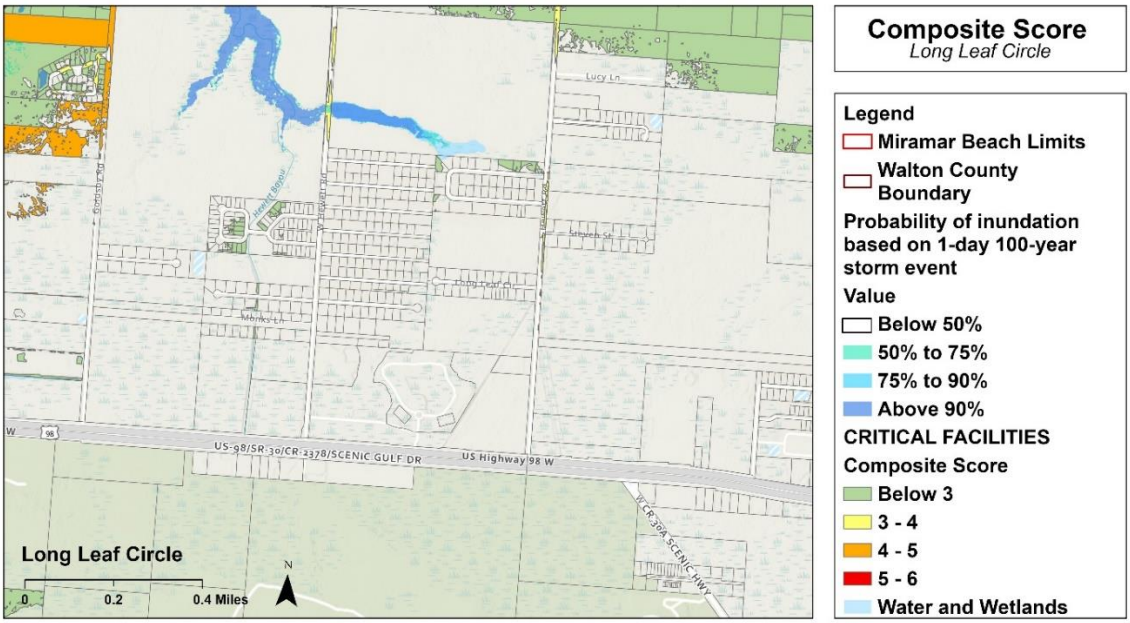


Figure 123. Longleaf Circle at 0 ft SLR and 1-day, 100-year event (FAU, 2023)

**Note flooding occurs to a limited extent in the rear yards of the neighborhoods along the extended waterways.*

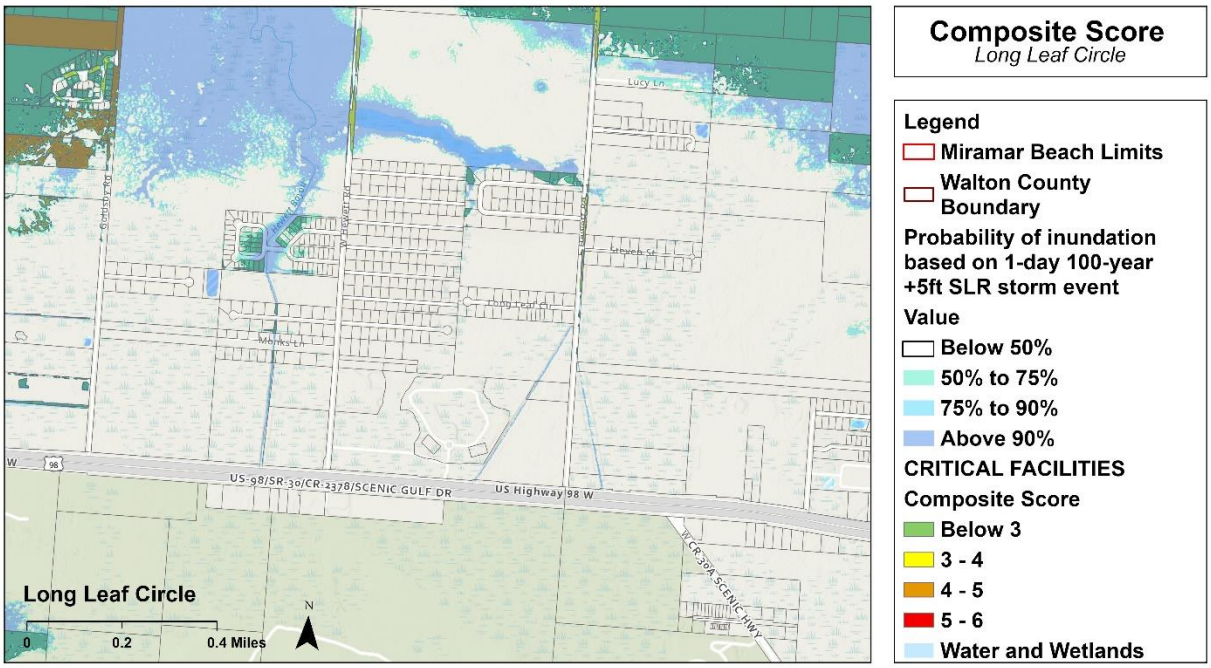


Figure 124. Longleaf Circle at 5 ft SLR and 1-day, 100-year event (FAU, 2023)

**Note flooding occurs in the neighborhoods along the extended waterways.*

Figure 125 shows the aerial of an area of Freeport. Figure 126 shows the current tiers of land use. Figure 127 shows the land use tiers superimposed over the flood maps. At zero feet of SLR, minor beachfront flooding may exist (see Figure 128). At 5 feet of SLR, the water bodies on bay waterways become overwhelmed and flood adjacent properties (Figure 129).

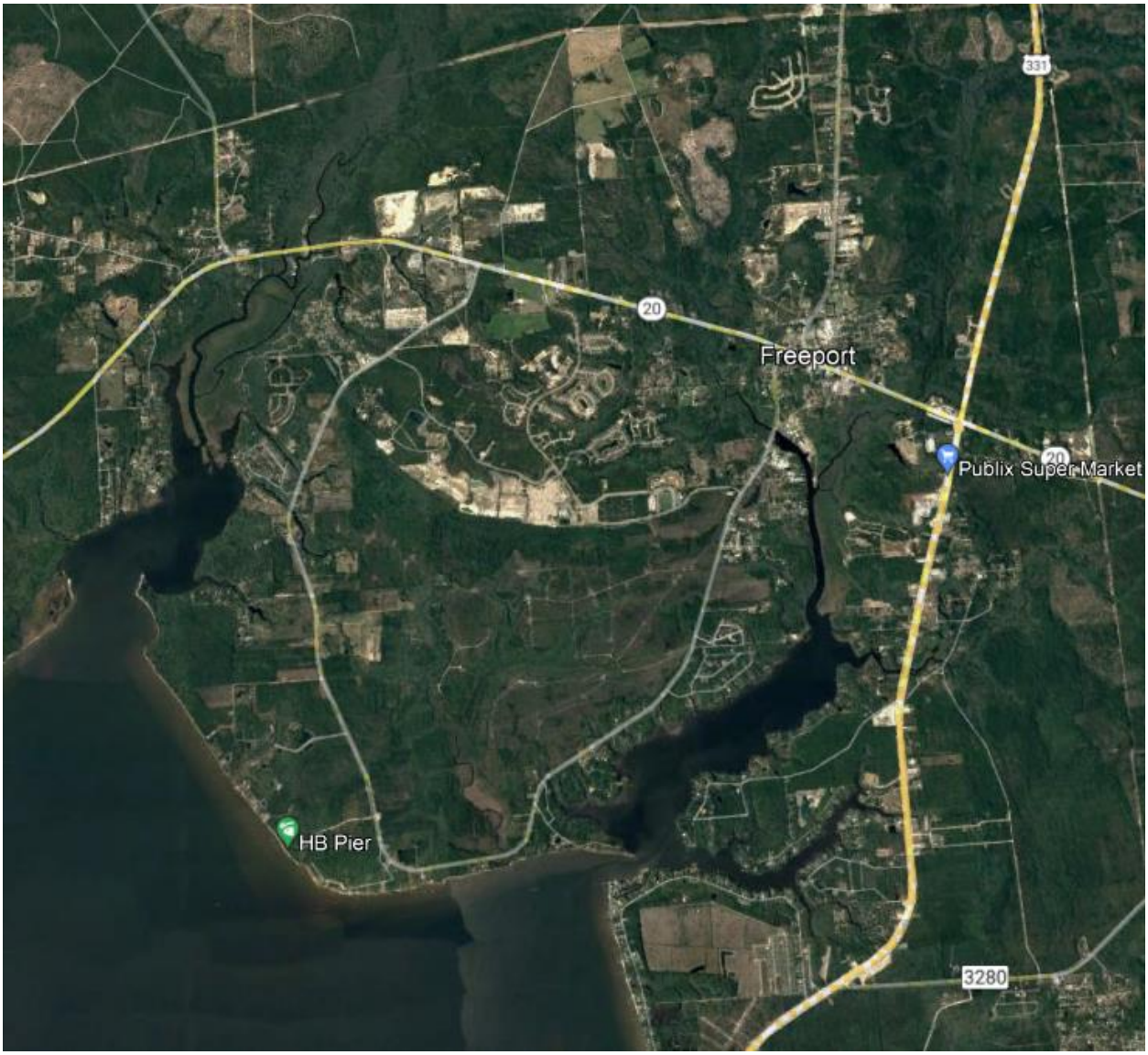


Figure 125. Freeport Aerial Map

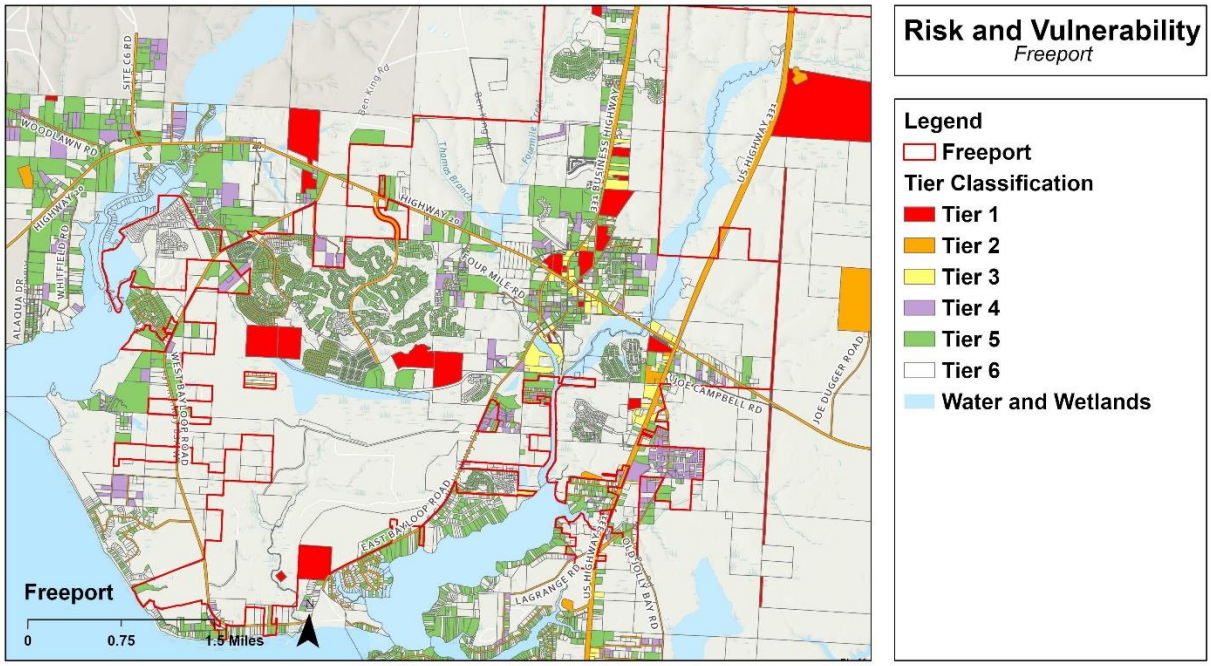


Figure 126. Identification of Critical Land uses for Freeport (FAU, 2023)

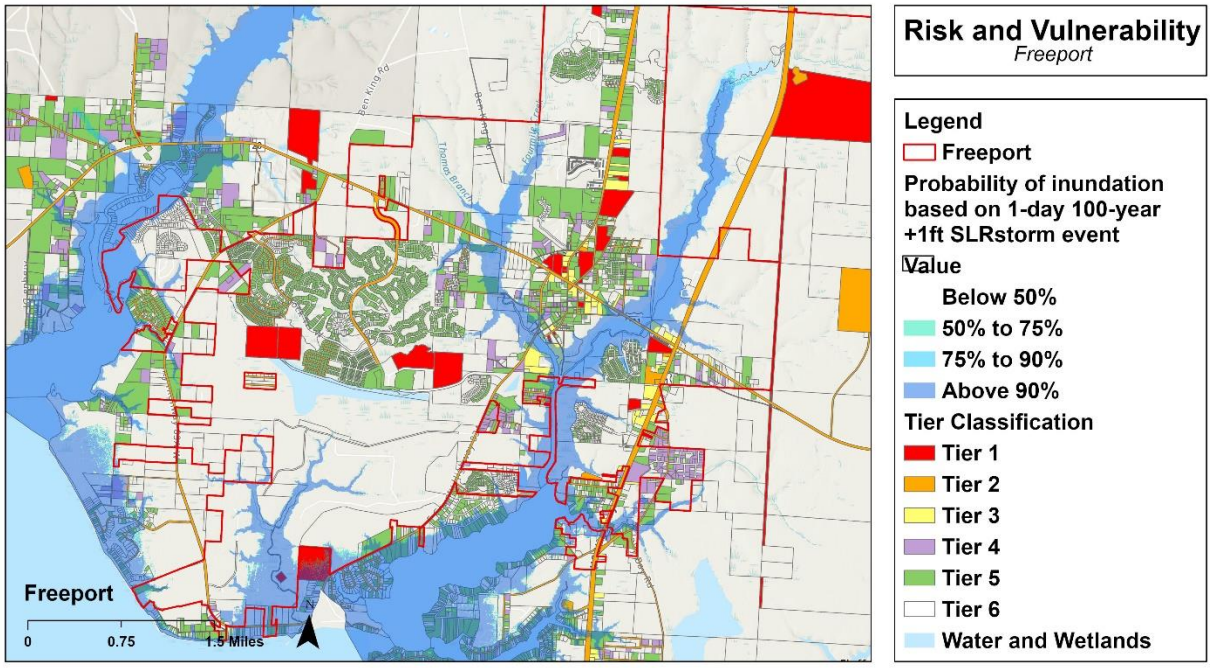


Figure 127. Land Use Flood Map Overlay for the Freeport area (FAU, 2023)

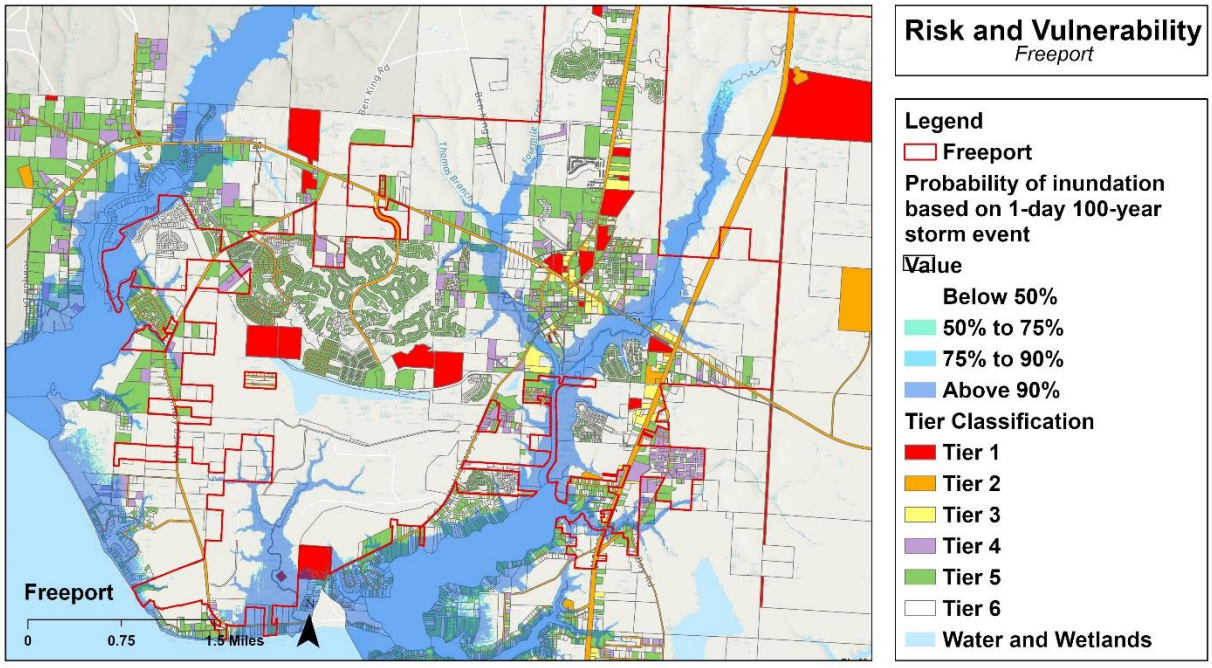


Figure 128. Freeport at 0 ft SLR and 1-day, 100-year event (FAU, 2023)

**Note minor bayfront flooding may exist.*

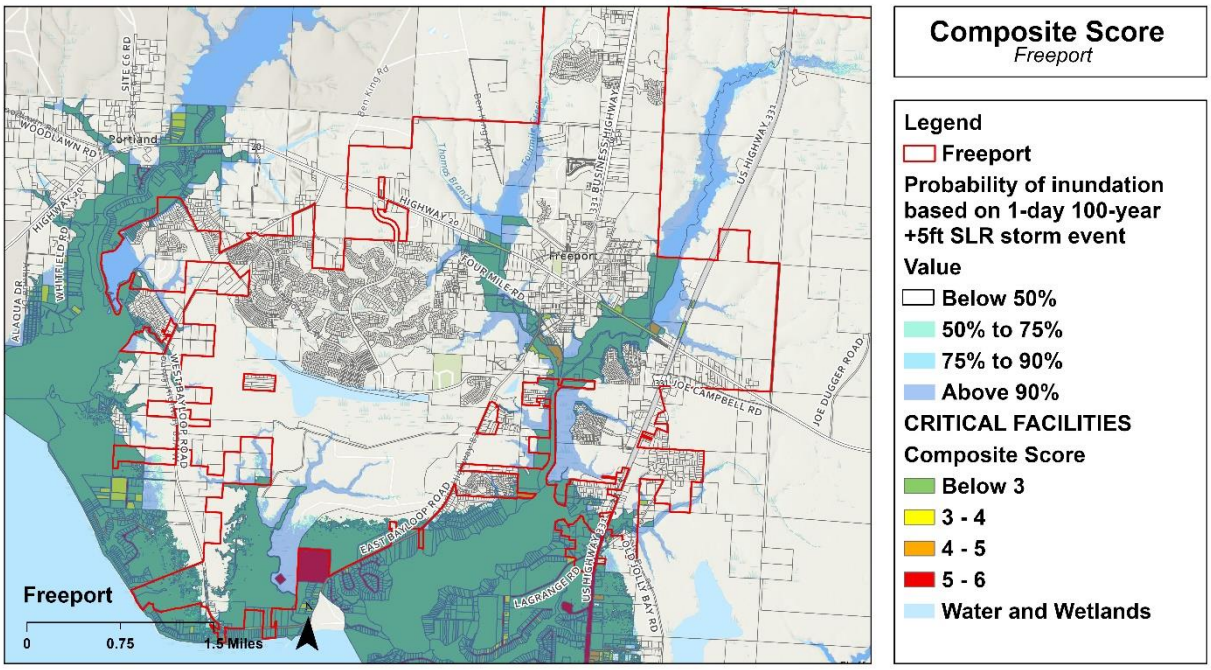


Figure 129. Freeport at 5 ft SLR and 1-day, 100-year event (FAU, 2023)

**Note bay waterways flood adjacent properties.*

Figure 130 shows the aerial of an area just east of Freeport. Figure 131 shows the current tiers of land use. Figure 132 shows the land use tiers superimposed over the flood maps. At zero feet of SLR, minor beachfront flooding may exist (Figure 133). At 5 feet of SLR, the water bodies on bay waterways become overwhelmed and flood adjacent properties (see Figure 134).

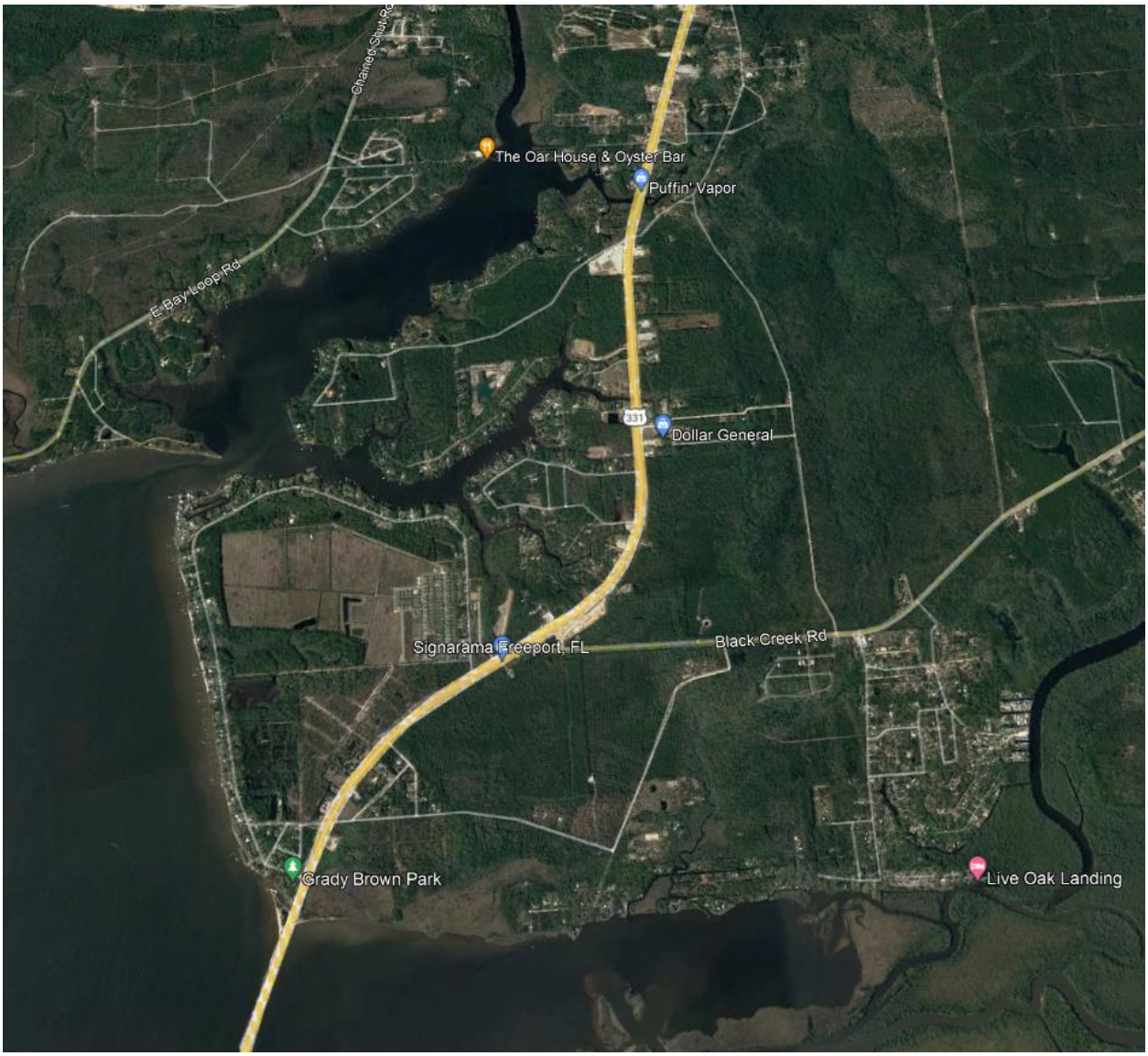


Figure 130. Area East of Freeport Aerial Map

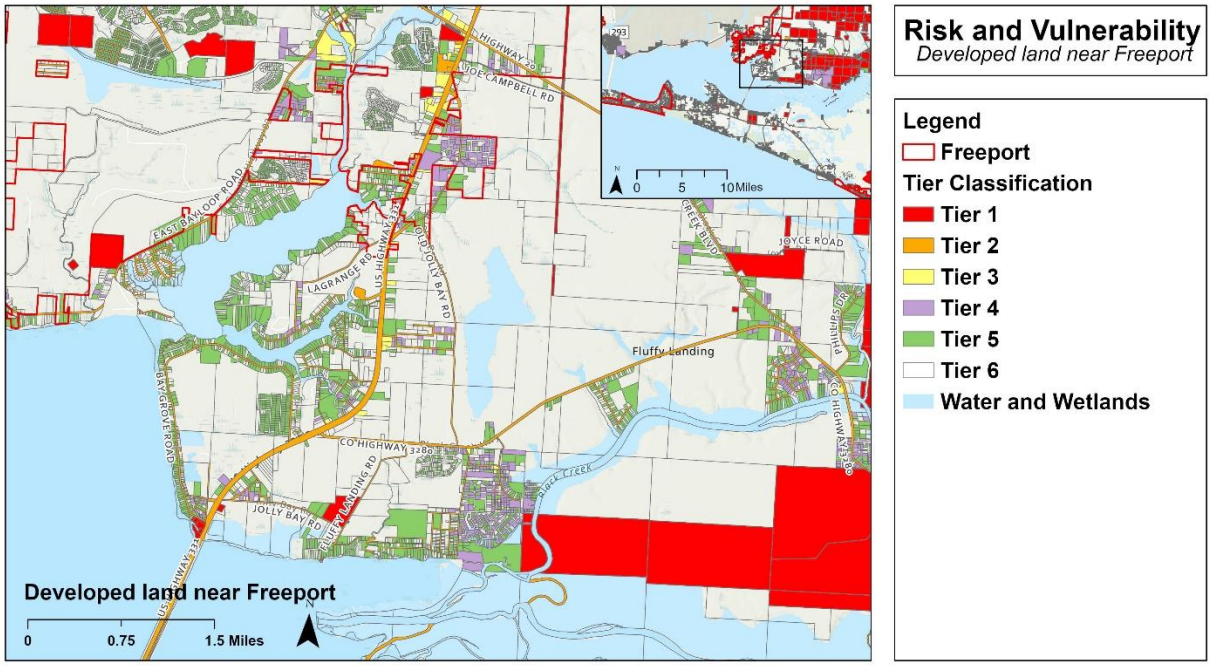


Figure 131. Identification of Critical Land uses for other land near Freeport (FAU, 2023)

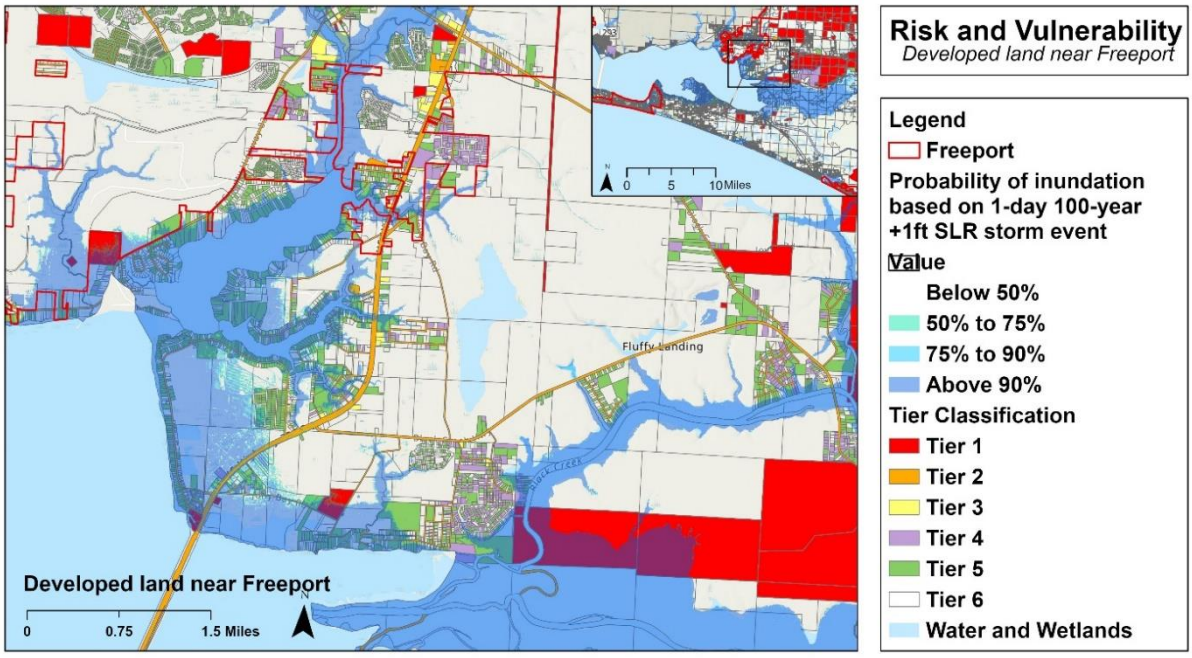


Figure 132. Land Use Flood Map Overlay for other land near Freeport (FAU, 2023)

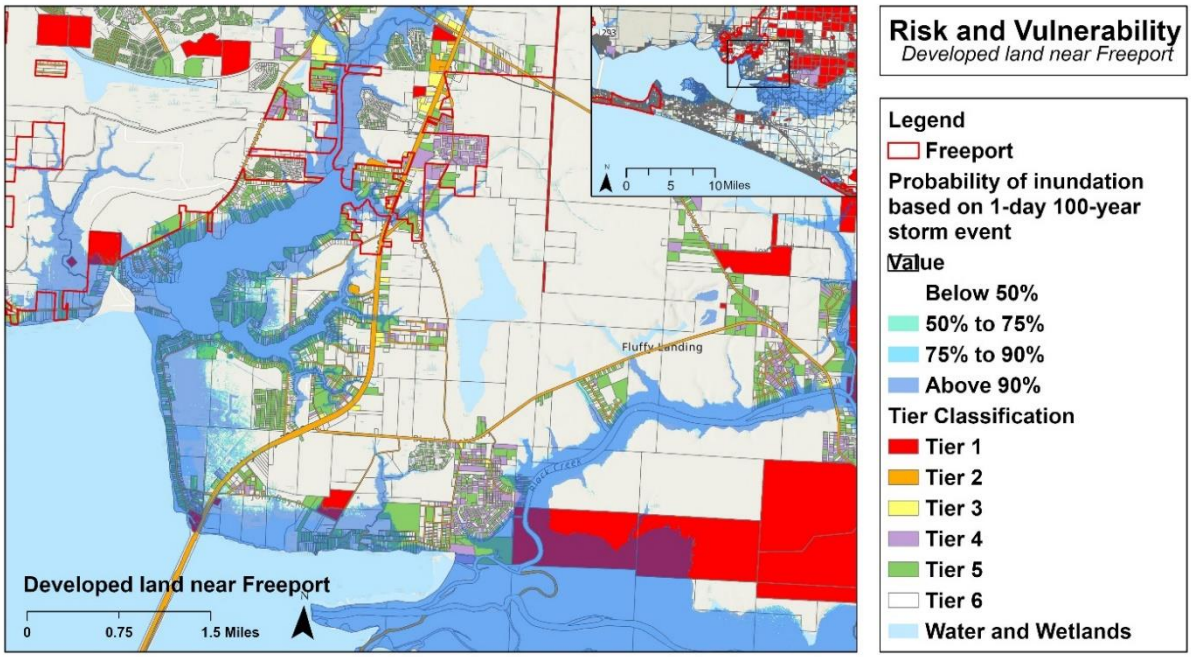


Figure 133. Area east of Freeport at 0 ft SLR and 1-day, 100-year event (FAU, 2023)

**Note minor bayfront flooding may exist.*

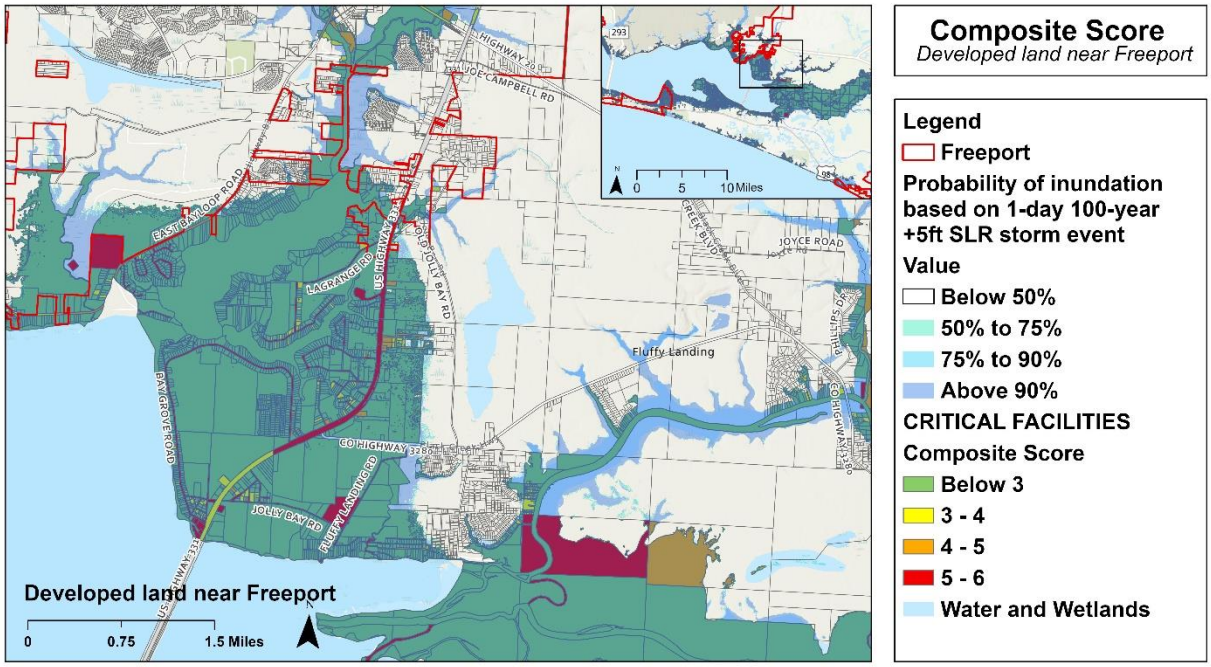


Figure 134. Area east of Freeport at 5 ft SLR and 1-day, 100-year event (FAU, 2023)

**Note bay waterways flood adjacent properties.*

Identification of critical land uses for the inland communities of Paxton and DeFuniak Springs are shown in Figure 135 and Figure 137. Drilling down to Paxton and DeFuniak Springs (Figure 136 and Figure 138) does not reveal any flooding. Because they are elevated, sea level rise poses no threat to either community.

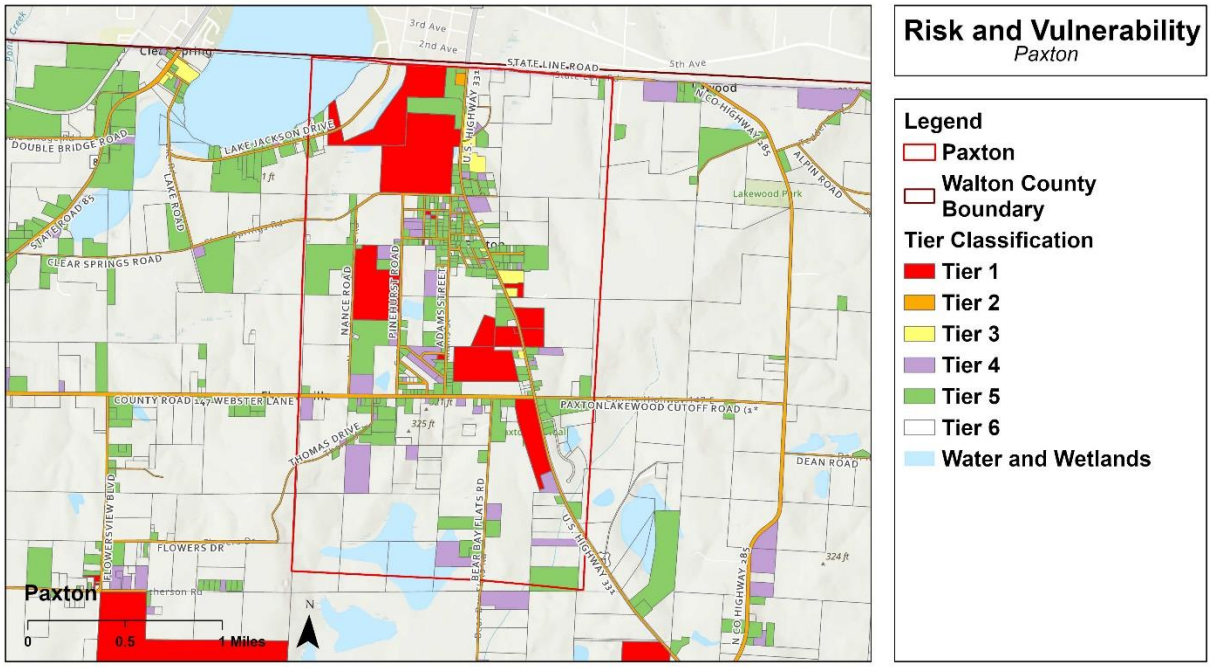


Figure 135. Identification of Critical Land uses for Paxton (FAU, 2023)

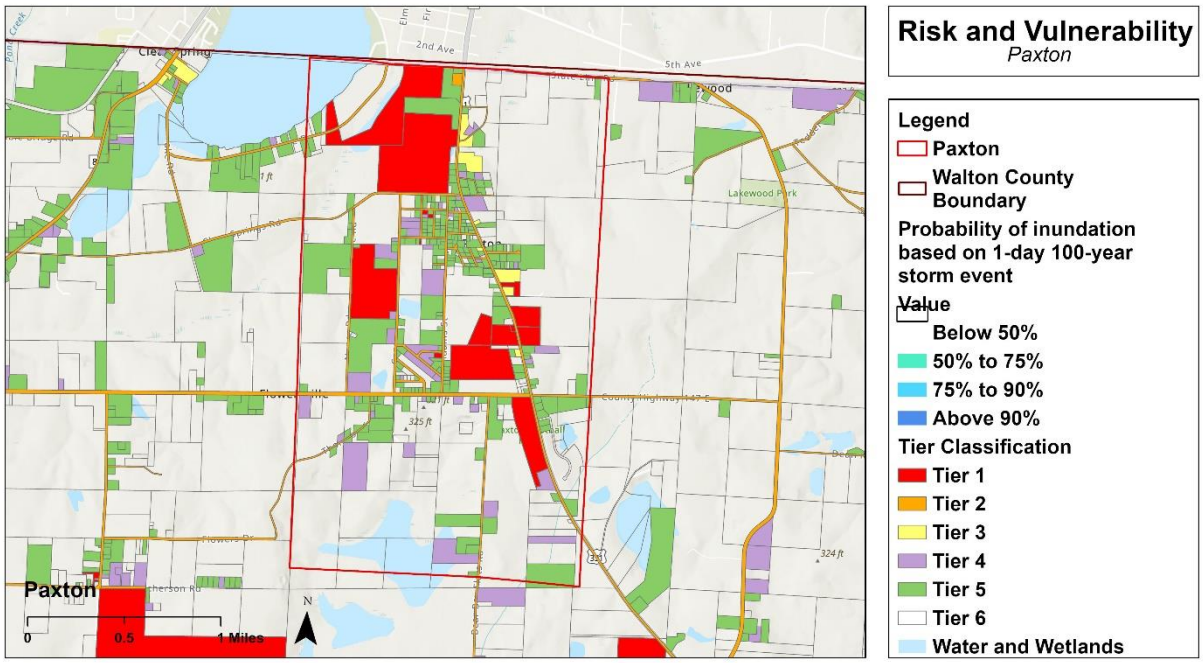


Figure 136. Paxton at 1-day, 100-year event (FAU, 2023)

**Note no flooding is present.*

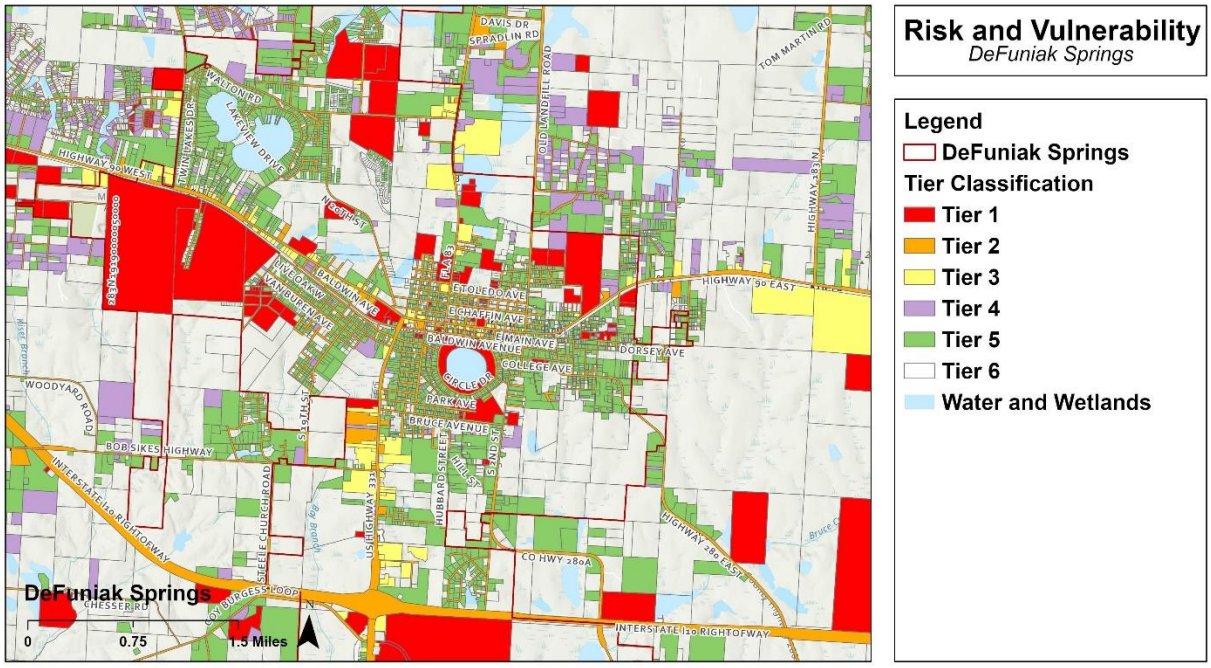


Figure 137. Land Use Classification in DeFuniak Springs (FAU, 2023)

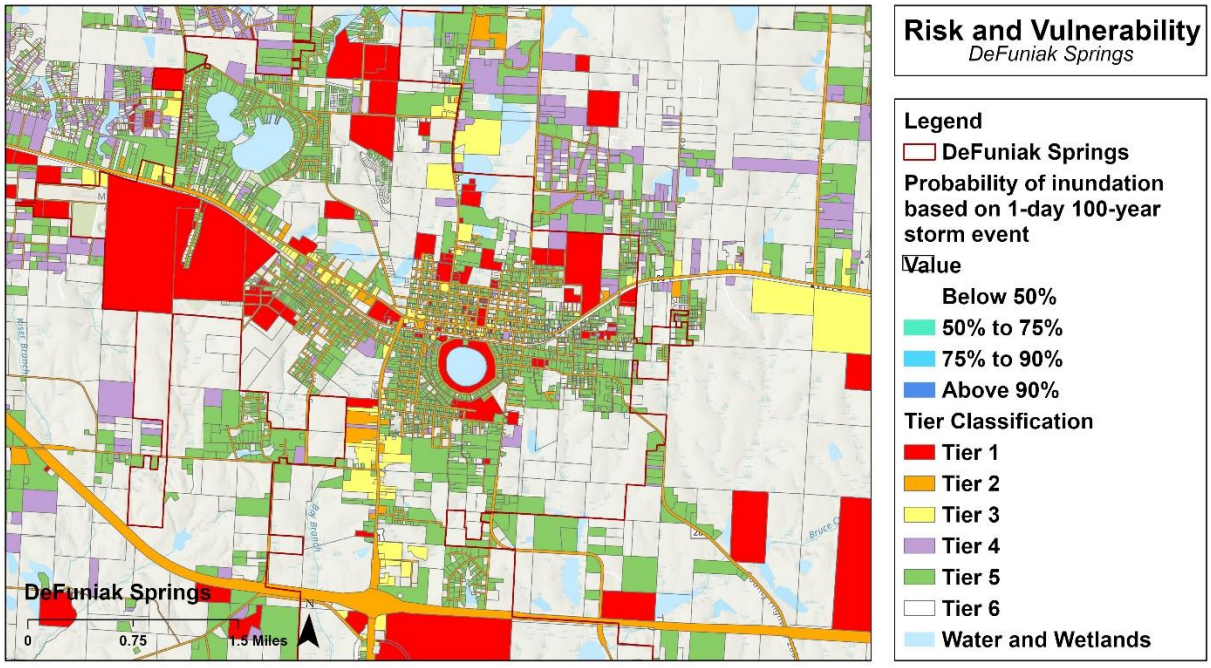


Figure 138. DeFuniak Springs at 1-day, 100-year event (FAU, 2023)

**Note no flooding is present.*

5.2.1 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more losses or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are currently more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. Figure 139 indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss. Most of these are on Miramar Beach (Figure 140).

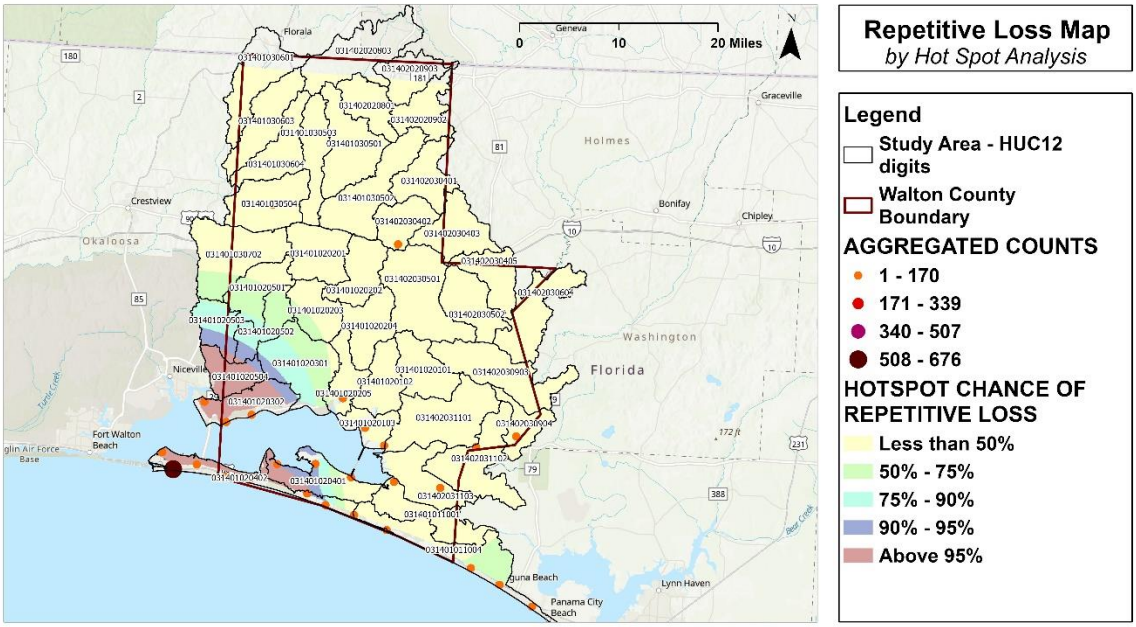


Figure 139. Repetitive Loss map for Walton County by Hot Spot Analysis (FAU, 2023)

**Note map processed by FAU.*

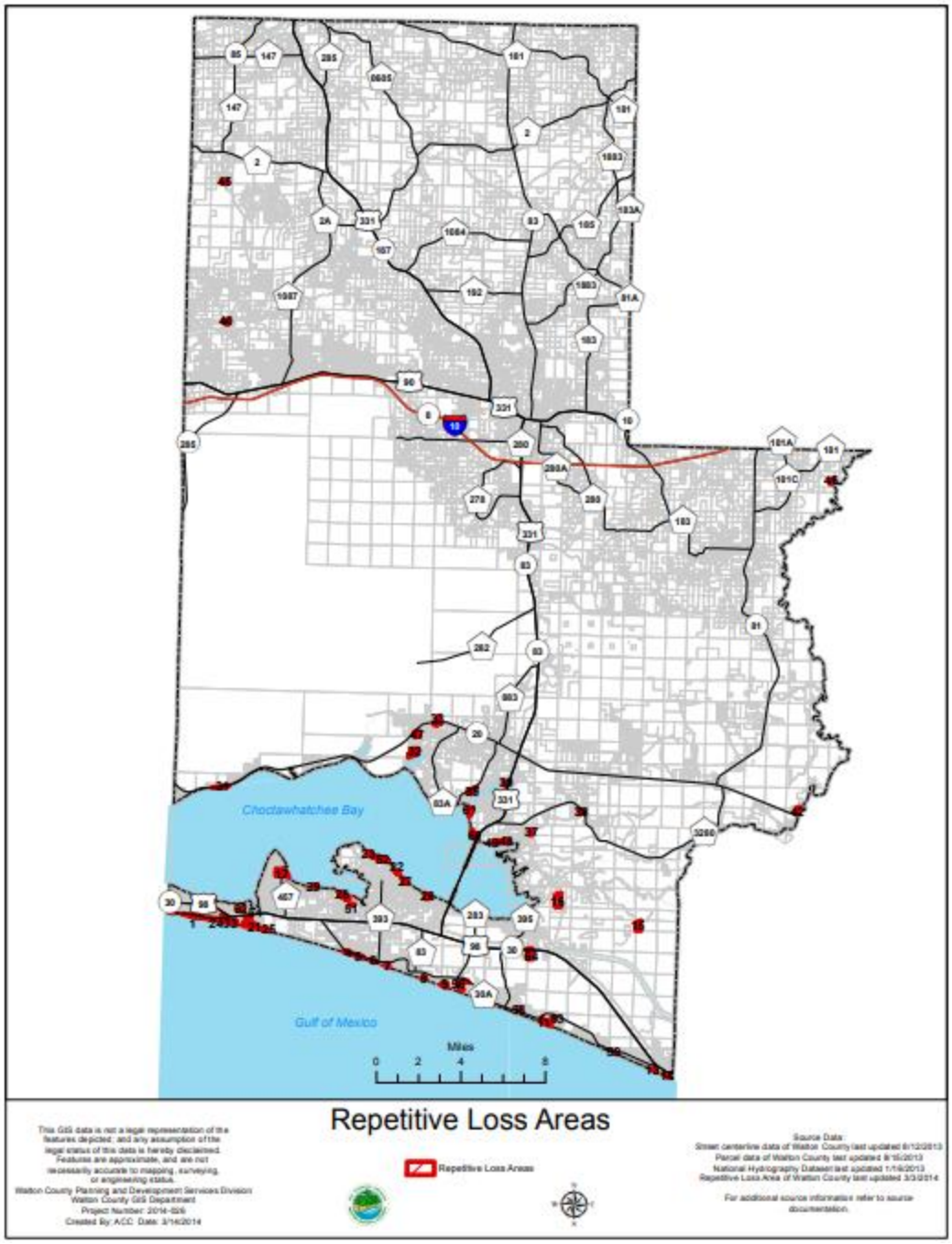


Figure 140. Drilldown of Hotspots

**Note areas are mostly on Miramar Beach.*

5.3 Solutions

For the Phase 1 guidance document, 35 solutions are referred to as the “Periodic Table” menu of green and grey infrastructure technologies (Figure 141). The ones that apply to the city are highlighted and discussed in more detail in the following sections. The yellow highlighted items are ideas that are easily implementable or are part of current permitting. They will provide help for regular storm events and nuisance flooding.

The peach-colored items are tangential to stormwater – they address the sanitary sewer system. Septic tanks on an island will fail with high water tables, creating water quality impacts on the adjacent canals and water bodies. They also do not work when flooded. Sanitary sewers will need to be protected and sealed. While the utilities in the County have been converting to sanitary sewer, continuing efforts will improve the long-term water quality and sewer sustainability.

The red items are those that are longer-term. As noted in the prior section, road bases are already failing. That will continue at an accelerated rate as the base remains wet. Raising roads has the major challenge of impacting flood insurance. The crown of the road must remain 18 inches below the finished floor, or the structure cannot obtain flood insurance (it is considered a basement which is not insurable in Florida).

Likewise, sea walls, identified as an issue in the prior section have two challenges, they need to be increased in height which may not be able to be done easily given the current condition or structure of the sea walls and the opening for street drains through the seawalls permits water to backflow into the streets.

The fact that sea walls are not permitted is also a challenge since certain low-lying areas may need sea walls for structure protection from sea level rise. Likewise, other policy issues, including altering zoning or property acquisitions to remove flood-prone areas from development, should also be considered. These are much longer-term strategies.

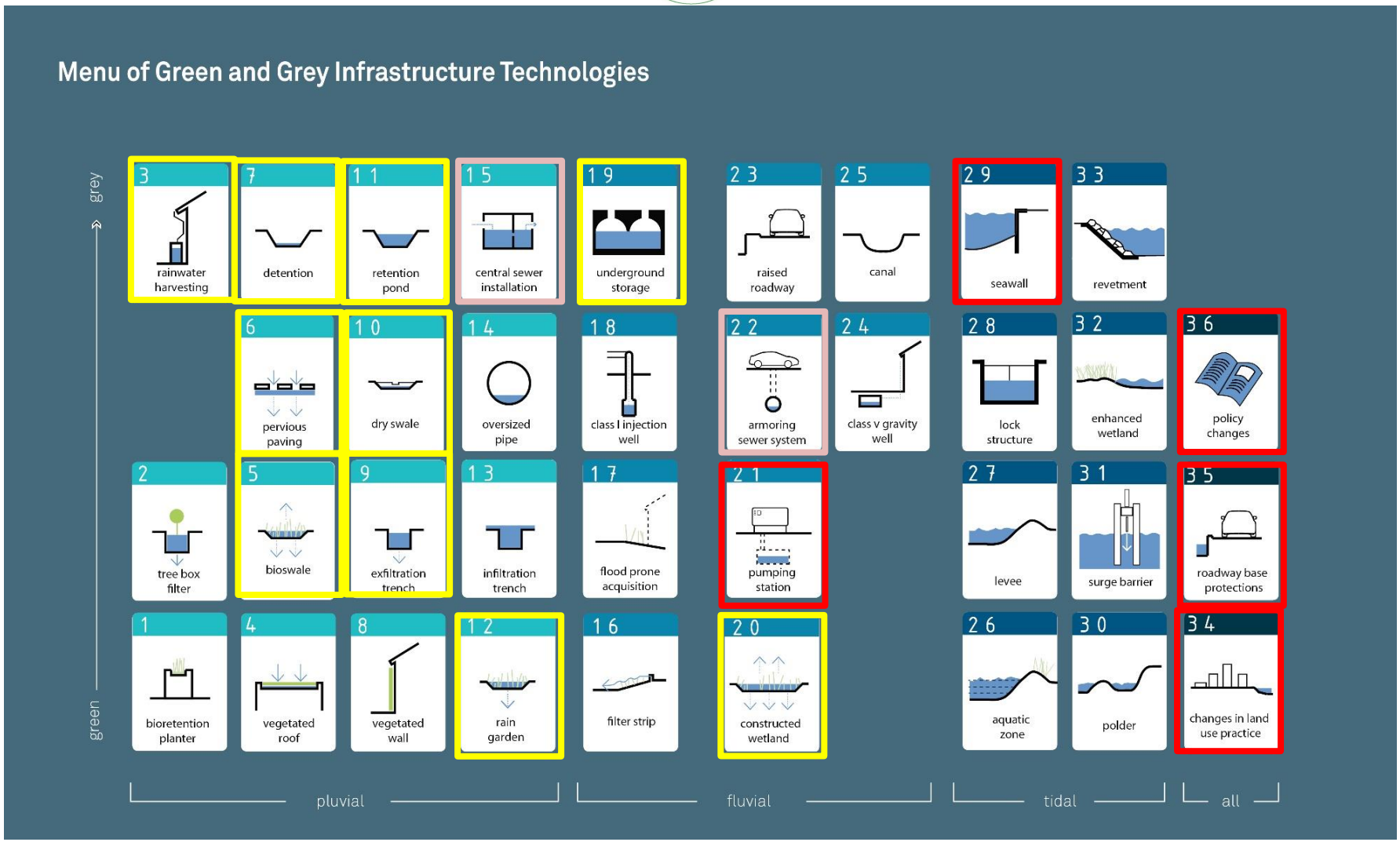


Figure 141. "Periodic Table" menu of green and grey infrastructure technology options

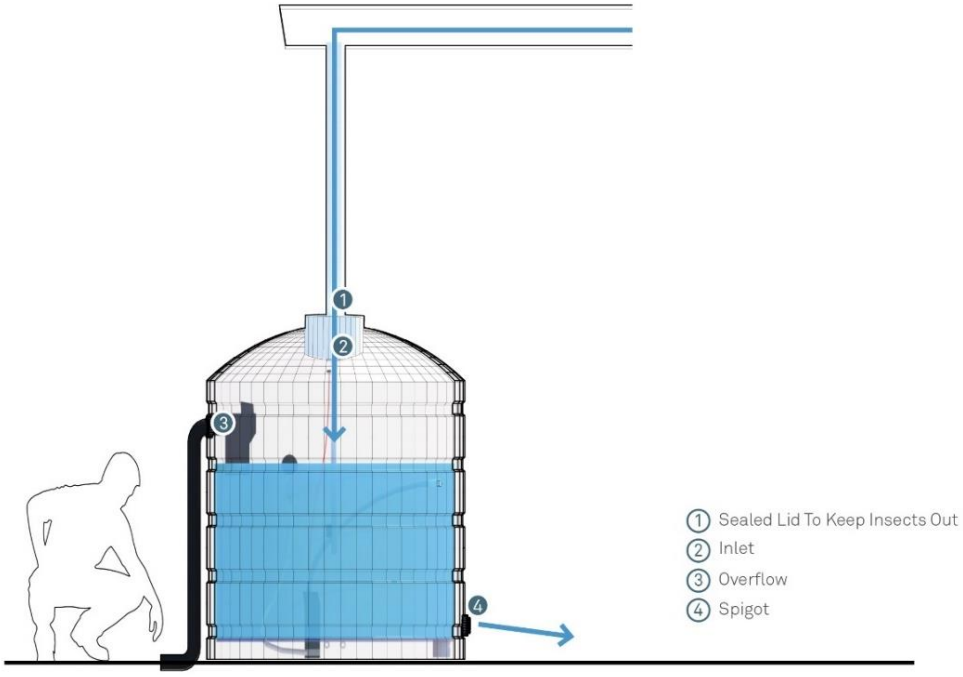
The menu is organized to address various flooding types, from pluvial (rainfall and runoff mitigation in upland areas), fluvial (runoff, high ground water, and surface water management in low-lying flood prone areas), tidal (flooding associated with storm surge, high ground water, and tidally influenced), and all (applies across the spectrum).

5.3.1 Rainwater Harvesting

Rainwater harvesting is the collection and storage of rain on a site in some form of container, rather than allowing it to run off. Typically, the rainwater is collected from a roof-like surface and redirected to a tank, cistern (Figure 142), or pond for later use for irrigation or other non-potable purpose. This option can be used in areas where some irrigation is needed for daily rain events. However, this strategy typically has limited use for large-scale events based on storage capacity limitations of the cisterns which are subject to overflow.

Figure 142. Rainwater Harvesting Cistern

A common location for rainwater harvesting is at the terminal end of downspouts for buildings. In areas with highly variable rainfall, the ability to store water for non-potable purposes is a well-understood means of water conservation. Note because the cistern will only hold a certain volume of water, a means to address cistern overflows is needed. The costs for these systems are low, and maintenance is limited to periodic cleaning to remove roof debris/sediment. Another notable benefit of rainwater harvesting is that it can also help a development acquire LEED® credits. Design considerations are summarized in Figure 143.



3. Rain Water Harvesting

Rainwater harvesting reduces runoff volume and peak flows. Cisterns, bladder tanks, and precast ferrocement septic tanks are generally larger than rain barrels and slim tanks, and are used for domestic water supply, rather than irrigation for landscaping. Most rainwater harvesting devices are modulated and can be connected to provide increased storage. Consider that in areas with rainfall more than 25 inches annually, a 1,000 square foot roof will produce a minimum of 15,000 gallons of rainwater per year. To capture this water for irrigation during the peak months approximately 10 rain barrels or one 500-gallon cistern are needed.

Where it can applied
filtration or infiltration (depends on which system is to be used)

Benefits
Upstream of major treatment system, and in place of street tress (not in swales or other filter devices) at the source of runoff

Barriers to implementation
A single tree box to a large urban tree box network

Cost
varies

Figure 143. Design considerations, benefits, barriers, and costs for a rainwater harvesting system

5.3.2 Pervious Paving

Transportation surfaces (roads, parking lots, and driveways) account for significant amounts of impervious urban surfaces. Permeable pavement allows rainfall to infiltrate down from these surfaces rather than running off into storm sewers. Rainfall moves into a rock chamber below the pavement. Water in the pore space between the aggregate either percolates out and down through surrounding soils or moves to a perforated drainpipe installed in the rock chamber. Water is slowly released to become ground flow or enter surface waters after it has been cleaned and cooled by moving through the pavement and underground rock chamber. Since impervious pavement is the primary source of stormwater runoff, low-impact development (LID) strategies recommend permeable paving for parking areas and other light-duty hard surfaces. The benefits of pervious surfacing include: 1) lower surface temperature, 2) less flash flooding and standing water, 3) fewer surface pollutants entering downstream waterbodies, 4) less stormwater runoff, 5) less need for detention ponds and other stormwater management practices, and 6) more recharge to water table aquifers.

Permeable paving techniques include pavement (Figure 144) and pavers (Figure 145). All permeable paving systems consist of a durable, load bearing, pervious surface overlying a crushed stone base that stores rainwater before it infiltrates into the underlying soil. Pervious pavements require maintenance. The holes that make the pavement pervious can become clogged with organics, plants, or sediments. Periodic removal of sediment is required, or the pavement will no longer be permeable. In Florida, because of the potential for plugging, pervious pavements are considered impervious when permitting and designing stormwater systems.

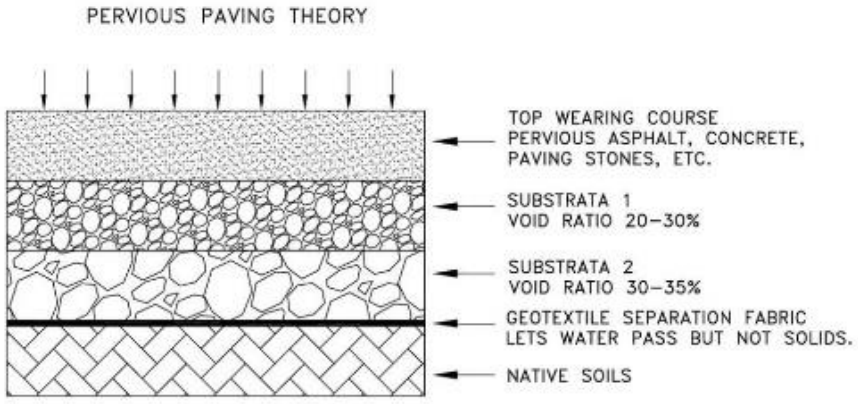
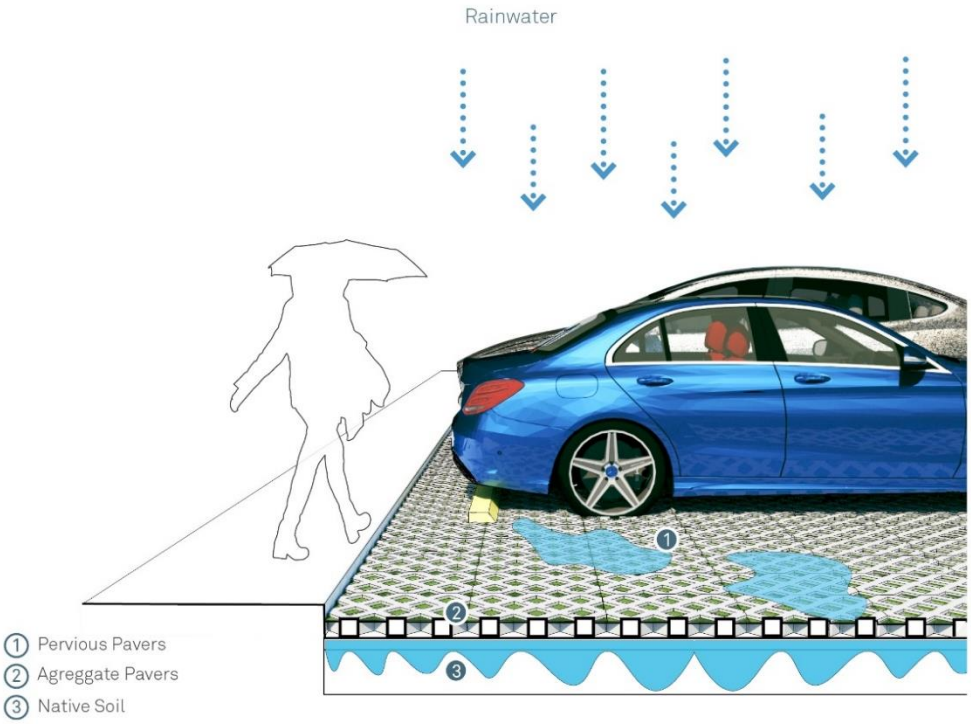


Figure 144. Pervious Pavement Detail

(https://www.grantspassoregon.gov/280/Pervious-Pavement-Alternative)

Figure 145. Example of a pervious paver driveway

Design considerations are summarized in Figure 146.



6. Pervious Paving

A pervious paving system includes a subsurface base made of course aggregate for stormwater storage. In some designs, pervious pavement is supported by underground layers of soil, gravel and sand to increase storage and maximize infiltration rates. Pervious paving removes sediment and other pollutants. It acts to reduce and distribute stormwater volume, encouraging groundwater infiltration. Multiple types of pervious paving, including modulated precast pavers, poured in place systems, porous asphalt, porous concrete, and gravel, offer varying levels of service. Reduction of the urban heat island effect is possible when using high-albedo, lightly colored systems.

Where it can applied
parking lots, patios, anything except paved roads due to traffic loading

Benefits
reduces roadway and parking lot flooding

Barriers to implementation
must be maintained via vacuuming or the perviousness fades after 2-3 years

Cost
$10-20/sf, requires bumpers and sub-base to maintain paver integrity

Figure 146. Design considerations, benefits, barriers, and costs for pervious paving

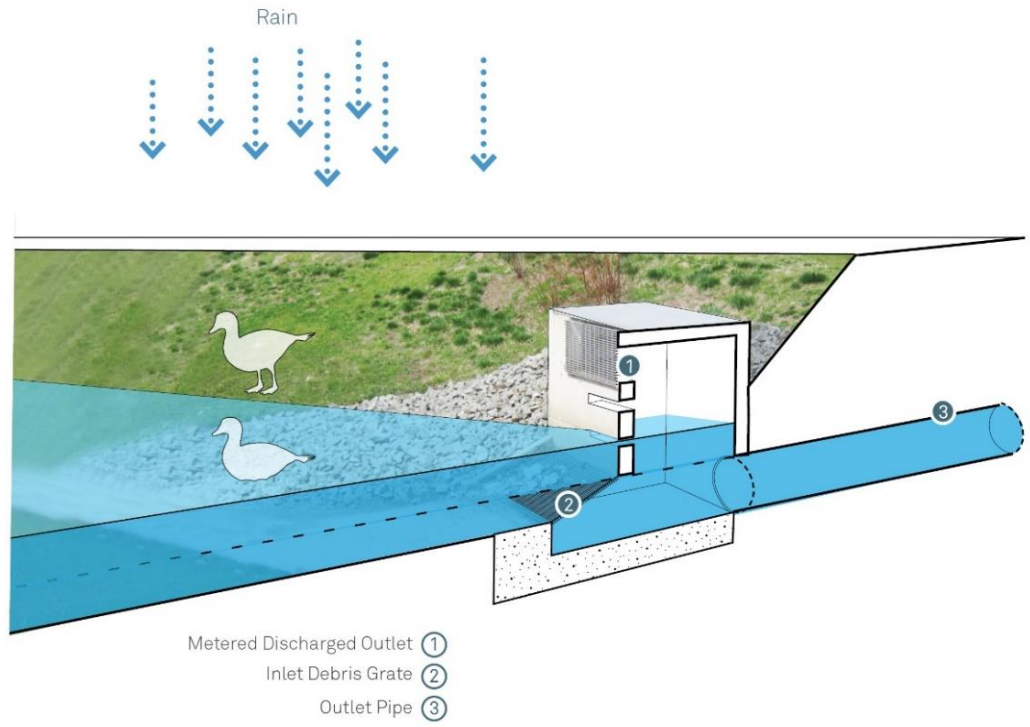
5.3.3 Detention

Already a requirement of the NWFWMD, detention ponds are widely used and designed for stormwater management applications. Detention is distinctly different from retention, which keeps the water on site, by releasing stormwater slowly with time to mimic the natural system or has an overflow (Figure 147). A detention basin will have an overflow that will go to an offsite stormwater conveyance system. The concept is to hold the water for a period of time and release it slowly back into the natural system. Effective detention designs dramatically reduce runoff rates, prevent most increases in flooding associated with new development, reduce run-off pollutants, and prevent erosion.

Figure 147. Detention basin with overflow

Detention basins are well developed from a technology perspective, widely used, and well understood. They are inexpensive to construct as long as the land is available. They will remove pollutants with limited added features. They do have two issues: 1) they tend to plug when not maintained, so to reduce ineffectiveness, mowing, aeration, and other maintenance needs are required; and 2) if the area is densely built with limited pervious surfaces present, the volume of

runoff may rapidly overwhelm the storage capacity of the basin. Design considerations are summarized in Figure 148.



7. Detention

Detention ponds are designed to completely evacuate water from storm events, usually within 24 hours. They primarily provide runoff volume control reducing peak flows that cause downstream scouring and loss of aquatic habitat. As a general rule, detention ponds should be implemented for drainage areas greater than 10 acres. On smaller sites it may be difficult to provide control since outlet diameter specifications needed to control small storm events are small and thus prone to clogging. Also, treatment costs per acre are reduced when implemented at larger scales.

Where it can applied
Common for new development, but difficult to retrofit; developer resist because it consumes land they could otherwise develop; limited to open areas

Benefits
Removes water from streets, reduces flooding

Barriers to implementation
Land availability, maintenance of pond, discharge location

Cost
$200k/acre

Figure 148. Design considerations, benefits, barriers, and costs for detention

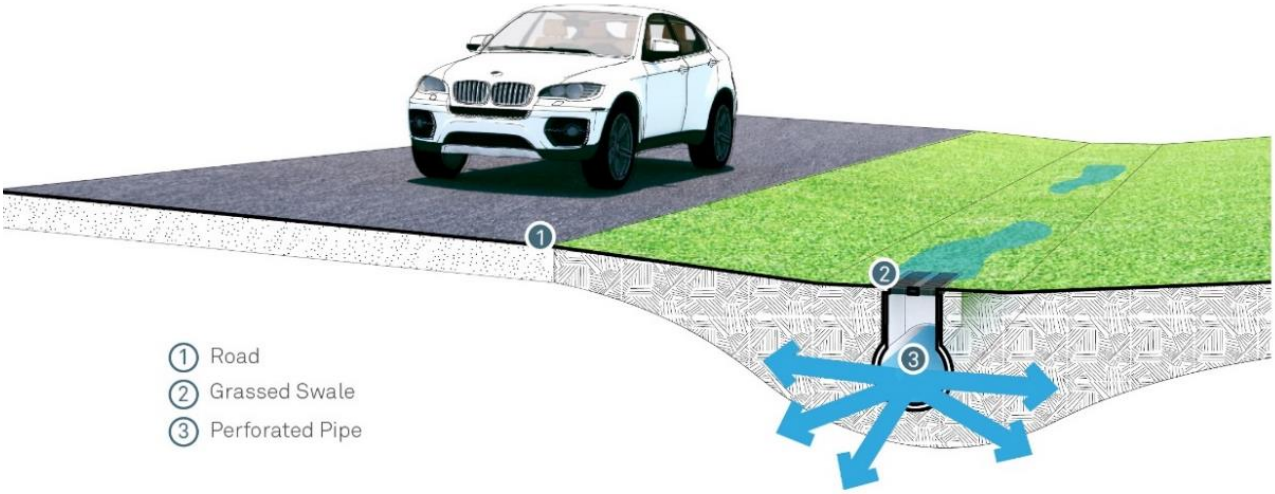
5.3.4 Exfiltration Trench

Exfiltration trenches work because the perforated piping is located above the water table, thereby allowing water to leak out; however, they cease to function if they are located below the water table. As the water table rises, exfiltration systems in low-lying areas will cease to work as they become submerged. Exfiltration trenches, or French drains, are commonly used in many areas of Florida, especially urban areas where the availability of ponds and retention areas is limited, and areas that have limited topography that limit storage options. The concept is simple: install a perforated pipe beneath the surface of a road, parking area, or swale, and have the drainage system empty to it. The difference in head between the surface of the drainage system and the water table, combined with the hydraulic conductivity of the soil, provides an indication of the amount of water that can be disposed of. The application is typically a 24-inch perforated pipe placed in a 4 ft gravel trench, laid fully above the water table to maximize the potential for water to exit the pipe and filter into the soil. The results of engineering calculations generally are characterized by the length of the trench required to dispose of a given volume of water.

Benefits of exfiltration trenches include that they are well developed from a technology perspective, widely used, well understood, and generally can dispose of large volumes of water, especially when large parts of the drainage system on-site are exfiltration trenches. They do have two issues – they tend to plug when not maintained, so to reduce maintenance, baffling is needed to prevent leaves and fines from entering the trench pipe. Unfortunately, this is only partially successful, so regular vacuum service is needed, which is difficult to implement. Second, if the area is densely built with limited pervious area, the volume of runoff may overwhelm the amount of water the soil can take. Recent rainfall and heightened water tables complicate exfiltration trench operation because the higher water tables cause them to work least efficiently when you need them most – rainfall at the end of the wet season. But they have value and function well.

The cost to install exfiltration trenches vary depending on the pipe trench width and depth. Typical costs are $150 per linear foot of trench/pipe installed. Developers routinely install them to reduce the amount of land required for retention ponds. They also will pull contaminants into the trench as opposed to allowing them to runoff to surface water bodies. That can also be an issue unless additional treatment is otherwise provided. Trenches do not work if not well maintained, in muck

soils and when the groundwater level inundates the trenches. In these circumstances, a better option is required. Design considerations are summarized in Figure 149.



9. Exfiltration Trench

Exfiltration trenches are particularly useful for sites with poorly-drained soils. Runoff gradually percolates through an engineered trench with amended soil over a period of days. Exfiltration trenches filter particulates as stormwater runoff moves through the media. Exfiltration trenches require less maintenance if upstream pre-treatment facilities like filter strips are used. Trees should not be planted near exfiltration trenches. These two actions reduce the potential for clogging the trench. Annual inspection is recommended to remove large debris and/or trash.

Where it can applied
Any low lying area where stormwater collects, and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways

Benefits
Excess water drains to aquifer, some treatment provided

Barriers to implementation
Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits

Cost
$250/lf

Figure 149. Design considerations, benefits, barriers, and costs for an exfiltration trench

5.3.5 Central Sewer Installation

As noted previously, less a stormwater issue than an operational solution for addressing septic tanks that will not function when flooded. Central sewers are regulated, and programs are in place to monitor them for breaks, leaks, and at the end of the pipe, treatment. They provide better protection to the environment and protect groundwater and adjacent water bodies. The concept is to use gravity lines to collect sewage from customers and convey it to a central treatment facility. Disposal can include many options including reuse for irrigation.

Installation of central sanitary sewers has been a standard practice for over 100 years, but many older developments in remote areas are still on septic tanks. In Florida, there are about 2.8 million septic tanks (FDOH, 2020). The challenge is that on-site treatment and disposal systems such as septic tanks may only work when the drain field is above water, thereby permitting soil treatment of the discharged water in the vadose zone. These systems do not function properly when the water table is high, and the discharge is essentially injected into the near-surface aquifer without treatment and often finds its way into local surface water bodies. Results from observing septic and sewer areas by FAU in Taylor County, demonstrate that there is an ongoing release of contaminants during the seasonal high water table elevation event (Meeroff and Morin, 2005; Meeroff, Morin and Bloetscher, 2007; Bocca, Meeroff and Bloetscher, 2007; Meeroff, Bloetscher, Bocca and Morin, 2008; Meeroff, Bloetscher, Long and Bocca, 2014). As a result, septic systems have the potential to contaminate certain stormwater infrastructures (exfiltration, infiltration pipelines), thereby making water quality permitting options more difficult.

Replacement of septic tanks with central sewer is problematic given that it can cost up to $20,000 per residential connection to install sewers and remove the old septic tank (not including sewer connection charges), which creates a challenge for residents and a difficult decision for public officials. Design considerations are summarized in Figure 150.

15. Central Sewer Installation

On site treatment and disposal systems such as septic tanks may only work when the drainfield is above water, thereby permitting soil treatment of the discharged water in the vadose zone. These systems do not function properly when the water table is high and the discharge is essentially injected into the near surface aquifer without treatment and often finds its way into local surface water bodies.

Where it can applied
All areas where there are septic tanks. Mostly a water quality issue

Benefits
Public health benefit of reducing discharges to lawns, canals and groundwater from septic tanks

Barriers to implementation
Cost, assessments against property owners, property rights issues

Cost
$15,000 per household

Figure 150. Design considerations, benefits, barriers, and costs for central sewer installation

5.3.6 Armored Sewer Systems

One challenge with central sewers is the potential for infiltration/inflow (I/I) due to saturated soil conditions and infrastructure structural issues (e.g., broken pipes, deteriorating pipes) will need to be addressed. Infiltration (Figure 151) is a direct result of groundwater that migrates into the pipes due to the pipes being underwater in low-lying areas, which is the normal situation for most of coastal Florida. Most utilities have peaks, which are likely to become larger if climate change results in increased rainfall volume. Peaks are caused by inflow during rain events – generally surface connections. Reducing infiltration and inflow reduces the demands on wastewater plants, frees capacity, and limits chlorides, which can make reuse disposal options a challenge. It will also reduce the pump run times on lift stations due to lower flows.

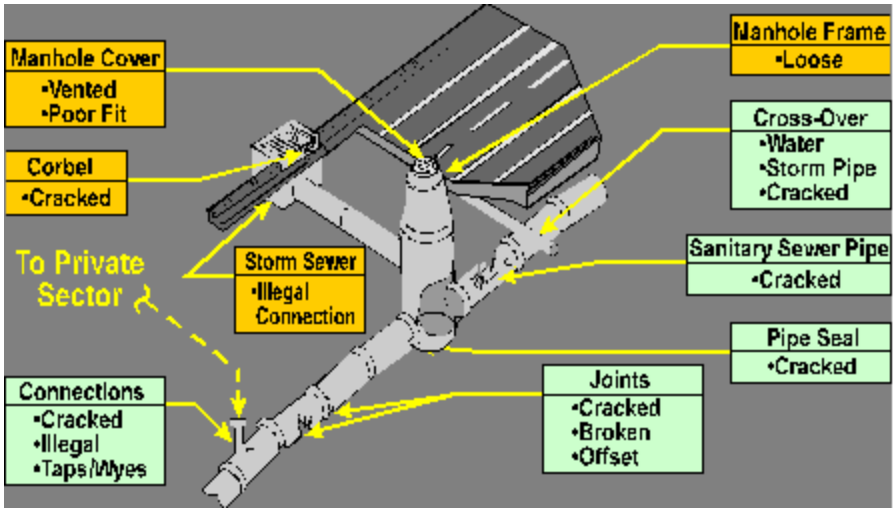


Figure 151. Potential infiltration and inflow areas (Bloetscher, 2008)

It is estimated that there are over one million manholes in Florida, nearly all of which are located in areas vulnerable to flooding. New sanitary sewer systems will need to be designed and installed to meet predicted future conditions that could include increased infiltration potential resulting from either change in rainfall patterns or sea level rise. New and existing systems will need to adapt to these different hydrologic conditions.

Sewer service lines may be damaged (a common occurrence in the rest of the state). As a result, services may cause infiltration issues that will be found in a low-flow inspection. There are no limits to implementation other than costs. The cost to seal manholes is estimated at

$100/manhole with other improvements such as chimney seals (Figure 152), LDL plugs (Figure 153), rain dishes (Figure 154), and ancillary corrections to service lines on both public and private property. A full inflow removal program is on the order of $500/ manhole, which will reduce costs associated with infiltration and generally pays for itself. The improvements will function until the area is fully inundated, and development moves elsewhere. It is a robust improvement that will last for years but does require ongoing upkeep as the system deteriorates with time.

Figure 152. Chimney seal installed (Courtesy USSI)

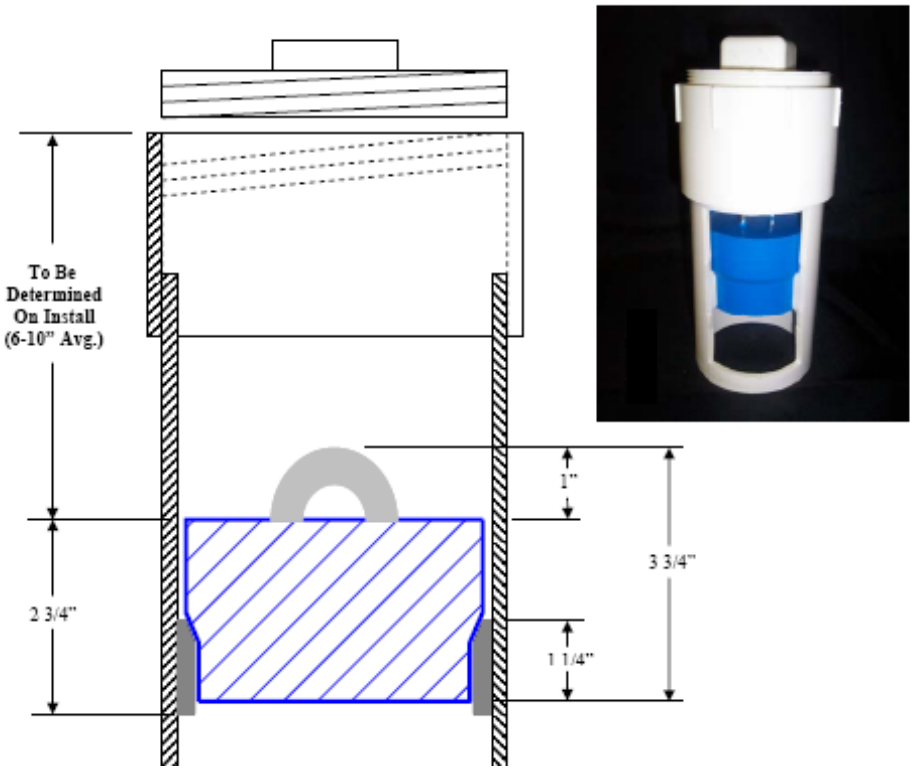
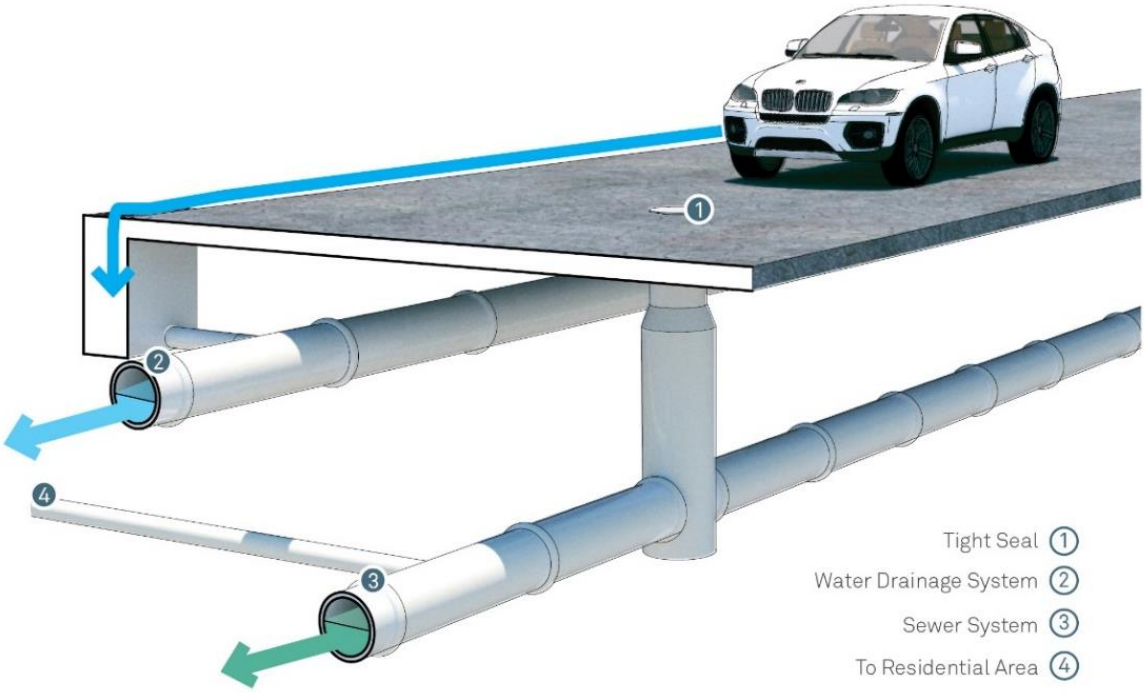


Figure 153. LDL plug design (Courtesy USSI)

Figure 154. Inflow defender manhole rain dish (Courtesy USSI)

Design considerations are summarized in Figure 155.



22. Armoring Sewer System

Increased infiltration/inflow (I/I) due to saturated soil conditions and infrastructure structural issues (e.g., broken pipes, deteriorating pipes) will need to be addressed. Infiltration is a direct result of groundwater that migrates into the pipes due the pipes being under water, which is the normal situation for most of coastal Florida. Most utilities have peaks, which are likely to become larger if climate change results in increased rainfall volume. Peaks are caused by inflow during rain events – generally surface connections. Reducing infiltration and inflow reduces the demands on wastewater plants, frees capacity, and limits chlorides, which can make reuse disposal options a challenge. It will also reduce the pump run times on lift stations due to lower flows.

Where it can applied
Any area where gravity sanitary sewers are installed, which is most of the City

Benefits
Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows. Major public health solution

Barriers to implementation
limited expense beyond capital cost

Cost
$500/manhole

Figure 155. Design considerations, benefits, barriers, and costs for armoring sewer systems

The protocol for identifying breaches in the system that lead to infiltration/inflow include:

- Inspection of all sanitary sewer manholes for damage, leakage, or other problems all documented in a report that identifies the problem type, location, and recommended repair.
- Repair the flow path in the bottom of the manhole (bench) in poor condition or exhibiting substantial leakage.
- Repair manhole walls in poor condition or exhibiting substantial leakage.
- Repair/seal chimneys in all manholes to reduce infiltration from the street during flooding events.
- Install dishes in all manholes to prevent infiltration.
- Install LDL™ plugs where manholes in the public right-of-way or other portions of the utility's system are damaged.
- Identify sewer system leaks, including those on private property (via sewer smoke testing on private property).
- Perform a low-flow inspection.

5.3.7 Pump Stations

In urban areas, stormwater collection and management systems may need to be redesigned and expanded to increase capacity since the current capacity is not likely to address new peaking factors associated with climate change. In low-lying areas, exfiltration trenches and other pipes are already inundated. As a result, a more consistent solution is required, which usually involves pumping. The concept is simple: drain the stormwater to a central area, install a pump, and move the water to another place (or waterbody). Pump stations are commonly used, are reliable, and can protect property. Emergency generators are often required to ensure operation during electrical power disruptions.

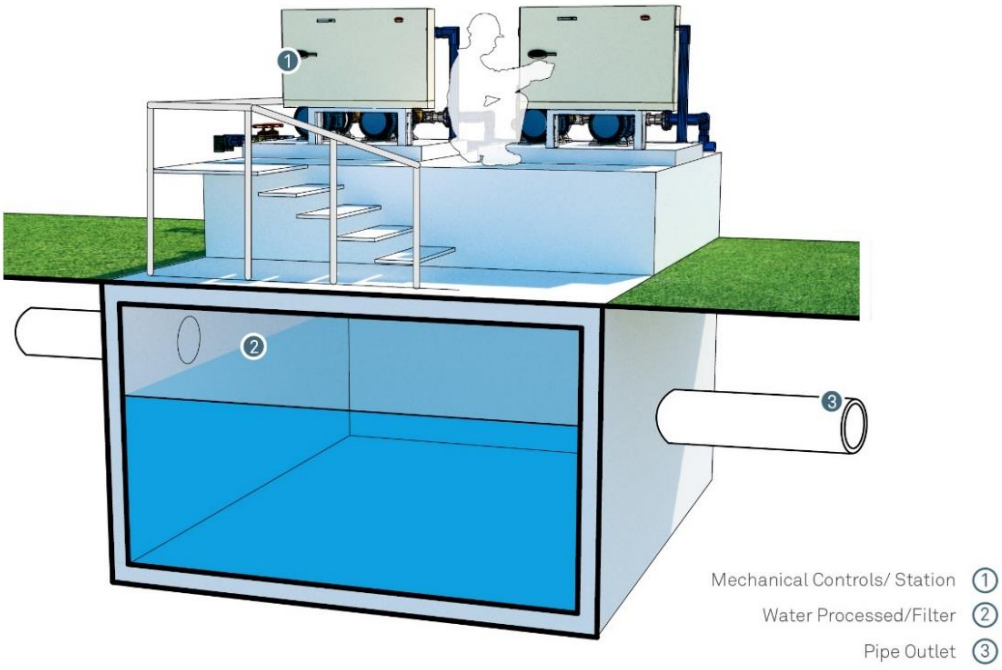
Pumping is a preferred strategy when retention areas and exfiltration are not feasible. The difference in head between the surface of the drainage system and the water table is not relevant as the only issue is that the receiving waterbody is lower than the pump to prevent backflow. The amount of pumping is proportional to the area served and the design storm of concern. The pump station demand will increase with time as groundwater levels rise, precipitation becomes more

intense, or water crosses the sea walls. Hence pumping stations must be designed to be expanded or they will have to be replaced.

The cost of pump stations starts at $250,000 and increases with demands and area served. Developers routinely install them when retention ponds cannot be constructed. Pump stations do not remove contaminants in and of themselves. Treatment can be added at the station with increased cost and maintenance. A bigger issue is water quality impacts on the receiving waterbody. It should be noted that water quality is sensitive to increased water temperatures, changes in patterns of precipitation, and changes in pollutant loadings. Note that pump stations are generally used with floodwalls or levees to protect smaller more densely populated areas or critical assets. They are generally cost prohibitive when dealing with large areas where the site can't be isolated from runoff from off-site.

Water quality impacts on surface waters are currently difficult to quantify. There are no current hydrologic observing systems for purposes of detecting effects on water resources, and limited studies of hydrologic trends in the southeast of Florida have been completed. Lower flows in streams during the summer and fall could substantially reduce available dilution in those streams, thereby concentrating salts and other pollutants. Temperature and nutrients will reduce dissolved oxygen (by increasing temperature and increasing metabolism). As a result, it may become more difficult to meet or maintain current surface water quality standards for receiving water bodies.

Pumping is one of the more robust solutions for dealing with runoff and sea level rise. Larger stations will be needed, employing more power, and requiring more maintenance. Studies for individual neighborhoods will be required to identify such needs. At some point, pump stations will cease to work when an area is completely inundated by coastal water bodies. Design considerations are summarized in Figure 156.



21. Pumping Station

In urban areas, stormwater collection and management systems may need to be redesigned and expanded to increase capacity since current capacity is not likely to address new peaking factors associated with climate change. In low lying areas, exfiltration trenches and other pipes are already inundated. As a result, a more consistent solution is required, which usually involves pumping. The concept is simple: drain the stormwater to a central area, install a pump, and move the water to another place (or water body). Pump stations are commonly used, are reliable, and can protect property. Emergency generators are often required to insure operation during electrical power disruptions.

Where it can applied
Regional (WMD) or Local Responsibility

Benefits
Creates regional system to use coastal ridge to protect inland property, keeps saltwater out

Barriers to implementation
SFWMD, western residents, private property rights arguments

Cost
$200 million ea

Figure 156. Design considerations, benefits, barriers, and costs for pump stations

5.3.8 Sea Walls

Sea walls have been successfully used as a means to protect areas of human habitation, conservation, and leisure activities from the action of tides, waves, or tsunamis. Historically they have been made of many different materials, from monolithic concrete barriers, brick or block walls, rubble mound structures, or steel sheet pile walls. They are naturally, heavily engineered, permanent structures that are costly to design but are a common site along the Florida coastline. The physical design of sea walls is highly variable; they can either be sloping or vertical and made from a wide range of materials. The design and the texture of the walls also have a significant impact on its performance. For example, while a smooth surface reflects wave energy better, irregular surfaces, on the other hand, disperse the direction of the waves better. Typically, the seawalls must have a deep foundation to enhance their stability. Also, earthen anchors are mostly buried deep into the land and connected by rods to the wall to help it overcome pressure from the landward side. Design considerations are summarized in Figure 157. The anchors are not appropriate for fill which is the case on most island and coastal communities. Deeper foundations are needed which cost more.

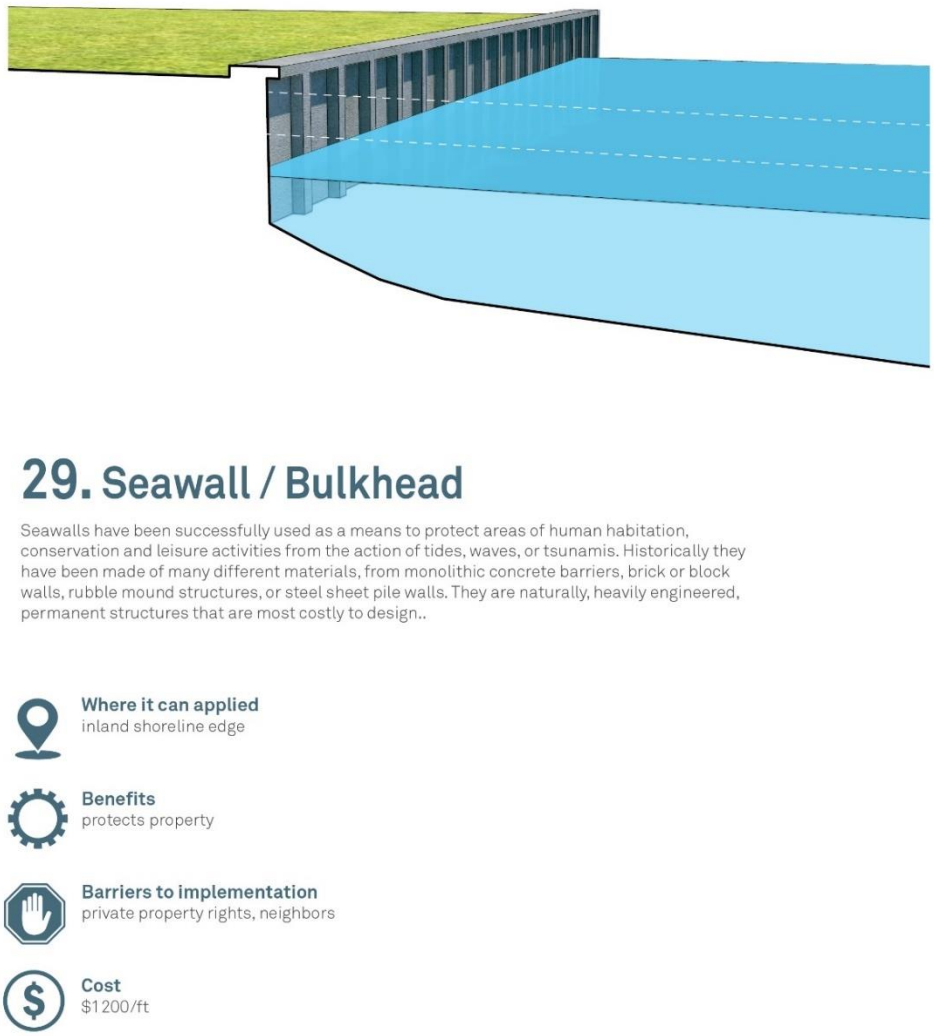


Figure 157. Design considerations, benefits, barriers, and costs for seawalls

The concept of sea walls is to prevent the property from flooding (Figure 158). Figure 159 shows the concept. However, as the sea rises, these walls may get overtopped. 8 ft is the minimum elevation suggested for the 2100 timeframe.

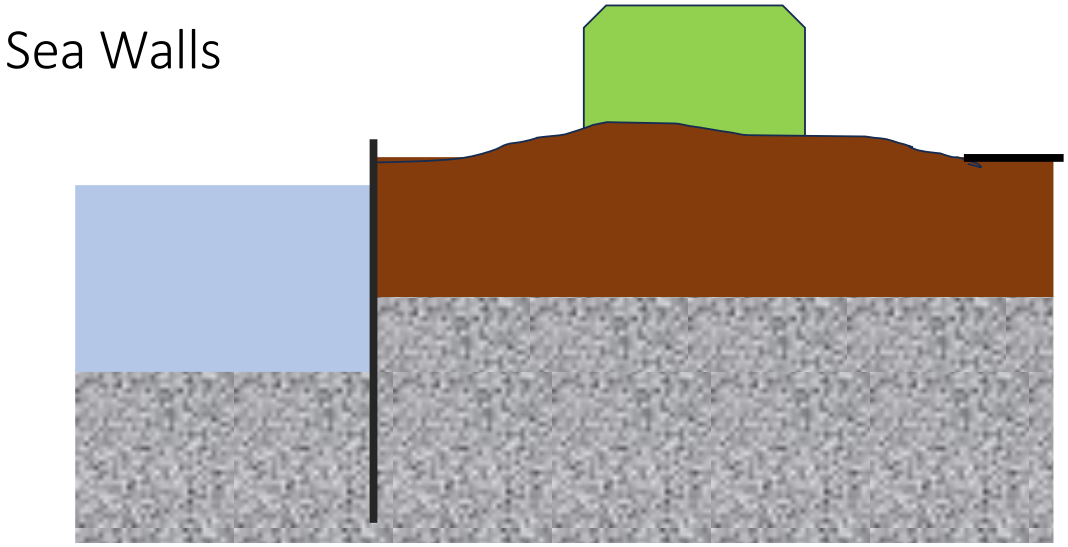


Figure 158. Sea Walls protect adjacent property

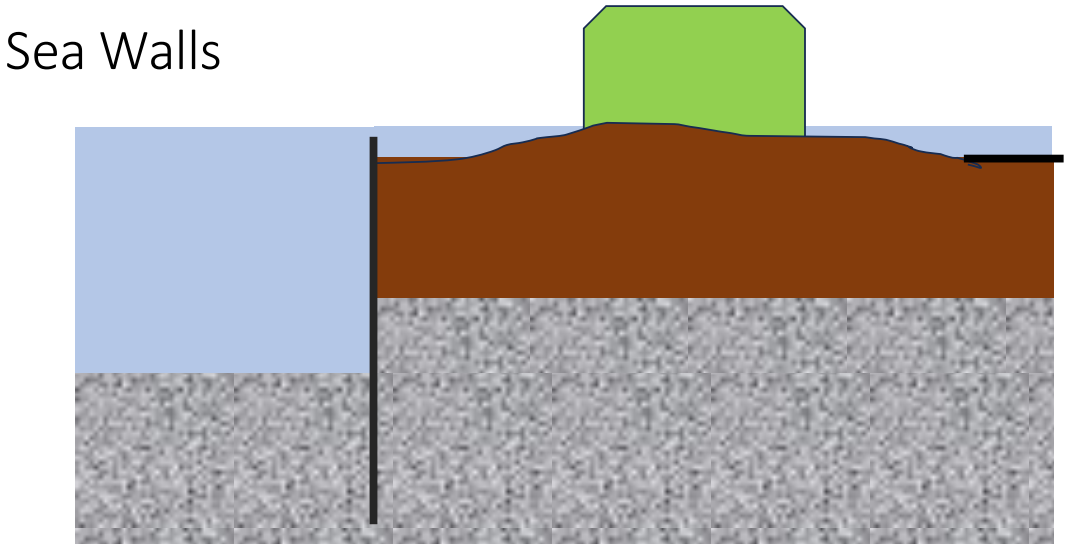


Figure 159. Sea walls will create flooding that cannot easily be removed if topped

There are challenges to sea walls and many of them are structurally deficient. As a result, they will not suffice for current conditions let alone future ones. Increasing sea wall height is needed but potentially requires policy adjustments and many current sea walls will not be structurally sufficient to add height. Failure of any sea walls invalidates all others on the same water body.

Another issue concerning sea walls are that stormwater conveyance pipes that run through the sea walls to drain roads (see Figure 160) can often time backflow into the adjacent streets (Figure 161). Hence the apparent flooding may be sea level or king tide induced. Tideflex and other companies have options to prevent backflow (Figure 162). All require periodic maintenance, especially in marine environments. Where sea walls may not be adequate to connect the valve inserts (Figure 163) are required – see the final installation in Figure 164. Consequentially, road base failures can result from failure to install these backflow devices.

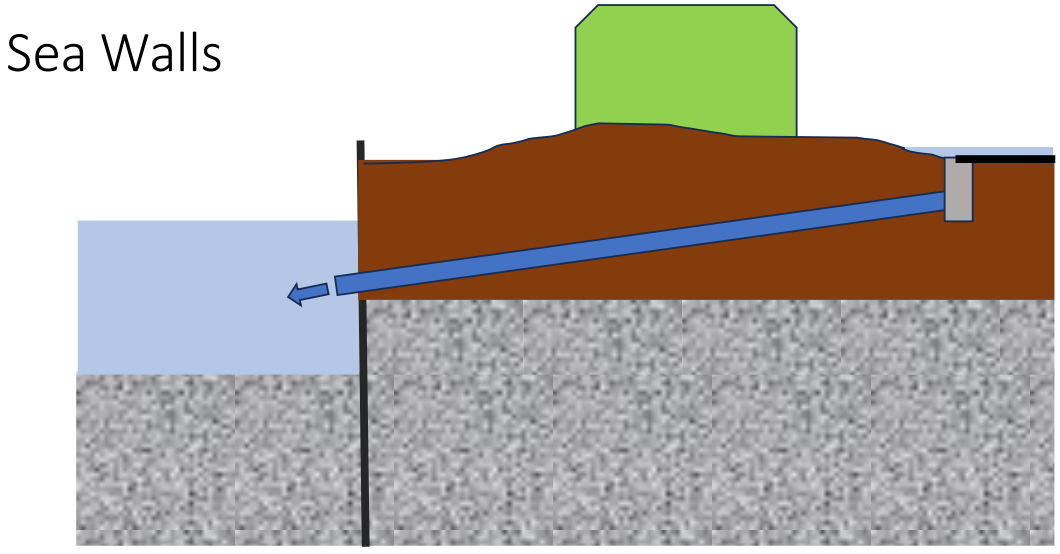


Figure 160. Storm Drains from Roads through Sea Walls

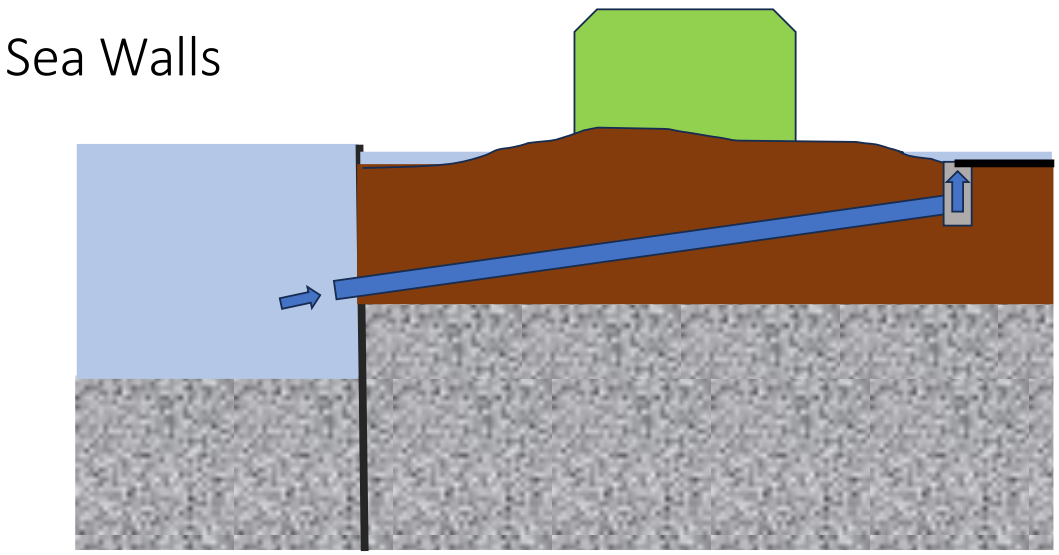


Figure 161. Storm Drains flow backward in coastal areas when tides or sea level rise

Figure 162. Tideflex Backflow Valve

Figure 163. Sea wall insert for Tideflex valve

Figure 164. Completed Tideflex installation with insert

5.3.9 Roadway Base Protection

Figure 165 shows the road base as intended to be developed with the water table below the base. Then the water tale rises (Figure 166), the fines within the base material move, causing the base to shift which then causes the pavement to flex as traffic moves on it. Cracks in the crown will develop; the first major indication that the base, not the pavement has failed. Geotextile and other means to prevent the movement of fines or intrusion of water are necessary.

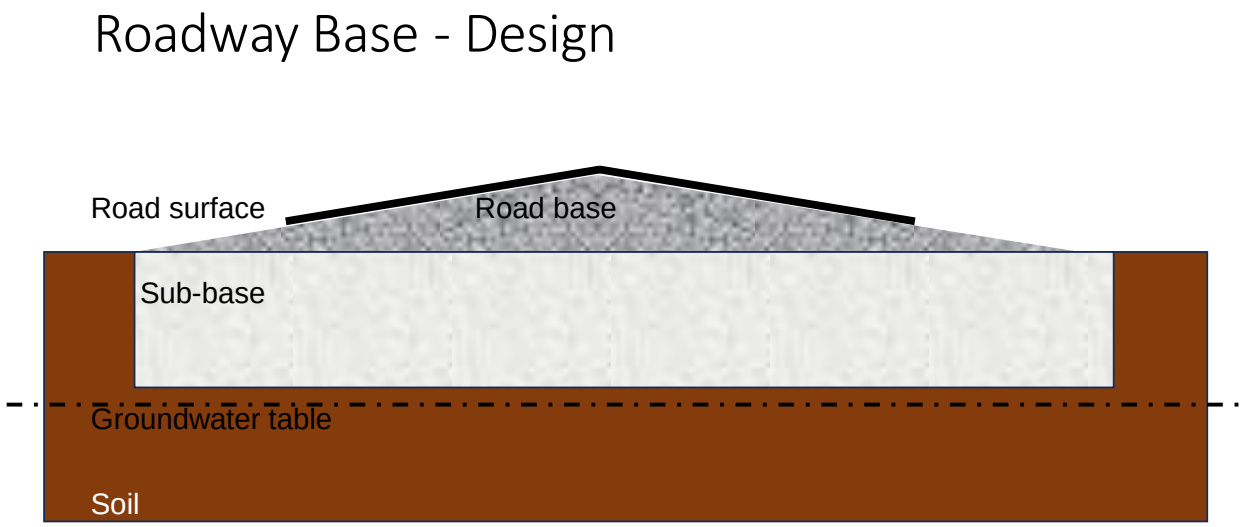


Figure 165. Roadways as intended to be constructed

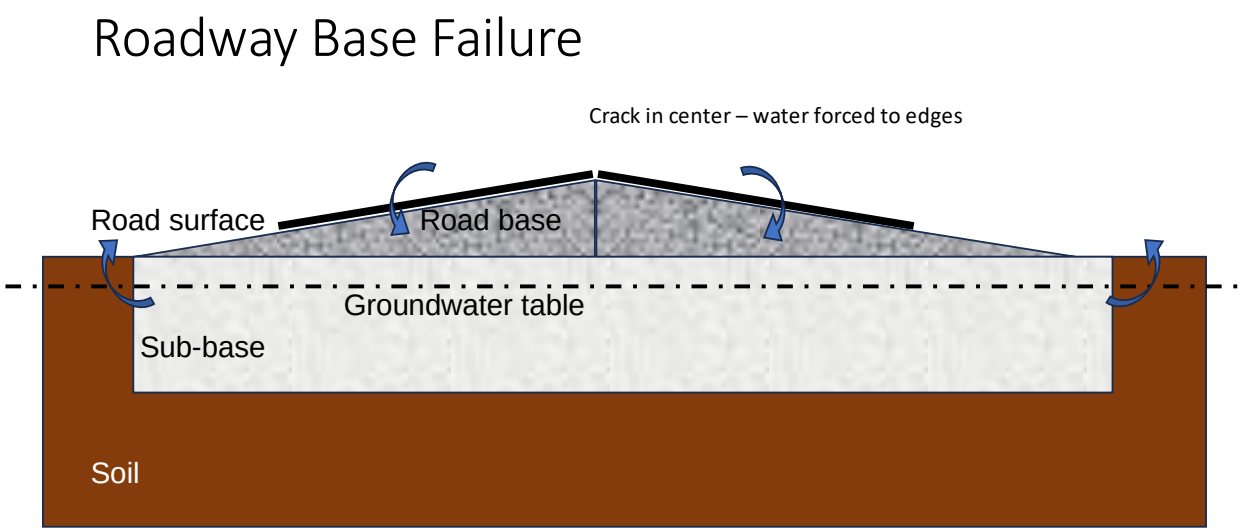
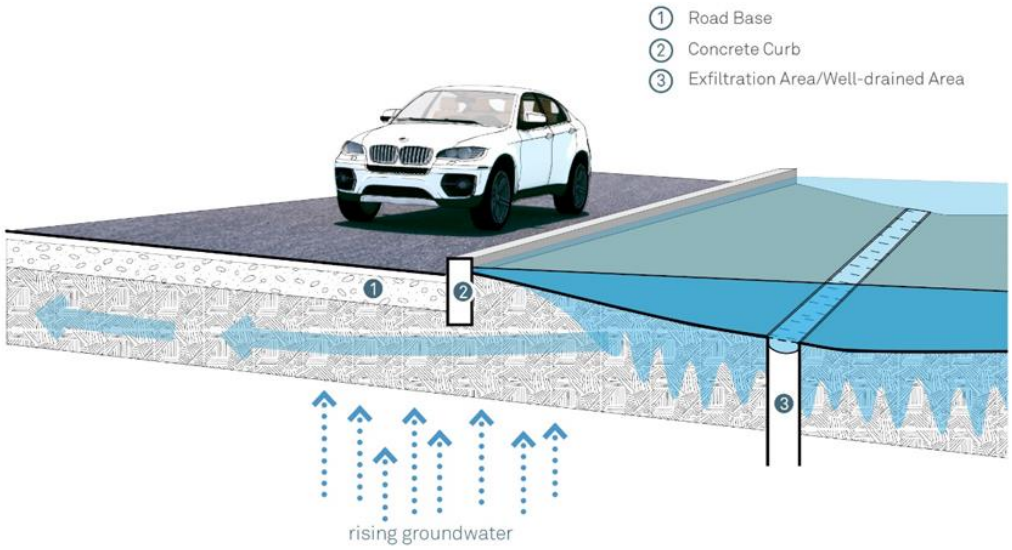


Figure 166. Roadways once the base gets wet and longitudinal cracks develop at the crown

Because it is critical to protect the roadway base, all efforts should begin with providing the base with adequate drainage systems to meet future conditions. At present, most base courses are installed above the water table. As long as the base stays dry, the roadway surface will remain stable. The costs for roadway base protection systems could exceed $1 million per lane-mile in 2000. Design considerations are summarized in Figure 167.



35. Roadway Base Protections

Because it is critical to protect the roadway base, all efforts should begin with providing the base with adequate drainage systems to meet future conditions. At present, most base courses are installed above the water table. As long as the base stays dry, the roadway surface will remain stable. As soon as the base is saturated, the roadway can deteriorate. As water levels rise, well point systems may need to be installed for more permanent drainage. However, well point water is usually turbid--containing sand, other particles, and contaminants from runoff, which requires an offsite discharge zone. The costs for such systems could exceed $1 million per lane mile.

Where it can applied
all roadways should consider protections, especially in low-lying areas

Benefits
reduced maintenance and longivity of roadway

Barriers to implementation
cost considerations

Cost
$1 million/mile

Figure 167. Design considerations, benefits, barriers, and costs for roadway base protections

5.3.10 Adaptive Land Use Practices

The use of low-impact development (LID) techniques to delay peak stormwater runoff and reduce total runoff can be a cost-effective option to consider from a land use perspective (Figure 168). In the long-term, development policies may need to include the 50- and 100-year vision of development, which may include runoff reduction strategies within the ordinances. This policy highlights a potential conflict point where the long-term tax base will depend on securing future protection, yet any development restrictions can potentially reduce the tax base. The County is aware that this is a delicate issue, and one that the County intends to take a critical, but balanced, look at. Additional development in flood-prone areas should not be permitted without local solutions. State and local agencies have been averse to such regulations due to private property rights arguments. However, certain properties may have value to local governments for various purposes (storage of stormwater for example or mangrove forests to counter waves). However, any policy decisions will need to be addressed in an intentional and careful manner.

34. Changes in Land-Use Practices

Reduced development and the migration of development in these areas should be a priority in local communities. The use of low impact development (LID) techniques to delay peak and reduce stormwater runoff can be a cost-effective option to consider from a land use perspective. Longer term, development policies will need to include the 50- and 100-year vision of development and require developers to include hardening within ordinances. Additional development in flood prone areas should not be permitted without local solutions. With time, at-risk property values will diminish due to the lack of ability to secure insurance and financing. The property may have value to local governments for various purposes (storage of stormwater for example or mangrove forests to counter waves). However, this is a policy decision that is likely years out.

Where it can applied
all low-lying and upland areas that are prone to flooding

Benefits
retention/filtration/infiltration/treatment

Barriers to implementation
conventional practices create obduracy

Cost
Varies

Figure 168. Design considerations, benefits, barriers, and costs for changes in land use practices

5.3.11 Policy Changes (to land uses)

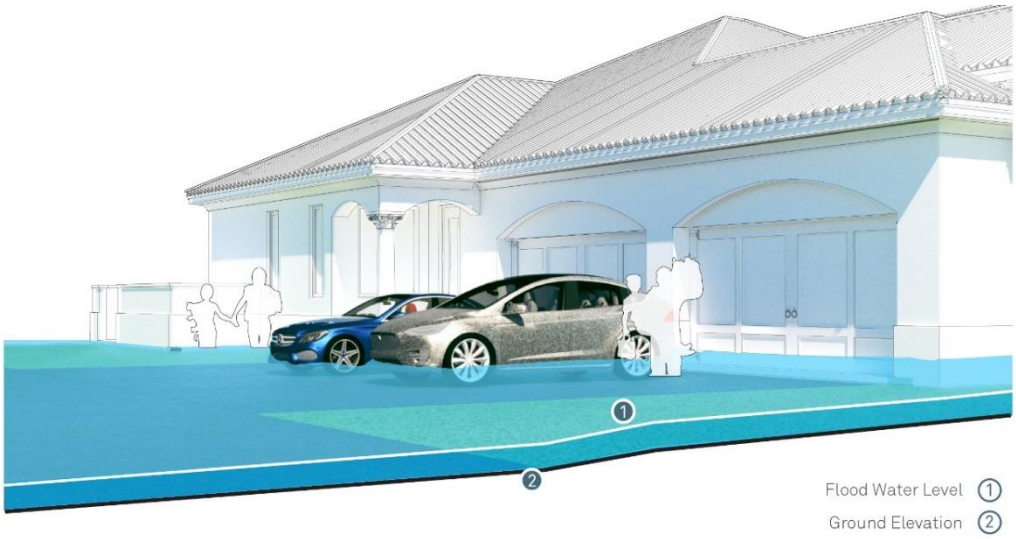
This option is wide ranging, from changes to zoning, requirements to elevate properties, and Eminent Domain of property. These solutions are site specific and designed to reduce the potential for flooding in the community. This would apply only where property could not be protected from flooding without changes to the property. Elevation issues are common in low-lying coastal areas (Figure 169).

Eminent Domain of property creates major issues with property rights. If properties were to be obtained in this manner, adjacent properties could be affected. The domino effect of this practice could suggest a lack of stability in the community, leading to lower property values, loss of taxable property and a loss of tax base. Reference Figure 169.

Figure 169. Policy Changes

5.3.12 Flood-Prone Property Acquisition

The loss of wetlands and other coastal ecosystems diminishes the ability to store water or to provide areas to direct excess precipitation to avoid flooding. Conservation of land to prevent development over areas where stormwater may collect, in floodplains and low areas should be a land use priority. While the NFIP and FEMA will not prohibit development in a flood zone, local officials have the capacity to enhance restrictions on land development and to acquire properties that are repetitive losses. The goal is to remove land that is subject to flooding from development pressures. Landowners may willingly sell property and may be compensated for losses incurred and zoning that prevents redevelopment. These are costly options, as acquisition of developed property can be a major cost. However, the benefits of not having to protect such properties may prove to have a positive long-term outcome. Reference Figure 170.



17. Flood Prone Acquisition

The loss of wetlands, mangroves and other coastal ecosystems diminishes the ability to store water or to provide areas to direct excess precipitation to avoid flooding. Conservation of land to prevent development over areas where stormwater may collect, in floodplains and low areas should be a land use priority. While the NFIP and FEMA will not prohibit development in a flood zone, local officials have the capacity to enhance restrictions on land development and to acquire properties that are repetitive losses. The goal is to remove land that is subject to flooding from development pressures. Landowners may willingly sell property, may be compensated for losses incurred and zoning that prevents redevelopment and a host of other options. These are costly options, as acquisition of developed property can be a major cost. However, the benefits of not having to protect such properties may prove to have a positive long-term outcome.

Where it can applied
Regional agency - could be any low lying areas

Benefits
removes flood prone areas from risk areas

Barriers to implementation
difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition

Cost
$200k-$1 million/acre depending on where it

Figure 170. Design considerations, benefits, barriers, and costs for flood prone acquisition

Table 10 outlines the options discussed in this section. Much of the coastal communities favor natural solutions over structural changes like sea walls. For Walton County these options are viable. Likewise long-term policies may be a valuable alternative to hard solutions.

Table 10. Summary of Gray and Green Infrastructure Options

Strategy Class	Implementation Strategy	Applications	Benefits	Cost (2000)	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition

Strategy Class	Implementation Strategy	Applications	Benefits	Cost (2000)	Barriers to Implementation
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

5.3.13 Policy Development

There are policy changes that can help long-term. An example policy for an adaptation element for sea level rise impacts is included in Appendix B. Modeling indicates that a tipping point exists between 2-3 feet of sea level rise, as this is the point where most current sea walls will be overwhelmed since the average height is only 3 – 3.5 feet high in most coastal communities. Therefore, despite the local sentiment to avoid creating structural solutions that might disrupt waterfront views, the following are long-term policy change recommendations for the community to consider:

1. Increase the finished floor elevation minimum height for all new construction to 2 feet freeboard above the flood elevation.
2. Upon reaching 1 foot of sea level rise above current levels, increase the finished floor elevation again by 1 foot and continue that pattern. An increase in 1 foot in sea level is likely at least 30 years away. Since housing averages less than 50 years before demolition and rebuilding in Florida, this would permit a gradual increase in finished floor elevations without negatively impacting an excessive number of residents at any one time.
3. Require sea walls that need to undergo major repairs to be replaced with new sea walls that are at the finished floor elevation, and that are designed to permit a 2-foot cap being placed upon them in the future. The approach is to increase sea wall requirements incrementally at the same time the finished floor elevation increases, as described in #2 above.
4. Create an inventory and conditions assessment of all stormwater infrastructure.
5. Review stormwater funding mechanisms to ensure enough revenue is being created to support near and long-term efforts.
6. Develop a program to prevent the inflow of seawater into the streets. The flooded streets will cause the road base and pavement to fail faster, increasing maintenance costs. How the County accomplishes this can be determined with time, but increasing maintenance costs to the roads will reach a tipping point. To that end, roadway bases may need to be rebuilt to better accommodate the higher groundwater elevations.

5.4 Capital Improvement and Financing Plan

Once the vulnerability assessment and mitigation measures have been determined, the next step is to implement the plan to address these issues. Often it is possible to add mitigation measures to existing capital improvement programs that infrastructure agencies are already spending money to operate and maintain. Agencies involved in flood protection are no different, they all

spend money on operations, debt, and capital. These factors are brought together in annual budget documents which are a necessary part of operations and are statutorily required for most jurisdictions. In most cases, all infrastructure agencies should be set up as an enterprise fund with a stormwater user fee or assessment to allow the organization to pay its way, which will also make it easier to evaluate the operational aspects of an infrastructure system.

Coordination between the financial, budget, and operating policies of a utility system allows managers to properly allocate costs to those benefiting from the service, develop pricing strategies that can be clearly explained to the public and prevent challenges to allocation methodologies. Operations, capital programs, and long-term variability of the utility system operation require financial and facility planning. Multi-year economic forecasts and financial plans are standard tools in business and are worthy of consideration by watershed and flood protection agencies.

An example process that USEPA (2013) suggests for capital plans is:

1. "Inventory existing management efforts in the watershed, considering local priorities and institutional drivers
2. Quantify the effectiveness of current management measures
3. Identify new management opportunities
4. Identify critical areas in the watershed where additional management efforts are needed
5. Identify possible management practices
6. Identify relative pollutant reduction efficiencies
7. Develop screening criteria to identify opportunities and constraints
8. Rank alternatives and develop candidate management opportunities"

From this process, a best practice is to develop a prioritized project list.

5.4.1 NWFWMD/USACE Regional Capital Improvement Projects

Florida has designated consistent funding for restoration through the Legacy Florida Act (Laws of Florida, Chapter 2016-201) and the Water Resources Law of 2017 (Laws of Florida, Chapter

2017-10, Senate Bill 10) and through the advancement of other projects. However, there are no projects in the five-year horizon in Walton County.

5.4.2 County-Wide Capital Improvement Projects

Walton County has about $2.6 million in improvements in their capital improvement program for drainage and drainage related issues. Some are state appropriations. The South Walton taxing district has a few projects on the beachfront. The remaining projects are really more maintenance from ad valorum taxes. Table 11 shows the funding for County's 5-year capital plan. The cost, the scale (regional or local), and an estimate of the risk and vulnerability are used to create a composite score for prioritization via the geomean of the two factors. Specific details can be found in the community capital plans.

The County needs to develop a long-term capital plan for stormwater drainage. In addition, there needs to be an assessment of existing infrastructure and how it may impact flooding. For example, a site on Longleaf Circle is a 4x repetitive loss property. Looking at the road, there is a ditch that connects to high catch basins and appears to flow west, away from the adjacent conveyance system, and is cut off from a positive outfall.

5.4.3 Local Capital Improvement Projects

Table 11 outlines the capital plans for the Walton County vicinity from potential entities impacting the watershed.

Table 11. Capital plan and prioritization estimate

Problem	Goal	Project Name	Budget	Status	Start	Funding	Scale	Risk	Consq	Score
Flooding/Road improvement	improve drainage	Old Town of Santa Rosa Regional Stormwater Management Facility and Event Venue Project (Nellie Drive Connector Road/SW Facility)	$1,200,000	Design	12/01/2022	State Funded Project (SCOP, SCRAP, CIGP, State Appropriations)	Local	1	1	1
Flooding/Road improvement	improve drainage	Old Seagrove Roadway & Drainage Improvements	$400,000	Design	6/12/22	State Funded Project (SCOP, SCRAP, CIGP, State Appropriations)	Local	1	1	1
Flooding/Road improvement	improve drainage	Allen Loop Drainage	$86,775	Design	04/12/2016	South Walton TIF Capital Improvement Projects	Local	2	1	1.75
Flooding/Road improvement	improve drainage	Blue Gulf Resort Roadway & Water Quality Improvements	$130,000	Design	07/20/2021	South Walton TIF Capital Improvement Projects	Local	2	1	1.75
Flooding/Road improvement	improve drainage	Driftwood Point Road Drainage	$70,000	Design		South Walton TIF Capital Improvement Projects	Local	2	1	1.75
Flooding/Road improvement	improve drainage	Fox Lake Drainage and Water Quality Improvements	$100,000	Design	12/10/2020	South Walton TIF Capital Improvement Projects	Local	2	1	1.75
Flooding/Road improvement	improve drainage	Norwood Drive, Open Gulf, Sand Trap Drainage Improvements	$100,000	Design	9/28/21	Ad Valorum	Local	1	1	1
Flooding/Road improvement	improve drainage	Walton Magnolia Lane Drainage	$147,163	Design	3/24/22	Ad Valorum	Local	1	1	1
Flooding/Road improvement	improve drainage	Old Seagrove Roadway & Drainage Improvements	$400,000	On hold until final neighborhood plan has been received	Tbd	Tbd	Local	1	1	1

Table 12 Walton County Roadway Capital Plan (which may include drainage projects as a part of the roadway design)

WALTON COUNTY ENGINEERING & PUBLIC WORKS DEPARTMENT
5 YEAR WORK PLAN
FY 24- FY 28
PRESENT DAY COSTS
BCC ADOPTED FEBRUARY 27, 2024

Project ID No.	Project Name/Limits	General Location	County Commissioner District	Phase	FUNDING SOURCE	2024	2025	2026	2027	2028	NOTES
1	13th Street Roadway & Drainage Improvements	Santa Rosa Beach	5	PD&E							
				ROW							
				DESIGN	FY 22/23 SWIF & Restore Act	$162,958					
				CONSTRUCTION/CEI	FY 26 SWIF (In-house)			$300,000			
2	Alderberry Connector Rd Extension	South Walton	4	PD&E							
				ROW							
				DESIGN	FY 27 SWIF				$600,000		
				CONSTRUCTION/CEI							
3	Allen Loop Roadway & Drainage Improvements	Dune Allen	4	PD&E							
				ROW							
				DESIGN							
				CONSTRUCTION/CEI	RESTORE FUNDS	$1,650,000					PENDING GRANT APPROVAL
4	Arbour Street (Dirt to Pave)	DeFuniak Springs West	3	PD&E							
				ROW							
				DESIGN							
				CONSTRUCTION/CEI	PW Capital				$106,500		
5	Blue Gulf Resort Roadway & Drainage Improvements	South Walton	5	PD&E							
				ROW							
				DESIGN							
				CONSTRUCTION/CEI	FY 28 SWIF					$2,090,000	
6	Brown Road (Dirt to Pave)	DeFuniak Springs North	2	PD&E							
				ROW							
				DESIGN							
				CONSTRUCTION/CEI	PW Capital			$349,500			
7	Cannon Drive Resurfacing	Paxton	2	PD&E							
				ROW							
				DESIGN							
				CONSTRUCTION/CEI	PW Maintenance		$150,000				
8	Carolyn Lane Resurfacing	Santa Rosa Beach	5	PD&E							
				ROW							
				DESIGN							
				CONSTRUCTION/CEI	PW Maintenance (In-House; MTLS Only)	$15,000					
9	Chat Holley & US 331 Intersection Improvements (Long Term Option)	South Walton	5	PD&E							
				ROW							
				DESIGN	FY 27 SWIF				$120,000		
				CONSTRUCTION/CEI						$300,000	
10	Clover Lane (Dirt to Pave)	Bruce East	2	PD&E							
				ROW							
				DESIGN							
				CONSTRUCTION/CEI	PW Capital					$81,000	
11	Cook Road Reconstruction	Northeast Walton	2	PD&E							
				ROW							
				DESIGN							
				CONSTRUCTION/CEI	PW Capital				$442,500		
12	Cottonwood Boulevard (Dirt to Pave)	DeFuniak Springs West	3	PD&E							
				ROW							
				DESIGN							
				CONSTRUCTION/CEI	PW Capital		$37,500				
13	Country Boulevard (Dirt to Pave)	DeFuniak Springs West	3	PD&E							
				ROW							
				DESIGN							
				CONSTRUCTION/CEI	PW Capital		$24,000				
14	County Line Road Paving (Resurfacing)	Northwest Walton	2	PD&E							
				ROW							
				DESIGN							
				CONSTRUCTION/CEI	PW Maintenance				$141,000		

6.0 ACTION PLAN

The key components of the implementation phase are: 1) the implementation team, 2) information/education, 3) capital improvement projects, 4) maintenance, 5) monitoring, and 6) evaluation and adjustments. A watershed implementation team shall be assembled, made up of key stakeholder partners from the planning team, particularly those whose responsibilities include making sure tasks are being implemented, reviewing monitoring data, ensuring technical assistance in the design and installation of management measures, finding new funding sources, and communicating results to the public.

6.1 Information/Education Plan

Every WMP should include an outreach component that involves the community. Because individual actions and voluntary practices are involved in the solutions outlined in the plan, effective public involvement and participation will promote the adoption of management practices, ensure sustainability, and encourage changes in behavior that will help to successfully achieve the goals and objectives. This comprehensive guide has six critical steps of outreach:

1. Defining goals and objectives
2. Identifying target audiences
3. Developing appropriate messaging
4. Selecting materials and activities
5. Distributing the messages
6. Conducting evaluation and continuous improvement

Although awareness of the issues is a good first start, the public should be educated on the challenges facing the watershed and become invested in the solution by knowing what specific actions they can take to participate in successful implementation (Appendix A).

For Walton County, several meetings with County staff were held to identify things to expand on or correct in the plan. Once those issues were resolved, the County created two outreach meetings for the public. One meeting was for the general public while the other meeting was to

host the local government elected officials and staff, emergency response personnel, and other technical specialist with knowledge of the needs of the local community as it relates to sea level rise preparedness and resiliency. The agenda was the same for both meetings; with Barge introducing the project and FAU outlining the WMP and modeling approach. A facilitated session (see advertisement flier in Figure 171) with the attendees was held to give a forum where they could share concerns and help identify potential future areas of study and repair. The solutions for the areas were adjusted based on that input. Reducing flooding and ensuring that new development does not negatively impact the current communities were the major concerns.

Figure 171. Flier for June 24th Meeting

6.2 Capital Improvement Project

This report has identified areas that have the potential to flood. The next recommended step would be to develop a list of capital improvement projects that could be implemented over a period of years to address flooding concerns in these areas. These projects are developed through what is normally referred to as the master planning process. The master planning process focuses on areas identified as flood prone areas. The first step in the process involves collecting existing data for the area to be evaluated. Land cover, soils data, flood maps and topography were all collected as a part of this study. The master planning process will also involve the collection of stormwater infrastructure and structure data within the flood prone areas. Once this data has been collected, the condition of the existing stormwater infrastructure can be evaluated to understand how it will perform during flood events.

Using the collected data, a detailed hydrologic and hydraulic analysis can be performed on the flood prone areas to identify public infrastructure or residential and commercial structures that are at risk of flooding. These areas are identified, and then alternative scenarios are developed to remove or reduce the flooding risk. The alternatives are developed to a conceptual level so that enough detail is provided to determine the estimated construction cost of a specific alternative along with the benefits of the alternative being constructed. Once a mitigation project has been identified and determined to be appropriate for reducing flooding, it is added to a capital improvement plan based on the municipality's ability to fund the projects over a 20 to 30 year window. This plan serves as a roadmap for the installation of flood mitigation projects based on available revenue generated by a stormwater utility, obtaining grant funding or some other source of funds. Additionally, as a part of this Water Management Plan we recommend a thorough review of all available funding sources and a long-term plan for financing the future improvements identified as stated previously in this section.

6.3 Maintenance Plan

The goal of managing stormwater is to protect public health, welfare, and safety by reducing flood impacts on a community, the potential for waterborne disease from flooding, and to lessen the potential for property damage if flooding occurs. Public and private property may include homes, businesses, roadways, railroads, bridges, utilities, etc., so the first objective is to remove excess water in a timely manner, to a place where it will not adversely impact the public and the

economy. To prevent flooding and the potential for health risks associated with stagnant water, stormwater runoff must be managed in an organized and systematic manner if property owners are to enjoy the full use of their property and roadways are to be clear. As a result, stormwater facilities must be constructed and maintained to reduce the negative impacts of runoff.

The burden of managing this stormwater typically falls to a local community stormwater organization – typically a special district, stormwater utility, or a division of a local government.

For this basin, these governments are:

- Walton County
- City of DeFuniak Springs, Freeport, and Paxton
- Northwest Florida Water Management District
- Army Corps of Engineers

Federal programs created under the Clean Water Act specify that those communities with local stormwater infrastructure – pipes, pumps, catch basins, exfiltration trenches, retention basins, etc. – are required to fund and perform the following:

- Annual Maintenance
    - Disk dry retention area bottoms
    - Disk swale bottoms
    - Maintain wet retention facilities

- Semi-Annual Maintenance
    - Correct areas of erosion, undercutting, or dead grass in wet and dry retention areas and swales
    - Take appropriate action on petroleum or other pollution spills noted
    - Swale cleaning
    - Remove invasive plants
    - Remove the sediment from exfiltration trenches
    - Clean exfiltration trenches

- As Needed Maintenance
    - Mow wet and dry retention areas and swales
    - Stabilize banks of wet and dry retention areas
    - Rehabilitate exfiltration trenches every 10 years
    - Correct wet and dry retention area equipment
    - Correct dry retention area bottoms
    - Nutrient/pesticide management
    - Clean bottom debris
    - Re-sod banks of wet and dry retention areas as needed
    - Inspect all retention ponds

Such maintenance activities also require good record-keeping to develop and maintain an accurate mapping of the drainage system and track improvements in areas with ongoing stormwater issues.

6.4 Monitoring and Compliance Requirements

Because stormwater protection is often more regional than local in many cases, most communities participate in programs under permits secured by a regional agency (county level is common) to address the interconnectedness of water bodies throughout neighboring jurisdictions. Monitoring programs are primarily administrative features of watershed management. A good environmental monitoring program (EMP) will assess the effectiveness of the overall hygienic practices in a facility and provide necessary information to prevent failures or property damage, or at least reduce the risk of same. The following are typical monitoring program elements:

Inspections:

- Annual
    - Wet retention area
    - Swale bottoms
    - Disk bottom

- Semi-Annual
    - Dry Retention areas
    - Exfiltration trenches
    - Swales
    - Sediment in wet retention, dry retention, and swale areas

- Quarterly
    - Catch basins

Stormwater Management Program:

- Submit annual inspection and maintenance report
- Conduct required inspections and maintenance
- Develop and maintain record-keeping system

New Development:

- Implement state, local and regional policies with regard to stormwater and drainage management controls.
- Review Land Development Regulations to determine where changes must be made, especially to swales, low-impact development, stormwater reuse, and landscaping.

Roads:

- Litter control
- Implement Best Management Practices (“BMPs”), also called Best Stormwater Practices.
- Perform maintenance of catch basins, grates, storm drains, structures, swales gutters and other features.

Flood Control:

- Ensure new development flood control meets performance standards in 62-40 F.A.C.
- Strengthen local comprehensive plans and submit them to the County.

- Maintain a GIS layer with water quality information.
- Ensure flood control meets with water management district rules.

Pesticides and Herbicides:

- Provide certification and licensing of applicators to the County.

Illicit Discharges:

- Conduct assessment of non-storm discharges,
- Provide copies of newly adopted ordinances prohibiting illicit discharges and dumping.
- Continue the random inspection program.
- Define allotment of state and resources to stormwater program
- Report and prosecute all violators.
- Conduct periodic training for staff on the identification and reporting of illicit discharges.
- Terminate illicit discharges and document same.
- Develop municipal procedures for handling and disposing of chemicals and spills, including training staff on emergency response.
- Distribute brochures to the public on the appropriate disposal of hazardous materials.
- Develop public outreach efforts for oil, and toxic and hazardous waste for public.
- Promote Amnesty Day for hazardous materials.
- Develop a voluntary storm drain marking program.
- Continue infiltration and inflow program on the sanitary sewer system.
- Investigate septic tank discharges to the stormwater system.

Industrial Runoff:

- Maintain inventory of high-risk discharges, including outfall and surface waters where discharge occurs.
- Provide ongoing inspections of high-risk facilities.
- Provide an annual report to the appropriate agency for enforcement.
- Monitor high-risk facility discharge water quality.

Construction Sites:

- Ensure stormwater system meets treatment performance standards in 62-40 FAC.
- Continue construction site inspection program to ensure reduction of off-site pollutants.
- Implement a standard, formalized checklist of stormwater management and water quality inspection items.
- Maintain a log of stormwater management activities at construction sites.
- Provide a detailed description of the inspection program and forms.
- Provide a summary of activities.
- Continue inspection certification program for stormwater management, erosion, and sediment control for operators, developers, and engineers.
- Develop outreach programs for local professional organizations.

Environmental/watershed monitoring programs should verify ongoing demonstration of maintenance through the use of logs, work orders, photographic documentation, and geographic information systems (GIS) support to ensure all of these facilities not only operate properly but also reduce pollutants. These requirements mean that the community needs funds to ensure that monies are available to properly execute the program to ensure compliance. Significant effort is required to maintain the functioning of stormwater systems, many of which have been neglected with time. Extra effort may be recommended prior to rainy seasons to limit flooding potential from unmaintained facilities.

6.5 Conclusions

In the near term, the major concerns for Walton are both rainstorms and inundation from storm surges and sea level rise along the coast. Section 5.4 noted capital projects underway or proposed for the community.

Longer term is noted that residents are not in favor of sea walls or other structural improvements as noted earlier. While the rejection of pumps and sea walls may be feasible in the near term, beachfront property and back bay communities will not the able to stave off the slow and steady creep of sea level rise forever. Modeling indicates that a tipping point exists between 3 and 4

ft of sea level rise, as this is the point where sea walls will be needed. Sea level has risen about 14 inches since 1929. Therefore, despite the local sentiment to avoid creating structural solutions that might disrupt waterfront views, the following should be long-term policy changes for the community:

1. Increase the finished floor elevation minimum height for all new construction to 2 ft freeboard above the FEMA floor elevation.
2. Upon reaching 1 ft of sea level rise above current levels, increase the finished floor elevation again by one foot and continue that pattern. An increase of 1 ft in sea level is likely at least 30 feet away. Since housing averages less than 50 years before demolition and rebuilding in Florida, this would permit a gradual increase in finished floor elevations without negatively impacting an excessive number of residents at any one time.
3. Evaluate where sea walls will be needed to protect property. The minimum future seal wall height will need to start at 6 ft NAVD88 tp create some freeboard
4. Develop a program to prevent the inflow of seawater into the streets. The flooded streets will cause the road base and pavement to fail faster, increasing maintenance costs. How the County accomplishes this can be determined with time, but increasing maintenance costs to the roads will reach a tipping point. To that end, roadway bases may need to be rebuilt using technology that is currently being developed but as yet, has not been implemented.

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APPENDIX A

Watershed Master Planning Initiative

Walton County Floodplain Ordinance and Ordinance Acceptance Documentation

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CHAPTER IV. RESOURCE PROTECTION STANDARDS

4.00.00. OVERALL PURPOSE AND INTENT

The purpose of this chapter is to protect, conserve and enhance Walton County's natural and historical features. It is the intent of the County to enhance resource protection by utilizing development management techniques to control potential negative impacts from development and redevelopment on the resources addressed herein. Specifically, it is the intent of the County to limit the specific impacts and cumulative impacts of development or redevelopment upon historic sites, wetlands, coastal dune lakes, coastal dune lines, water quality, water quantity, wildlife habitats, living marine resources, or other natural resources through the use of site design techniques, such as clustering, elevation on pilings, setbacks, and buffering. The intent of this policy is to avoid such impact and to permit mitigation of impacts only as a last resort.

4.00.01. *Permits Required.*

A. *Local Development Order.* Unless exempt under Section 1.15.00, a development order is required for all development or redevelopment of real property within the County. As a part of the application process defined in Chapter 1 of this Code, a landowner or developer must apply the provisions of this chapter before any other design work is done for any proposed land development. Application of the provisions of this chapter will divide a proposed development site into zones or areas that may be developed with minimal regulation, zones that may be developed under more stringent regulation and zones that must generally be left free of development activity. The proposed development must be designed to fit within the areas and zones that may be developed on each site. Should the proposed development occur under the jurisdiction of a Regional General Permit and Ecosystem Management Agreement, then the proposed development shall be reviewed in accordance with those specific criteria.

B. *State and Federal Permits*. New developments and redevelopment with the potential to impact the quantity or quality of natural resources addressed in this chapter will be required to obtain the necessary permits from all applicable state and/or federal agencies. The County shall attach a disclaimer to the issuance of a **development permit** that states, the issuance of a development permit does not in any way create any rights on the part of the applicant to obtain a permit from a state or federal agency and does not create any liability on the part of the County for issuance of the permit if the applicant fails to obtain requisite approvals or fulfill the obligations imposed by a state or federal agency or undertakes actions that result in a violation of state or federal law. The County shall include a permit condition that all other applicable state or federal permits be obtained before commencement of the development.

4.00.02. *General Requirements.*

A. Applications for Development Approval for sites to be served by an on-site wastewater treatment system and located in areas identified in the soils map included in the County's Geographic Information System (GIS) as belonging to a soils series that poses moderate to severe limitations to development shall provide a detailed soils analysis that indicates soils suitability for construction and use of septic tanks and absorption fields. Development shall be clustered on the portion of site posing the fewest restrictions, based on the characteristics of the soils of the site. The site soils analysis shall be done in coordination with the Soil Conservation Service and the Florida Department of Health. If the Board of County Commissioners, in coordination with SCS and DOH, finds that the soils are unsuitable for septic tanks, an aerobic system or other suitable alternative on-site wastewater treatment system shall be required.

4.01.00. WETLANDS PROTECTION

4.01.01. *Purpose and Intent.*

The purpose of the creation of a wetlands protection zone is to preserve the value and function of existing wetland systems in the County as animal and plant habitat, as natural flood storage areas and as buffers between surface water bodies and activities on adjacent uplands. The County's intent in creation of the wetlands protection zone in this section is to create zones which cover defined wetland areas where no development will be allowed and zones adjacent to those defined wetland areas where development will be allowed under specified regulatory controls. It is not the intention of the County to duplicate the form or function of existing state and federal wetlands regulatory programs. Rather, it is the intention of the County to utilize land use controls which are unique to local government authority to supplement these programs.

4.01.02. *Wetland Protection Zones.*

The primary wetland zone is the actual jurisdictional (USACE or FDEP) wetland. The secondary wetland zone is the buffer surrounding the primary wetland zone.

A. Location of Primary Wetland Protection Zones. All lands within the areas defined by Rule 17-340, F.A.C. F.S. and Rule 9J-5.003(149), F.A.C., as being "waters of the state" shall be considered within a Primary Wetland Protection Zone. The specific boundaries of wetlands shall be determined in accordance with these definitions through site-specific field inspections conducted by a qualified person for a development order or development permit and shall be subject to review and approval by the County before the issuance of a development order or development permit. It shall be the responsibility of an applicant to submit documentation, exhibits, studies, etc., for the purpose of establishing the boundaries of this Zone on their site.

B. Location of Secondary Wetland Protection Zones. All lands within 25 feet landward of

the upland edge of the Primary Wetland Protection Zone.

4.01.03. *Restrictions on Development.*

A. Within Primary Wetland Protection Zones.

1. Dredge and fill activities shall be prohibited, except where demonstrated to be necessary to the public interest, and the applicant has demonstrated that such activity will not negatively impact estuarine water quality, oyster beds, natural functions, or endangered species habitat. Receipt of a permit from the U.S. Army Corps of Engineers and/or the Department of Environmental Protection and/or the Northwest Florida Water Management District authorizing all proposed dredge and fill activities in this Zone shall constitute demonstration of compliance with these standards for the purposes of this section.

2. Developments or redevelopments, located entirely within the Primary Wetland Protection Zone (no upland area) which propose impacts to wetlands that are deemed unavoidable, because the impacts cannot be eliminated through revised site design, clustering, setbacks, elevation, existing upland utilization, buffering, or other land development standards, development within the wetland(s) shall conform to the following criteria:

a. The applicant must secure all permits for the proposed wetland impacts from the appropriate regional, state, and federal agencies having jurisdiction prior to the commencement of construction.
b. When wetland impacts cannot be avoided and are properly permitted by regional, state and federal agencies having jurisdiction, the following are allowable uses:

    i. Uses consistent with the underlying land use as depicted on the Land Development Code Official Zoning Map (OZM) with limited densities and intensities.
    ii. Access to the site.
    iii. Internal traffic circulation, where other alternatives do not exist, or for purposes of public safety.
    iv. Utility transmission and collection lines.
    v. Pretreated stormwater management.

c. No new lot or parcel shall be created after November 7, 1996, which consists entirely of wetlands, unless accompanied by a deed restriction that prohibits future development on the lot or parcel.
d. Wetlands crossings that connect upland areas are permissible provided the natural water flow between wetlands is not interrupted.

e. To prevent the loss of all reasonable and beneficial use of property due to wetland restrictions, i.e. there are no buildable upland areas and wetland impacts cannot be avoided, then the property shall be allowed to develop one (1) residential dwelling unit for a lot of record existing on or before November 7, 1996, provided that all permits are issued by all regional, state and federal agencies having jurisdiction.

B. *Within Secondary Wetland Protection Zones*.

Within this Zone, clearing of native vegetation to allow for crosswalks, public access facilities, landward portions of docks, boardwalks, necessary infrastructure, or otherwise shall be limited to 25 percent of the total area within the Secondary Wetland Protection Zone on that site.

1. A development exception may also be made within this Secondary Wetland Protection Zone for a vehicular access driveway to the upland developable portion of a property, where it can be demonstrated that the driveway would result in a reduced impact on wetlands than would otherwise be necessary to comply with wetland buffering requirements. Development subject to this exemption shall demonstrate that:

a. No reasonable alternative means of access from a public way to uplands of the same owner is available;
b. The driveway minimizes the road length and width through the wetland to the maximum extent practicable including shoulders and side slopes;
c. The driveway crosses the wetland along the edge or narrowest portion of the wetland that requires the least amount of fill;
d. The driveway attempts to limit the wetland crossing to the portion of wetland that is degraded, for example, dominated by non-native invasive plants;
e. The driveway includes retaining walls or guardrails to allow for road shoulders and/or side slope widths to be narrowed to minimize encroachment into wetlands;
f. The driveway application is consistent with all other provisions of the Comprehensive Plan and Land Development Code; and
g. The requisite permits have been secured from the appropriate regional, state, and federal agencies having jurisdiction over the wetland.

2. For single family residential on individual residential lots, the Planning Director may allow up to 40% encroachment of the total area of the Secondary Wetland Protection Zone in cases where the strict application of this secondary wetland protection buffer would result in otherwise unnecessary impact to the Primary Wetland Protection Zone. In these cases, regulatory agency permitting for wetland impact shall be unnecessary and or unobtainable.

3. In new residential developments, the Secondary Wetland Protection Zone shall be located entirely within common areas and defined as such within a recorded subdivision plat and also have appropriate protective restrictive covenant language. The General Notes section of the plat, or site plan when platting is not required, shall include a note providing that the Secondary Wetland Protection Zone shall remain intact, uncleared, and undisturbed in accordance with the approved development order for the development.

C. *Density Transfer from Both Wetland Protection Zones*.

In order to encourage the location of development landward of the boundaries of both of these Zones, the County hereby authorizes a transfer of allocated density from areas in the Zones to adjacent uplands, subject to the following conditions:

1. If buildable upland is available, development shall locate on the non-wetland portions of a development site and residential densities shall be transferred on-site from wetland areas to contiguous non-wetland areas within the same development subject to the following:

    a. If buildable uplands are available on-site, but the development will cause or result in a disturbance of the wetland, residential densities may only be transferred on-site from the impacted wetland areas to non-wetland areas based on the maximum wetland density of one (1) dwelling unit per 20 acres with a maximum wetland area intensity of 0.10 (10%) Impervious Surface Ratio (ISR), provided that the zoning district maximum allowable density or intensity is not less. Residential densities may be transferred on-site from the non-impacted wetland areas to non-wetland areas at the density of the underlying zoning district; or

    b. If buildable uplands are available on-site and the development will not cause or result in any disturbance of the wetland, residential densities may be transferred on-site from the wetland areas to the non-wetland areas at the density of the underlying zoning district. This provision shall apply only when no disturbance of the wetland will occur through the proposed development or redevelopment.

2. For purposes of this Code, disturbance of wetlands shall be any alteration or material change to the Primary Wetland Protection Zone, including but not limited to, dredging or filling.

3. All such on-site density transfers shall:

    a. Be contiguous to property under the same ownership or control;
    b. Developed in accordance with the County's Land Development Code.
    c. Not result in lot sizes that are less than 5,000 square feet for single family

residential lots unless the lot is within a planned unit development approved in accordance with the Walton County Comprehensive Plan and Land Development Code. The minimum lot size shall not include the wetland area.

4.01.04. Wetland Enhancement and Restoration

A. To incentivize the enhancement, restoration or creation of wetlands the following density bonus is available for planned unit developments that are 100 acres in size:

1. Enhancement of one (1) acre of existing wetlands will result in the allotment of two (2) additional units per acre. Enhancement includes the modification of specific structural features of an existing wetland to increase one or more functions based one or more management objectives.
2. Restoration of one (1) acre of wetlands will result in the allotment of four (4) additional units per acre. Restoration involves the return of an ecosystem to a close approximation of its condition prior to disturbance. Restoration requires one or more of the following processes: reconstruction of antecedent physical conditions; chemical adjustment of the soil and water; and/or biological manipulation, including the reintroduction of absent native flora and fauna.
3. Creation of one (1) acre of wetlands will result in the allotment of eight (8) additional units per acre. Construction or creation of a wetland in an area that was not a wetland in the recent past (within the last 100 -200 years) and that is isolated from existing wetlands (not directly adjacent).

B. Wetland enhancement, restoration or creation activities must be accomplished under the guidance and supervision of an environmental professional with adequate training and experience.

C. A management plan must be included within the Planned Unit Development and all areas which have been used to obtain a density bonus shall be preserved within a conservation easement to preclude the future alteration of these areas.

D. Density shall only be applied to the development of non-environmentally sensitive uplands and areas not deemed a flood hazard concern.

4.02.00. COASTAL RESOURCE PROTECTION

4.02.01. *Purpose and Intent.*

The purpose for the creation of regulations governing development in the coastal areas of the County is the protection and enhancement of the resources which are unique to the County's dune systems and dune lake systems. It is the intention of the County to protect people and property in the coastal areas by defining appropriate land use mechanisms here which will serve to limit development in defined high hazard areas and also protect and enhance the quality and function of existing coastal natural resources.

4.02.02. ***Restrictions on Development within the Coastal Protection Zone.***

The Coastal Protection Zone (CPZ) is defined as all lands on any site adjacent to the Gulf of Mexico or a related coastal dune system within an area defined as follows:

A. The area that extends fifty (50) feet seaward of the landward toe of the primary dune ridge; or

B. The area seaward of a line fifty (50) feet landward of the crest of the primary dune when the toe cannot be determined; or

C. Twenty-five (25) feet landward of the top of the higher bluff regions where no primary dune exists.

1. Development within this Zone is limited to those activities which are presumed to have insignificant adverse effect on the resources within the Zone. The following activities are presumed to have an insignificant adverse effect:

    a. The designation and development of scenic, historic, wildlife, or scientific preserves.

    b, Minor maintenance or emergency repair to existing structures or existing improved areas.

    c. Constructing fences where no fill activity is required and where navigational access will not be impaired by construction of the fence.

    d. Development limited to boardwalks, dune walkovers and overlook pavilions, coastline access structures, and erosion control measures that will enhance and protect the dune system. FDEP Standards and Regulations shall apply to such construction.

i. No activities shall be permitted which create erosion of a dune or the dune system.

ii. Natural dune vegetation within the overlay zone shall be disturbed only to the extent necessary to construct these boardwalks and related structures; however, in no case may more than ten percent of the existing vegetation or dune be disturbed.

iii. All boardwalks and any other constructed features will be constructed to allow potential animal movement and to maintain density and vigor of vegetation and to prevent blowouts.

iv. If these regulations render a property owner unable to build a single-family dwelling unit on an existing lot of record as of the date of plan adoption November 7, 1996 that lies wholly within the zone, then the owner shall be allowed to construct a single-family residential dwelling unit, providing that the owner complies with all permit requirements of the FDEP and limits the extent of disturbance to the minimum area necessary to accommodate the dwelling unit and access driveway.

4.02.03 ***Restrictions on Development within the Coastal Dune Lake Protection Zone***.

The Coastal Dune Lake Protection Zone is defined as being all lands within an area beginning at the mean or ordinary high water line of the coastal dune lakes and their tributaries and extending 300 feet landward.

A. Stormwater management: Property owners must submit a stormwater plan for the property, unless the improvements are deemed de minimis or otherwise not required within the Land Development Code, as a condition of obtaining a development order or building permit, which must use or incorporate appropriate “Low Impact Development” stormwater practices. The lake buffer areas and impervious surface limitations included herein shall qualify as “Low Impact Development” for the purposes of this section. Additional “Low Impact Development” tools and techniques include but are not limited to: approved pervious pavement systems certified by a Professional Engineer, bio-retention swales, rain gardens, and rain barrels. Low Impact Development techniques may be used independently or in combination with traditional stormwater management techniques in order to meet the requirements of Section 5.06.00. The stormwater plan shall be certified by a Professional Engineer licensed by the State of Florida. The County shall implement a monitoring program to confirm compliance with the stormwater plan.

B. Erosion control: Specific erosion control measures shall be utilized during construction activity, such as staked and staggered hay bales, siltation barriers, floating silt and filter berms.

Further, erosion and sedimentation controls shall be left in place until the disturbed areas are stabilized with permanent vegetation that will prevent the transport of sediment off site.
C. Hazardous wastes: No land use shall be allowed within the zone which stores, handles or generates hazardous wastes.

D. Seawalls, bulkheads, revetments and rip-rap are not permitted.

E. No new point or non-point sources of pollution shall be discharged into the lakes, such as treated wastewater effluent or untreated stormwater runoff. For lots adjacent to Coastal Dune Lakes: All new development, and redevelopment that requires a modification, replacement or upgrade to an onsite sewage treatment and disposal system shall be required connect to central sewer at the time of development or redevelopment. Within the CDLPZ, new on-site sewage treatment and disposal systems shall be prohibited where connection to sewer is available. Where central sewer is not available, septic tank drain fields must be located at least 100 feet from the ordinary or mean high water line, whichever applies.

F. Open Space: All new development and redevelopment shall preserve at least 60 percent of the portion of the parcel within the 300-foot protection zone as pervious surface. Vegetative clearing within this preserved area shall be limited to that which is necessary to accommodate the 40 percent impervious development that is permitted. Clearing of native vegetation shall not exceed 50 percent of the gross square footage of the portion of the parcel that is within the 300-foot CDLPZ.

G. No construction or disturbance will be allowed in the natural outlet from a coastal dune lake. A buffer area of not less than 50 feet of vegetated area will be left undisturbed along either side of the natural outlet from the lake.

H. No construction or disturbance including clearing of native vegetation will be allowed within 100 feet from the ordinary or mean high water line from a Coastal Dune Lake. For lots of record created before November 7, 1996 that are 200 feet of less in depth, this shoreline setback shall be a minimum of 25 feet or 25 percent of the lot depth, whichever is greater. No development, other than boardwalks, docks, or other shoreline access structures shall be allowed with the exception of clearing a 10 foot wide perpendicular to the shore access to the shoreline. All existing native vegetation will be preserved within this setback and buffer area.

I. Where any portion of a parcel is located within the Coastal Dune Lake Protection Zone (CDLPZ), a Land Clearing Permit is required to better control erosion and sedimentation to protect these environmentally sensitive Coastal Dune Lakes, and assure compliance with applicable provisions of this Code. It shall be unlawful for any person to clear any portion of a parcel located within the CDLPZ without first obtaining a Land Clearing Permit from the County in accordance with the provisions of Chapter 1. Should replanting or restoration be required, all plant materials shall be native vegetation appropriate to a dune lake ecosystem.

J. Hardship relief from the application of the numeric percentage restrictions in paragraph F above may be sought by a property owner through application to the Zoning Board of Adjustment pursuant to the variance criteria found in Chapter 1 of this Land Development Code. In no event, shall the Zoning Board of Adjustment increase the allowable vegetative clearing and impervious area to more than 53 percent of the portion of the parcel that is within the 300-foot CDPLZ.

K. In the event a dwelling unit is more than 50 percent destroyed due to age related structural deterioration, natural disaster, fire, wind or water damage the owner is entitled to re-build a single family residential unit to the same footprint dimensions as the previously existing dwelling unit, irrespective of Section 1.15.00. In cases where the entire structure is being re-built, the dwelling may be re-built in a new location except that, the relocated dwelling footprint must be re-built so as to avoid encroachment into the dune lake setback/buffer areas described above to the maximum extent possible. If there is insufficient buildable area to re-build the previously existing footprint and avoid all encroachment into buffer/setback areas, the County Zoning Board of Adjustments may grant a variance to the building setback requirements found in Chapter 5 of the Land Development Code by the minimum extent necessary to accommodate the allowable footprint. Additionally, any owner shall have the option to rebuild on the existing footprint so long as the re-built dwelling is does not encroach any further into the buffer/setback areas.

1. In order to best protect the dune lake, the owner shall re-build the primary dwelling unit, including its access driveway, in a manner that minimizes any disturbance to the native vegetation on site. Future planting of vegetation must be in native vegetation appropriate to a dune lake ecosystem.

4.02.04 ***Restrictions on Development within the Coastal High Hazard Zone***.

The creation of new lots (through platting, lot splits, or other method) that lie entirely within the Coastal High-Hazard Area is prohibited. The creation of new lots contiguous to or partially within the Coastal High-Hazard Ares shall be prohibited unless the newly created lot contains sufficient buildable area outside of the Coastal High Hazard Area for the intended use.

4.02.05 ***General Requirements for all Coastal Zones*****.**

The following restrictions and/or standards shall apply to all development and other human activities within all of the Zones created above. Applications for development and/or building permits for all construction in all Coastal Zones shall be certified by an architect or professional engineer registered in the State of Florida. Such certification shall state that the design plans and specifications for the construction are in compliance with the criteria established by this section.

A. Applications for development and/or building permits for all construction in all Coastal

Zones shall include a topographic map prepared by a licensed surveyor which clearly identifies the primary dune system and the location of each relevant Coastal Zone. The map shall be verified by the County Engineer on a case-by-case basis.

B. The County shall not approve any construction seaward of the Coastal Construction Control Line, including construction of coastal or shore protection structures, until an applicant has received all necessary permits for such construction from the Florida Department of Environmental Protection and from any other state or federal agency with permitting authority over such construction. The County shall issue no development order or permit for construction on a new parcel if such new parcel lies entirely seaward of the Coastal Construction Control Line. No motor-driven vehicles are permitted to be driven on dunes with the exception of emergency vehicles responding to an emergency. No activities shall be permitted which create erosion on the dunes. The placement of colored or silty fill material within any Coastal Zone where the beaches may become discolored by such materials is prohibited as provided within Section 4.07.00

C. Where the public has established an access way through private lands to lands seaward of mean high tide or water line by prescription, prescriptive easement, or any other legal means, development of [or] construction shall not interfere with such right of access unless a comparable alternative access way is provided. The developer shall have the right to improve, consolidate, or relocate such public access ways so long as they are:

1. Of substantially similar quality and convenience to the public;
2. Approved by the local government; and
3. Consistent with the coastal management element of the local comprehensive

4.03.00. SHORELINE PROTECTION

4.03.01. *Purpose and Intent.*

The purpose of the creation of regulations governing development of areas adjacent to surface water bodies in the County is the protection and enhancement of the quality and function of the natural systems which are unique to the shoreline areas of these water bodies. It is the intent of the County to use local land use regulatory mechanisms such as density transfer, buffering and clearing restrictions to preserve and/or enhance the water quality in these water bodies. The County hereby creates two types of shoreline protection zones as described below in which special restrictions on development apply.

4.03.02 *Exemptions.* Single-family development on existing lots of record established before November 7, 1996, that lack sufficient depth to meet the above listed buffer requirements for inlets, creeks, rivers, and the Choctawhatchee River and Bay System shall be subject to a

reduced buffer. A lot lacking sufficient depth means a lot that is 200 feet or less. Such lots shall be subject to a minimum buffer of 25 feet or 25 percent of the depth of the lots, whichever is greater. Clearing within this buffered setback shall be limited to a maximum swath of ten (10) feet for access purposes.

4.03.03. ***Restrictions on Development within the Shoreline Protection Zones***.

A. *Within the Shoreline Protection Zone*. *This zone shall encompass all land within fifty (50) feet of the mean high water line of each inlet, creek, natural non-manmade lake, and river within the County*. Man-made canals and ditches are specifically excluded from this definition and such features shall be subject to a twenty-five (25) foot setback requirement only. Development activities related to the following are permitted within this Zone and are presumed to have an insignificant adverse effect on the resources within the Zone:

1. Scenic, historic, wildlife, or scientific preserves.
2. Minor maintenance or emergency repair to existing structures or improved areas.
3. Clearing walking trails having no structural components.
4. Boardwalks, docks and other shoreline access structures.
5. Commercial or recreational fishing or hunting, and creation and maintenance of temporary blinds.
6. Cultivating agricultural or horticultural products that occur naturally on the site.
7. Constructing fences where no fill activity is required and where navigational access will not be impaired by construction of the fence.
8. Developing a "wetlands stormwater discharge facility" or "treatment wetland" in accordance with state permits received under Chapter 16-611, Florida Administrative Code.

B. *Within the Bay Shoreline Protection Zone. This Zone shall encompass the Bay itself and all area within 50 feet landward of the mean high water line of Choctawhatchee Bay and bayous directly connected with the Bay.*

1. No development shall be located within 50 feet landward of the mean high water line of Choctawhatchee Bay and bayous connected directly to the Bay, with the exception of boardwalks, public access facilities and/or landward portions of docks which are otherwise permitted or exempted from permitting under the same applicable regulations. Newly platted subdivision lots must be of sufficient depth to meet the 50 foot shoreline setback requirement.
2. Within this buffer area, clearing of native vegetation shall be limited to 25 percent of the total area within the Zone on that site.
3. Within this buffer area, no pier, dock or walkway shall be located over submerged land which is vegetated with seagrasses except as necessary to reach waters at a depth of one foot below the lowest point of the boat, including the motor, at mean low tide. Boring to set pilings is allowed; however, any material removed must be disposed of at

an upland site intended for this purpose. Unless vessel access would be prohibited, the docking terminus shall not be located over submerged vegetation areas, such as seagrass beds.

4. Seawalls: New vertical seawalls and bulkheads shall be prohibited along Choctawhatchee Bay, unless the property is located directly in between two properties that have an existing seawall, provided that the length of the seawall does not exceed 150 feet. In other areas, alternatives such as revetments, rip-rap, native vegetation and other shoreline protection structures which serve to dissipate wave energies shall be required.
5. Notwithstanding the limitations on clearing for access pursuant to Subsection 2 above, commercial water-dependent uses proposed on lots or parcels located within 150 feet landward of the mean or ordinary high water line of the Choctawhatchee Bay and bayous shall be allowed to clear up to the minimum necessary to ensure viable access to the particular water-dependent use for which development approval is sought.
6. Landward of this buffer area, development activities will be permitted in this Zone, subject to the following restrictions and standards:

    a. Septic tanks: Septic tank drain fields must be located at least 75 feet from the ordinary or mean high water line, whichever applies;
    b. Ensuring that untreated stormwater runoff from lawn fertilizers, pesticides, or patios, driveways, etc., do not enter the Choctawhatchee River and Bay system is required pursuant to Section 5.06.00.
    c. Erosion control: Specific erosion control measures shall be utilized during construction activity, such as staked and staggered hay bales, siltation barriers, floating silt and filter berms. Further, erosion and sedimentation controls shall be left in place until the disturbed areas are stabilized with permanent vegetation that will prevent the transport of sediment off site.
    d. Hazardous wastes: No land use shall be allowed within the zone which stores, handles or generates hazardous wastes.
    e. Native vegetative communities, including habitat for listed species, in this zone shall be protected in accordance with Comprehensive Plan Policy C-1.7.3.
    f. No new point or non-point sources of pollution shall be discharged into the Bay System, such as treated wastewater effluent or untreated stormwater runoff unless permitted by FDEP and/or the NWFWMD.

4.03.04. *General Restrictions*. The following general restrictions will apply to any of the authorized development activities permitted along the shoreline of any surface water body in the County:

A. The native ground cover, shrubs, and trees within these Zones must be retained, wherever feasible.
B. All new or redeveloped shoreline land uses shall:

1. Locate on existing upland areas;
2. Be constructed to conform to coastal construction building codes;
3. Be constructed in accordance with the policies for construction within the Coastal High-Hazard Area;
4. Demonstrate that existing public utilities, infrastructure and services are in place to support the proposed use;
5. Not be in conflict with existing, conforming, adjacent land uses;
6. Provide public access where traditional public access points are directly affected by the development;
7. Landscape using native plant species;
8. Provide for the treatment of all discharge, including stormwater runoff, from land uses into bodies of water to incorporate standards for treatment adequate to meet the County's adopted level of service standard for drainage facilities;

C. All new, expanded or redeveloped marinas located or to be located on the shoreline of any surface water body shall comply with the following criteria:

1. Demonstrate the presence of upland areas that are large enough to accommodate all required utility and support facilities and provide enough parking to satisfy the projected demand based upon the County's parking regulations;
2. Provide a hurricane mitigation and evacuation plan;
3. Be located in proximity to existing channels so that minimum or no dredging shall be required for provision of docking facilities;
4. Have available sewage treatment facilities to serve the anticipated volume of waste consistent with County's adopted level of service standard for sanitary sewer facilities;
5. Delineate immediate access points with channel markers that indicate speed limits and any other applicable regulations;
6. Be sited in areas consistent with the land uses in the FLUM;
7. Locate in areas away from sea grass beds, oyster reefs, marsh grasses, and other important fish and shellfish spawning and nursery areas; and require adequate water depth to accommodate the proposed boats use without disturbance of seagrasses and submerged habitats;
8. Demonstrate a public need;
9. Dry storage and other land-based alternatives are preferential to dredged basins wherever feasible.
10. Use of hazardous materials shall be located or stored on the uplands to the maximum extent practical.
11. Facilities accommodating live-a-boards shall have permanent built-in connections for sewage pump-outs as well as upland restrooms and laundry facilities.

4.04.00. GROUNDWATER AND WELLHEADS

4.04.01. *Purpose and Intent*.

The purpose of groundwater protection standards is to safeguard the health, safety and welfare of the citizens of Walton County. This is accomplished through ensuring the protection of the principal source of water for domestic, agricultural, and industrial use. The availability of adequate and dependable supplies of good quality water is of primary importance to the future of the County. Therefore, standards are described in this section with the intent of protecting both the quantity and quality of the groundwater supply. It is further the intent of this section to control development in and adjacent to designated wellheads to protect water supplies from potential contamination.

4.04.02. *Wellhead Protection Zones*.

Location of Wellhead Protection Zones. The Wellhead protection zone is located between a 200 and a 500-foot radius of the public potable water wells identified on the wellfields map maintained in the offices of the Planning and Zoning Department; and Areas of High Aquifer Recharge (Floridan Aquifer) as identified within the Supporting Documentation for the Walton County Comprehensive Plan.
The zone determined to be within the cone of influence for public water supply wells is located within a 200-foot radius of the public potable water wells.

4.04.03. *Restrictions on Development*.

A. Within the Cone of Influence. All areas within a designated Cone of Influence are hereby designated as a zone of exclusion where no development or redevelopment will be permitted by the County. Where development is proposed in areas with existing wells, these wells shall be abandoned, including adequate sealing and plugging according to Rule 17.28, F.A.C.

B. Within the Wellhead Protection Zone the following uses are prohibited:

    1. Landfills.
    2. Facilities for the bulk storage, handling or processing of materials on the Florida Substance List.
    3. Activities that require the storage, use, handling, production or transportation of restricted substances, including but not limited to the following: agricultural chemicals, petroleum products, hazardous/toxic wastes, industrial chemicals, medical wastes.
    4. Septic tank systems, unless otherwise approved by the Florida Department of Environmental Regulation or the Department of Health and Rehabilitative Services, documented by a copy of a valid permit or authorization.

5. Stormwater wet retention/detention areas, unless otherwise approved by the Department of Environmental Regulation and Northwest Florida Water Management District, documented by a valid permit or authorization.
6. Feedlots or other concentrated animal facilities.
7. Wastewater treatment plant effluent discharges, including but not limited to, percolation ponds, surface water discharge, spray irrigation, or drain fields.
8. Mines.
9. Excavation of waterways or drainage facilities which intersect the water table.
10. Other noxious uses or activities which might impact the quality and quantity of potable water resources.
11. Stormwater management practices utilizing percolation ponds, drainage wells and sinkholes for stormwater disposal where recharge is into potable water aquifers.
12. Excavation of waterways or drainage facilities which intersect the water table and other noxious uses or activities which might impact the quality and quantity of potable water resources.

4.05.00. WILDLIFE HABITAT, OPEN SPACE, AND UNIQUE NATURAL AREAS

4.05.01. *General Habitat Preservation Requirements*.

The County shall assist in the application of and compliance with all state and federal regulations which pertain to endangered or threatened species, and guidelines which pertain to species of special concern listed by the Florida Game and Fresh Water Fish Commission and will provide for protection of areas known to provide habitats for these species by not issuing any development order or development permit until proof is provided by an applicant that all necessary state and federal requirements relating to such species have been met.

4.05.02. *General Natural Community Vegetation, Open Space, and Wildlife Habitat Preservation Requirements.*

In order to protect native or natural vegetative communities determined to be endangered, threatened or of special concern, as determined by the Department of Agriculture or Florida Game and Freshwater Fish Commission, and as identified by FNAI, others, or in the County's GIS, as occurring in Walton County, including habitat of endangered, threatened or special concern designated species, all new development shall be required to comply with the following native vegetation requirements:

A. Native or natural vegetation shall be identified on a site-by-site basis using the FNAI inventory, LANDSAT maps, soil surveys of the USDA Soil Conservation Service, field analysis, or other best available data source as provided by an environmental professional. The developer shall design and locate improvements to minimize the removal of such native or natural vegetation. Because the clearing of land as an adjunct of construction is defined as development and requires a permit from the County, no land alteration, clearing or grubbing may be carried out prior to issuance of a final development order or development permit, including the issuance of a building permit.

B. Preservation of Natural Communities south of the Choctawhatchee Bay:

1. Natural communities identified as “Coastal Uplands” by the most recent version of the FNAI Guide to Natural Communities incorporated herein by reference, including Beach Dune, Coastal Berm, Coastal Grassland, and Coastal Strand vegetation.

    a. Within Coastal Upland natural communities located seaward of the landward line of the CPZ, the applicant for development approval is required to preserve, in its existing state, ninety-five (95) percent of such natural community vegetation. Notwithstanding this limitation, dune walkovers are allowed within such coastal upland natural communities if permitted by the appropriate state and federal agencies. For redevelopment scenarios where natural community vegetation no longer exists within this area, restoration is required.

b. Within Coastal Upland natural communities located landward of the CCCL and not located within the CPZ, one hundred (100) percent of the Coastal Upland natural community remaining outside the building footprint (including parking and access areas) must be preserved and retained, with the exception that a ten foot buffer around the proposed structure may be cleared or impacted to allow construction and maintenance of the structure, as needed. Existing ~~native~~ natural community vegetation shall remain in all required landscape buffers, as a condition for development approval.

c. Vegetation or landscaping material planted on a dune or within a dune system shall be limited to native salt-resistant native plants beneficial for dune protection and for beach/dune stabilization.

2. High Pine and Scrub: For development on parcels of two acres or more having areas characterized as High Pine and Scrub natural communities as defined by the most recent version of FNAI Guide to Natural Communities, fifty (50) percent of the natural community on the site shall be retained. The foregoing does not apply to parcels utilized for industrial, agricultural, or public facilities. Within coastal dune lake drainage basins, the above-mentioned percentage of natural community vegetation shall be preserved, and in addition, the removal of ~~native~~ natural community vegetation and its replacement by lawns and landscaping shall be kept to the minimum which is reasonably necessary to develop the property.

C. ***Preservation of Natural Communities north of Choctawhatchee Bay***:

For development on parcels of two acres or more having areas characterized as "High Pine and Scrub" and/or "Hardwood Forested Uplands" as defined by the most recent version of FNAI Guide to Natural Communities, twenty-five (25) percent of the identified natural community on the site shall be retained. The foregoing does not apply to parcels utilized for industrial, agricultural or public facilities.

D. Habitat for endangered, threatened or species of special concern listed by the Department of Agriculture or the Florida Game and Freshwater Fish Commission. No land alteration activity is allowed which alters the ecological integrity, balance or character of land or water areas determined by means of the due process provisions of the Federal Endangered Species Act to be critical habitat, or lands documented as utilized any federal or state-designated species, except in cases where the developer commits to a plan approved by the U.S. Fish and Wildlife Service and The Florida Fish and Wildlife Conservation Commission to relocate or recover the species to another parcel of land.

E. At least one-half of the natural community that is preserved pursuant to Section 4.05.02

B. and C. above shall be preserved in a compact configuration, with an overall 20 foot width. The location of this natural community vegetation shall provide separation between development projects, or shall be located so as to buffer or protect wetlands, listed species habitat, floodplains, dunes, bluffs, lakes, or public or private conservation areas.

F. Natural community vegetation that is preserved shall be preserved in a compact configuration to the greatest extent possible. Where the natural community on one parcel is contiguous with natural community vegetation on one or more adjacent parcels, the developable portion shall be located to minimize disruption of this contiguity to the maximum extent possible. This requirement shall be applied on a site-by-site basis and shall apply to public as well as private development.

G. The highest priority for selecting the natural community vegetation to be preserved on a proposed development site shall be with respect to buffering or protecting environmentally sensitive areas such as wetlands, threatened, endangered, or species of special concern habitat, floodplains, dunes, bluffs, lakes, or public or private conservation areas.

H. Natural community vegetation located within ten (10) feet of any proposed structure shall not be included within the percentage of preserved natural community vegetation identified in order to meet the preservation requirements included in this Section.

I. For parcels containing the above described protected natural communities, the developer and the County may agree to allow the developer to pay a fee to remove up to a maximum of fifty percent (50%) of the total natural community vegetation that must otherwise be preserved in accordance with these paragraphs. The fee for such clearing shall be the most recent assessed value, as provided by the Walton County Property Appraiser, of the land area/acreage that is proposed for clearing that would have otherwise been preserved. This fee shall be placed in a fund for the acquisition and preservation of parcels of land which contain the types of natural communities subject to buy out. Alternatively, and on a case-by-case review, the Board of County Commissioners may authorize the use of such preservation funds for other preservation or restoration projects of ecological significance such as the creation of greenways, preserves or other similar projects within the general geographic area of where these funds were collected or within similar vegetative community areas. For new residential development, in order to utilize the preservation buy out option, all remaining preservation areas must be placed in common areas and defined as such within a recorded subdivision plat and also have appropriate protective restrictive covenant language. Alternatively, if not utilizing the buyout option, preservation areas must be recorded in applicable deed restrictions, a conservation easement recorded, or within recorded common areas.

J. The County and the developer may agree to count any area which is permanently dedicated to the public for use as a greenway toward meeting the natural community preservation requirements established above. As a further incentive, the County and developer may agree to reduce the remaining preserved area outside of the greenway dedication by an area which is equal to one-half of the area of the greenway dedication.

4.05.03 Restoration and Creation of Natural Communities

A. To incentivize the restoration or creation of the protected natural communities described in this Section, the following density bonus is available for planned unit developments that are 100 acres in size or greater per Section 2.05.03.C of the Land Development Code.

1. Restoration of one (1) acre of protected natural community will result in the allotment of two (2) additional units per acre. Restoration involves the return of an ecosystem to a close approximation of its condition prior to disturbance. Restoration requires one or more of the following processes: reconstruction of antecedent physical conditions; chemical adjustment of the soil and water; and/or biological manipulation, including the reintroduction of absent native flora and fauna.
2. Creation of one (1) acre of protected natural community will result in the allotment of four (4) additional units per acre. Construction or creation of a protected natural community would be in an area that was not in the recent past.

B. Natural community restoration or creation activities must be accomplished under the guidance and supervision of an environmental professional with adequate training and experience.

C. A management plan must be included within the Planned Unit Development and all areas which have been used to obtain a density bonus shall be preserved within a conservation easement to preclude the future alteration of these areas.

D. Density shall only be applied to the development of non-environmentally sensitive uplands and areas not deemed a flood hazard concern.

4.06.00 Maintenance of Natural Areas Requiring Preservation

The intent of this Section is to provide a permit process for the routine maintenance of plant material and plant communities within natural areas requiring preservation. For the purposes of this permit, the designated preservation areas are limited to the Coastal Dune Lake Protection Zone and the natural community preservation area designated through a Development Order or delineated on an existing Plat. This permit is not intended for, nor does it allow, the wholesale removal of preserved natural plant communities or general clearing activities.

4.06.01 Permit Process.

A. Permit Required for Maintenance: Within the preservation area there shall be no mowing, clearing, grading, construction, storage, or disturbance of vegetation of any kind except as permitted by the County.

B. Routine maintenance, as allowed under this provision, shall have a limited scope and follow the intent to preserve the health and functionality of the preservation area. Limited removal of dead/declining plant material and ground level debris are permitted. Maintenance for fuel reduction as outlined by Firewise USA programs and as certified by an environmental professional is permitted. Removal of plant material from traffic visibility triangles is permitted. Selective pruning of trees to maintain the health of the tree or to prevent/remove storm damage is permitted.

C. If the plant material in the designated preservation area was used to satisfy the requirement of a required landscape buffer, the routine maintenance of this preservation area shall not cause the planting density to fall below that which was originally required of the landscape buffer.

1. Removal of any dead/declining tree with a caliper measurement of 4” or above shall be replaced with the same species, or with another native tree associated with the preservation area plant community. Minimum installation size shall be container class #15.
2. Removal of any dead/declining shrub with a height of 18” or above shall be replaced with the same species, or with another native shrub associated with this preservation area plant community. Minimum installation size shall be a container class #7.

D. Soil disturbance should be kept to a minimum. However, when the routine removal of exotic invasive plants or the removal of dead/declining material disturbs the soil and leaves exposed earth, reestablishment of native groundcover is required. Acceptable methods include hydro- seed or installation of container grown native ground cover. Groundcover species shall be native and appropriate to the preservation community.

E. Removal of exotic/invasive vegetation does not require a permit. However, removal practices should follow the guidelines of the Florida Exotic Pest Council (FLEPPC).

1. Removal of exotic/invasive plant material should be limited to hand removal or removal using minimally invasive mechanical tools such as a Weed Wrench™.
2. The use of herbicides should be limited and applied in an intentional manner based on the physiology of the targeted plant. Although not required, it is recommended that herbicides be applied by a certified applicator licensed by the Florida Department of Agriculture and Consumer Services (FDACS).

3. It should be noted that prescribed fire is not always effective as a means of exotic/invasive plant removal and should only be employed for the health of the ecosystem and at the recommendation of an environmental professional. Invasive vines that have covered mature tree canopy should be removed prior to prescribed fire methods in order to limit damage to the mature trees.

4.06.02 Restoration Plans Resulting from Unpermitted Clearing.

Unpermitted clearing or maintenance activities in violation of the Walton County Land Development Code shall be subject to Code Compliance procedures under Chapter 7. In addition to any applicable Code Compliance actions, a violation will require submittal of a Restoration Plan in conjunction with a Less Than Minor Development Order approval process as per Chapter 1 of this Code. The following shall apply:

A. The applicant for Restoration Plan approval will be subject to Section 7.01.08 of this land Development Code.

B. Restoration of the affected area will be required. A Restoration Plan - Less than Minor Development Order will consist of the following:

1. A landscape plan shall be developed by a Landscape Architect and include the following:

i. The landscape plan shall include a survey of the property and illustrate the location for each individual plant and listed species to be replanted.

ii. The required species will be selected based on the vegetative community as determined by the environmental assessment.

iii. The plan must provide a calculation for the quantity of plantings for the area to be restored. A minimum of one hundred (100) plants per one thousand square feet (1000sqft) with a combination of canopy trees, understory trees, shrubs, and grasses must be utilized.

2. All plantings must be installed and inspected within sixty (60) days from the approval date of the restoration plan. Failure to complete the restoration per the approved permit will be subject to further enforcement action and may include daily fines.

4.07.00. WHITE SAND PROTECTION RESTRICTIONS

4.07.01. *Purpose and Intent*
While it is recognized that within the Restricted Area, naturally occurring soil may not be of the white beach sand type, the purpose of this section is to maintain, preserve and protect the natural function and color of the fine to medium grained white sands of Walton County beaches. It is the intent of this section to prohibit the importation, use, and relocation of red clay and other prohibited materials that tend to discolor, darken or stain the natural white sands of Walton County beaches, and to prevent the transportation of prohibited soils whether by wind or water by requiring containment and removal of red clay and other discoloring, darkening or staining materials. The Walton County Board of County Commissioners acknowledges that the white sands of Walton County beaches promote tourism and enhance the quality of life of the residents of Walton County. The permanent discoloration, darkening or staining of the white sands on the beaches of Walton County would harm the public welfare making the enactment of this section necessary. The Board of County Commissioners hereby declares that red clay and all other prohibited materials that are capable of staining the natural white sands of Walton County beaches constitute a nuisance and irreversible harm to the people of the County. (Ord. No. 2005-24, § 1, 6-28-05)

4.07.02. *White Sand Protection Zone.*
These restrictions shall apply to the area located south of Scenic Gulf Drive (Old 98) eastward from the Okaloosa County line to its intersection with US 98, thence south of US 98 to County Road 30A, thence south of County Road 30A eastward to the juncture of U.S. Highway 98 and the Bay County line. The restricted area shall also include any lakes and adjoining land surrounding said lake, when said lake abuts County Road 30A. In the restricted area, there shall be no use of construction material that is subject to wind or water transport, and that permanently discolors the white beach sands. Such construction materials include, but are not limited to, red or yellow clay or sand. (Ord. No. 2005-24, § 1, 6-28-05)

4.07.03. *Definitions.*

Unless the context clearly requires another meaning, the following words shall have the meanings provided herein:

Approved materials means mineralogical composition of white sand of a sufficiently similar gradation to the existing beach sand as determined by the County Engineer, the Plans Review Engineer or their designee, as applicable, with a Munsell Color Chart value of 8.00 or white and a chroma of 1.00 on the 2.5, 5, 7.5 or 10YR or 2.5Y scale when checked in a dry air condition. For road bed construction; oyster shell, limestone, white dolomite, or other approved material, shall be reasonably the same color as approved sand after exposure to the sun.

Approved supply or source means any entity, person, company or location by which or from which material is pre-approved to be provided, used or delivered from off-or on-site.

Darkening, discoloring or staining means having the ability to permanently change the color or darken the natural white sands of Walton County beaches or other approved material whenever coming into contact with such sands or materials.

Disturb means to loosen or move material by digging or other similar operation, whether or not such material is removed from the disturbed area.

Natural function means, but is not limited to, its function as soil material for vegetation, as material for natural protective barriers along the shorelines, as habitat for animals and as a recreational medium.

Permanently change means to darken, discolor or stain the sands of Walton County beaches for longer than six months.

Prohibited materials means any discoloring or staining materials, imported or transferred to a site which includes material with a Munsell Color Chart (2000 edition) value darker than 8.00 and a chroma greater than 1.0 on the 2.5, 5, 7.5, 10YR, or 2.5Y scale when checked in a dry condition or any other material which, in whole or in part, is composed of or contains clay or any other substance that would darken, stain or discolor the natural white sands of Walton County beaches and a grain size with over ten percent by weight of the sample outside the range stated under fine to medium grained sand.

Storm means tropical depression, tropical storm or hurricane.

Supplier means the owner of or the place of origin of a material.
Transfer for use means to transport by any mechanical or manual means, from parcel to parcel or within a parcel. Use when used as a verb means to utilize a material to provide fill, to provide support, to establish an even grade, to shape the contours of land, or any similar purpose.

Walton County Beaches means all land waterward of the Coastal Construction Control Line (CCCL) and three hundred (300) feet landward of the CCCL or CR 30-A, whichever is less and any area within three (300) hundred feet landward of the mean high water line or, where applicable, the ordinary high water line of a coastal dune lake.

White Sand Protection Zone (WSPZ) means that area of Walton County located south of Scenic Gulf Drive (Old 98) eastward from the Okaloosa County line to its intersection with US 98, thence south of US 98 to County Road 30A, thence south of County Road 30A eastward to the juncture of U.S. Highway 98 and the Bay County line. The restricted area shall also include any coastal dune lakes and adjoining land surrounding the lake when the lake abuts County Road 30-A.

Wind or water transport shall mean the movement of improved or transferred material from the site of its initial or subsequent mechanical deposit from parcel to parcel or within a parcel

or any other location by means of the naturally generated forces of wind, rain, or wave action. (Ord. No. 2005-24, § 1, 6-28-05)

4.07.04. *Importation, Transfer, and Use Prohibited; Exemptions*.

No person may import or cause to be imported into the WSPZ of Walton County, Florida any construction or landscaping material that is not an approved material. No person may use, or transfer for use, any prohibited material into the WSPZ in connection with any paving, road surfacing, filling, landscaping, construction work or any other improvement to real property. No person may transfer from parcel to parcel any construction material that is not an approved material where such material is to be used in connection with any paving, road surfacing, filling, landscaping, construction work or any other improvement to real property in any part of the WSPZ whether leased or not. This section shall not be construed to prohibit the importation or use of sod or plants to be used for landscaping.

The Board of County Commissioners may exempt the application of this section in particular projects or parts of projects upon determination by four-fifths' vote of the Board of County Commissioners that an emergency exists and that an immediate exemption is required to protect the public health, safety or welfare.

Material which is uncovered on-site which does not meet the sand criteria within the WSPZ may be utilized on site for balancing the earthwork on-site. Pre-development conditions based on the existing soil strata will need to be re-established upon completion of earthwork operations. Existing soil conditions will need to be documented so that post-development conditions will be similar in nature. Similar in nature will mean that the material is similar in both coloration and grain size and be free of debris, rocks, clay, or other foreign matter.

4.07.05. *Removal and Containment.*

Any materials imported on-site which do not meet the minimum materials criteria of the WSPZ shall be removed. Where a contractor is required to remove prohibited materials, they shall be removed immediately. Prohibited materials not required to be removed immediately shall be contained on-site through the use of such reliable methods as are approved or prescribed by the County Engineer, including the employment of site fencing, covering or other pre-approved means.

4.07.06. *Approval of Material.*

Any project within, or the use of, a roadway right-of-way or public easement involving land disturbance, filling, paving, road surfacing, reconstruction, redevelopment, improvement, landscaping, placement of sand or dune building in the WSPZ shall require approval of the sand material supply or source by the County Engineer prior to finalizing design, applying for a permit or commencement of site work. A request shall be made to the County Engineer for a right of way agreement. All construction projects involving land disturbance, filling, reconstruction, redevelopment, improvement, landscaping, or placement of sand in the WSPZ shall require either: a) the supplier of the material, or b) an individual to obtain approval of the sand material source by the Plans Review Engineer prior to finalizing design, applying for a

permit or commencement of site work. In all situations, a request shall be made to the Plans Review Engineer at the time application is made for a Development Order. Approval of the subject material is required prior to the material being delivered to the site. Recommendations for use and retroactive approval will not be considered when there has been a violation of the white sand protection restrictions.

When requesting approval of material, the applicant, supplier, or entity requesting approval of a sand source shall provide the following:

A. Geologic description of the sample, including color standard to the Unified Soil Classification System and Munsell Color Charts.
B. Sample of sand material;
C. Schematic site design indicating area of placement of material.
D. A signed affidavit, furnished by the County, attesting to the receipt of a copy of this provision and agreeing to comply with these provisions.

The County Engineer or Plans Review Engineer, or their designee, as applicable, shall consider characteristics of the site and its location including: sand grain size, topography and vegetation to determine suitability of the sand sample. It shall be the responsibility of the sand supplier to provide assurance that their product meets the specifications of this Code. Rejected material shall be removed at the owner's expense. The County Engineer or the Plans Review Engineer or their designee as applicable may conduct a visual inspection or require sample analysis of each load of sand if necessary to ensure the integrity of the material. The County Engineer or the Plans Review Engineer or their designee, as applicable, shall approve or disapprove any application for material placement. (Ord. No. 2005-24, § 1, 6-28-05)

4.07.07. *Exemptions.*
Prohibited materials may be used under concrete or asphalt roads if exempted from these requirements, provided that the material is protected from wind or water transport during the construction process, is capped with either asphalt or concrete, is approved by the County Engineer or the Plans Review Engineer or their designee, as applicable, and is recommended to and approved by the Board of County Commissioners. Public infrastructure projects and beach and dune restoration projects conducted by Walton County are also exempt from this ordinance as they serve the public interest by providing protection to public and private lands, infrastructure, natural areas and the economy of Walton County. These projects shall be approved by the Board of County Commissioners before a project may commence. Remedial work after a storm as defined in Chapter 4.07.03 and placement of approved material may be approved by the County Engineer or the plans review engineer, or their designee, as applicable. Such approved material shall be sand that is similar to the pre-storm beach sand in both coloration and grain size and be free of debris, rocks, clay, or other foreign matter. (Ord. No. 2005-24, § 1, 6-28-05)

4.07.08. *Violations.*

Violations of this section shall be punishable as provided in Section 1-6 of the Code of Ordinances of Walton County. Additionally, the Code Enforcement Division and the Building Official are authorized to issue a stop work order (after inspection by the appropriate County staff) when it is alleged that a violation exists. When the County Engineer or the Plans Review Engineer or their designee, as applicable, recommends approval of prohibited materials and the Board of County Commissioners approves its use for road construction or site work, AND the use of prohibited material results in discoloring the white sand beaches, the owner or his representative shall be considered in violation of this section. After the discoloring material found to be in violation is removed as required by this section, the owner or his representative shall immediately restore the affected areas to their original condition in both topography and color. After restoration of the affected area, the County Engineer or the Plans Review Engineer or their designee, as applicable, shall inspect for compliance. (Ord. No. 2005-24, § 1, 6-28-05)

4.08.00. Historical Resources Protections

4.08.01. Site Plan Evaluation

Site plans for new development will be evaluated for identification of historic resources based on a professionally acceptable methodology.

A. Significant historical and archaeological sites, including but not limited to, sites on the Florida Master Site File, shall be protected by implementing the following:

1. As part of all site plan evaluations, County staff shall identify whether or not the proposed construction activity and/or final development would disturb a site listed on the Florida Master Site File. If so, the developer shall be notified and shall, in turn, notify the Florida Division of Historical Resources, Bureau of Historic Preservation, Compliance Review Section and shall enter a binding agreement with the County in which the developer agrees to comply with the recommended course of action or mitigation requested by the Division prior to the development order being issued.
2. All developers shall affirm that they have notified the construction manager of the potential for artifact discoveries within the County. In the event of the discovery of artifacts of potential historical or archaeological significance during construction, the construction manager shall immediately suspend all disruptive activity within a fifty foot (50') radius of the site of discovery and report the suspected finding(s) to the Florida Department of State, Division of Historical Resources, Bureau of Historic Preservation, Compliance Review Section, to the developer, and to Walton County. From the date of notification, construction shall be suspended for a period of up to one-hundred-twenty (120) days to allow evaluation of the site. The developer shall comply with the recommended course of action or mitigation requested by the Division and notify Walton County in writing of the action or mitigation requested.

4.09.00. FLOODPLAIN PROTECTION AND DAMAGE PREVENTION*

*Editor's note: Ord. No. 2005-27, adopted Oct. 11, 2005, repealed the former App. C, § 4.05.01--4.05.04, and enacted a new App. C, §§ 4.05.01--4.05.06, as set out herein. The former App. C, §§ 4.05.01--4.05.04, pertained to floodplain resource protection and damage prevention and derived from Ord. No. 97-28, adopted July 24, 1997. Ord. 2010-08, adopted May 10, 2010, amended App. C, §4.05.01—4.05.06 and added §4.05.07. Ord. No 2014-05, adopted January 28, 2014, repealed App. C, § 4.05.01—4.05.07, and enacted a new App. C § 4.05.01—4.05.16, as set out herein.

4.09.01. Purpose, Intent, and Objectives.

A. Title. These regulations shall be known as the Floodplain Management Ordinance of Walton County, hereinafter referred to as “this ordinance”.
B. Scope. The provisions of this ordinance shall apply to all development that is wholly within or partially within any flood hazard area, including but not limited to the subdivision of land; filling, grading, and other site improvements and utility installations; construction, alteration, remodeling, enlargement, improvement, replacement, repair, relocation or demolition of buildings, structures, and facilities that are exempt from the Florida Building Code; placement, installation, or replacement of manufactured homes and manufactured buildings; installation or replacement of tanks; placement of recreational vehicles; installation of swimming pools; and any other development.
C. Intent. The purposes of this ordinance and the flood load and flood resistant construction requirements of the Florida Building Code are to establish minimum requirements to safeguard the public health, safety, and general welfare and to minimize public and private losses due to flooding through regulation of development in flood hazard areas to:
    1. Minimize unnecessary disruption of commerce, access and public service during times of flooding;
    2. Require the use of appropriate construction practices in order to prevent or minimize future flood damage;
    3. Manage filling, grading, dredging, mining, paving, excavation, drilling operations, storage of equipment or materials, and other development which may increase flood damage or erosion potential;
    4. Manage the alteration of flood hazard areas, watercourses, and shorelines to minimize the impact of development on the natural and beneficial functions of the floodplain;
    5. Minimize damage to public and private facilities and utilities;
    6. Help maintain a stable tax base by providing for the sound use and development of flood hazard areas;
    7. Minimize the need for future expenditure of public funds for flood control projects and response to and recovery from flood events; and
    8. Meet the requirements of the National Flood Insurance Program for community participation as set forth in the Title 44 Code of Federal Regulations, Section 59.22.

D. Coordination with the Florida Building Code. This ordinance is intended to be administered and enforced in conjunction with the Florida Building Code. Where cited, ASCE 24 refers to the edition of the standard that is referenced by the Florida Building Code.
E. Warning. The degree of flood protection required by this ordinance and the Florida Building Code, as amended by this community, is considered the minimum reasonable for regulatory purposes and is based on scientific and engineering considerations. Larger floods can and will occur. Flood heights may be increased by man-made or natural causes. This ordinance does not imply that land outside of mapped special flood hazard areas, or that uses permitted within such flood hazard areas, will be free from flooding or flood damage. The flood hazard areas and base flood elevations contained in the Flood Insurance Study and shown on Flood Insurance Rate Maps and the requirements of Title 44 Code of Federal Regulations, Sections 59 and 60 may be revised by the Federal Emergency Management Agency, requiring this community to revise these regulations to remain eligible for participation in the National Flood Insurance Program. No guaranty of vested use, existing use, or future use is implied or expressed by compliance with this ordinance.
F. Disclaimer of Liability. This ordinance shall not create liability on the part of the Board of County Commissioners of Walton County or by any officer or employee thereof for any flood damage that results from reliance on this ordinance or any administrative decision lawfully made thereunder.

4.09.02. Applicability.

A. General. Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall be applicable.
B. Areas to which this ordinance applies. This ordinance shall apply to all flood hazard areas within Walton County, as established in Section 4.09.02(C) of this ordinance.
C. Basis for establishing flood hazard areas. The Flood Insurance Study for Walton County, Florida and Incorporated Areas dated December 30, 2020, and all subsequent amendments and revisions, and the accompanying Flood Insurance Rate Maps (FIRM), and all subsequent amendments and revisions to such maps, are adopted by reference as a part of this ordinance and shall serve as the minimum basis for establishing flood hazard areas. Studies and maps that establish flood hazard areas are on file at Walton County Planning and Development Services, 842 State Highway 20, Unit 110, Freeport, FL 32439.
D. Submission of additional data to establish flood hazard areas. To establish flood hazard areas and base flood elevations, pursuant to Section 4.09.06 of this ordinance the Floodplain Administrator may require submission of additional data. Where field surveyed topography prepared by a Florida licensed professional surveyor or digital topography accepted by the community indicates that ground elevations:

    1. Are below the closest applicable base flood elevation, even in areas not delineated as a special flood hazard area on a FIRM, the area shall be considered

as flood hazard area and subject to the requirements of this ordinance and, as applicable, the requirements of the Florida Building Code.

2. Are above the closest applicable base flood elevation, the area shall be regulated as special flood hazard area unless the applicant obtains a Letter of Map Change that removes the area from the special flood hazard area.

E. Other laws. The provisions of this ordinance shall not be deemed to nullify any provisions of local, state or federal law.

F. Abrogation and greater restrictions. This ordinance supersedes any ordinance in effect for management of development in flood hazard areas. However, it is not intended to repeal or abrogate any existing ordinances including but not limited to land development regulations, zoning ordinances, stormwater management regulations, or the Florida Building Code. In the event of a conflict between this ordinance and any other ordinance, the more restrictive shall govern. This ordinance shall not impair any deed restriction, covenant or easement, but any land that is subject to such interests shall also be governed by this ordinance.

G. Interpretation. In the interpretation and application of this ordinance, all provisions shall be:

1. Considered as minimum requirements;
2. Liberally construed in favor of the governing body; and
3. Deemed neither to limit nor repeal any other powers granted under state statutes.

4.09.03. Definitions.

A. Scope. Unless otherwise expressly stated, the following words and terms shall, for the purposes of this ordinance, have the meanings shown in this section, and shall only be applied in the context of Section 4.09.

B. Terms defined in the Florida Building Code. Where terms are not defined in this ordinance and are defined in the Florida Building Code, such terms shall have the meanings ascribed to them in that code.

C. Terms not defined. Where terms are not defined in this ordinance or the Florida Building Code, such terms shall have ordinarily accepted meanings such as the context implies.

Accessory structure. For the floodplain management purposes, a structure used only for parking and storage that is located on the same parcel of property as a principal structure and the use of which is incidental to the use of the principal structure.

Agricultural structure. For floodplain management purposes, a walled and roofed structure used exclusively for agricultural purposes or uses in connection with the production, harvesting, storage, raising, or drying of agricultural commodities and livestock, including aquatic organisms. Structures that house tools or equipment used in connection with these purposes or uses are also considered to have agricultural purposes or uses.

Alteration of a watercourse. A dam, impoundment, channel relocation, change in channel alignment, channelization, or change in cross-sectional area of the channel or the channel capacity, or any other form of modification which may alter, impede, retard or change the direction and/or velocity of the riverine flow of water during conditions of the base flood.

Appeal. A request for a review of the Floodplain Administrator's interpretation of any provision of this ordinance or a request for a variance.

ASCE 24. A standard titled Flood Resistant Design and Construction that is referenced by the Florida Building Code. ASCE 24 is developed and published by the American Society of Civil Engineers, Reston, VA.

Base flood. A flood having a 1-percent chance of being equaled or exceeded in any given year. [Also defined in FBC, B, Section 1612.2.] The base flood is commonly referred to as the "100 year flood" or the "1-percent-annual chance flood."

Base flood elevation. The elevation of the base flood, including wave height, relative to the National Geodetic Vertical Datum (NGVD), North American Vertical Datum (NAVD) or other datum specified on the Flood Insurance Rate Map (FIRM). [Also defined in FBC, B, Section 1612.2.]

Basement. The portion of a building having its floor subgrade (below ground level) on all sides. [Also defined in FBC, B, Section 1612.2.]

Coastal A Zone. Area within a special flood hazard area, landward of a V zone or landward of an open coast without mapped coastal high hazard areas. In a coastal A zone, the principal source of flooding must be astronomical tides, storm surges, seiches or tsunamis, not riverine flooding. During the base flood conditions, the potential for breaking wave height shall be greater than or equal to 1 ½ feet (457 mm). The inland limit of the coastal A zone is (a) the Limit of Moderate Wave Action if delineated on a FIRM, or (b) designated by the authority having jurisdiction.

Coastal construction control line. The line established by the State of Florida pursuant to section 161.053, F.S., and recorded in the official records of the community, which defines that portion of the beach-dune system subject to severe fluctuations based on a 100-year storm surge, storm waves or other predictable weather conditions.

Coastal high hazard area. A special flood hazard area extending from offshore to the inland limit of a primary frontal dune along an open coast and any other area subject to high velocity wave action from storms or seismic sources. Coastal high hazard areas are also referred to as "high hazard areas subject to high velocity wave action" or "V Zones" and are designated on Flood Insurance Rate Maps (FIRM) as Zone V1 V30, VE, or V.

Design flood. The flood associated with the greater of the following two areas: [Also defined in FBC, B, Section 1612.2.]

1. Area with a floodplain subject to a 1-percent or greater chance of flooding in any year; or
2. Area designated as a flood hazard area on the community's flood hazard map, or otherwise legally designated.

Design flood elevation. The elevation of the "design flood," including wave height, relative to the datum specified on the community's legally designated flood hazard map. In areas designated as Zone AO, the design flood elevation shall be the elevation of the highest existing grade of the building's perimeter plus the depth number (in feet) specified on the flood hazard map. In areas designated as Zone AO where the depth number is not specified on the map, the depth number shall be taken as being equal to 2 feet. [Also defined in FBC, B, Section 1612.2.]

Development. Any man-made change to improved or unimproved real estate, including but not limited to, buildings or other structures, tanks, temporary structures, temporary or permanent storage of equipment or materials, mining, dredging, filling, grading, paving, excavations, drilling operations or any other land disturbing activities.

Encroachment. The placement of fill, excavation, buildings, permanent structures or other development into a flood hazard area which may impede or alter the flow capacity of riverine flood hazard areas.

Existing building and existing structure. Any buildings and structures for which the "start of construction" commenced before November 16, 1977. [Also defined in FBC, B, Section 1612.2.]

Federal Emergency Management Agency (FEMA). The federal agency that, in addition to carrying out other functions, administers the National Flood Insurance Program.

Flood or flooding. A general and temporary condition of partial or complete inundation of normally dry land from: [Also defined in FBC, B, Section 1612.2.]

1. The overflow of inland or tidal waters.
2. The unusual and rapid accumulation or runoff of surface waters from any source.

Flood damage-resistant materials. Any construction material capable of withstanding direct and prolonged contact with floodwaters without sustaining any damage that requires more than cosmetic repair. [Also defined in FBC, B, Section 1612.2.]

Flood hazard area. The greater of the following two areas: [Also defined in FBC, B, Section 1612.2.]

1. The area within a floodplain subject to a 1-percent or greater chance of flooding in any year.
2. The area designated as a flood hazard area on the community's flood hazard map, or otherwise legally designated.

Flood Insurance Rate Map (FIRM). The official map of the community on which the Federal Emergency Management Agency has delineated both special flood hazard areas and the risk premium zones applicable to the community. [Also defined in FBC, B, Section 1612.2.]

Flood Insurance Study (FIS). The official report provided by the Federal Emergency Management Agency that contains the Flood Insurance Rate Map, the Flood Boundary and Floodway Map (if applicable), the water surface elevations of the base flood, and supporting technical data. [Also defined in FBC, B, Section 1612.2.]

Floodplain Administrator. The office or position designated and charged with the administration and enforcement of this ordinance (may be referred to as the Floodplain Manager).

Floodplain development permit or approval. An official document or certificate issued by the community, or other evidence of approval or concurrence, which authorizes performance of specific development activities that are located in flood hazard areas and that are determined to be compliant with this ordinance.

Floodway. The channel of a river or other riverine watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one (1) foot. [Also defined in FBC, B, Section 1612.2.]

Floodway encroachment analysis. An engineering analysis of the impact that a proposed encroachment into a floodway is expected to have on the floodway boundaries and base flood elevations; the evaluation shall be prepared by a qualified Florida licensed engineer using standard engineering methods and models.

Florida Building Code. The family of codes adopted by the Florida Building Commission, including: Florida Building Code, Building; Florida Building Code, Residential; Florida Building Code, Existing Building; Florida Building Code, Mechanical; Florida Building Code, Plumbing; Florida Building Code, Fuel Gas.

Functionally dependent use. A use which cannot perform its intended purpose unless it is located or carried out in close proximity to water, including only docking facilities, port facilities that are necessary for the loading and unloading of cargo or passengers, and ship

building and ship repair facilities; the term does not include long term storage or related manufacturing facilities.

Highest adjacent grade. The highest natural elevation of the ground surface prior to construction next to the proposed walls or foundation of a structure.

Historic structure. Any structure that is determined eligible for the exception to the flood hazard area requirements of the Florida Building Code, Existing Building, Chapter 11 Historic Buildings.

Letter of Map Change (LOMC). An official determination issued by FEMA that amends or revises an effective Flood Insurance Rate Map or Flood Insurance Study. Letters of Map Change include:

1. Letter of Map Amendment (LOMA): An amendment based on technical data showing that a property was incorrectly included in a designated special flood hazard area. A LOMA amends the current effective Flood Insurance Rate Map and establishes that a specific property, portion of a property, or structure is not located in a special flood hazard area.
2. Letter of Map Revision (LOMR): A revision based on technical data that may show changes to flood zones, flood elevations, special flood hazard area boundaries and floodway delineations, and other planimetric features.
3. Letter of Map Revision Based on Fill (LOMR-F): A determination that a structure or parcel of land has been elevated by fill above the base flood elevation and is, therefore, no longer located within the special flood hazard area. In order to qualify for this determination, the fill must have been permitted and placed in accordance with the community's floodplain management regulations.
4. Conditional Letter of Map Revision (CLOMR): A formal review and comment as to whether a proposed flood protection project or other project complies with the minimum NFIP requirements for such projects with respect to delineation of special flood hazard areas. A CLOMR does not revise the effective Flood Insurance Rate Map or Flood Insurance Study; upon submission and approval of certified as-built documentation, a Letter of Map Revision may be issued by FEMA to revise the effective FIRM.

Light-duty truck. As defined in 40 C.F.R. 86.082-2, any motor vehicle rated at 8,500 pounds Gross Vehicular Weight Rating or less which has a vehicular curb weight of 6,000 pounds or less and which has a basic vehicle frontal area of 45 square feet or less, which is:

1. Designed primarily for purposes of transportation of property or is a derivation of such a vehicle, or
2. Designed primarily for transportation of persons and has a capacity of more than 12 persons; or

3. Available with special features enabling off-street or off-highway operation and use.

Limit of Moderate Wave Action. Line shown on FIRMs to indicate the inland limit of the 1 ½-foot breaking wave height during the base flood.

Lowest floor. The lowest floor of the lowest enclosed area of a building or structure, including basement, but excluding any unfinished or flood-resistant enclosure, other than a basement, usable solely for vehicle parking, building access or limited storage provided that such enclosure is not built so as to render the structure in violation of the non-elevation requirements of the Florida Building Code or ASCE 24. [Also defined in FBC, B, Section 1612.2.]

Manufactured home. A structure, transportable in one or more sections, which is eight (8) feet or more in width and greater than four hundred (400) square feet, and which is built on a permanent, integral chassis and is designed for use with or without a permanent foundation when attached to the required utilities. The term "manufactured home" does not include a "recreational vehicle" or "park trailer." [Also defined in 15C-1.0101, F.A.C.]

Manufactured home park or subdivision. A parcel (or contiguous parcels) of land divided into two or more manufactured home lots for rent or sale.

Market value. The value of buildings and structures, excluding the land and other improvements on the parcel. Market value is the Actual Cash Value (like-kind replacement cost depreciated for age, wear and tear, neglect, and quality of construction), determined by a qualified independent appraiser, or tax assessment value adjusted to approximate market value by a factor provided by the Property Appraiser.

New construction. For the purposes of administration of this ordinance and the flood resistant construction requirements of the Florida Building Code, structures for which the "start of construction" commenced on or after November 16, 1977 and includes any subsequent improvements to such structures.

Park trailer. A transportable unit which has a body width not exceeding fourteen (14) feet and which is built on a single chassis and is designed to provide seasonal or temporary living quarters when connected to utilities necessary for operation of installed fixtures and appliances. [Defined in section 320.01, F.S.]

Recreational vehicle. A vehicle, including a park trailer, which is: [See section 320.01, F.S.)

1. Built on a single chassis;
2. Four hundred (400) square feet or less when measured at the largest horizontal projection;
3. Designed to be self-propelled or permanently towable by a light duty truck; and
4. Designed primarily not for use as a permanent dwelling but as temporary living

quarters for recreational, camping, travel, or seasonal use.

Sand dunes. Naturally occurring accumulations of sand in ridges or mounds landward of the beach.

Special flood hazard area. An area in the floodplain subject to a 1 percent or greater chance of flooding in any given year. Special flood hazard areas are shown on FIRMs as Zone A, AO, A1 A30, AE, A99, AH, V1 V30, VE or V. [Also defined in FBC, B Section 1612.2.]

Start of construction. The date of issuance for new construction and substantial improvements to existing structures, provided the actual start of construction, repair, reconstruction, rehabilitation, addition, placement, or other improvement is within 180 days of the date of the issuance. The actual start of construction means either the first placement of permanent construction of a building (including a manufactured home) on a site, such as the pouring of slab or footings, the installation of piles, the construction of columns. Permanent construction does not include land preparation (such as clearing, grading, or filling), the installation of streets or walkways, excavation for a basement, footings, piers, or foundations, the erection of temporary forms or the installation of accessory buildings such as garages or sheds not occupied as dwelling units or not part of the main buildings. For a substantial improvement, the actual "start of construction" means the first alteration of any wall, ceiling, floor or other structural part of a building, whether or not that alteration affects the external dimensions of the building. [Also defined in FBC, B Section 1612.2.]

Substantial damage. Damage of any origin sustained by a building or structure whereby the cost of restoring the building or structure to its before-damaged condition would equal or exceed 50 percent of the market value of the building or structure before the damage occurred. The term also includes flood-related damage sustained by a structure on two separate occasions during a ten (10)-year period for which the cost of repairs at the time of each such flood event, on average, equals or exceeds 25 percent of the market value of the structure before the damage occurred. [Also defined in FBC, B Section 1612.2.]

Substantial improvement. Any combination of repair, reconstruction, rehabilitation, addition, or other improvement of a building or structure taking place during a five (5)–year period, the cumulative cost of which equals or exceeds 50 percent of the market value of the building or structure before the improvement or repair is started. For each building or structure, the five (5)–year period begins on the date of the first improvement or repair of that building or structure subsequent to March 1, 2011. If the structure has incurred "substantial damage," any repairs are considered substantial improvement regardless of the actual repair work performed. The term does not, however, include either: [Also defined in FBC, B, Section 1612.2.]

1. Any project for improvement of a building required to correct existing health,

sanitary, or safety code violations identified by the building official and that are the minimum necessary to assure safe living conditions.

2. Any alteration of a historic structure provided the alteration will not preclude the structure's continued designation as a historic structure.

Variance. A grant of relief from the requirements of this ordinance, or the flood resistant construction requirements of the Florida Building Code, which permits construction in a manner that would not otherwise be permitted by this ordinance or the Florida Building Code.

Watercourse. A river, creek, stream, channel or other topographic feature in, on, through, or over which water flows at least periodically.

4.09.04. Duties and Powers of the Floodplain Administrator.

A. Designation. The Floodplain Manager is designated as the Floodplain Administrator. The Floodplain Administrator may delegate performance of certain duties to other employees.

B. General. The Floodplain Administrator is authorized and directed to administer and enforce the provisions of this ordinance. The Floodplain Administrator shall have the authority to render interpretations of this ordinance consistent with the intent and purpose of this ordinance and may establish policies and procedures in order to clarify the application of its provisions. Such interpretations, policies, and procedures shall not have the effect of waiving requirements specifically provided in this ordinance without the granting of a variance pursuant to Section 4.09.08 of this ordinance.

C. Applications and permits. The Floodplain Administrator, in coordination with other pertinent offices of the community, shall:

1. Review applications and plans to determine whether proposed new development will be located in flood hazard areas;
2. Review applications for modification of any existing development in flood hazard areas for compliance with the requirements of this ordinance;
3. Interpret flood hazard area boundaries where such interpretation is necessary to determine the exact location of boundaries; a person contesting the determination shall have the opportunity to appeal the interpretation;
4. Provide available flood elevation and flood hazard information;
5. Determine whether additional flood hazard data shall be obtained from other sources or shall be developed by an applicant;
6. Review applications to determine whether proposed development will be reasonably safe from flooding;
7. Issue floodplain development permits or approvals for development other than buildings and structures that are subject to the Florida Building Code, including

buildings, structures and facilities exempt from the Florida Building Code, when compliance with this ordinance is demonstrated, or disapprove the same in the event of noncompliance; and

8. Coordinate with and provide comments to the Building Official to assure that applications, plan reviews, and inspections for buildings and structures in flood hazard areas comply with the applicable provisions of this ordinance.

D. Substantial improvement and substantial damage determinations. For applications for building permits to improve buildings and structures, including alterations, movement, enlargement, replacement, repair, change of occupancy, additions, rehabilitations, renovations, substantial improvements, repairs of substantial damage, and any other improvement of or work on such buildings and structures, the Floodplain Administrator, in coordination with the Building Official, shall:

1. Estimate the market value, or require the applicant to obtain an appraisal of the market value prepared by a qualified independent appraiser, of the building or structure before the start of construction of the proposed work; in the case of repair, the market value of the building or structure shall be the market value before the damage occurred and before any repairs are made;
2. Compare the cost to perform the improvement, the cost to repair a damaged building to its pre-damaged condition, or the combined costs of improvements and repairs, if applicable, to the market value of the building or structure;
3. Determine and document whether the proposed work constitutes substantial improvement or repair of substantial damage; the determination requires evaluation of previous permits issued for improvements and repairs as specified in the definition of “substantial improvement”; for proposed work to repair damage caused by flooding, the determination requires evaluation of previous permits issued to repair flood-related damage as specified in the definition of “substantial damage”; and
4. Notify the applicant if it is determined that the work constitutes substantial improvement or repair of substantial damage and that compliance with the flood resistant construction requirements of the Florida Building Code and this ordinance is required.

E. Modifications of the strict application of the requirements of the Florida Building Code. The Floodplain Administrator shall review requests submitted to the Building Official that seek approval to modify the strict application of the flood load and flood resistant construction requirements of the Florida Building Code to determine whether such requests require the granting of a variance pursuant to Section 4.09.08 of this ordinance.

F. Notices and orders. The Floodplain Administrator shall coordinate with appropriate local agencies for the issuance of all necessary notices or orders to ensure compliance with this ordinance.

G. Inspections. The Floodplain Administrator shall make the required inspections as specified in Section 4.09.07 of this ordinance for development that is not subject to the Florida Building Code, including buildings, structures and facilities exempt from the Florida Building Code. The Floodplain Administrator shall inspect flood hazard areas to determine if development is undertaken without issuance of a permit.

H. Other duties of the Floodplain Administrator. The Floodplain Administrator shall have other duties, including but not limited to:

1. Establish, in coordination with the Building Official, procedures for administering and documenting determinations of substantial improvement and substantial damage made pursuant to Section 4.09.04(D) of this ordinance;
2. Require that applicants proposing alteration of a watercourse notify adjacent communities and the Florida Division of Emergency Management, State Floodplain Management Office, and submit copies of such notifications to the Federal Emergency Management Agency (FEMA);
3. Require applicants who submit hydrologic and hydraulic engineering analyses to support permit applications to submit to FEMA the data and information necessary to maintain the Flood Insurance Rate Maps if the analyses propose to change base flood elevations, flood hazard area boundaries, or floodway designations; such submissions shall be made within 6 months of such data becoming available;
4. Review required design certifications and documentation of elevations specified by this ordinance and the Florida Building Code and this ordinance to determine that such certifications and documentations are complete;
5. Notify the Federal Emergency Management Agency when the corporate boundaries of Walton County are modified; and
6. Advise applicants for new buildings and structures, including substantial improvements, that are located in any unit of the Coastal Barrier Resources System established by the Coastal Barrier Resources Act (Pub. L. 97-348) and the Coastal Barrier Improvement Act of 1990 (Pub. L. 101-591) that federal flood insurance is not available on such construction; areas subject to this limitation are identified on Flood Insurance Rate Maps as “Coastal Barrier Resource System Areas” and “Otherwise Protected Areas.”

I. Floodplain management records. Regardless of any limitation on the period required for retention of public records, the Floodplain Administrator shall maintain and permanently keep and make available for public inspection all records that are necessary for the administration of this ordinance and the flood resistant construction requirements of the Florida Building Code, including Flood Insurance Rate Maps; Letters of Change; records of issuance of permits and denial of permits; determinations of whether proposed work constitutes substantial improvement or repair of substantial damage; required design certifications and documentation of elevations specified by the Florida Building Code and this ordinance; notifications to adjacent communities, FEMA, and the state related to

alterations of watercourses; assurances that the flood carrying capacity of altered watercourses will be maintained; documentation related to appeals and variances, including justification for issuance or denial; and records of enforcement actions taken pursuant to this ordinance and the flood resistant construction requirements of the Florida Building Code. These records shall be available for public inspection at Walton County Planning and Development Services 842 State Highway 20 E, Unit 110, Freeport, FL 32439.

J. Certification requirements for the Floodplain Administrator. The Floodplain Administrator shall become certified and maintain said certification in good standing during employment with Walton County. The requirements for certification are as follows:

1. Within one year of being hired or designated as such, the Floodplain Administrator shall apply to sit for and obtain a passing grade on the Certified Floodplain Manager® examination administered by the Association of State Floodplain Managers (ASFPM).
2. The Floodplain Administrator shall be required to maintain the Floodplain Manager Certification® through continuing education credits as required by ASFPM.
3. Failure to pass the examination, or upon deactivation of the Certified Floodplain Manager® certification by ASFPM, the Floodplain Administrator shall be subject to probation, relocation, or termination of employment as determined by the County Administrator.

4.09.05. Permits.

A. Permits required. Any owner or owner's authorized agent (hereinafter "applicant") who intends to undertake any development activity within the scope of this ordinance, including buildings, structures and facilities exempt from the Florida Building Code, which is wholly within or partially within any flood hazard area shall first make application to the Floodplain Administrator, and the Building Official if applicable, and shall obtain the required permit(s) and approval(s). No such permit or approval shall be issued until compliance with the requirements of this ordinance and all other applicable codes and regulations has been satisfied.

B. Floodplain development permits or approvals. Floodplain development permits or approvals shall be issued pursuant to this ordinance for any development activities not subject to the requirements of the Florida Building Code, including buildings, structures and facilities exempt from the Florida Building Code. Depending on the nature and extent of proposed development that includes a building or structure, the Floodplain Administrator may determine that a floodplain development permit or approval is required in addition to a building permit.

C. Buildings, structures and facilities exempt from the Florida Building Code. Pursuant to the

requirements of federal regulation for participation in the National Flood Insurance Program (44 C.F.R. Sections 59 and 60), floodplain development permits or approvals shall be required for the following buildings, structures and facilities that are exempt from the Florida Building Code and any further exemptions provided by law, which are subject to the requirements of this ordinance:

1. Railroads and ancillary facilities associated with the railroad.
2. Nonresidential farm buildings on farms, as provided in section 604.50, F.S.
3. Temporary buildings or sheds used exclusively for construction purposes.
4. Mobile or modular structures used as temporary offices.
5. Those structures or facilities of electric utilities, as defined in section 366.02, F.S., which are directly involved in the generation, transmission, or distribution of electricity.
6. Chickees constructed by the Miccosukee Tribe of Indians of Florida or the Seminole Tribe of Florida. As used in this paragraph, the term “chickee” means an open-sided wooden hut that has a thatched roof of palm or palmetto or other traditional materials, and that does not incorporate any electrical, plumbing, or other non-wood features.
7. Family mausoleums not exceeding 250 square feet in area which are prefabricated and assembled on site or preassembled and delivered on site and have walls, roofs, and a floor constructed of granite, marble, or reinforced concrete.
8. Temporary housing provided by the Department of Corrections to any prisoner in the state correctional system.
9. Structures identified in section 553.73(10)(k), F.S., are not exempt from the Florida Building Code if such structures are located in flood hazard areas established on Flood Insurance Rate Maps.

D. Application for a permit or approval. To obtain a floodplain development permit or approval the applicant shall first file an application in writing on a form furnished by the community. The information provided shall:

1. Identify and describe the development to be covered by the permit or approval.
2. Describe the land on which the proposed development is to be conducted by legal description, street address or similar description that will readily identify and definitively locate the site.
3. Indicate the use and occupancy for which the proposed development is intended.
4. Be accompanied by a site plan or construction documents as specified in Section 4.09.06 of this ordinance.
5. State the valuation of the proposed work.
6. Be signed by the applicant or the applicant's authorized agent.
7. Give such other data and information as required by the Floodplain Administrator.

E. Validity of permit or approval. The issuance of a floodplain development permit or approval

pursuant to this ordinance shall not be construed to be a permit for, or approval of, any violation of this ordinance, the Florida Building Codes, or any other ordinance of this community. The issuance of permits based on submitted applications, construction documents, and information shall not prevent the Floodplain Administrator from requiring the correction of errors and omissions.

F. Expiration. A floodplain development permit or approval shall become invalid unless the work authorized by such permit is commenced within 180 days after its issuance, or if the work authorized is suspended or abandoned for a period of 180 days after the work commences. Extensions for periods of not more than 180 days each shall be requested in writing and justifiable cause shall be demonstrated.

G. Suspension or revocation. The Floodplain Administrator is authorized to suspend or revoke a floodplain development permit or approval if the permit was issued in error, on the basis of incorrect, inaccurate or incomplete information, or in violation of this ordinance or any other ordinance, regulation or requirement of this community.

H. Other permits required. Floodplain development permits and building permits shall include a condition that all other applicable state or federal permits be obtained before commencement of the permitted development, including but not limited to the following:

1. The Northwest Florida Water Management District; section 373.036, F.S.
2. Florida Department of Health for onsite sewage treatment and disposal systems; section 381.0065, F.S. and Chapter 64E-6, F.A.C.
3. Florida Department of Environmental Protection for construction, reconstruction, changes, or physical activities for shore protection or other activities seaward of the coastal construction control line; section 161.141, F.S.
4. Florida Department of Environmental Protection for activities subject to the Joint Coastal Permit; section 161.055, F.S.
5. Florida Department of Environmental Protection for activities that affect wetlands and alter surface water flows, in conjunction with the U.S. Army Corps of Engineers; Section 404 of the Clean Water Act.
6. Federal permits and approvals.

4.09.06. Site Plans and Construction Documents.

A. Information for development in flood hazard areas. The site plan or construction documents for any development subject to the requirements of this ordinance shall be drawn to scale and shall include, as applicable to the proposed development:

1. Delineation of flood hazard areas, floodway boundaries and flood zone(s), base flood elevation(s), and ground elevations if necessary for review of the proposed development.

2. Where base flood elevations, or floodway data are not included on the FIRM or in the Flood Insurance Study, they shall be established in accordance with Section 4.09.06(B)(2) or (3) of this ordinance.
3. Where the parcel on which the proposed development will take place will have more than 50 lots or is larger than 5 acres and the base flood elevations are not included on the FIRM or in the Flood Insurance Study, such elevations shall be established in accordance with Section 4.09.06(B)(1) of this ordinance.
4. Location of the proposed activity and proposed structures, and locations of existing buildings and structures; in coastal high hazard areas, new buildings shall be located landward of the reach of mean high tide.
5. Location, extent, amount, and proposed final grades of any filling, grading, or excavation.
6. Where the placement of fill is proposed, the amount, type, and source of fill material; compaction specifications; a description of the intended purpose of the fill areas; and evidence that the proposed fill areas are the minimum necessary to achieve the intended purpose.
7. Delineation of the Coastal Construction Control Line or notation that the site is seaward of the coastal construction control line, if applicable.
8. Extent of any proposed alteration of sand dunes or mangrove stands, provided such alteration is approved by the Florida Department of Environmental Protection.
9. Existing and proposed alignment of any proposed alteration of a watercourse.

The Floodplain Administrator is authorized to waive the submission of site plans, construction documents, and other data that are required by this ordinance but that are not required to be prepared by a registered design professional if it is found that the nature of the proposed development is such that the review of such submissions is not necessary to ascertain compliance with this ordinance.

B. Information in flood hazard areas without base flood elevations (approximate Zone A). Where flood hazard areas are delineated on the FIRM and base flood elevation data have not been provided, the Floodplain Administrator shall:

    1. Require the applicant to include base flood elevation data prepared in accordance with currently accepted engineering practices.
    2. Obtain, review, and provide to applicants base flood elevation and floodway data available from a federal or state agency or other source or require the applicant to obtain and use base flood elevation and floodway data available from a federal or state agency or other source
    3. Where base flood elevation and floodway data are not available from another source, where the available data are deemed by the Floodplain Administrator to not reasonably reflect flooding conditions, or where the available data are known to be scientifically or technically incorrect or otherwise inadequate:
        a. Require the applicant to include base flood elevation data prepared in

accordance with currently accepted engineering practices; or

b. Specify that the base flood elevation is three (3) feet above the highest adjacent grade at the location of the development, provided there is no evidence indicating flood depths have been or may be greater than three (3) feet.

4. Where the base flood elevation data are to be used to support a Letter of Map Change from FEMA, advise the applicant that the analyses shall be prepared by a Florida licensed engineer in a format required by FEMA, and that it shall be the responsibility of the applicant to satisfy the submittal requirements and pay the processing fees.

C. Additional analyses and certifications. As applicable to the location and nature of the proposed development activity, and in addition to the requirements of this section, the applicant shall have the following analyses signed and sealed by a Florida licensed engineer for submission with the site plan and construction documents:

1. For development activities proposed to be located in a regulatory floodway, a floodway encroachment analysis that demonstrates that the encroachment of the proposed development will not cause any increase in base flood elevations; where the applicant proposes to undertake development activities that do increase base flood elevations, the applicant shall submit such analysis to FEMA as specified in Section 4.09.06(D) of this ordinance and shall submit the Conditional Letter of Map Revision, if issued by FEMA, with the site plan and construction documents.
2. For development activities proposed to be located in a riverine flood hazard area for which base flood elevations are included in the Flood Insurance Study or on the FIRM and floodways have not been designated, hydrologic and hydraulic analyses that demonstrate that the cumulative effect of the proposed development, when combined with all other existing and anticipated flood hazard area encroachments, will not increase the base flood elevation more than one (1) foot at any point within the community. This requirement does not apply in isolated flood hazard areas not connected to a riverine flood hazard area or in flood hazard areas identified as Zone AO or Zone AH.
3. For alteration of a watercourse, an engineering analysis prepared in accordance with standard engineering practices which demonstrates that the flood-carrying capacity of the altered or relocated portion of the watercourse will not be decreased, and certification that the altered watercourse shall be maintained in a manner which preserves the channel's flood-carrying capacity; the applicant shall submit the analysis to FEMA as specified in Section 4.09.06(D) of this ordinance.
4. For activities that propose to alter sand dunes or mangrove stands in coastal high hazard areas (Zone V), an engineering analysis that demonstrates that the proposed alteration will not increase the potential for flood damage.

D. Submission of additional data. When additional hydrologic, hydraulic or other engineering data, studies, and additional analyses are submitted to support an application, the applicant has the right to seek a Letter of Map Change from FEMA to change the base flood elevations, change floodway boundaries, or change boundaries of flood hazard areas shown on FIRMs, and to submit such data to FEMA for such purposes. The analyses shall be prepared by a Florida licensed engineer in a format required by FEMA. Submittal requirements and processing fees shall be the responsibility of the applicant.

4.09.07. Inspections.

A. General. Development for which a floodplain development permit or approval is required shall be subject to inspection.

1. Development other than buildings and structures. The Floodplain Administrator shall inspect all development to determine compliance with the requirements of this ordinance and the conditions of issued floodplain development permits or approvals.
2. Buildings, structures and facilities exempt from the Florida Building Code. The Floodplain Administrator shall inspect buildings, structures and facilities exempt from the Florida Building Code to determine compliance with the requirements of this ordinance and the conditions of issued floodplain development permits or approvals.

    a. Buildings, structures and facilities exempt from the Florida Building Code, lowest floor inspection. Upon placement of the lowest floor, including basement, and prior to further vertical construction, the owner of a building, structure or facility exempt from the Florida Building Code, or the owner's authorized agent, shall submit to the Floodplain Administrator:

        i. If a design flood elevation was used to determine the required elevation of the lowest floor, the certification of elevation of the lowest floor prepared and sealed by a Florida licensed professional surveyor; or
        ii. If the elevation used to determine the required elevation of the lowest floor was determined in accordance with Section 4.09.06(B)(3)(b) of this ordinance, the documentation of height of the lowest floor above highest adjacent grade, prepared by the owner or the owner's authorized agent.

    b. Buildings, structures and facilities exempt from the Florida Building Code, final inspection. As part of the final inspection, the owner or owner's authorized agent shall submit to the Floodplain Administrator a final certification of elevation of the lowest floor or final documentation of the height of the lowest floor above the highest adjacent grade; such certifications and documentations shall be prepared as specified in Section 4.09.07(2)(a). of this ordinance.

3. Manufactured homes. The Floodplain Administrator shall inspect manufactured homes that are installed or replaced in flood hazard areas to determine compliance with the requirements of this ordinance and the conditions of the issued permit. Upon placement of a manufactured home, certification of the elevation of the lowest floor shall be submitted to the Floodplain Administrator.

4.09.08. Variances and Appeals.

A. General. The Walton County Board of Adjustments shall hear and decide on requests for appeals and requests for variances from the strict application of this ordinance. Pursuant to section 553.73(5), F.S., the Walton County Board of Adjustments shall hear and decide on requests for appeals and requests for variances from the strict application of the flood resistant construction requirements of the Florida Building Code. This section does not apply to Section 3109 of the Florida Building Code, Building.

B. Appeals. The Walton County Board of Adjustments shall hear and decide appeals when it is alleged there is an error in any requirement, decision, or determination made by the Floodplain Administrator in the administration and enforcement of this ordinance. Any person aggrieved by the decision of Walton County Board of Adjustments may appeal such decision to the Circuit Court, as provided by Florida Statutes.

C. Limitations on authority to grant variances. The Walton County Board of Adjustments shall base its decisions on variances on technical justifications submitted by applicants, the considerations for issuance in Section 4.09.08(G) of this ordinance, the conditions of issuance set forth in Section 4.09.08(H) of this ordinance, and the comments and recommendations of the Floodplain Administrator and the Building Official. The Walton County Board of Adjustments has the right to attach such conditions as it deems necessary to further the purposes and objectives of this ordinance.

D. Restrictions in floodways. A variance shall not be issued for any proposed development in a floodway if any increase in base flood elevations would result, as evidenced by the applicable analyses and certifications required in Section 4.09.06(C) of this ordinance.

E. Historic buildings. A variance is authorized to be issued for the repair, improvement, or rehabilitation of a historic building that is determined eligible for the exception to the flood resistant construction requirements of the Florida Building Code, Existing Building, Chapter 12 Historic Buildings, upon a determination that the proposed repair, improvement, or rehabilitation will not preclude the building's continued designation as a historic building and the variance is the minimum necessary to preserve the historic character and design of the building. If the proposed work precludes the building's continued designation as a historic building, a variance shall not be granted and the building and any repair, improvement, and rehabilitation shall be subject to the requirements of the Florida Building

Code.

F. Functionally dependent uses. A variance is authorized to be issued for the construction or substantial improvement necessary for the conduct of a functionally dependent use, as defined in this ordinance, provided the variance meets the requirements of Section 4.09.08(D), is the minimum necessary considering the flood hazard, and all due consideration has been given to use of methods and materials that minimize flood damage during occurrence of the base flood.

G. Considerations for issuance of variances. In reviewing requests for variances, the Walton County Board of Adjustments shall consider all technical evaluations, all relevant factors, all other applicable provisions of the Florida Building Code, this ordinance, and the following:
    1. The danger that materials and debris may be swept onto other lands resulting in further injury or damage;
    2. The danger to life and property due to flooding or erosion damage;
    3. The susceptibility of the proposed development, including contents, to flood damage and the effect of such damage on current and future owners;
    4. The importance of the services provided by the proposed development to the community;
    5. The availability of alternate locations for the proposed development that are subject to lower risk of flooding or erosion;
    6. The compatibility of the proposed development with existing and anticipated development;
    7. The relationship of the proposed development to the comprehensive plan and floodplain management program for the area;
    8. The safety of access to the property in times of flooding for ordinary and emergency vehicles;
    9. The expected heights, velocity, duration, rate of rise and debris and sediment transport of the floodwaters and the effects of wave action, if applicable, expected at the site; and
    10. The costs of providing governmental services during and after flood conditions including maintenance and repair of public utilities and facilities such as sewer, gas, electrical and water systems, streets and bridges.

H. Conditions for issuance of variances. Variances shall be issued only upon:

1. Submission by the applicant, of a showing of good and sufficient cause that the unique characteristics of the size, configuration, or topography of the site limit compliance with any provision of this ordinance or the required elevation standards;
2. Determination by the Walton County Board of Adjustments that:
    a. Failure to grant the variance would result in exceptional hardship due to the physical characteristics of the land that render the lot undevelopable; increased costs to satisfy the requirements or inconvenience do not constitute hardship;

b. The granting of a variance will not result in increased flood heights, additional threats to public safety, extraordinary public expense, nor create nuisances, cause fraud on or victimization of the public or conflict with existing local laws and ordinances; and
c. The variance is the minimum necessary, considering the flood hazard, to afford relief;

3. Receipt of a signed statement by the applicant that the variance, if granted, shall be recorded in the Office of the Clerk of the Court in such a manner that it appears in the chain of title of the affected parcel of land; and
4. If the request is for a variance to allow construction of the lowest floor of a new building, or substantial improvement of a building, below the required elevation, a copy in the record of a written notice from the Floodplain Administrator to the applicant for the variance, specifying the difference between the base flood elevation and the proposed elevation of the lowest floor, stating that the cost of federal flood insurance will be commensurate with the increased risk resulting from the reduced floor elevation (up to amounts as high as $25 for $100 of insurance coverage), and stating that construction below the base flood elevation increases risks to life and property.

I. *Agricultural Structures.* A variance is authorized to be issued for the construction or substantial improvement of agricultural structures provided the requirements of this section are satisfied and:

1. A determination has been made that the proposed agricultural structure:
   a. Is used exclusively in connection with the production, harvesting, storage, raising, or drying of agricultural commodities and livestock, or storage of tools or equipment used in connection with these purposes or uses, and will be restricted to such exclusive uses.

   b. Has low damage potential (amount of physical damage, contents damage, and loss of function).

   c. Does not increase risks and pose a danger to public health, safety, and welfare if flooded and contents are released, including but not limited to the effects of flooding on manure storage, livestock confinement operations, liquified natural gas terminals, and production and storage of highly volatile, toxic, or water-reactive materials.

   d. Is not located in a coastal high hazard area (Zone V/VE), except for aquaculture structures dependent on close proximity to water.

   e. Complies with the wet floodproofing construction requirements of paragraph (2), below.

2. Wet floodproofing construction requirements.

a. Anchored to resist flotation, collapse, and lateral movement.

b. When enclosed by walls, walls have flood openings that comply with the flood opening requirements of ASCE 24, Chapter 2.

c. Flood damage-resistant materials are used below the base flood elevation plus one (1) foot.

d. Mechanical, electrical, and utility equipment, including plumbing fixtures, are elevated above the base flood elevation plus one (1) foot.

4.09.09. Violations.

A. Violations. Any development that is not within the scope of the Florida Building Code but that is regulated by this ordinance that is performed without an issued permit, that is in conflict with an issued permit, or that does not fully comply with this ordinance, shall be deemed a violation of this ordinance. A building or structure without the documentation of elevation of the lowest floor, other required design certifications, or other evidence of compliance required by this ordinance or the Florida Building Code is presumed to be a violation until such time as that documentation is provided.

B. Authority. For development that is not within the scope of the Florida Building Code but that is regulated by this ordinance and that is determined to be a violation, the Floodplain Administrator is authorized to serve notices of violation or stop work orders to owners of the property involved, to the owner's agent, or to the person or persons performing the work.

C. Unlawful continuance. Any person who shall continue any work after having been served with a notice of violation or a stop work order, except such work as that person is directed to perform to remove or remedy a violation or unsafe condition, shall be subject to penalties as prescribed by Chapter 7, Walton County Land Development Code.

4.09.10. Flood Resistant Development: Building and Structures.

A. Design and construction of buildings, structures and facilities exempt from the Florida Building Code. Pursuant to Section 4.09.05(C) of this ordinance, buildings, structures, and facilities that are exempt from the Florida Building Code, including substantial improvement or repair of substantial damage of such buildings, structures and facilities, shall be designed and constructed in accordance with the flood load and flood resistant construction requirements of ASCE 24. Structures exempt from the Florida Building Code that are not walled and roofed buildings shall comply with the requirements of Section 4.09.16 of this ordinance.

B. Buildings and structures seaward of the coastal construction control line. If extending, in whole or in part, seaward of the coastal construction control line and also located, in whole

or in part, in a flood hazard area:

1. Buildings and structures shall be designed and constructed to comply with the more restrictive applicable requirements of the Florida Building Code, Building Section 3109 and Section 1612 or Florida Building Code, Residential Section R322.
2. Minor structures and non-habitable major structures as defined in section 161.54, F.S., shall be designed and constructed to comply with the intent and applicable provisions of this ordinance and ASCE 24.

C. Buildings and structures with enclosed areas below the Lowest Floor Elevation. Enclosures below the lowest floor shall be constructed in accordance with the Florida Building Code Residential R322.2.2 or R322.3.5, as applicable to the flood zone. For enclosed parking, storage, building access areas and crawlspaces that are 6 feet in height or greater, a copy of a legally recorded deed restriction prohibiting the conversion of the area below the lowest floor to a use or dimension contrary to the building's originally approved design shall be presented as a condition for issuance of a Building Permit.

D. Elevation Certificates. Elevation Certificates are required to verify building elevations as required in the Florida Building Code Sections 110.3(1.1), 110.23(5.1), and R322.1.10. Elevations shall be certified on FEMA Form 81-31. Certificates shall be reviewed by the Floodplain Administrator at the following stages of construction:

1. Prior to obtaining a building permit for a building in an area of special flood hazard, an Elevation Certificate based on the proposed construction drawings shall be provided to the Floodplain Administrator for review. Existing highest adjacent grade and lowest adjacent grade shall be noted on the certificate, as well as the proposed elevation of the top of the lowest floor or the lowest horizontal structural member of the lowest floor, and the proposed elevation of the top of the floor of any enclosures.
2. Within 30 days of placement of the slab, or installation of the floor sheathing, or placement of the lowest horizontal structural member, an Elevation Certificate based on the building under construction shall be provided to the Floodplain Management Administrator.
3. Prior to the building receiving power, an Elevation Certificate based on finished construction shall be provided to the Floodplain Administrator that includes elevations that are based on final grading.

E. *Coastal A Zones, Florida Building Code, Building.* Amend Section 1612 as follows:

1612.4.1 Modification of ASCE 24. Reserved.

1612.4.3 Modification of ASCE 24 (Coastal A Zone). Stem walls shall not be permitted in Coastal A Zones.

F. *Coastal A Zones, Florida Building Code, Residential.* Amend Section R322.3 as follows:

> *R322.3.3 Foundations.* Buildings and structures erected in coastal high-hazard areas and Coastal A Zones shall be supported on pilings or columns and shall be adequately anchored to such pilings or columns. The space below the elevated building shall be either free of obstruction or, if enclosed with walls, the walls shall meet the requirements of Section R322.3.4. Pilings shall have adequate soil penetrations to resist the combined wave and wind loads (lateral and uplift). Water-loading values used shall be those associated with the design flood. Wind-loading values shall be those required by this code. Pile embedment shall include consideration of decreased resistance capacity caused by scour of soil strata surrounding the piling. Pile systems design and installation shall be certified in accordance with Section R322.3.6. Spread footing, mat, raft or other foundations that support columns shall not be permitted where soil investigations that are required in accordance with Section R401.4 indicate that soil material under the spread footing, mat, raft or other foundation is subject to scour or erosion from wave-velocity flow conditions. If permitted, spread footing, mat, raft, or other foundations that support columns shall be designed in accordance with ASCE 24. Slabs, pools, pool decks and walkways shall be located and constructed to be structurally independent of buildings and structures and their foundations to prevent transfer of flood loads to the buildings and structures during conditions of flooding, scour, or erosion from wave-velocity flow conditions, unless the buildings and structures and their foundations are designed to resist the additional flood load.

G. *Substantial Damage and Substantial Improvement.* Amend the definitions of Substantial Damage and Substantial Improvement in Section 202 the Florida Building Code, Building and Section 202 the Florida Building Code, Existing Building, as follows:

> Substantial Damage. For the purpose of determining compliance with the flood provisions of this code, damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred. The term also includes flood-related damage sustained by a structure on two separate occasions during a 10-year period for which the cost of repairs at the time of each flood event, on average, equals or exceeds 25 per cent of the market value of the structure before the damage occurred.
>
> Substantial Improvement. For the purposes of determining compliance with the flood provisions of this code, any combination of repair, reconstruction, rehabilitation, alteration, addition or other improvement of a building or structure taking place during a five (5)-year period, the cost of which equals or exceeds 50 percent of the market value of the structure before the improvement or repair is started. For each building or structure, the five (5)-year period begins on the date of the first improvement or repair of that building or structure subsequent to March 1, 2011. If the structure has sustained substantial damage, any repairs are considered substantial

improvement regardless of the actual repair work performed. The term does not, however, include either

1. Any project for improvement of a building required to correct existing health, sanitary or safety code violations identified by the building official and that are the minimum necessary to assure safe living conditions.
2. Any alteration of a historic structure provided that the alteration will not preclude the structure's continued designation as a historic structure.

H. *Accessory structures.* Accessory structures are permitted below the base flood elevation provided the accessory structures are used only for parking or storage and:

1. If located in special flood hazard areas (Zone A/AE) other than coastal high hazard areas, are one-story and not larger than 600 sq. ft.
2. If located in special flood hazard areas (Zone A/AE) other than coastal high hazard areas, have flood openings in accordance with Section R322.2 of the Florida Building Code, Residential.
3. If located in coastal high hazard areas (Zone V/VE), are not located below elevated buildings and are not larger than 100 sq. ft.
4. Are anchored to resist flotation, collapse or lateral movement resulting from flood loads.
5. Have flood damage-resistant materials used below the base flood elevation plus one (1) foot.
6. Have mechanical, plumbing, and electrical systems, including plumbing fixtures, elevated to or above the base flood elevation plus one (1) foot.

4.09.11. SUBDIVISIONS.

A. Minimum requirements. Subdivision proposals, including proposals for manufactured home parks and subdivisions, shall be reviewed to determine that:

1. Such proposals are consistent with the need to minimize flood damage and will be reasonably safe from flooding;
2. All public utilities and facilities such as sewer, gas, electric, communications, and water systems are located and constructed to minimize or eliminate flood damage; and
3. Adequate drainage is provided to reduce exposure to flood hazards; in Zones AH and AO, adequate drainage paths shall be provided to guide floodwaters around and away from proposed structures.

B. Subdivision plats. Where any portion of proposed subdivisions, including manufactured home parks and subdivisions, lies within a flood hazard area, the following shall be required:

1. Delineation of flood hazard areas, floodway boundaries and flood zones, and design flood elevations, as appropriate, shall be shown on plats;
2. Where the subdivision has more than 50 lots or is larger than 5 acres and base flood elevations are not included on the FIRM, the base flood elevations determined in accordance with Section 4.09.06(B)(1) of this ordinance; and
3. Compliance with the site improvement and utilities requirements of Section 4.09.12 of this ordinance.

4.09.12. Site, Utilities and Limitations.

A. Minimum requirements. All proposed new development shall be reviewed to determine that:

1. Such proposals are consistent with the need to minimize flood damage and will be reasonably safe from flooding;
2. All public utilities and facilities such as sewer, gas, electric, communications, and water systems are located and constructed to minimize or eliminate flood damage; and
3. Adequate drainage is provided to reduce exposure to flood hazards; in Zones AH and AO, adequate drainage paths shall be provided to guide floodwaters around and away from proposed structures

B. Sanitary sewage facilities. All new and replacement sanitary sewage facilities, private sewage treatment plants (including all pumping stations and collector systems), and on-site waste disposal systems shall be designed in accordance with the standards for onsite sewage treatment and disposal systems in Chapter 64E-6, F.A.C. and ASCE 24 Chapter 7 to minimize or eliminate infiltration of floodwaters into the facilities and discharge from the facilities into flood waters, and impairment of the facilities and systems.

C. Water supply facilities. All new and replacement water supply facilities shall be designed in accordance with the water well construction standards in Chapter 62-532.500, F.A.C. and ASCE 24 Chapter 7 to minimize or eliminate infiltration of floodwaters into the systems.

D. Limitations on sites in regulatory floodways. No development, including but not limited to site improvements, and land disturbing activity involving re-grading, shall be authorized in the regulatory floodway unless the floodway encroachment analysis required in Section 4.09.06(C)(1) of this ordinance demonstrates that the proposed development or land disturbing activity will not result in any increase in the base flood elevation.

E. Limitations on placement of fill. Subject to the limitations of this ordinance, fill shall be designed to be stable under conditions of flooding including rapid rise and rapid drawdown of floodwaters, prolonged inundation, and protection against flood-related erosion and scour. Fill shall be limited in thickness to an average of no more than one (1) foot over the entire development site, and hydrologically equivalent storage volume shall be provided at a ratio of 1 to 1 or greater for the placement of fill associated with all new development with the exception of one and two family dwellings. In addition to these requirements, if intended to support buildings and structures (Zone A only), fill shall comply with the requirements of the Florida Building Code.

F. Limitations on sites in coastal high hazard areas (Zone V). In coastal high hazard areas seaward of the Coastal Construction Control Line, alteration of sand dunes and mangrove stands shall be permitted only if such alteration is approved by the Florida Department of Environmental Protection and only if the engineering analysis required by Section 4.09.06(C)(4) of this ordinance demonstrates that the proposed alteration will not increase the potential for flood damage from high velocity wave action. Construction or restoration of dunes under or around elevated buildings and structures shall comply with Section 4.09.16(H)(3) of this ordinance.

4.09.13. Manufactured Homes.

A. General. All manufactured homes installed in flood hazard areas shall be installed by an installer that is licensed pursuant to section 320.8249, F.S., and shall comply with the requirements of Chapter 15C-1, F.A.C. and the requirements of this ordinance. If located seaward of the coastal construction line, all manufactured homes shall comply with the more restrictive of the applicable requirements.

B. Foundations. All new manufactured homes and replacement manufactured homes installed in flood hazard areas shall be installed on permanent, reinforced foundations that:

1. In flood hazard areas (Zone A) other than coastal high hazard areas and Coastal A Zones, are designed in accordance with the foundation requirements of the Florida Building Code, Residential Section R322.2 and this ordinance.
2. In coastal high hazard areas (Zone V) and Coastal A Zones, are designed in accordance with the foundation requirements of the Florida Building Code, Residential Section R322.3 and this ordinance.

C. Anchoring. All new manufactured homes and replacement manufactured homes shall be installed using methods and practices which minimize flood damage and shall be securely anchored to an adequately anchored foundation system to resist flotation, collapse or lateral movement. Methods of anchoring include, but are not limited to, use of over-the-top or frame ties to ground anchors. This anchoring requirement is in addition to applicable

state and local anchoring requirements for wind resistance.

D. Elevation. All manufactured homes that are placed, replaced, or substantially improved in flood hazard areas shall be elevated such that the bottom of the frame is at or above the elevation required, as applicable to the flood hazard area, in the *Florida Building Code, Residential* Section R322.2 (Zone A) or Section R322.3 (Zone V and Coastal A Zones).

E. Enclosures. Enclosed areas below elevated manufactured homes shall comply with the requirements of the Florida Building Code, Residential Section R322 for such enclosed areas, as applicable to the flood hazard area. A copy of a legally recorded deed restriction prohibiting the conversion of the area below the lowest floor to a use or dimension contrary to the building's originally approved design shall be presented as a condition for issuance of a final Certificate of Occupancy.

F. Utility equipment. Utility equipment that serves manufactured homes, including electric, heating, ventilation, plumbing, and air conditioning equipment and other service facilities, shall comply with the requirements of the Florida Building Code, Residential Section R322, as applicable to the flood hazard area.

4.09.14. Recreational Vehicles and Park Trailers.

A. Temporary placement. Recreational vehicles and park trailers placed temporarily in flood hazard areas shall:

1. Be on the site for fewer than 180 consecutive days; or
2. Be fully licensed and ready for highway use, which means the recreational vehicle or park model is on wheels or jacking system, is attached to the site only by quick-disconnect type utilities and security devices, and has no permanent attachments such as additions, rooms, stairs, decks and porches.

B. Permanent placement. Recreational vehicles and park trailers shall not be permanently installed.

C. Placement in the Regulatory Floodway, Coastal High Hazard Areas (Zone V) and Coastal A Zones. Recreational vehicles shall be prohibited within the Regulatory Floodway, coastal high hazard areas (Zone V), and Coastal A Zones, except in existing recreational vehicle parks. This section does not restrict temporary parking of a recreational vehicle on a previously developed parcel where the vehicle is to be removed in the case of a threat of flooding.

4.09.15. Tanks.

A. Underground tanks. Underground tanks in flood hazard areas shall be anchored to prevent

flotation, collapse or lateral movement resulting from hydrodynamic and hydrostatic loads during conditions of the design flood, including the effects of buoyancy assuming the tank is empty.

B. Above-ground tanks, not elevated. Above-ground tanks that do not meet the elevation requirements of Section 4.09.015(C) of this ordinance shall:

1. Be permitted in flood hazard areas (Zone A) other than coastal high hazard areas and Coastal A Zones, provided the tanks are anchored or otherwise designed and constructed to prevent flotation, collapse, or lateral movement resulting from hydrodynamic and hydrostatic loads during conditions of the design flood, including the effects of buoyancy assuming the tank is empty and the effects of flood-borne debris.
2. Not be permitted in coastal high hazard areas (Zone V) and Coastal A Zones.

C. Above-ground tanks, elevated. Above-ground tanks in flood hazard areas shall be attached to an elevated to or above the design flood elevation on a supporting structure that is designed to prevent flotation, collapse, or lateral movement during conditions of the design flood. Tank-supporting structures shall meet the foundation requirements of the applicable flood hazard area.

D. Tank inlets and vents. Tank inlets, fill openings, outlets and vents shall be:

1. At or above the design flood elevation or fitted with covers designed to prevent the inflow of floodwater or outflow of the contents of the tanks during conditions of the design flood; and
2. Anchored to prevent lateral movement resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy, during conditions of the design flood.

4.09.16. Other Development.

A. General requirements for other development. All development, including man-made changes to improved or unimproved real estate for which specific provisions are not specified in this ordinance or the Florida Building Code, shall:

1. Be located and constructed to minimize flood damage;
2. Meet the limitations of Section 4.09.12(D) of this ordinance if located in a regulated floodway;
3. Be anchored to prevent flotation, collapse or lateral movement resulting from hydrostatic loads, including the effects of buoyancy, during conditions of the design flood;
4. Be constructed of flood damage-resistant materials; and
5. Have mechanical, plumbing, and electrical systems above the design flood elevation,

except that minimum electric service required to address life safety and electric code requirements is permitted below the design flood elevation provided it conforms to the provisions of the electrical part of building code for wet locations.

B. Fences in regulated floodways. Fences in regulated floodways that have the potential to block the passage of floodwaters, such as stockade fences and wire mesh fences, shall meet the limitations of Section 4.09.12(D) of this ordinance.

C. Retaining walls, sidewalks and driveways in regulated floodways. Retaining walls and sidewalks and driveways that involve the placement of fill in regulated floodways shall meet the limitations of Section 4.09.12(D) of this ordinance.

D. Roads and watercourse crossings in regulated floodways. Roads and watercourse crossings, including roads, bridges, culverts, low-water crossings and similar means for vehicles or pedestrians to travel from one side of a watercourse to the other side, that encroach into regulated floodways shall meet the limitations of Section 4.09.12(D) of this ordinance. Alteration of a watercourse that is part of a road or watercourse crossing shall meet the requirements of Section 4.09.06(C)(3) of this ordinance.

E. Concrete slabs used as parking pads, enclosure floors, landings, decks, walkways, patios and similar nonstructural uses in coastal high hazard areas (Zone V) and Coastal A Zones. In coastal high hazard areas and Coastal A Zones, concrete slabs used as parking pads, enclosure floors, landings, decks, walkways, patios and similar nonstructural uses are permitted beneath or adjacent to buildings and structures provided the concrete slabs are designed and constructed to be:

1. Structurally independent of the foundation system of the building or structure;
2. Frangible and not reinforced, so as to minimize debris during flooding that is capable of causing significant damage to any structure; and
3. Have a maximum slab thickness of not more than four (4) inches.

F. Decks and patios in coastal high hazard areas (Zone V) and Coastal A Zones. In addition to the requirements of the Florida Building Code, in coastal high hazard areas and Coastal A Zones, decks and patios shall be located, designed, and constructed in compliance with the following:

1. A deck that is structurally attached to a building or structure shall have the bottom of the lowest horizontal structural member at or above the design flood elevation and any supporting members that extend below the design flood elevation shall comply with the foundation requirements that apply to the building or structure, which shall be designed to accommodate any increased loads resulting from the attached deck.
2. A deck or patio that is located below the design flood elevation shall be structurally

independent from buildings or structures and their foundation systems, and shall be designed and constructed either to remain intact and in place during design flood conditions or to break apart into small pieces to minimize debris during flooding that is capable of causing structural damage to the building or structure or to adjacent buildings and structures.

3. A deck or patio that has a vertical thickness of more than twelve (12) inches or that is constructed with more than the minimum amount of fill necessary for site drainage shall not be approved unless an analysis prepared by a qualified registered design professional demonstrates no harmful diversion of floodwaters or wave runup and wave reflection that would increase damage to the building or structure or to adjacent elevated buildings and structures.
4. A deck or patio that has a vertical thickness of twelve (12) inches or less and that is at natural grade or on nonstructural fill material that is similar to and compatible with local soils and is the minimum amount necessary for site drainage may be approved without requiring analysis of the impact on diversion of floodwaters or wave runup and wave reflection.

G. Other development in coastal high hazard areas (Zone V) and Coastal A Zones. In coastal high hazard areas and Coastal A Zones, development activities other than buildings and structures shall be permitted only if also authorized by the appropriate federal, state or local authority; if located outside the footprint of, and not structurally attached to, buildings and structures; and if analyses prepared by qualified registered design professionals demonstrate no harmful diversion of floodwaters or wave runup and wave reflection that would increase damage to adjacent buildings and structures. Such other development activities include but are not limited to:

1. Bulkheads, seawalls, retaining walls, revetments, and similar erosion control structures;
2. Solid fences and privacy walls, and fences prone to trapping debris, unless designed and constructed to fail under flood conditions less than the design flood or otherwise function to avoid obstruction of floodwaters; and
3. On-site sewage treatment and disposal systems defined in 64E-6.002, F.A.C., as filled systems or mound systems.

H. Nonstructural fill in coastal high hazard areas (Zone V) and Coastal A Zones. In coastal high hazard areas and Coastal A Zones:

1. Minor grading and the placement of minor quantities of nonstructural fill shall be permitted for landscaping and for drainage purposes under and around buildings.
2. Nonstructural fill with finished slopes that are steeper than one unit vertical to five units horizontal shall be permitted only if an analysis prepared by a qualified registered design professional demonstrates no harmful diversion of floodwaters or wave run-up and wave reflection that would increase damage to adjacent elevated

buildings and structures.

3. Where authorized by the Florida Department of Environmental Protection or applicable local approval, sand dune construction and restoration of sand dunes under or around elevated buildings are permitted without additional engineering analysis or certification of the diversion of floodwater or wave runup and wave reflection if the scale and location of the dune work is consistent with local beach-dune morphology and the vertical clearance is maintained between the top of the sand dune and the lowest horizontal structural member of the building.

ORDINANCE NO. 2021-31

AN ORDINANCE OF WALTON COUNTY, FLORIDA, AMENDING CHAPTER 1 AND CHAPTER 4 OF THE WALTON COUNTY LAND DEVELOPMENT CODE; REPEALING CHAPTER 10.5 OF THE WALTON COUNTY CODE OF ORDINANCES; PROVIDING FOR SEVERABILITY; PROVIDING FOR CODIFICATION; AND PROVIDING FOR AN EFFECTIVE DATE.

WHEREAS, the Legislature of the State of Florida has, in Chapter 125, Florida Statutes, delegated the responsibility to local governmental units to adopt regulations designed to promote the public health, safety, and general welfare of its citizens; and

WHEREAS, pursuant to Section 163.3184, Florida Statutes, the Walton County Planning Commission and Board of County Commissioners have held public hearings with due public notice and received public comments concerning the subject of amending the Land Development Code; and

WHEREAS, after due public notice having been proivded, the Walton County Planning Commission held a public hearing on September 9, 2021 and the Walton County Board of County Commissioners held public hearings on September 23, 2021 and October 12, 2021, to consider the proposed amendments included herein, in accordiance with Section 163.3184, Florida Statutes.

WHEREAS, the Walton County Board of County Commissioners considered all oral and written comments received during such public hearings, including the data and analyses provided for this amendment, the recommendations of the Planning Commision; and

WHEREAS, unincorporated Walton County was accepted for participation in the National Flood Insurance Program on November 16, 1977 and the Board of County Commissioners desires to continue to meet the requirements of Title 44 Code of Federal Regulations, Sections 59 and 60, necessary for such participation; and

WHEREAS, the Board of County Commissioners adopted Ordinance No. 2014-05 on January 28, 2014 to repeal and replace Land Development Code Section 4.05, subsequently renumbered to Section 4.09, and now desires to amend Section 1.13.00 for consistent terminology and desires to amend Section 4.09; and

WHEREAS, the Federal Emergency Management Agency released FEMA Policy #104-008-03 Floodplain Management Requirements for Agricultural Structures and Accessory Structures; and

WHEREAS, the Board of County Commissioners has determined it appropriate to adopt regulations that are consistent with the FEMA Policy to allow issuance of permits for wet floodproofed accessory structures that are not larger than the sizes specified in the FEMA Policy and to provide for variances for wet floodproofed agricultural structures; and

WHEREAS, Walton County participates in the National Flood Insurance Program and participates in the NFIP's Community Rating System, a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum program requirements, achieving a CRS rating of Class 6; and

WHEREAS, in 2020 the NFIP Community Rating System established certain minimum prerequisites for communities to qualify for or maintain class ratings of Class 8 or better and to satisfy the prerequisite and for Walton County to maintain the current CRS rating, all manufactured homes installed or replaced in special flood hazard areas must be elevated such that the lowest floors are at or above at least the base flood elevation plus 1 foot, which necessitates modification of the existing requirements; and

WHEREAS, the Board of County Commissioners determined that it is in the public interest to amend the floodplain management regulations to better protect owners and occupants of manufactured homes and to continue participating in the Community Rating System at the current class rating.

WHEREAS, Chapter 553, Florida Statutes, was adopted by the Florida Legislature to provide a mechanism for the uniform adoption, updating, amendment, interpretation and enforcement of a state building code, called the *Florida Building Code*; and

WHEREAS, Chapter 553, Florida Statutes, allows for local technical amendments to the *Florida Building Code* that provide for more stringent requirements than those specified in the Code and allows adoption of local administrative and local technical amendments to the Florida Building Code to implement the National Flood Insurance Program and incentives; and

WHEREAS, the Board of County Commissioners previously adopted requires for accumulation of costs of improvements and cost of repair of flood damage and, for the purposes of the National Flood Insurance Programs' Community Rating System and, pursuant to section 553.73(5), F.S., is formatting that requirement to coordinate with the *Florida Building Code*; and

WHEREAS, the Board of County Commissioners is adopting new requirements to fully apply coastal high hazard area requirements in Coastal A Zones for the purpose of participating in the National Flood Insurance Program's Community Rating System and, pursuant to section 553.73(5), F.S., is formatting that requirement to coordinate with the *Florida Building Code*; and

WHEREAS, the Board of County Commissioners has determined that it is in the public interest to adopt the proposed local technical amendments to the *Florida Building Code* and the proposed amendments are not more stringent than necessary to address the need identified, do not discriminate against materials, products or construction techniques of demonstrated capabilities, are in compliance with section 553.73(4), Florida Statutes; and

WHEREAS, the Board of County Commissioners adopted Ordinance No. 93-15 on December 14, 1992 to adopt Land Development Code of Ordinances Chapter 10.5, which was not repealed when superseded by floodplain management regulations in the Land Development Code (currently located in Chapter 4), and now desires to repeal Code of Ordinances Chapter 10.5 to eliminate duplication and conflict.

NOW, THEREFORE, BE IT ORDAINED by the Board of County Commissioners of Walton County, Florida, as follows:

SECTION I. PURPOSE AND INTENT.

This Ordinance is hereby enacted to carry out the purpose and intent of, and exercise the authority set out in, the Local Government Comprehensive Planning and Land Development Regulation Act, Chapter 163, Part II, Florida Statutes, as amended.

SECTION II. CHAPTER 1 of the Walton County Land Development Code is amended as follows (deletions are ~~strike-through~~; additions are underlined):

CHAPTER 1. GENERAL PROVISIONS

1.13.00. - DEVELOPMENT APPROVALS

The intent of this Chapter is to establish pre-application, submittal, review and decision-making criteria involved in consideration of all new development proposals in Walton County.

*** *** ***

I. Floodplain Data Required:

1. For all Less than Minor (if applicable), Minor and Major Development Plans the ~~100-year~~ base flood elevation from current FEMA maps~~, and minimum required floor elevations if applicable, from current FEMA maps~~.

2. The boundaries of the ~~100-year floodplain~~ special flood hazard area and floodway, if applicable, for all parts of the proposed development.

3. A depiction of existing surface water bodies, wetlands, streams, and canals, within the proposed development site, which depiction shall include the boundaries and elevations of any jurisdictional wetland(s).

4. Each application shall include information relating to and drawing(s) depicting flood information, which shall indicate:

(a) Elevation in relation to the datum on the flood insurance rate map ~~mean sea level~~ of the proposed lowest floor (including basement) of each structure;

(b) Elevation in relation to the datum on the flood insurance rate map ~~mean sea level~~ level to which any nonresidential structure will be floodproofed;

(c) Certification by a registered professional engineer or architect that each nonresidential floodproofed structure will meet the floodproofing criteria provided in the Florida Building ~~this~~ Code; and

(d) A description of the extent to which any watercourse will be altered or relocated as a result of proposed development.

SECTION III. CHAPTER 4 of the Walton County Land Development Code is amended as follows (deletions are ~~strike-through~~; additions are underlined):

CHAPTER 4. RESOURCE PROTECTION STANDARDS

4.09.00. - FLOODPLAIN PROTECTION AND DAMAGE PREVENTION

4.09.01. - Purpose, Intent, and Objectives.

A. *Title.* These regulations shall be known as the Floodplain Management Ordinance of Walton County, hereinafter referred to as "this ordinance".

B. *Scope.* The provisions of this ordinance shall apply to all development that is wholly within or partially within any flood hazard area, including but not limited to the subdivision of land; filling, grading, and other site improvements and utility installations; construction, alteration, remodeling, enlargement, improvement, replacement, repair, relocation or demolition of buildings, structures, and facilities that are exempt from the Florida Building Code; placement, installation, or replacement of manufactured homes and manufactured buildings; installation or replacement of tanks; placement of recreational vehicles; installation of swimming pools; and any other development.

C. *Intent.* The purposes of this ordinance and the flood load and flood resistant construction requirements of the Florida Building Code are to establish minimum requirements to safeguard the public health, safety, and general welfare and to minimize public and private losses due to flooding through regulation of development in flood hazard areas to:

1. Minimize unnecessary disruption of commerce, access and public service during times of flooding;
2. Require the use of appropriate construction practices in order to prevent or minimize future flood damage;
3. Manage filling, grading, dredging, mining, paving, excavation, drilling operations, storage of equipment or materials, and other development which may increase flood damage or erosion potential;
4. Manage the alteration of flood hazard areas, watercourses, and shorelines to minimize the impact of development on the natural and beneficial functions of the floodplain;
5. Minimize damage to public and private facilities and utilities;
6. Help maintain a stable tax base by providing for the sound use and development of flood hazard areas;
7. Minimize the need for future expenditure of public funds for flood control projects and response to and recovery from flood events; and
8. Meet the requirements of the National Flood Insurance Program for community participation as set forth in the Title 44 Code of Federal Regulations, Section 59.22.

D. *Coordination with the Florida Building Code.* This ordinance is intended to be administered and enforced in conjunction with the Florida Building Code. Where cited, ASCE 24 refers to the edition of the standard that is referenced by the Florida Building Code.

E. *Warning.* The degree of flood protection required by this ordinance and the Florida Building Code, as amended by this community, is considered the minimum reasonable for regulatory purposes and is based on scientific and engineering considerations. Larger floods can and will occur. Flood heights may be increased by man-made or natural causes. This ordinance does not imply that land outside of mapped special flood hazard areas, or that uses permitted within such flood hazard areas, will be free from flooding or flood damage. The flood hazard areas and base flood elevations contained in the Flood Insurance Study and

shown on Flood Insurance Rate Maps and the requirements of Title 44 Code of Federal Regulations, Sections 59 and 60 may be revised by the Federal Emergency Management Agency, requiring this community to revise these regulations to remain eligible for participation in the National Flood Insurance Program. No guaranty of vested use, existing use, or future use is implied or expressed by compliance with this ordinance.

F. *Disclaimer of Liability.* This ordinance shall not create liability on the part of the Board of County Commissioners of Walton County or by any officer or employee thereof for any flood damage that results from reliance on this ordinance or any administrative decision lawfully made thereunder.

4.09.02. - Applicability.

A. *General.* Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall be applicable.

B. *Areas to which this ordinance applies.* This ordinance shall apply to all flood hazard areas within Walton County, as established in Section 4.09.02(C) of this ordinance.

C. *Basis for establishing flood hazard areas.* The Flood Insurance Study for Walton County, Florida and Incorporated Areas dated December 30, 2020 ~~September 29, 2010~~, and all subsequent amendments and revisions, and the accompanying Flood Insurance Rate Maps (FIRM), and all subsequent amendments and revisions to such maps, are adopted by reference as a part of this ordinance and shall serve as the minimum basis for establishing flood hazard areas. Studies and maps that establish flood hazard areas are on file at Walton County Planning and Development Services, 842 State Highway 20, Unit 110, Freeport, FL 32439.

D. *Submission of additional data to establish flood hazard areas.* To establish flood hazard areas and base flood elevations, pursuant to Section 4.09.06 ~~4.05.06~~ of this ordinance the Floodplain Administrator may require submission of additional data. Where field surveyed topography prepared by a Florida licensed professional surveyor or digital topography accepted by the community indicates that ground elevations:

1. Are below the closest applicable base flood elevation, even in areas not delineated as a special flood hazard area on a FIRM, the area shall be considered as flood hazard area and subject to the requirements of this ordinance and, as applicable, the requirements of the Florida Building Code.

2. Are above the closest applicable base flood elevation, the area shall be regulated as special flood hazard area unless the applicant obtains a Letter of Map Change that removes the area from the special flood hazard area.

E. *Other laws.* The provisions of this ordinance shall not be deemed to nullify any provisions of local, state or federal law.

F. *Abrogation and greater restrictions.* This ordinance supersedes any ordinance in effect for management of development in flood hazard areas. However, it is not intended to repeal or abrogate any existing ordinances including but not limited to land development regulations, zoning ordinances, stormwater management regulations, or the Florida Building Code. In the event of a conflict between this ordinance and any other ordinance, the more restrictive shall govern. This ordinance shall not impair any deed restriction, covenant or easement, but any land that is subject to such interests shall also be governed by this ordinance.

G. *Interpretation.* In the interpretation and application of this ordinance, all provisions shall be:

1. Considered as minimum requirements;

2. Liberally construed in favor of the governing body; and

3. Deemed neither to limit nor repeal any other powers granted under state statutes.

4.09.03. - Definitions.

A. *Scope.* Unless otherwise expressly stated, the following words and terms shall, for the purposes of this ordinance, have the meanings shown in this section, and shall only be applied in the context of Section 4.09.

B. *Terms defined in the Florida Building Code.* Where terms are not defined in this ordinance and are defined in the Florida Building Code, such terms shall have the meanings ascribed to them in that code.

C. *Terms not defined.* Where terms are not defined in this ordinance or the Florida Building Code, such terms shall have ordinarily accepted meanings such as the context implies.

DEFINITIONS

Accessory structure. For the floodplain management purposes, a structure used only for parking and storage that is located on the same parcel of property as a principal structure and the use of which is incidental to the use of the principal structure.

Agricultural structure. For floodplain management purposes, a walled and roofed structure used exclusively for agricultural purposes or uses in connection with the production, harvesting, storage, raising, or drying of agricultural commodities and livestock, including aquatic organisms. Structures that house tools or equipment used in connection with these purposes or uses are also considered to have agricultural purposes or uses.

Alteration of a watercourse. A dam, impoundment, channel relocation, change in channel alignment, channelization, or change in cross-sectional area of the channel or the channel capacity, or any other form of modification which may alter, impede, retard or change the direction and/or velocity of the riverine flow of water during conditions of the base flood.

Appeal. A request for a review of the Floodplain Administrator's interpretation of any provision of this ordinance or a request for a variance.

ASCE 24. A standard titled Flood Resistant Design and Construction that is referenced by the Florida Building Code. ASCE 24 is developed and published by the American Society of Civil Engineers, Reston, VA.

Base flood. A flood having a one-percent chance of being equaled or exceeded in any given year. (Also defined in FBC, B, Section 1612.2.) The base flood is commonly referred to as the "100 year flood" or the "1-percent-annual chance flood."

Base flood elevation. The elevation of the base flood, including wave height, relative to the National Geodetic Vertical Datum (NGVD), North American Vertical Datum (NAVD) or other datum specified on the Flood Insurance Rate Map (FIRM). (Also defined in FBC, B, Section 1612.2.)

Basement. The portion of a building having its floor subgrade (below ground level) on all sides. (Also defined in FBC, B, Section 1612.2.)

Coastal A Zone. Area within a special flood hazard area, landward of a V zone or landward of an open coast without mapped coastal high hazard areas. In a coastal A zone, the principal source of flooding must be astronomical tides, storm surges, seiches or tsunamis, not riverine flooding. During the base flood conditions, the potential for breaking wave height shall be

greater than or equal to 1 ½ feet (457 mm). The inland limit of the coastal A zone is (a) the Limit of Moderate Wave Action if delineated on a FIRM, or (b) designated by the authority having jurisdiction. ~~Flood hazard areas that are currently located within areas identified on the Walton County Coastal A Zone Map, as adopted on March 1, 2011~~.

Coastal construction control line. The line established by the State of Florida pursuant to section 161.053, F.S., and recorded in the official records of the community, which defines that portion of the beach-dune system subject to severe fluctuations based on a 100-year storm surge, storm waves or other predictable weather conditions.

Coastal high hazard area. A special flood hazard area extending from offshore to the inland limit of a primary frontal dune along an open coast and any other area subject to high velocity wave action from storms or seismic sources. Coastal high hazard areas are also referred to as "high hazard areas subject to high velocity wave action" or "V Zones" and are designated on Flood Insurance Rate Maps (FIRM) as Zone V1 V30, VE, or V. ~~(Note: The FBC, B, defines and uses the term "flood hazard areas subject to high velocity wave action" and the FBC, R uses the term "coastal high hazard areas.")~~

Design flood. The flood associated with the greater of the following two areas: (Also defined in FBC, B, Section 1612.2.)

1. Area with a floodplain subject to a one-percent or greater chance of flooding in any year; or
2. Area designated as a flood hazard area on the community's flood hazard map, or otherwise legally designated.

Design flood elevation. The elevation of the "design flood," including wave height, relative to the datum specified on the community's legally designated flood hazard map. In areas designated as Zone AO, the design flood elevation shall be the elevation of the highest existing grade of the building's perimeter plus the depth number (in feet) specified on the flood hazard map. In areas designated as Zone AO where the depth number is not specified on the map, the depth number shall be taken as being equal to two feet. (Also defined in FBC, B, Section 1612.2.)

Development. Any manmade change to improved or unimproved real estate, including but not limited to, buildings or other structures, tanks, temporary structures, temporary or permanent storage of equipment or materials, mining, dredging, filling, grading, paving, excavations, drilling operations or any other land disturbing activities.

Encroachment. The placement of fill, excavation, buildings, permanent structures or other development into a flood hazard area which may impede or alter the flow capacity of riverine flood hazard areas.

Existing building and existing structure. Any buildings and structures for which the "start of construction" commenced before November 16, 1977. (Also defined in FBC, B, Section 1612.2.)

~~*Existing manufactured home park or subdivision.* A manufactured home park or subdivision for which the construction of facilities for servicing the lots on which the manufactured homes are to be affixed (including, at a minimum, the installation of utilities, the construction of streets, and either final site grading or the pouring of concrete pads) is completed before November 16, 1977.~~

~~*Expansion to an existing manufactured home park or subdivision.* The preparation of additional sites by the construction of facilities for servicing the lots on which the manufactured homes are to be affixed (including the installation of utilities, the construction of streets, and either final site grading or the pouring of concrete pads).~~

Federal Emergency Management Agency (FEMA). The federal agency that, in addition to carrying out other functions, administers the National Flood Insurance Program.

Flood or flooding. A general and temporary condition of partial or complete inundation of normally dry land from: (Also defined in FBC, B, Section 1612.2.)

1. The overflow of inland or tidal waters.
2. The unusual and rapid accumulation or runoff of surface waters from any source.

Flood damage-resistant materials. Any construction material capable of withstanding direct and prolonged contact with floodwaters without sustaining any damage that requires more than cosmetic repair. (Also defined in FBC, B, Section 1612.2.)

Flood hazard area. The greater of the following two areas: (Also defined in FBC, B, Section 1612.2.)

1. The area within a floodplain subject to a one-percent or greater chance of flooding in any year.
2. The area designated as a flood hazard area on the community's flood hazard map, or otherwise legally designated.

Flood Insurance Rate Map (FIRM). The official map of the community on which the Federal Emergency Management Agency has delineated both special flood hazard areas and the risk premium zones applicable to the community. (Also defined in FBC, B, Section 1612.2.)

Flood Insurance Study (FIS). The official report provided by the Federal Emergency Management Agency that contains the Flood Insurance Rate Map, the Flood Boundary and Floodway Map (if applicable), the water surface elevations of the base flood, and supporting technical data. (Also defined in FBC, B, Section 1612.2.)

Floodplain Administrator. The office or position designated and charged with the administration and enforcement of this ordinance (may be referred to as the Floodplain Manager).

Floodplain development permit or approval. An official document or certificate issued by the community, or other evidence of approval or concurrence, which authorizes performance of specific development activities that are located in flood hazard areas and that are determined to be compliant with this ordinance.

Floodway. The channel of a river or other riverine watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot. (Also defined in FBC, B, Section 1612.2.)

Floodway encroachment analysis. An engineering analysis of the impact that a proposed encroachment into a floodway is expected to have on the floodway boundaries and base flood elevations; the evaluation shall be prepared by a qualified Florida licensed engineer using standard engineering methods and models.

Florida Building Code. The family of codes adopted by the Florida Building Commission, including: Florida Building Code, Building; Florida Building Code, Residential; Florida Building Code, Existing Building; Florida Building Code, Mechanical; Florida Building Code, Plumbing; Florida Building Code, Fuel Gas.

Functionally dependent use. A use which cannot perform its intended purpose unless it is located or carried out in close proximity to water, including only docking facilities, port facilities that are necessary for the loading and unloading of cargo or passengers, and ship building and

ship repair facilities; the term does not include long term storage or related manufacturing facilities.

Highest adjacent grade. The highest natural elevation of the ground surface prior to construction next to the proposed walls or foundation of a structure.

Historic structure. Any structure that is determined eligible for the exception to the flood hazard area requirements of the Florida Building Code, Existing Building, Chapter 12 ~~11~~ Historic Buildings.

Letter of Map Change (LOMC). An official determination issued by FEMA that amends or revises an effective Flood Insurance Rate Map or Flood Insurance Study. Letters of Map Change include:

1. *Letter of Map Amendment (LOMA):* An amendment based on technical data showing that a property was incorrectly included in a designated special flood hazard area. A LOMA amends the current effective Flood Insurance Rate Map and establishes that a specific property, portion of a property, or structure is not located in a special flood hazard area.
2. *Letter of Map Revision (LOMR):* A revision based on technical data that may show changes to flood zones, flood elevations, special flood hazard area boundaries and floodway delineations, and other planimetric features.
3. *Letter of Map Revision Based on Fill (LOMR-F):* A determination that a structure or parcel of land has been elevated by fill above the base flood elevation and is, therefore, no longer located within the special flood hazard area. In order to qualify for this determination, the fill must have been permitted and placed in accordance with the community's floodplain management regulations.
4. *Conditional Letter of Map Revision (CLOMR):* A formal review and comment as to whether a proposed flood protection project or other project complies with the minimum NFIP requirements for such projects with respect to delineation of special flood hazard areas. A CLOMR does not revise the effective Flood Insurance Rate Map or Flood Insurance Study; upon submission and approval of certified as-built documentation, a Letter of Map Revision may be issued by FEMA to revise the effective FIRM.

Light-duty truck. As defined in 40 C.F.R. 86.082-2, any motor vehicle rated at 8,500 pounds Gross Vehicular Weight Rating or less which has a vehicular curb weight of 6,000 pounds or less and which has a basic vehicle frontal area of 45 square feet or less, which is:

1. Designed primarily for purposes of transportation of property or is a derivation of such a vehicle, or
2. Designed primarily for transportation of persons and has a capacity of more than 12 persons; or
3. Available with special features enabling off-street or off-highway operation and use.

Limit of Moderate Wave Action. Line shown on FIRMs to indicate the inland limit of the 1 ½-foot breaking wave height during the base flood.

Lowest floor. The lowest floor of the lowest enclosed area of a building or structure, including basement, but excluding any unfinished or flood-resistant enclosure, other than a basement, usable solely for vehicle parking, building access or limited storage provided that such enclosure is not built so as to render the structure in violation of the non-elevation requirements of the Florida Building Code or ASCE 24. (Also defined in FBC, B, Section 1612.2.)

Manufactured home. A structure, transportable in one or more sections, which is eight feet or more in width and greater than 400 square feet, and which is built on a permanent, integral chassis and is designed for use with or without a permanent foundation when attached to the required utilities. The term "manufactured home" does not include a "recreational vehicle" or "park trailer." (Also defined in 15C-1.0101, F.A.C.)

Manufactured home park or subdivision. A parcel (or contiguous parcels) of land divided into two or more manufactured home lots for rent or sale.

Market value. ~~The price at which a property will change hands between a willing buyer and a willing seller, neither party being under compulsion to buy or sell and both having reasonable knowledge of relevant facts. As used in this ordinance, the term refers to the market~~ The value of buildings and structures, excluding the land and other improvements on the parcel. Market value ~~may be established by a qualified independent appraiser~~, is the Actual Cash Value (like-kind replacement cost depreciated for age, wear and tear, neglect, and quality of construction) determined by a qualified independent appraiser, or tax assessment value adjusted to approximate market value by a factor provided by the Property Appraiser.

New construction. For the purposes of administration of this ordinance and the flood resistant construction requirements of the Florida Building Code, structures for which the "start of construction" commenced on or after November 16, 1977 and includes any subsequent improvements to such structures.

~~*New manufactured home park or subdivision.* A manufactured home park or subdivision for which the construction of facilities for servicing the lots on which the manufactured homes are to be affixed (including at a minimum, the installation of utilities, the construction of streets, and either final site grading or the pouring of concrete pads) is completed on or after November 16, 1977.~~

Park trailer. A transportable unit which has a body width not exceeding 14 feet and which is built on a single chassis and is designed to provide seasonal or temporary living quarters when connected to utilities necessary for operation of installed fixtures and appliances. (Defined in F.S. § 320.01)

Recreational vehicle. A vehicle, including a park trailer, which is: (See F.S. § 320.01)

1. Built on a single chassis;
2. Four hundred square feet or less when measured at the largest horizontal projection;
3. Designed to be self propelled or permanently towable by a light duty truck; and
4. Designed primarily not for use as a permanent dwelling but as temporary living quarters for recreational, camping, travel, or seasonal use.

Sand dunes. Naturally occurring accumulations of sand in ridges or mounds landward of the beach.

Special flood hazard area. An area in the floodplain subject to a one percent or greater chance of flooding in any given year. Special flood hazard areas are shown on FIRMs as Zone A, AO, A1 A30, AE, A99, AH, V1 V30, VE or V. (Also defined in FBC, B Section 1612.2.)

Start of construction. The date of issuance for new construction and substantial improvements to existing structures, provided the actual start of construction, repair, reconstruction, rehabilitation, addition, placement, or other improvement is within 180 days of the date of the issuance. The actual start of construction means either the first placement of permanent construction of a building (including a manufactured home) on a site, such as the pouring of slab or footings, the installation of piles, the construction of columns. Permanent

construction does not include land preparation (such as clearing, grading, or filling), the installation of streets or walkways, excavation for a basement, footings, piers, or foundations, the erection of temporary forms or the installation of accessory buildings such as garages or sheds not occupied as dwelling units or not part of the main buildings. For a substantial improvement, the actual "start of construction" means the first alteration of any wall, ceiling, floor or other structural part of a building, whether or not that alteration affects the external dimensions of the building. (Also defined in FBC, B Section 1612.2.)

Substantial damage. Damage of any origin sustained by a building or structure whereby the cost of restoring the building or structure to its before-damaged condition would equal or exceed 50 percent of the market value of the building or structure before the damage occurred. The term also includes flood-related damage sustained by a structure on two separate occasions during a ten-year period for which the cost of repairs at the time of each such flood event, on average, equals or exceeds 25 percent of the market value of the structure before the damage occurred. (Also defined in FBC, B Section 1612.2.)

Substantial improvement. Any combination of repair, reconstruction, rehabilitation, addition, or other improvement of a building or structure taking place during a five-year period, the cumulative cost of which equals or exceeds 50 percent of the market value of the building or structure before the improvement or repair is started. For each building or structure, the five-year period begins on the date of the first improvement or repair of that building or structure subsequent to March 1, 2011. If the structure has incurred "substantial damage," any repairs are considered substantial improvement regardless of the actual repair work performed. The term does not, however, include either: (Also defined in FBC, B, Section 1612.2.)

1. Any project for improvement of a building required to correct existing health, sanitary, or safety code violations identified by the building official and that are the minimum necessary to assure safe living conditions.
2. Any alteration of a historic structure provided the alteration will not preclude the structure's continued designation as a historic structure.

Variance. A grant of relief from the requirements of this ordinance, or the flood resistant construction requirements of the Florida Building Code, which permits construction in a manner that would not otherwise be permitted by this ordinance or the Florida Building Code.

Watercourse. A river, creek, stream, channel or other topographic feature in, on, through, or over which water flows at least periodically.

4.09.04. - Duties and Powers of the Floodplain Administrator.

A. *Designation.* The Floodplain Manager is designated as the Floodplain Administrator. The Floodplain Administrator may delegate performance of certain duties to other employees.

B. *General.* The Floodplain Administrator is authorized and directed to administer and enforce the provisions of this ordinance. The Floodplain Administrator shall have the authority to render interpretations of this ordinance consistent with the intent and purpose of this ordinance and may establish policies and procedures in order to clarify the application of its provisions. Such interpretations, policies, and procedures shall not have the effect of waiving requirements specifically provided in this ordinance without the granting of a variance pursuant to Section 4.09.08 of this ordinance.

C. *Applications and permits.* The Floodplain Administrator, in coordination with other pertinent offices of the community, shall:

1. Review applications and plans to determine whether proposed new development will be located in flood hazard areas;
2. Review applications for modification of any existing development in flood hazard areas for compliance with the requirements of this ordinance;
3. Interpret flood hazard area boundaries where such interpretation is necessary to determine the exact location of boundaries; a person contesting the determination shall have the opportunity to appeal the interpretation;
4. Provide available flood elevation and flood hazard information;
5. Determine whether additional flood hazard data shall be obtained from other sources or shall be developed by an applicant;
6. Review applications to determine whether proposed development will be reasonably safe from flooding;
7. Issue floodplain development permits or approvals for development other than buildings and structures that are subject to the Florida Building Code, including buildings, structures and facilities exempt from the Florida Building Code, when compliance with this ordinance is demonstrated, or disapprove the same in the event of noncompliance; and
8. Coordinate with and provide comments to the Building Official to assure that applications, plan reviews, and inspections for buildings and structures in flood hazard areas comply with the applicable provisions of this ordinance.

D. *Substantial improvement and substantial damage determinations.* For applications for building permits to improve buildings and structures, including alterations, movement, enlargement, replacement, repair, change of occupancy, additions, rehabilitations, renovations, substantial improvements, repairs of substantial damage, and any other improvement of or work on such buildings and structures, the Floodplain Administrator, in coordination with the Building Official, shall:

1. Estimate the market value, or require the applicant to obtain an appraisal of the market value prepared by a qualified independent appraiser, of the building or structure before the start of construction of the proposed work; in the case of repair, the market value of the building or structure shall be the market value before the damage occurred and before any repairs are made;
2. Compare the cost to perform the improvement, the cost to repair a damaged building to its pre-damaged condition, or the combined costs of improvements and repairs, if applicable, to the market value of the building or structure;
3. Determine and document whether the proposed work constitutes substantial improvement or repair of substantial damage; the determination requires evaluation of previous permits issued for improvements and repairs as specified in the definition of "substantial improvement"; for proposed work to repair damage caused by flooding, the determination requires evaluation of previous permits issued to repair flood-related damage as specified in the definition of "substantial damage"; and
4. Notify the applicant if it is determined that the work constitutes substantial improvement or repair of substantial damage and that compliance with the flood resistant construction requirements of the Florida Building Code and this ordinance is required.

E. *Modifications of the strict application of the requirements of the Florida Building Code.* The Floodplain Administrator shall review requests submitted to the Building Official that seek approval to modify the strict application of the flood load and flood resistant construction requirements of the Florida Building Code to determine whether such requests require the granting of a variance pursuant to Section 4.09.08 ~~4.05.08~~ of this ordinance.

F. *Notices and orders.* The Floodplain Administrator shall coordinate with appropriate local agencies for the issuance of all necessary notices or orders to ensure compliance with this ordinance.

G. *Inspections.* The Floodplain Administrator shall make the required inspections as specified in Section 4.09.07 of this ordinance for development that is not subject to the Florida Building Code, including buildings, structures and facilities exempt from the Florida Building Code. The Floodplain Administrator shall inspect flood hazard areas to determine if development is undertaken without issuance of a permit.

H. *Other duties of the Floodplain Administrator.* The Floodplain Administrator shall have other duties, including but not limited to:

1. Establish, in coordination with the Building Official, procedures for administering and documenting determinations of substantial improvement and substantial damage made pursuant to Section 4.09.04(D) of this ordinance;

2. Require that applicants proposing alteration of a watercourse notify adjacent communities and the Florida Division of Emergency Management, State Floodplain Management Office, and submit copies of such notifications to the Federal Emergency Management Agency (FEMA);

3. Require applicants who submit hydrologic and hydraulic engineering analyses to support permit applications to submit to FEMA the data and information necessary to maintain the Flood Insurance Rate Maps if the analyses propose to change base flood elevations, flood hazard area boundaries, or floodway designations; such submissions shall be made within six months of such data becoming available;

4. Review required design certifications and documentation of elevations specified by this ordinance and the Florida Building Code and this ordinance to determine that such certifications and documentations are complete;

5. Notify the Federal Emergency Management Agency when the corporate boundaries of Walton County are modified; and

6. Advise applicants for new buildings and structures, including substantial improvements, that are located in any unit of the Coastal Barrier Resources System established by the Coastal Barrier Resources Act (Pub. L. 97-348) and the Coastal Barrier Improvement Act of 1990 (Pub. L. 101-591) that federal flood insurance is not available on such construction; areas subject to this limitation are identified on Flood Insurance Rate Maps as "Coastal Barrier Resource System Areas" and "Otherwise Protected Areas."

I. Floodplain management records. Regardless of any limitation on the period required for retention of public records, the Floodplain Administrator shall maintain and permanently keep and make available for public inspection all records that are necessary for the administration of this ordinance and the flood resistant construction requirements of the Florida Building Code, including Flood Insurance Rate Maps; Letters of Change; records of issuance of permits and denial of permits; determinations of whether proposed work constitutes substantial improvement or repair of substantial damage; required design

certifications and documentation of elevations specified by the Florida Building Code and this ordinance; notifications to adjacent communities, FEMA, and the state related to alterations of watercourses; assurances that the flood carrying capacity of altered watercourses will be maintained; documentation related to appeals and variances, including justification for issuance or denial; and records of enforcement actions taken pursuant to this ordinance and the flood resistant construction requirements of the Florida Building Code. These records shall be available for public inspection at Walton County Planning and Development Services, 842 State Highway 20 E, Unit 110, Freeport, FL 32439.

J. *Certification requirements for the Floodplain Administrator.* The Floodplain Administrator shall become certified and maintain said certification in good standing during employment with Walton County. The requirements for certification are as follows:

1. Within one year of being hired or designated as such, the Floodplain Administrator shall apply to sit for and obtain a passing grade on the Certified Floodplain Manager® examination administered by the Association of State Floodplain Managers (ASFPM).
2. The Floodplain Administrator shall be required to maintain the Floodplain Manager Certification® through continuing education credits as required by ASFPM.
3. Failure to pass the examination, or upon deactivation of the Certified Floodplain Manager® certification by ASFPM, the Floodplain Administrator shall be subject to probation, relocation, or termination of employment as determined by the County Administrator.

4.09.05. - Permits.

A. *Permits required.* Any owner or owner's authorized agent (hereinafter "applicant") who intends to undertake any development activity within the scope of this ordinance, including buildings, structures and facilities exempt from the Florida Building Code, which is wholly within or partially within any flood hazard area shall first make application to the Floodplain Administrator, and the Building Official if applicable, and shall obtain the required permit(s) and approval(s). No such permit or approval shall be issued until compliance with the requirements of this ordinance and all other applicable codes and regulations has been satisfied.

B. *Floodplain development permits or approvals.* Floodplain development permits or approvals shall be issued pursuant to this ordinance for any development activities not subject to the requirements of the Florida Building Code, including buildings, structures and facilities exempt from the Florida Building Code. Depending on the nature and extent of proposed development that includes a building or structure, the Floodplain Administrator may determine that a floodplain development permit or approval is required in addition to a building permit.

C. *Buildings, structures and facilities exempt from the Florida Building Code.* Pursuant to the requirements of federal regulation for participation in the National Flood Insurance Program (44 C.F.R. Sections 59 and 60), floodplain development permits or approvals shall be required for the following buildings, structures and facilities that are exempt from the Florida Building Code and any further exemptions provided by law, which are subject to the requirements of this ordinance:

1. Railroads and ancillary facilities associated with the railroad.
2. Nonresidential farm buildings on farms, as provided in F.S. § 604.50.
3. Temporary buildings or sheds used exclusively for construction purposes.

4. Mobile or modular structures used as temporary offices.

5. Those structures or facilities of electric utilities, as defined in F.S. § 366.02, which are directly involved in the generation, transmission, or distribution of electricity.

6. Chickees constructed by the Miccosukee Tribe of Indians of Florida or the Seminole Tribe of Florida. As used in this paragraph, the term "chickee" means an open-sided wooden hut that has a thatched roof of palm or palmetto or other traditional materials, and that does not incorporate any electrical, plumbing, or other non-wood features.

7. Family mausoleums not exceeding 250 square feet in area which are prefabricated and assembled on site or preassembled and delivered on site and have walls, roofs, and a floor constructed of granite, marble, or reinforced concrete.

8. Temporary housing provided by the Department of Corrections to any prisoner in the state correctional system.

9. Structures identified in F.S. § 553.73(10)(k), are not exempt from the Florida Building Code if such structures are located in flood hazard areas established on Flood Insurance Rate Maps.

D. *Application for a permit or approval.* To obtain a floodplain development permit or approval the applicant shall first file an application in writing on a form furnished by the community. The information provided shall:

1. Identify and describe the development to be covered by the permit or approval.

2. Describe the land on which the proposed development is to be conducted by legal description, street address or similar description that will readily identify and definitively locate the site.

3. Indicate the use and occupancy for which the proposed development is intended.

4. Be accompanied by a site plan or construction documents as specified in Section 4.09.06 of this ordinance.

5. State the valuation of the proposed work.

6. Be signed by the applicant or the applicant's authorized agent.

7. Give such other data and information as required by the Floodplain Administrator.

E. *Validity of permit or approval.* The issuance of a floodplain development permit or approval pursuant to this ordinance shall not be construed to be a permit for, or approval of, any violation of this ordinance, the Florida Building Codes, or any other ordinance of this community. The issuance of permits based on submitted applications, construction documents, and information shall not prevent the Floodplain Administrator from requiring the correction of errors and omissions.

F. *Expiration.* A floodplain development permit or approval shall become invalid unless the work authorized by such permit is commenced within 180 days after its issuance, or if the work authorized is suspended or abandoned for a period of 180 days after the work commences. Extensions for periods of not more than 180 days each shall be requested in writing and justifiable cause shall be demonstrated.

G. *Suspension or revocation.* The Floodplain Administrator is authorized to suspend or revoke a floodplain development permit or approval if the permit was issued in error, on the basis of incorrect, inaccurate or incomplete information, or in violation of this ordinance or any other ordinance, regulation or requirement of this community.

H. *Other permits required.* Floodplain development permits and building permits shall include a condition that all other applicable state or federal permits be obtained before commencement of the permitted development, including but not limited to the following:

1. The Northwest Florida Water Management District; F.S. § 373.036.
2. Florida Department of Health for onsite sewage treatment and disposal systems; F.S. § 381.0065, and Chapter 64E-6, F.A.C.
3. Florida Department of Environmental Protection for construction, reconstruction, changes, or physical activities for shore protection or other activities seaward of the coastal construction control line; F.S. § 161.141.
4. Florida Department of Environmental Protection for activities subject to the Joint Coastal Permit; F.S. § 161.055.
5. Florida Department of Environmental Protection for activities that affect wetlands and alter surface water flows, in conjunction with the U.S. Army Corps of Engineers; Section 404 of the Clean Water Act.
6. Federal permits and approvals.

4.09.06. - Site Plans and Construction Documents.

A. *Information for development in flood hazard areas.* The site plan or construction documents for any development subject to the requirements of this ordinance shall be drawn to scale and shall include, as applicable to the proposed development:

1. Delineation of flood hazard areas, floodway boundaries and flood zone(s), base flood elevation(s), and ground elevations if necessary for review of the proposed development.
2. Where base flood elevations, or floodway data are not included on the FIRM or in the Flood Insurance Study, they shall be established in accordance with Section 4.09.06(B)(2) or (3) of this ordinance.
3. Where the parcels on which the proposed development will take place will have more than 50 lots or is larger than five acres and the base flood elevations are not included on the FIRM or in the Flood Insurance Study, such elevations shall be established in accordance with Section 4.09.06(B)(1) of this ordinance.
4. Location of the proposed activity and proposed structures, and locations of existing buildings and structures; in coastal high hazard areas, new buildings shall be located landward of the reach of mean high tide.
5. Location, extent, amount, and proposed final grades of any filling, grading, or excavation.
6. Where the placement of fill is proposed, the amount, type, and source of fill material; compaction specifications; a description of the intended purpose of the fill areas; and evidence that the proposed fill areas are the minimum necessary to achieve the intended purpose.
7. Delineation of the Coastal Construction Control Line or notation that the site is seaward of the coastal construction control line, if applicable.
8. Extent of any proposed alteration of sand dunes or mangrove stands, provided such alteration is approved by the Florida Department of Environmental Protection.

9. Existing and proposed alignment of any proposed alteration of a watercourse.

The Floodplain Administrator is authorized to waive the submission of site plans, construction documents, and other data that are required by this ordinance but that are not required to be prepared by a registered design professional if it is found that the nature of the proposed development is such that the review of such submissions is not necessary to ascertain compliance with this ordinance.

B. *Information in flood hazard areas without base flood elevations (approximate Zone A).* Where flood hazard areas are delineated on the FIRM and base flood elevation data have not been provided, the Floodplain Administrator shall:

1. Require the applicant to include base flood elevation data prepared in accordance with currently accepted engineering practices.
2. Obtain, review, and provide to applicants base flood elevation and floodway data available from a federal or state agency or other source or require the applicant to obtain and use base flood elevation and floodway data available from a federal or state agency or other source.
3. Where base flood elevation and floodway data are not available from another source, where the available data are deemed by the Floodplain Administrator to not reasonably reflect flooding conditions, or where the available data are known to be scientifically or technically incorrect or otherwise inadequate:
   a. Require the applicant to include base flood elevation data prepared in accordance with currently accepted engineering practices; or
   b. Specify that the base flood elevation is three feet above the highest adjacent grade at the location of the development, provided there is no evidence indicating flood depths have been or may be greater than three feet.
4. Where the base flood elevation data are to be used to support a Letter of Map Change from FEMA, advise the applicant that the analyses shall be prepared by a Florida licensed engineer in a format required by FEMA, and that it shall be the responsibility of the applicant to satisfy the submittal requirements and pay the processing fees.

C. *Additional analyses and certifications.* As applicable to the location and nature of the proposed development activity, and in addition to the requirements of this section, the applicant shall have the following analyses signed and sealed by a Florida licensed engineer for submission with the site plan and construction documents:

1. For development activities proposed to be located in a regulatory floodway, a floodway encroachment analysis that demonstrates that the encroachment of the proposed development will not cause any increase in base flood elevations; where the applicant proposes to undertake development activities that do increase base flood elevations, the applicant shall submit such analysis to FEMA as specified in Section 4.09.06(D) of this ordinance and shall submit the Conditional Letter of Map Revision, if issued by FEMA, with the site plan and construction documents.
2. For development activities proposed to be located in a riverine flood hazard area for which base flood elevations are included in the Flood Insurance Study or on the FIRM and floodways have not been designated, hydrologic and hydraulic analyses that demonstrate that the cumulative effect of the proposed development, when combined with all other existing and anticipated flood hazard area encroachments, will not increase the base flood elevation more than one foot at any point within the

community. This requirement does not apply in isolated flood hazard areas not connected to a riverine flood hazard area or in flood hazard areas identified as Zone AO or Zone AH.

3. For alteration of a watercourse, an engineering analysis prepared in accordance with standard engineering practices which demonstrates that the flood-carrying capacity of the altered or relocated portion of the watercourse will not be decreased, and certification that the altered watercourse shall be maintained in a manner which preserves the channel's flood-carrying capacity; the applicant shall submit the analysis to FEMA as specified in Section 4.09.06(D) of this ordinance.

4. For activities that propose to alter sand dunes or mangrove stands in coastal high hazard areas (Zone V), an engineering analysis that demonstrates that the proposed alteration will not increase the potential for flood damage.

D. *Submission of additional data.* When additional hydrologic, hydraulic or other engineering data, studies, and additional analyses are submitted to support an application, the applicant has the right to seek a Letter of Map Change from FEMA to change the base flood elevations, change floodway boundaries, or change boundaries of flood hazard areas shown on FIRMs, and to submit such data to FEMA for such purposes. The analyses shall be prepared by a Florida licensed engineer in a format required by FEMA. Submittal requirements and processing fees shall be the responsibility of the applicant.

4.09.07. - Inspections.

A. *General.* Development for which a floodplain development permit or approval is required shall be subject to inspection.

1. *Development other than buildings and structures.* The Floodplain Administrator shall inspect all development to determine compliance with the requirements of this ordinance and the conditions of issued floodplain development permits or approvals.

2. *Buildings, structures and facilities exempt from the Florida Building Code.* The Floodplain Administrator shall inspect buildings, structures and facilities exempt from the Florida Building Code to determine compliance with the requirements of this ordinance and the conditions of issued floodplain development permits or approvals.

a. Buildings, structures and facilities exempt from the Florida Building Code, lowest floor inspection. Upon placement of the lowest floor, including basement, and prior to further vertical construction, the owner of a building, structure or facility exempt from the Florida Building Code, or the owner's authorized agent, shall submit to the Floodplain Administrator:

i. If a design flood elevation was used to determine the required elevation of the lowest floor, the certification of elevation of the lowest floor prepared and sealed by a Florida licensed professional surveyor; or

ii. If the elevation used to determine the required elevation of the lowest floor was determined in accordance with Section 4.09.06(B)(3)(b) of this ordinance, the documentation of height of the lowest floor above highest adjacent grade, prepared by the owner or the owner's authorized agent.

b. Buildings, structures and facilities exempt from the Florida Building Code, final inspection. As part of the final inspection, the owner or owner's authorized agent shall submit to the Floodplain Administrator a final certification of elevation of the lowest floor or final documentation of the height of the lowest floor above the

highest adjacent grade; such certifications and documentations shall be prepared as specified in Section 4.09.07(2)(a). of this ordinance.

3. *Manufactured homes.* The Floodplain Administrator shall inspect manufactured homes that are installed or replaced in flood hazard areas to determine compliance with the requirements of this ordinance and the conditions of the issued permit. Upon placement of a manufactured home, certification of the elevation of the lowest floor shall be submitted to the Floodplain Administrator.

4.09.08. - Variances and Appeals.

A. *General.* The Walton County Board of Adjustments shall hear and decide on requests for appeals and requests for variances from the strict application of this ordinance. Pursuant to F.S. § 553.73(5), the Walton County Board of Adjustments shall hear and decide on requests for appeals and requests for variances from the strict application of the flood resistant construction requirements of the Florida Building Code. This section does not apply to Section 3109 of the Florida Building Code, Building.

B. *Appeals.* The Walton County Board of Adjustments shall hear and decide appeals when it is alleged there is an error in any requirement, decision, or determination made by the Floodplain Administrator in the administration and enforcement of this ordinance. Any person aggrieved by the decision of Walton County Board of Adjustments may appeal such decision to the Circuit Court, as provided by Florida Statutes.

C. *Limitations on authority to grant variances.* The Walton County Board of Adjustments shall base its decisions on variances on technical justifications submitted by applicants, the considerations for issuance in Section 4.09.08(G) of this ordinance, the conditions of issuance set forth in Section 4.09.08(H) of this ordinance, and the comments and recommendations of the Floodplain Administrator and the Building Official. The Walton County Board of Adjustments has the right to attach such conditions as it deems necessary to further the purposes and objectives of this ordinance.

D. *Restrictions in floodways.* A variance shall not be issued for any proposed development in a floodway if any increase in base flood elevations would result, as evidenced by the applicable analyses and certifications required in Section 4.09.06(C) of this ordinance.

E. *Historic buildings.* A variance is authorized to be issued for the repair, improvement, or rehabilitation of a historic building that is determined eligible for the exception to the flood resistant construction requirements of the Florida Building Code, Existing Building, Chapter 12 ~~44~~ Historic Buildings, upon a determination that the proposed repair, improvement, or rehabilitation will not preclude the building's continued designation as a historic building and the variance is the minimum necessary to preserve the historic character and design of the building. If the proposed work precludes the building's continued designation as a historic building, a variance shall not be granted and the building and any repair, improvement, and rehabilitation shall be subject to the requirements of the Florida Building Code.

F. *Functionally dependent uses.* A variance is authorized to be issued for the construction or substantial improvement necessary for the conduct of a functionally dependent use, as defined in this ordinance, provided the variance meets the requirements of Section 4.09.08(D), is the minimum necessary considering the flood hazard, and all due consideration has been given to use of methods and materials that minimize flood damage during occurrence of the base flood.

G. *Considerations for issuance of variances.* In reviewing requests for variances, the Walton County Board of Adjustments shall consider all technical evaluations, all relevant factors, all other applicable provisions of the Florida Building Code, this ordinance, and the following:

1. The danger that materials and debris may be swept onto other lands resulting in further injury or damage;
2. The danger to life and property due to flooding or erosion damage;
3. The susceptibility of the proposed development, including contents, to flood damage and the effect of such damage on current and future owners;
4. The importance of the services provided by the proposed development to the community;
5. The availability of alternate locations for the proposed development that are subject to lower risk of flooding or erosion;
6. The compatibility of the proposed development with existing and anticipated development;
7. The relationship of the proposed development to the comprehensive plan and floodplain management program for the area;
8. The safety of access to the property in times of flooding for ordinary and emergency vehicles;
9. The expected heights, velocity, duration, rate of rise and debris and sediment transport of the floodwaters and the effects of wave action, if applicable, expected at the site; and
10. The costs of providing governmental services during and after flood conditions including maintenance and repair of public utilities and facilities such as sewer, gas, electrical and water systems, streets and bridges.

H. *Conditions for issuance of variances.* Variances shall be issued only upon:

1. Submission by the applicant, of a showing of good and sufficient cause that the unique characteristics of the size, configuration, or topography of the site limit compliance with any provision of this ordinance or the required elevation standards;
2. Determination by the Walton County Board of Adjustments that:
    a. Failure to grant the variance would result in exceptional hardship due to the physical characteristics of the land that render the lot undevelopable; increased costs to satisfy the requirements or inconvenience do not constitute hardship;
    b. The granting of a variance will not result in increased flood heights, additional threats to public safety, extraordinary public expense, nor create nuisances, cause fraud on or victimization of the public or conflict with existing local laws and ordinances; and
    c. The variance is the minimum necessary, considering the flood hazard, to afford relief;
3. Receipt of a signed statement by the applicant that the variance, if granted, shall be recorded in the Office of the Clerk of the Court in such a manner that it appears in the chain of title of the affected parcel of land; and

4. If the request is for a variance to allow construction of the lowest floor of a new building, or substantial improvement of a building, below the required elevation, a copy in the record of a written notice from the Floodplain Administrator to the applicant for the variance, specifying the difference between the base flood elevation and the proposed elevation of the lowest floor, stating that the cost of federal flood insurance will be commensurate with the increased risk resulting from the reduced floor elevation (up to amounts as high as $25.00 for $100.00 of insurance coverage), and stating that construction below the base flood elevation increases risks to life and property.

I. *Agricultural structures.* A variance is authorized to be issued for the construction or substantial improvement of agricultural structures provided the requirements of this section are satisfied and:

1. A determination has been made that the proposed agricultural structure:
   a. Is used exclusively in connection with the production, harvesting, storage, raising, or drying of agricultural commodities and livestock, or storage of tools or equipment used in connection with these purposes or uses, and will be restricted to such exclusive uses.
   b. Has low damage potential (amount of physical damage, contents damage, and loss of function).
   c. Does not increase risks and pose a danger to public health, safety, and welfare if flooded and contents are released, including but not limited to the effects of flooding on manure storage, livestock confinement operations, liquified natural gas terminals, and production and storage of highly volatile, toxic, or water-reactive materials.
   d. Is not located in a coastal high hazard area (Zone V/VE), except for aquaculture structures dependent on close proximity to water.
   e. Complies with the wet floodproofing construction requirements of paragraph (2), below.
2. Wet floodproofing construction requirements.
   a. Anchored to resist flotation, collapse, and lateral movement.
   b. When enclosed by walls, walls have flood openings that comply with the flood opening requirements of ASCE 24, Chapter 2.
   c. Flood damage-resistant materials are used below the base flood elevation plus one (1) foot.
   d. Mechanical, electrical, and utility equipment, including plumbing fixtures, are elevated above the base flood elevation plus one (1) foot.

4.09.09. - Violations.

A. *Violations.* Any development that is not within the scope of the Florida Building Code but that is regulated by this ordinance that is performed without an issued permit, that is in

conflict with an issued permit, or that does not fully comply with this ordinance, shall be deemed a violation of this ordinance. A building or structure without the documentation of elevation of the lowest floor, other required design certifications, or other evidence of compliance required by this ordinance or the Florida Building Code is presumed to be a violation until such time as that documentation is provided.

B. *Authority.* For development that is not within the scope of the Florida Building Code but that is regulated by this ordinance and that is determined to be a violation, the Floodplain Administrator is authorized to serve notices of violation or stop work orders to owners of the property involved, to the owner's agent, or to the person or persons performing the work.

C. *Unlawful continuance.* Any person who shall continue any work after having been served with a notice of violation or a stop work order, except such work as that person is directed to perform to remove or remedy a violation or unsafe condition, shall be subject to penalties as prescribed by Chapter 7, Walton County Land Development Code.

4.09.10. - Flood Resistant Development: Building and Structures.

A. *Design and construction of buildings, structures and facilities exempt from the Florida Building Code.* Pursuant to Section 4.09.05(C) of this ordinance, buildings, structures, and facilities that are exempt from the Florida Building Code, including substantial improvement or repair of substantial damage of such buildings, structures and facilities, shall be designed and constructed in accordance with the flood load and flood resistant construction requirements of ASCE 24. Structures exempt from the Florida Building Code that are not walled and roofed buildings shall comply with the requirements of Section 4.09.16 of this ordinance.

B. *Buildings and structures seaward of the coastal construction control line.* If extending, in whole or in part, seaward of the coastal construction control line and also located, in whole or in part, in a flood hazard area:

1. Buildings and structures shall be designed and constructed to comply with the more restrictive applicable requirements of the Florida Building Code, Building Section 3109 and Section 1612 or Florida Building Code, Residential Section R322.

2. Minor structures and non-habitable major structures as defined in F.S. § 161.54, shall be designed and constructed to comply with the intent and applicable provisions of this ordinance and ASCE 24.

C. *Buildings and structures with enclosed areas below the* <u>*Lowest Floor*</u> ~~*Design Flood*~~ *Elevation.* Enclosures below the lowest floor shall be constructed in accordance with the Florida Building Code, <u>Residential</u> R322.2.2 or R322.3.5, as applicable to the flood zone. For enclosed parking, storage, building access areas and crawlspaces that are six feet in height or greater, a copy of a legally recorded deed restriction prohibiting the conversion of the area below the lowest floor to a use or dimension contrary to the building's originally approved design shall be presented as a condition for issuance of a Building Permit.

D. *Elevation Certificates.* Elevation Certificates are required to verify building elevations as required in the Florida Building Code Sections 110.3(1.1), 110.23(5.1), and R322.1.10. Elevations shall be certified on FEMA Form 81-31. Certificates shall be reviewed by the Floodplain Administrator at the following stages of construction:

1. Prior to obtaining a building permit for a building in an area of special flood hazard, an Elevation Certificate based on the proposed construction drawings shall be provided to the Floodplain Administrator for review. Existing highest adjacent grade and lowest adjacent grade shall be noted on the certificate, as well as the proposed elevation of

the top of the lowest floor or the lowest horizontal structural member of the lowest floor, and the proposed elevation of the top of the floor of any enclosures.

2. Within 30 days of placement of the slab, or installation of the floor sheathing, or placement of the lowest horizontal structural member, an Elevation Certificate based on the building under construction shall be provided to the Floodplain Management Administrator.

3. Prior to the building receiving power, an Elevation Certificate based on finished construction shall be provided to the Floodplain Administrator that includes elevations that are based on final grading.

E. *Coastal A Zones, Florida Building Code, Building.* Amend Section 1612 as follows:

1612.4.1 Modification of ASCE 24. Reserved. ~~Table 6-1 and Section 6.2.1 in ASCE 24 shall be modified as follows:~~

~~1. The title of Table 6.1 shall be "Minimum Elevation of Floodproofing, Relative to Base Flood Elevation (BFE) or Design Flood Elevation (DFE), in Coastal A Zones and in Other Flood Hazard Areas that are not High Risk Flood Hazard Areas."~~

~~2. Section 6.2.1 shall be modified to permit dry floodproofing in Coastal A Zones, as follows: "Dry floodproofing of nonresidential structures and nonresidential areas of mixed-use structures shall not be allowed unless such structures are located outside of High Risk Flood Hazard areas and Coastal High Hazard Areas. Dry floodproofing shall be permitted in Coastal A Zones provided wave loads and the potential for erosion and local scour are accounted for in the design. Dry floodproofing of residential structures or residential areas of mixed-use structures shall not be permitted."~~

1612.4.3 Modification of ASCE 24 (Coastal A Zone). Stem walls shall not be permitted in Coastal A Zones.

F. *Coastal A Zones, Florida Building Code, Residential.* Amend Section R322.3 as follows:

R322.3.3 Foundations. Buildings and structures erected in coastal high-hazard areas and Coastal A Zones shall be supported on pilings or columns and shall be adequately anchored to such pilings or columns. The space below the elevated building shall be either free of obstruction or, if enclosed with walls, the walls shall meet the requirements of Section R322.3.4. Pilings shall have adequate soil penetrations to resist the combined wave and wind loads (lateral and uplift). Water-loading values used shall be those associated with the design flood. Wind-loading values shall be those required by this code. Pile embedment shall include consideration of decreased resistance capacity caused by scour of soil strata surrounding the piling. Pile systems design and installation shall be certified in accordance with Section R322.3.6. Spread footing, mat, raft or other foundations that support columns shall not be permitted where soil investigations that are required in accordance with Section R401.4 indicate that soil material under the spread footing, mat, raft or other foundation is subject to scour or erosion from wave-velocity flow conditions. If permitted, spread footing, mat, raft or other foundations that support columns shall be designed in accordance with ASCE 24. Slabs, pools, pool decks and walkways shall be located and constructed to be structurally independent of buildings and structures and their foundations to prevent transfer of flood loads to the buildings and structures during conditions of flooding,

scour or erosion from wave-velocity flow conditions, unless the buildings and structures and their foundations are designed to resist the additional flood load.

~~**Exception:** In Coastal A Zones, stem wall foundations supporting a floor system above and backfilled with soil or gravel to the underside of the floor system shall be permitted provided the foundations are designed to account for wave action, debris impact, erosion and local scour. Where soils are susceptible to erosion and local scour, stem wall foundations shall have deep footings to account for the loss of soil.~~

G. *Substantial Damage and Substantial Improvement.* Amend the definitions of Substantial Damage and Substantial Improvement in Section 202 the Florida Building Code, Building and Section 202 the Florida Building Code, Existing Building, as follows:

Substantial Damage. For the purpose of determining compliance with the flood provisions of this code, damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred. The term also includes flood-related damage sustained by a structure on two separate occasions during a 10-year period for which the cost of repairs at the time of each flood event, on average, equals or exceeds 25 per cent of the market value of the structure before the damage occurred.

Substantial Improvement. For the purposes of determining compliance with the flood provisions of this code, any combination of repair, reconstruction, rehabilitation, alteration, addition or other improvement of a building or structure taking place during a five (5)-year period, the cost of which equals or exceeds 50 percent of the market value of the structure before the improvement or repair is started. For each building or structure, the five (5)-year period begins on the date of the first improvement or repair of that building or structure subsequent to March 1, 2011. If the structure has sustained substantial damage, any repairs are considered substantial improvement regardless of the actual repair work performed. The term does not, however, include either

1. Any project for improvement of a building required to correct existing health, sanitary or safety code violations identified by the building official and that are the minimum necessary to assure safe living conditions.
2. Any alteration of a historic structure provided that the alteration will not preclude the structure's continued designation as a historic structure.

H. *Accessory structures.* Accessory structures are permitted below the base flood elevation provided the accessory structures are used only for parking or storage and:

1. If located in special flood hazard areas (Zone A/AE) other than coastal high hazard areas, are one-story and not larger than 600 sq. ft.
2. If located in special flood hazard areas (Zone A/AE) other than coastal high hazard areas, have flood openings in accordance with Section R322.2 of the Florida Building Code, Residential.
3. If located in coastal high hazard areas (Zone V/VE), are not located below elevated buildings and are not larger than 100 sq. ft.
4. Are anchored to resist flotation, collapse or lateral movement resulting from flood loads.

5. Have flood damage-resistant materials used below the base flood elevation plus one (1) foot.

6. Have mechanical, plumbing and electrical systems, including plumbing fixtures, elevated to or above the base flood elevation plus one (1) foot.

4.09.11. - Subdivisions.

A. *Minimum requirements.* Subdivision proposals, including proposals for manufactured home parks and subdivisions, shall be reviewed to determine that:

1. Such proposals are consistent with the need to minimize flood damage and will be reasonably safe from flooding;

2. All public utilities and facilities such as sewer, gas, electric, communications, and water systems are located and constructed to minimize or eliminate flood damage; and

3. Adequate drainage is provided to reduce exposure to flood hazards; in Zones AH and AO, adequate drainage paths shall be provided to guide floodwaters around and away from proposed structures.

B. *Subdivision plats.* Where any portion of proposed subdivisions, including manufactured home parks and subdivisions, lies within a flood hazard area, the following shall be required:

1. Delineation of flood hazard areas, floodway boundaries and flood zones, and design flood elevations, as appropriate, shall be shown on plats;

2. Where the subdivision has more than 50 lots or is larger than five acres and base flood elevations are not included on the FIRM, the base flood elevations determined in accordance with Section 4.09.06(B)(1) of this ordinance; and

3. Compliance with the site improvement and utilities requirements of Section 4.09.12 ~~4.05.12~~ of this ordinance.

4.09.12. - Site, Utilities and Limitations.

A. *Minimum requirements.* All proposed new development shall be reviewed to determine that:

1. Such proposals are consistent with the need to minimize flood damage and will be reasonably safe from flooding;

2. All public utilities and facilities such as sewer, gas, electric, communications, and water systems are located and constructed to minimize or eliminate flood damage; and

3. Adequate drainage is provided to reduce exposure to flood hazards; in Zones AH and AO, adequate drainage paths shall be provided to guide floodwaters around and away from proposed structures

B. *Sanitary sewage facilities.* All new and replacement sanitary sewage facilities, private sewage treatment plants (including all pumping stations and collector systems), and on-site waste disposal systems shall be designed in accordance with the standards for onsite sewage treatment and disposal systems in Chapter 64E-6, F.A.C. and ASCE 24 Chapter 7 to minimize or eliminate infiltration of floodwaters into the facilities and discharge from the facilities into flood waters, and impairment of the facilities and systems.

C. *Water supply facilities.* All new and replacement water supply facilities shall be designed in accordance with the water well construction standards in Chapter 62-532.500, F.A.C. and ASCE 24 Chapter 7 to minimize or eliminate infiltration of floodwaters into the systems.

D. *Limitations on sites in regulatory floodways.* No development, including but not limited to site improvements, and land disturbing activity involving re-grading, shall be authorized in the regulatory floodway unless the floodway encroachment analysis required in Section 4.09.06(C)(1) of this ordinance demonstrates that the proposed development or land disturbing activity will not result in any increase in the base flood elevation.

E. *Limitations on placement of fill.* Subject to the limitations of this ordinance, fill shall be designed to be stable under conditions of flooding including rapid rise and rapid drawdown of floodwaters, prolonged inundation, and protection against flood-related erosion and scour. Fill shall be limited in thickness to an average of no more than one foot over the entire development site, and hydrologically equivalent storage volume shall be provided at a ratio of one to one or greater for the placement of fill associated with all new development with the exception of one and two family dwellings. In addition to these requirements, if intended to support buildings and structures (Zone A only), fill shall comply with the requirements of the Florida Building Code.

F. *Limitations on sites in coastal high hazard areas (Zone V).* In coastal high hazard areas seaward of the Coastal Construction Control Line, alteration of sand dunes and mangrove stands shall be permitted only if such alteration is approved by the Florida Department of Environmental Protection and only if the engineering analysis required by Section 4.09.06(C)(4) of this ordinance demonstrates that the proposed alteration will not increase the potential for flood damage from high velocity wave action. Construction or restoration of dunes under or around elevated buildings and structures shall comply with Section 4.09.16(H)(3) of this ordinance.

4.09.13. - Manufactured Homes.

A. *General.* All manufactured homes installed in flood hazard areas shall be installed by an installer that is licensed pursuant to F.S. § 320.8249, and shall comply with the requirements of Chapter 15C-1, F.A.C. and the requirements of this ordinance. If located seaward of the coastal construction line, all manufactured homes shall comply with the more restrictive of the applicable requirements.

B. *Foundations.* All new manufactured homes and replacement manufactured homes installed in flood hazard areas shall be installed on permanent, reinforced foundations that:

1. In flood hazard areas (Zone A) other than coastal high hazard areas and Coastal A Zones, are designed in accordance with the foundation requirements of the Florida Building Code, Residential Section R322.2 and this ordinance.

2. In coastal high hazard areas (Zone V) and Coastal A Zones, are designed in accordance with the foundation requirements of the Florida Building Code, Residential Section R322.3 and this ordinance.

C. *Anchoring.* All new manufactured homes and replacement manufactured homes shall be installed using methods and practices which minimize flood damage and shall be securely anchored to an adequately anchored foundation system to resist flotation, collapse or lateral movement. Methods of anchoring include, but are not limited to, use of over-the-top or frame ties to ground anchors. This anchoring requirement is in addition to applicable state and local anchoring requirements for wind resistance.

D. *Elevation.* All manufactured homes that are placed, replaced, or substantially improved in flood hazard areas shall be elevated such that the bottom of the frame is at or above the elevation required, as applicable to the flood hazard area, in the *Florida Building Code, Residential* Section R322.2 (Zone A) or Section R322.3 (Zone V and Coastal A Zones). ~~Manufactured homes that are placed, replaced, or substantially improved shall comply with Section 4.09.13(D)(1) or 4.09.13(D)(2) of this ordinance, as applicable.~~

~~1. General elevation requirement. Unless subject to the requirements of Section 4.09.13(D)(2) of this ordinance, all manufactured homes that are placed, replaced, or substantially improved on sites located: (a) outside of a manufactured home park or subdivision; (b) in a new manufactured home park or subdivision; (c) in an expansion to an existing manufactured home park or subdivision; or (d) in an existing manufactured home park or subdivision upon which a manufactured home has incurred "substantial damage" as the result of a flood, shall be elevated such that the bottom of the frame is at or above the elevation required, as applicable to the flood hazard area, in the Florida Building Code, Residential Section R322.2 (Zone A) or Section R322.3 (Zone V).~~

~~2. Elevation requirement for certain existing manufactured home parks and subdivisions. Manufactured homes that are not subject to Section 4.09.13(D)(1) of this ordinance, including manufactured homes that are placed, replaced, or substantially improved on sites located in an existing manufactured home park or subdivision, unless on a site where substantial damage as result of flooding has occurred, shall be elevated such that either the:~~

~~a. Bottom of the frame of the manufactured home is at or above the elevation required, as applicable to the flood hazard area, in the Florida Building Code, Residential Section R322.2 (Zone A) or Section R322.3 (Zone V); or~~

~~b. Bottom of the frame is supported by reinforced piers or other foundation elements of at least equivalent strength that are not less than 36 inches in height above grade.~~

E. *Enclosures.* Enclosed areas below elevated manufactured homes shall comply with the requirements of the Florida Building Code, Residential Section R322 for such enclosed areas, as applicable to the flood hazard area. A copy of a legally recorded deed restriction prohibiting the conversion of the area below the lowest floor to a use or dimension contrary to the building's originally approved design shall be presented as a condition for issuance of a final Certificate of Occupancy.

F. *Utility equipment.* Utility equipment that serves manufactured homes, including electric, heating, ventilation, plumbing, and air conditioning equipment and other service facilities, shall comply with the requirements of the Florida Building Code, Residential Section R322, as applicable to the flood hazard area.

4.09.14. - Recreational Vehicles and Park Trailers.

A. *Temporary placement.* Recreational vehicles and park trailers placed temporarily in flood hazard areas shall:

1. Be on the site for fewer than 180 consecutive days; or
2. Be fully licensed and ready for highway use, which means the recreational vehicle or park model is on wheels or jacking system, is attached to the site only by quick-disconnect type utilities and security devices, and has no permanent attachments such as additions, rooms, stairs, decks and porches.

B. *Permanent placement.* Recreational vehicles and park trailers shall not be permanently installed.

C. *Placement in the Regulatory Floodway, Coastal High Hazard Areas (Zone V) and Coastal A Zones.* Recreational vehicles shall be prohibited within the Regulatory Floodway, coastal high hazard areas (Zone V), and Coastal A Zones, except in existing recreational vehicle parks. This section does not restrict temporary parking of a recreational vehicle on a previously developed parcel where the vehicle is to be removed in the case of a threat of flooding.

4.09.15. - Tanks.

A. *Underground tanks.* Underground tanks in flood hazard areas shall be anchored to prevent flotation, collapse or lateral movement resulting from hydrodynamic and hydrostatic loads during conditions of the design flood, including the effects of buoyancy assuming the tank is empty.

B. *Above-ground tanks, not elevated.* Above-ground tanks that do not meet the elevation requirements of Section 4.09.015(C) of this ordinance shall:

1. Be permitted in flood hazard areas (Zone A) other than coastal high hazard areas and Coastal A Zones, provided the tanks are anchored or otherwise designed and constructed to prevent flotation, collapse or lateral movement resulting from hydrodynamic and hydrostatic loads during conditions of the design flood, including the effects of buoyancy assuming the tank is empty and the effects of flood-borne debris.

2. Not be permitted in coastal high hazard areas (Zone V) and Coastal A Zones.

C. *Above-ground tanks, elevated.* Above-ground tanks in flood hazard areas shall be attached to and elevated to or above the design flood elevation on a supporting structure that is designed to prevent flotation, collapse or lateral movement during conditions of the design flood. Tank-supporting structures shall meet the foundation requirements of the applicable flood hazard area.

D. *Tank inlets and vents.* Tank inlets, fill openings, outlets and vents shall be:

1. At or above the design flood elevation or fitted with covers designed to prevent the inflow of floodwater or outflow of the contents of the tanks during conditions of the design flood; and

2. Anchored to prevent lateral movement resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy, during conditions of the design flood.

4.09.16. - Other Development.

A. *General requirements for other development.* All development, including manmade changes to improved or unimproved real estate for which specific provisions are not specified in this ordinance or the Florida Building Code, shall:

1. Be located and constructed to minimize flood damage;

2. Meet the limitations of Section 4.09.12(D) of this ordinance if located in a regulated floodway;

3. Be anchored to prevent flotation, collapse or lateral movement resulting from hydrostatic loads, including the effects of buoyancy, during conditions of the design flood;

4. Be constructed of flood damage-resistant materials; and

5. Have mechanical, plumbing, and electrical systems above the design flood elevation, except that minimum electric service required to address life safety and electric code requirements is permitted below the design flood elevation provided it conforms to the provisions of the electrical part of building code for wet locations.

B. *Fences in regulated floodways.* Fences in regulated floodways that have the potential to block the passage of floodwaters, such as stockade fences and wire mesh fences, shall meet the limitations of Section 4.09.12(D) of this ordinance.

C. *Retaining walls, sidewalks and driveways in regulated floodways.* Retaining walls and sidewalks and driveways that involve the placement of fill in regulated floodways shall meet the limitations of Section 4.09.12(D) of this ordinance.

D. *Roads and watercourse crossings in regulated floodways.* Roads and watercourse crossings, including roads, bridges, culverts, low-water crossings and similar means for vehicles or pedestrians to travel from one side of a watercourse to the other side, that encroach into regulated floodways shall meet the limitations of Section 4.09.12(D) of this ordinance. Alteration of a watercourse that is part of a road or watercourse crossing shall meet the requirements of Section 4.09.06(C)(3) of this ordinance.

E. *Concrete slabs used as parking pads, enclosure floors, landings, decks, walkways, patios and similar nonstructural uses in coastal high hazard areas (Zone V) and Coastal A Zones.* In coastal high hazard areas and Coastal A Zones, concrete slabs used as parking pads, enclosure floors, landings, decks, walkways, patios and similar nonstructural uses are permitted beneath or adjacent to buildings and structures provided the concrete slabs are designed and constructed to be:

1. Structurally independent of the foundation system of the building or structure;

2. Frangible and not reinforced, so as to minimize debris during flooding that is capable of causing significant damage to any structure; and

3. Have a maximum slab thickness of not more than four inches.

F. *Decks and patios in coastal high hazard areas (Zone V) and Coastal A Zones.* In addition to the requirements of the Florida Building Code, in coastal high hazard areas and Coastal A Zones, decks and patios shall be located, designed, and constructed in compliance with the following:

1. A deck that is structurally attached to a building or structure shall have the bottom of the lowest horizontal structural member at or above the design flood elevation and any supporting members that extend below the design flood elevation shall comply with the foundation requirements that apply to the building or structure, which shall be designed to accommodate any increased loads resulting from the attached deck.

2. A deck or patio that is located below the design flood elevation shall be structurally independent from buildings or structures and their foundation systems, and shall be designed and constructed either to remain intact and in place during design flood conditions or to break apart into small pieces to minimize debris during flooding that is capable of causing structural damage to the building or structure or to adjacent buildings and structures.

3. A deck or patio that has a vertical thickness of more than 12 inches or that is constructed with more than the minimum amount of fill necessary for site drainage shall not be approved unless an analysis prepared by a qualified registered design

professional demonstrates no harmful diversion of floodwaters or wave runup and wave reflection that would increase damage to the building or structure or to adjacent elevated buildings and structures.

4. A deck or patio that has a vertical thickness of 12 inches or less and that is at natural grade or on nonstructural fill material that is similar to and compatible with local soils and is the minimum amount necessary for site drainage may be approved without requiring analysis of the impact on diversion of floodwaters or wave runup and wave reflection.

G. *Other development in coastal high hazard areas (Zone V) and Coastal A Zones.* In coastal high hazard areas and Coastal A Zones, development activities other than buildings and structures shall be permitted only if also authorized by the appropriate federal, state or local authority; if located outside the footprint of, and not structurally attached to, buildings and structures; and if analyses prepared by qualified registered design professionals demonstrate no harmful diversion of floodwaters or wave runup and wave reflection that would increase damage to adjacent buildings and structures. Such other development activities include but are not limited to:

1. Bulkheads, seawalls, retaining walls, revetments, and similar erosion control structures;

2. Solid fences and privacy walls, and fences prone to trapping debris, unless designed and constructed to fail under flood conditions less than the design flood or otherwise function to avoid obstruction of floodwaters; and

3. On-site sewage treatment and disposal systems defined in 64E-6.002, F.A.C., as filled systems or mound systems.

H. *Nonstructural fill in coastal high hazard areas (Zone V) and Coastal A Zones.* In coastal high hazard areas and Coastal A Zones:

1. Minor grading and the placement of minor quantities of nonstructural fill shall be permitted for landscaping and for drainage purposes under and around buildings.

2. Nonstructural fill with finished slopes that are steeper than one unit vertical to five units horizontal shall be permitted only if an analysis prepared by a qualified registered design professional demonstrates no harmful diversion of floodwaters or wave runup and wave reflection that would increase damage to adjacent elevated buildings and structures.

3. Where authorized by the Florida Department of Environmental Protection or applicable local approval, sand dune construction and restoration of sand dunes under or around elevated buildings are permitted without additional engineering analysis or certification of the diversion of floodwater or wave runup and wave reflection if the scale and location of the dune work is consistent with local beach-dune morphology and the vertical clearance is maintained between the top of the sand dune and the lowest horizontal structural member of the building.

SECTION IV. CHAPTER 10.5, Flood Damage Prevention, of the Walton County Code of Ordinances is repealed.

SECTION V. FISCAL IMPACT STATEMENT.

In terms of design, plan application review, construction and inspection of buildings and structures, the cost impact as an overall average is negligible in regard to the local technical amendments because all development has been subject to the requirements of the local floodplain management ordinance adopted for participation in the National Flood Insurance Program. In terms of lower potential for flood damage, there will be continued savings and benefits to consumers.

SECTION VI. APPLICABILITY.

For the purposes of jurisdictional applicability, this ordinance shall apply in the unincorporated areas of Walton County. This ordinance shall apply to all applications for development, including building permit applications and subdivision proposals, submitted on or after the effective date of this ordinance.

SECTION VII. INCLUSION INTO THE CODE OF ORDINANCES.

It is the intent of the Board of County Commissioners of Walton County that the provisions of this ordinance shall become and be made a part of the Walton County Code of Laws, and that the sections of this ordinance may be renumbered or relettered and the word "ordinance" may be changed to "section," "article," "regulation," or such other appropriate word or phrase in order to accomplish such intentions.

SECTION VIII. SEVERABILITY.

If any section, subsection, sentence, clause or phrase of this ordinance is, for any reason, declared by the courts to be unconstitutional or invalid, such decision shall not affect the validity of the ordinance as a whole, or any part thereof, other than the part so declared.

SECTION IX. EFFECTIVE DATE.

The effective date shall be as provided by law.
Duly enacted by the Board of County Commissioners of Walton County, Florida, at a regularly scheduled public hearing on the 12TH day of OCTOBER, 2021.

BOARD OF COUNTY COMMISSIONERS
WALTON COUNTY, FLORIDA

ATTEST:

COUNTY COMMISSIONERS SEAL WALTON COUNTY, FLORIDA

By: _____
Trey Nick, Chairman
Board of County Commissioners

Dori Condle
Alex Alford
Clerk of Court

APPENDIX B

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401011001

PEACH CREEK

Principal Investigator: Frederick Bloetscher, Ph.D., P.E.

Co-Principal Investigators: Weibo Liu, Ph.D., Daniel Meeroff, Ph.D., Diana Mitsova, Ph.D., S. Nagarajan, Ph.D., Hongbo Su, Ph.D., Ramesh Teegavarapu, Ph.D., Zhixiao Xie, Ph.D., Yan Yong, Ph.D., and Caiyun Zhang, Ph.D., Ahmet Urusan, Ph.D., Shannon Egger, Eva Suarez, Ph.D.

Research Assistant: Leticia Sabio

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (Figure 1). Figure 2 shows Walton County Drainage Network and the location of urban areas (cities and towns). In Figure 3, the HUC-12 (031401011001) is highlighted among all the HUCs to help identifying its location.

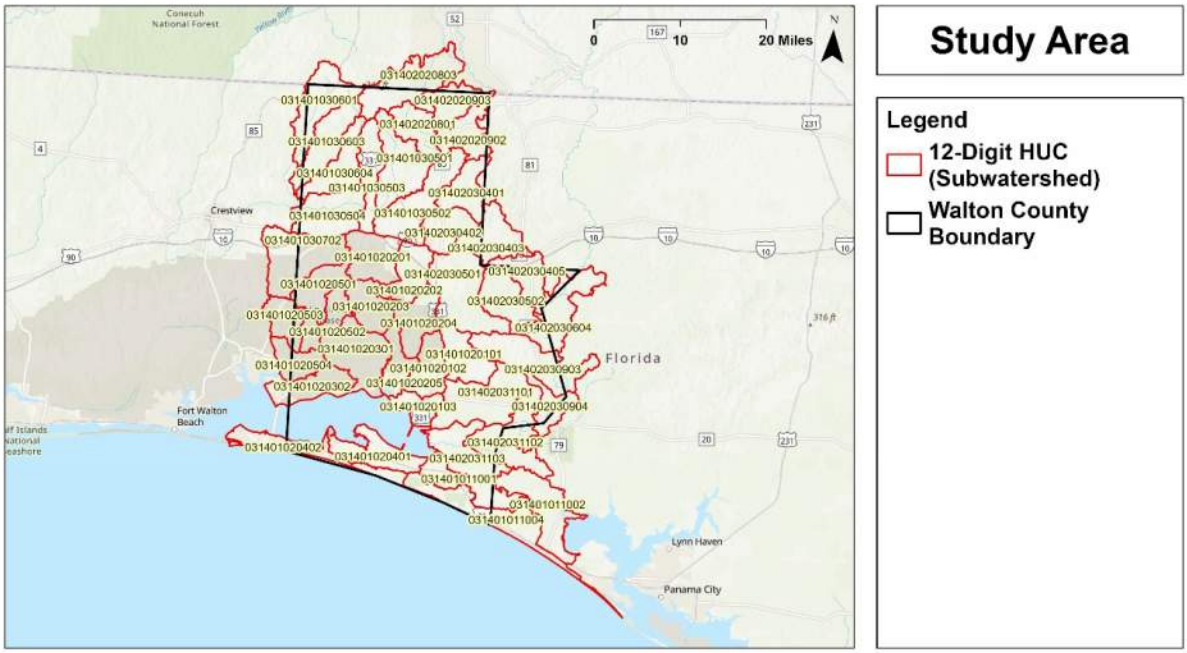

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

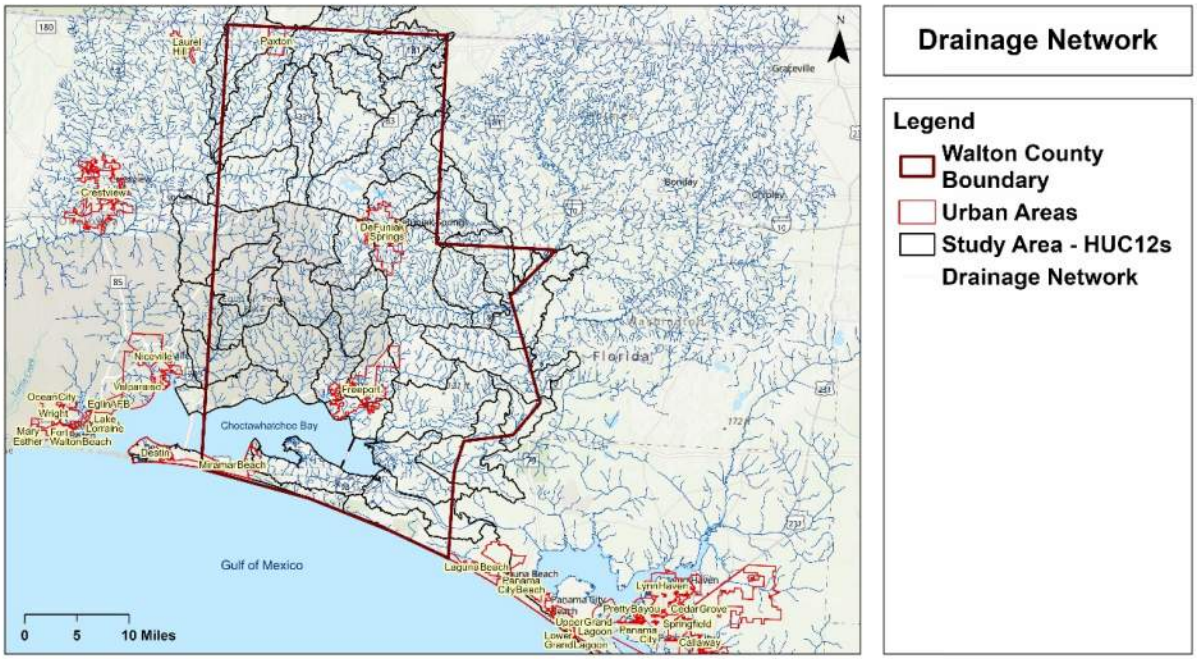

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

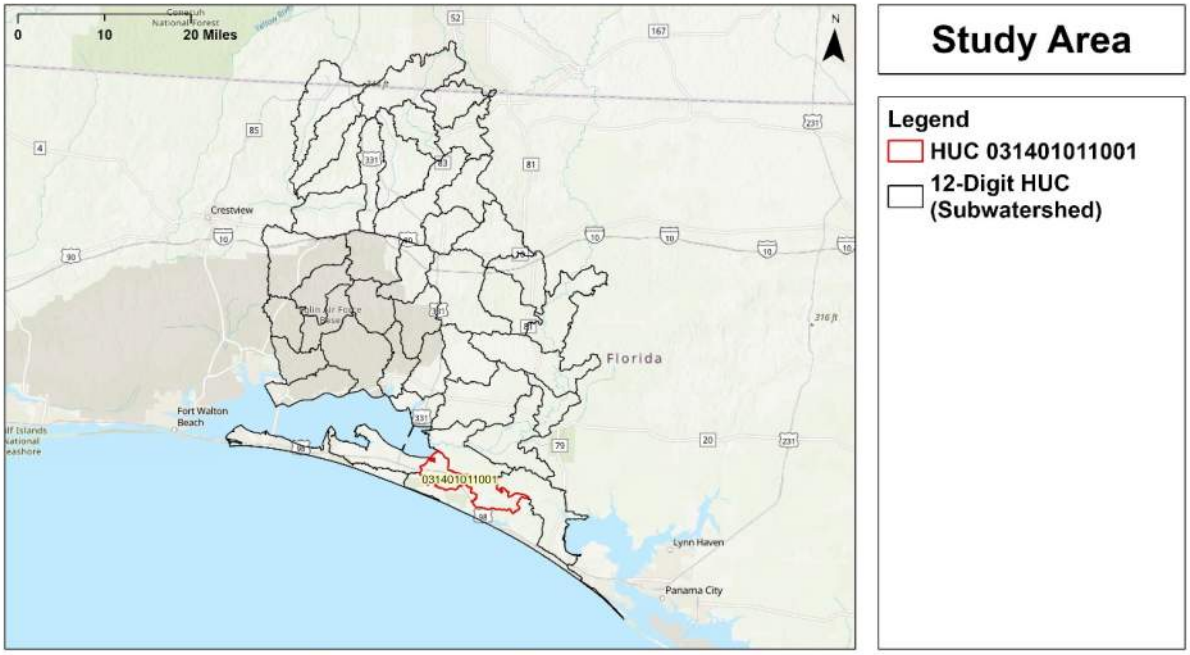

Figure 3. HUC 031401011001sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental

conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic

community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in Table 1. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

Figures 12 and 13 in the county-wide report show the current and projected land use for the County. Based on the 2017 future land use map for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in Table 2.

Table 2. Land Use in Walton County (Prepared by FAU from future land use map) versus land use in the entire watershed (2023 Florida Geographic Data Library (FGDL))

Level 1 Land Use-Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	52958.9	7.17%
Barren Land	9242.1	1.25%
Rangeland	40326.7	5.46%
Transportation, Communication, and Utilities	11815.7	1.60%
Upland Forest	356796.1	48.30%
Urban and Built-Up	52194.8	7.07%
Water	61593.9	8.34%
Wetlands	153759.9	20.82%
Total	**738687.9**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 1.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (Figure 4). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

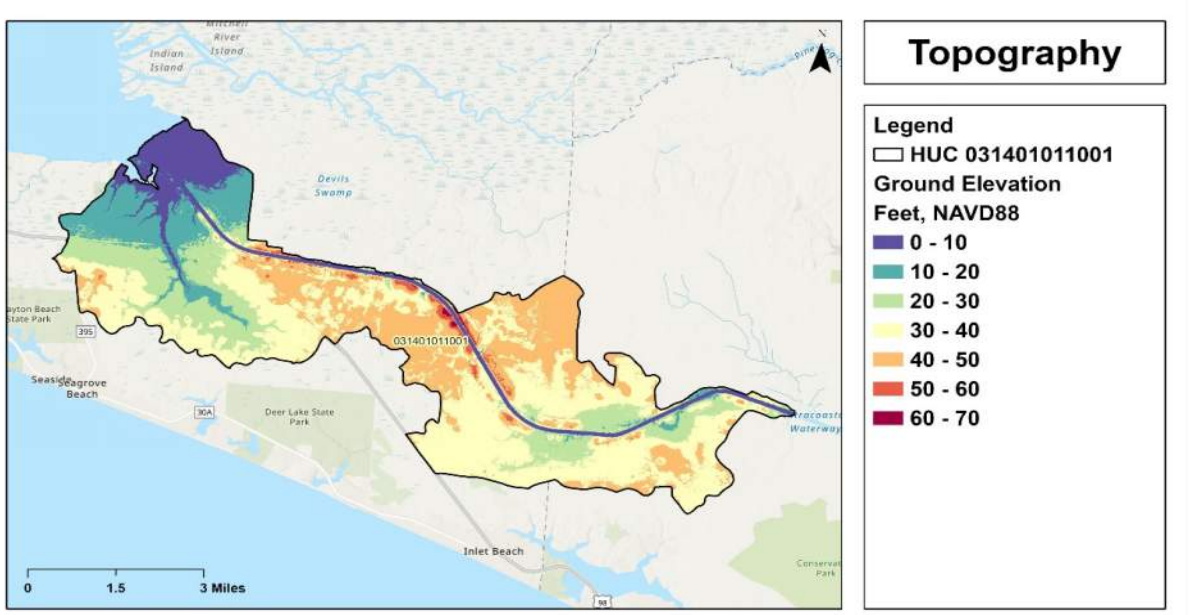

Figure 4. Topographic map of the HUC 031401011001 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401011001 sub-watershed is shown in Figure 5.

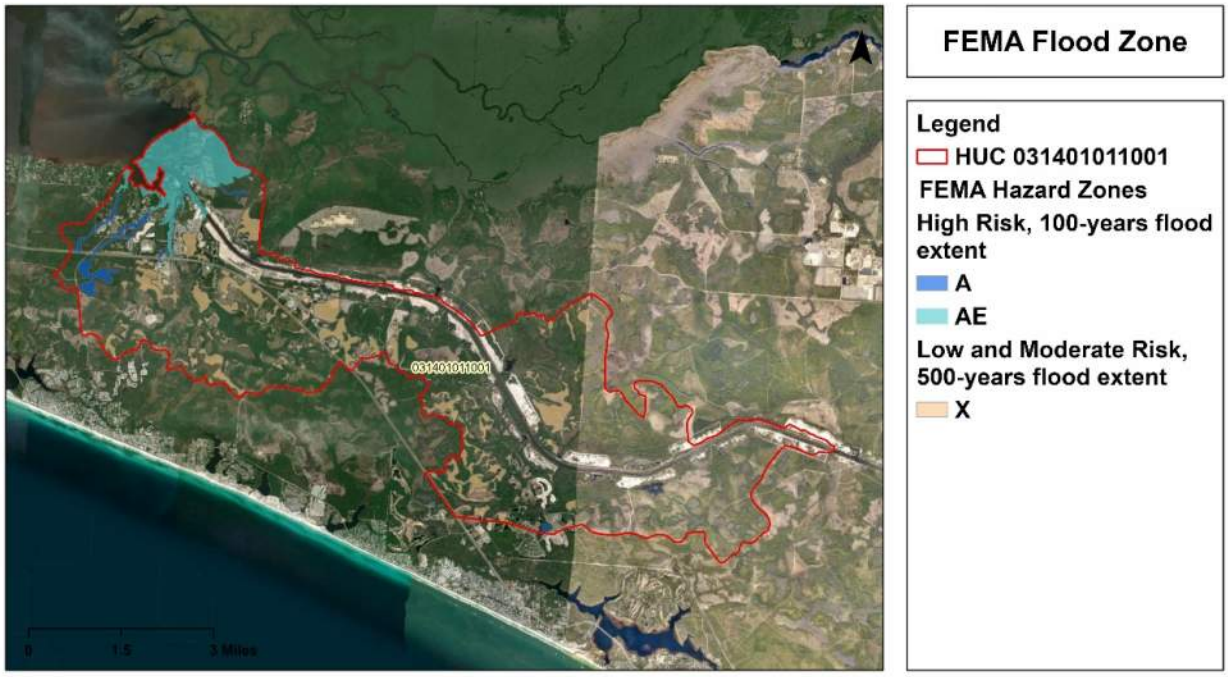

Figure 5. FEMA Flood Zone map (2020) for HUC 031401011001 sub-watershed, processed by FAU.
(Data Source: FEMA)

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401011001 as it will reach the area through Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem.

This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. Figure 6 shows the bathymetry offshore.

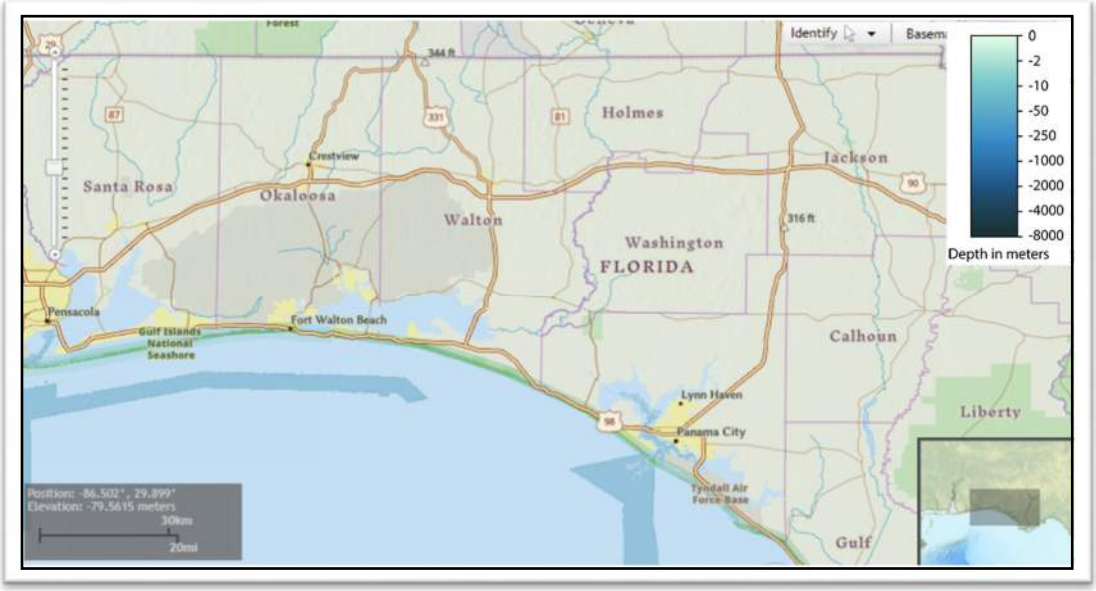

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. Figure 7 shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

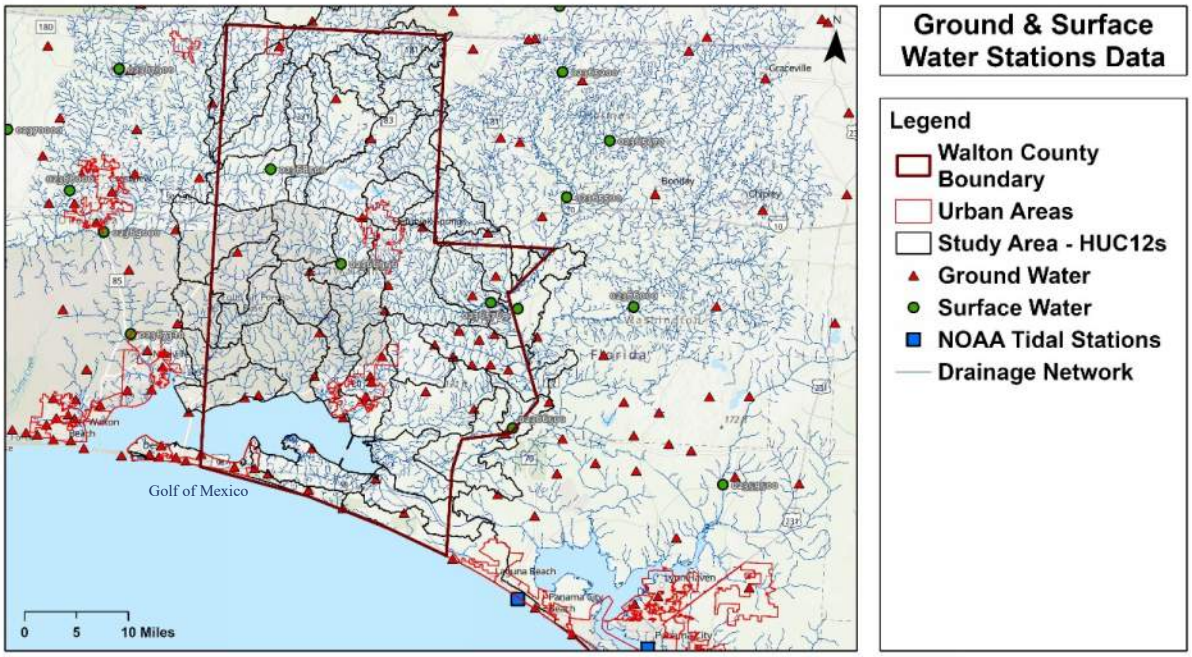

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The major water bodies in the sub-watershed are the Choctawhatchee Bay at the west side of the HUC-12 with the associated rivers and canals:

- Intracoastal Waterway

- Tucker Bayou
- Peach Creek

Given that stream flow data are critical for estimating flooding, Figure 8 shows the historical streamflow during June 2022 to July 2023 for USGS 02366500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401011001, which is USGS 02366500 Choctawhatchee River NR Bruce FLA.

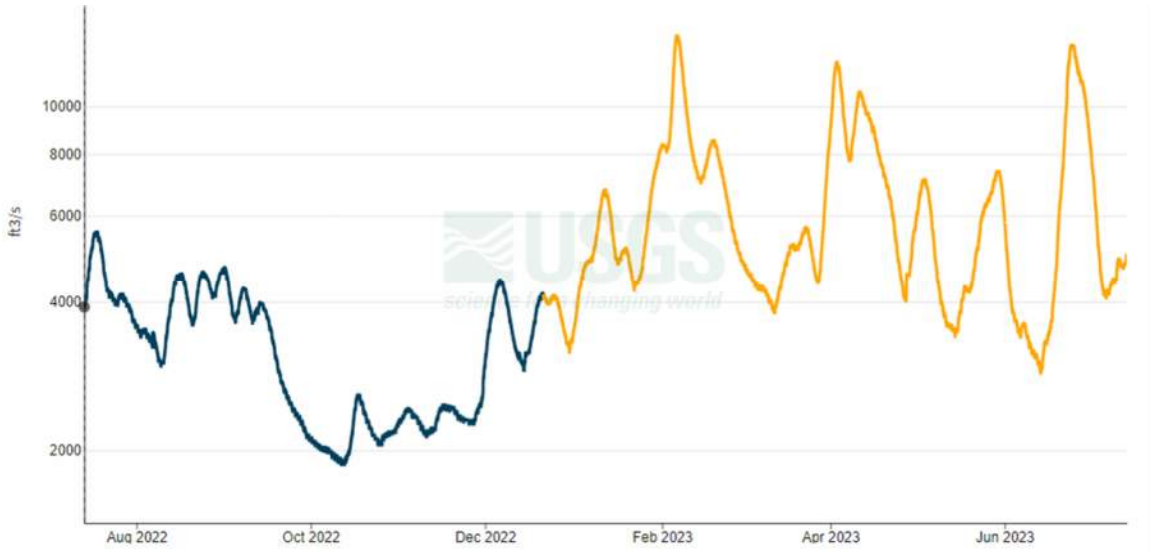

Figure 8. Average streamflow for Choctawhatchee River NR Bruce FLA (USGS 02366500 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366500/#parameterCode=00065&period=P365D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station

(or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Figure 9 shows the drainage network of HUC 031401011001 and points out the location of the ground water stations in the surroundings. No surface water stations were identified. A groundwater-surface layer for the HUC 031401011001 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (Figure 10).

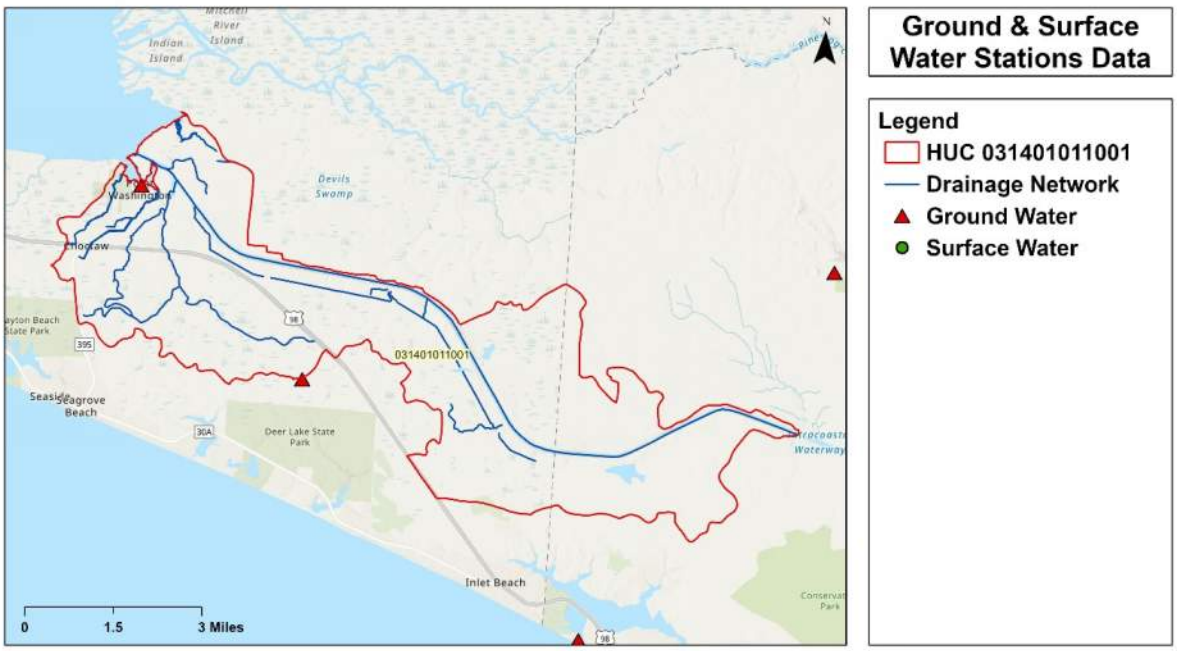

Figure 9. Ground and Surface Water Stations in the HUC 031401011001 sub-watershed, processed by FAU.

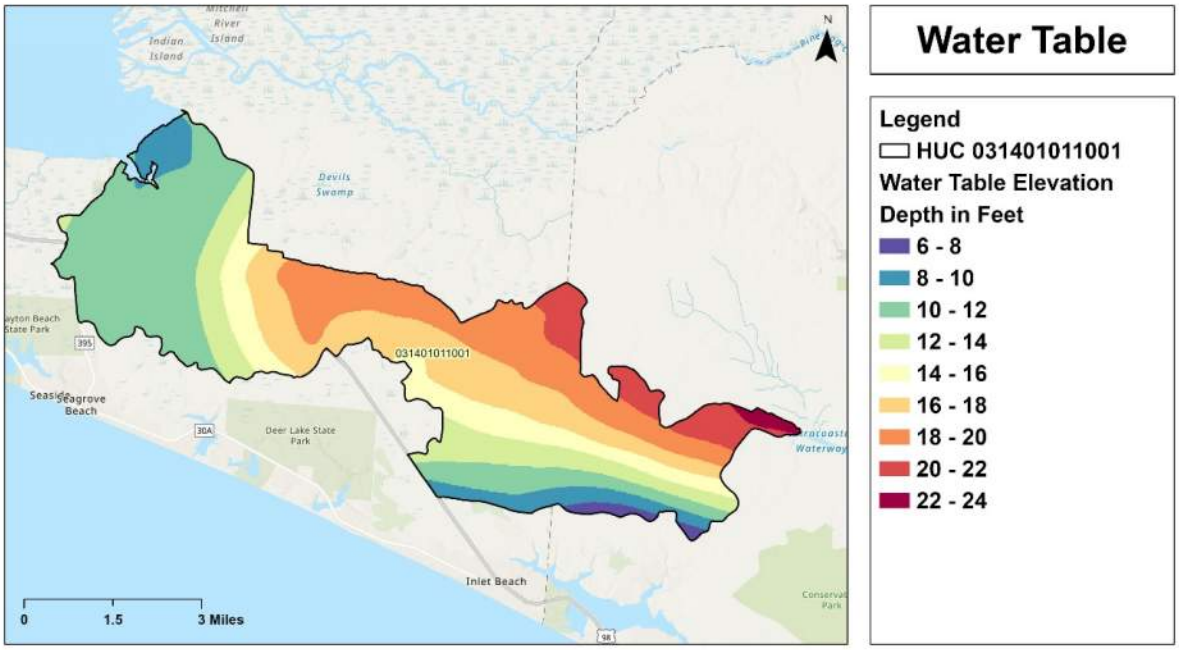

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401011001 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. Figure 11 shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches for the entire county.

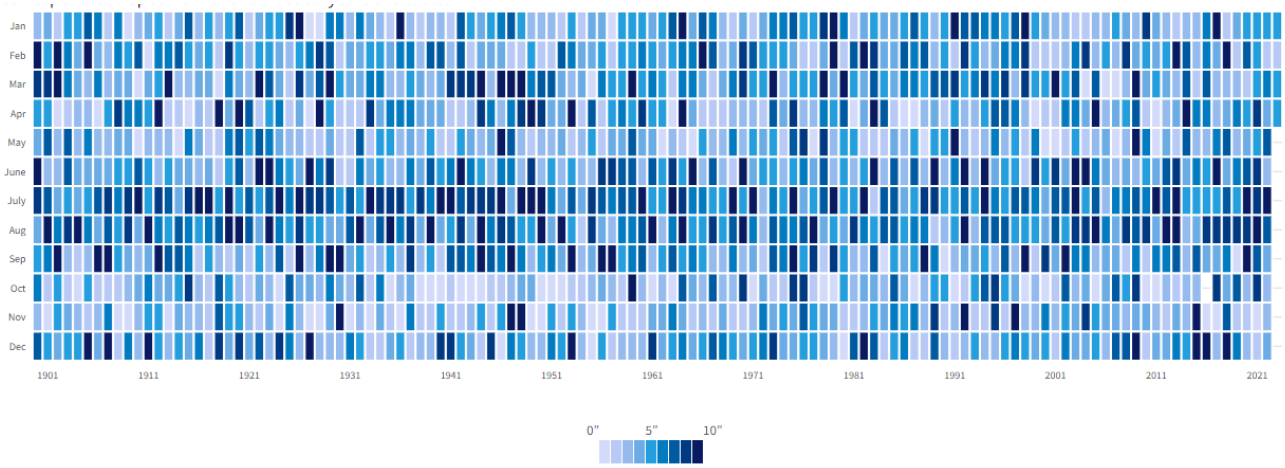

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation)

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. Figure 12 shows the two closest tide stations to Walton County. Since there is no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

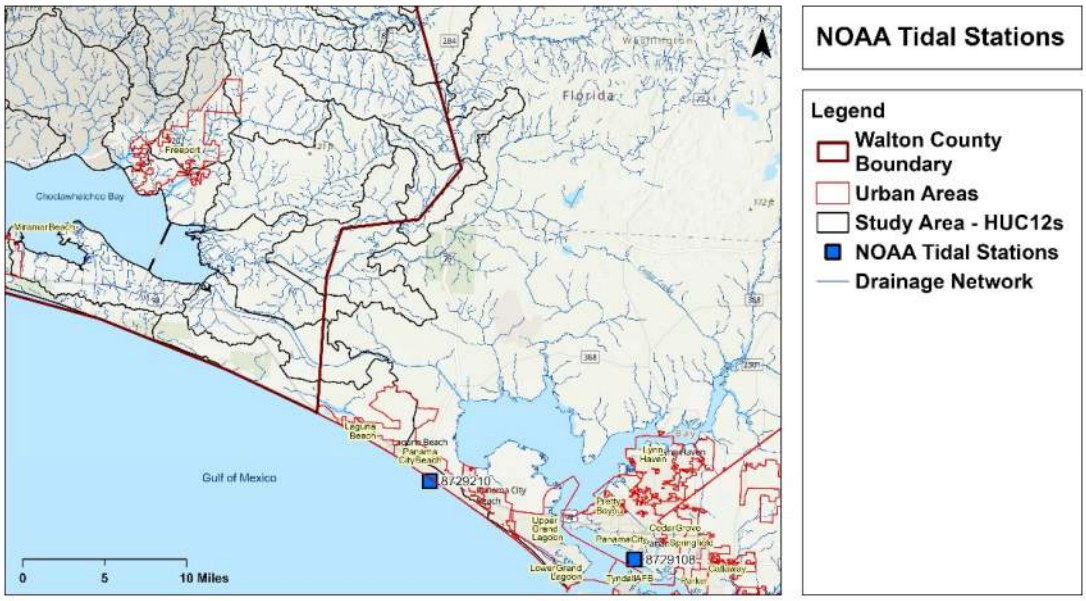

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in Figure 13.

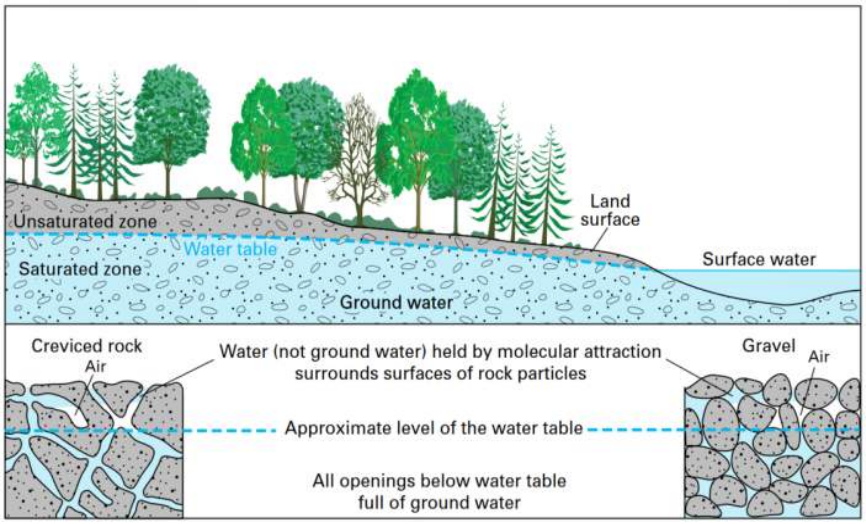

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in Figure 14. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

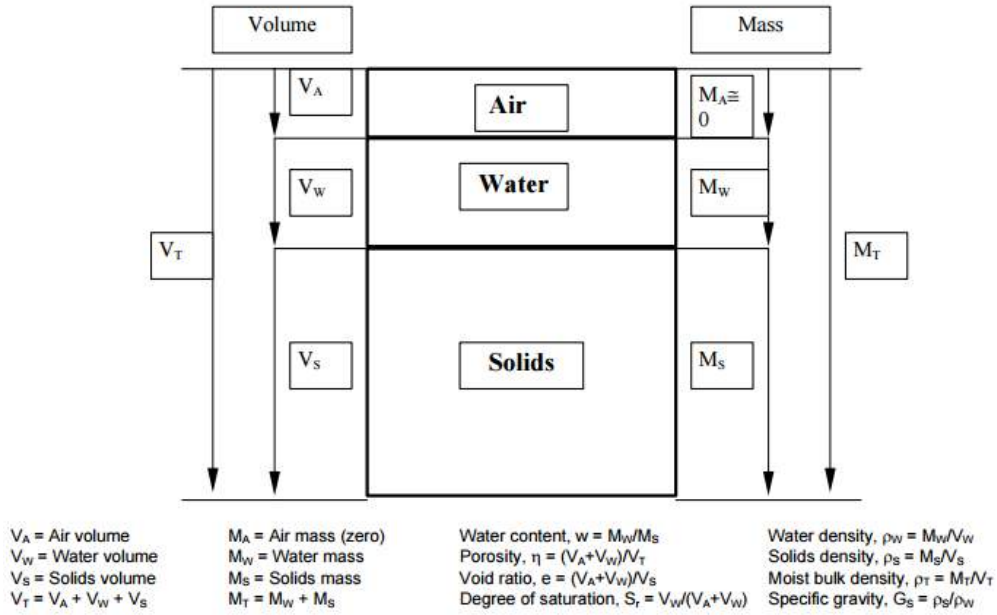

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). Figure 15 shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

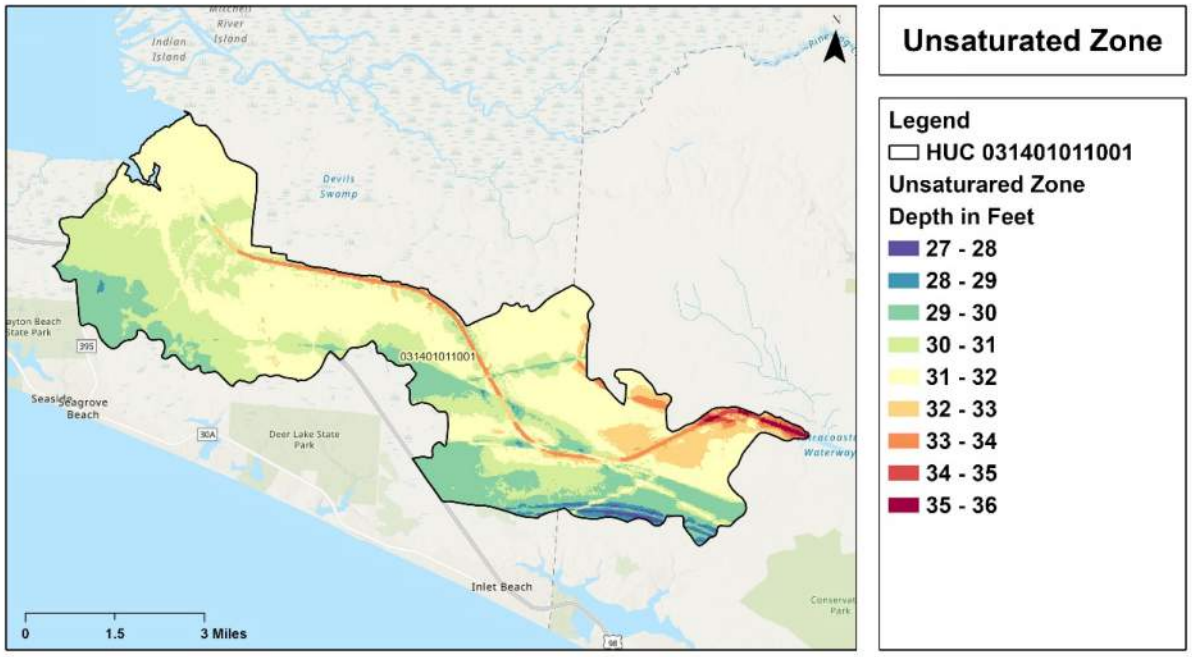

Figure 15. Unsaturated zone map for HUC 031401011001, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in Figure 16, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (Figure 17), the estimated soil storage capacity can be illustrated. Much of the basin has a medium amount of soil storage capacity, ranging between 30 to 33 inches of capacity left.

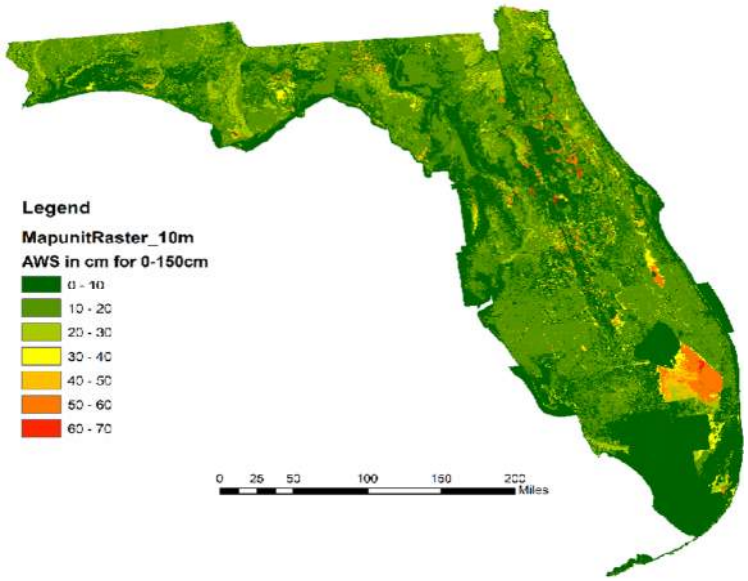

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

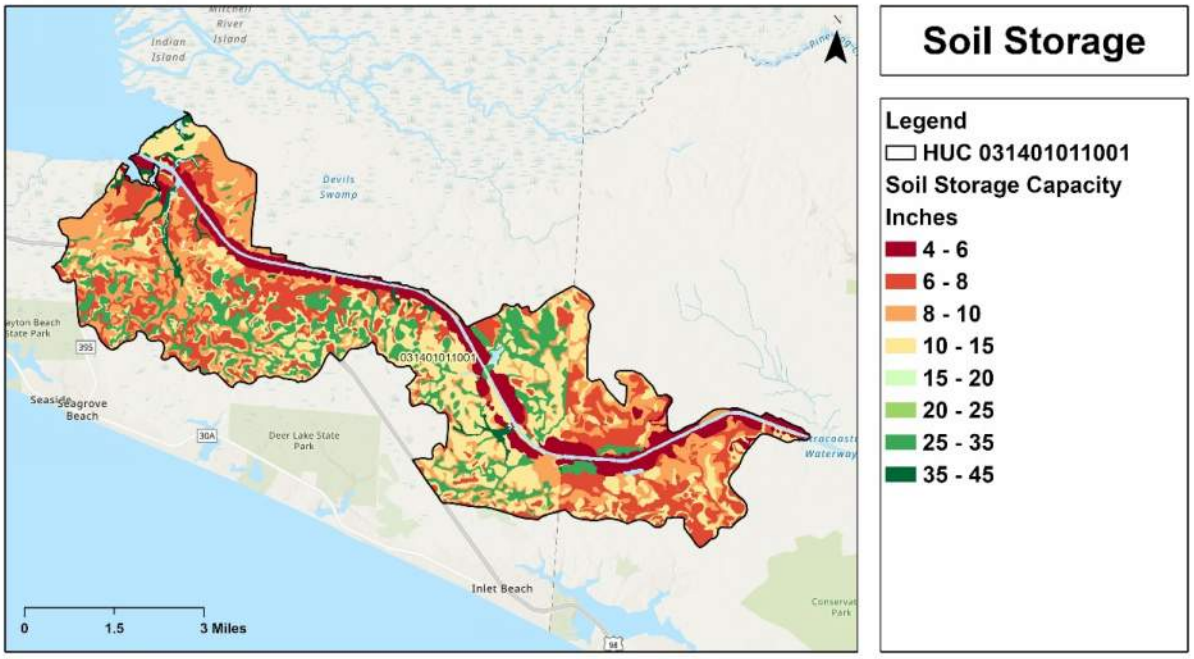

Figure 17. Water storage capacity of soil for the HUC 031401011001, processed by FAU.

Lastly, Figure 18 shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

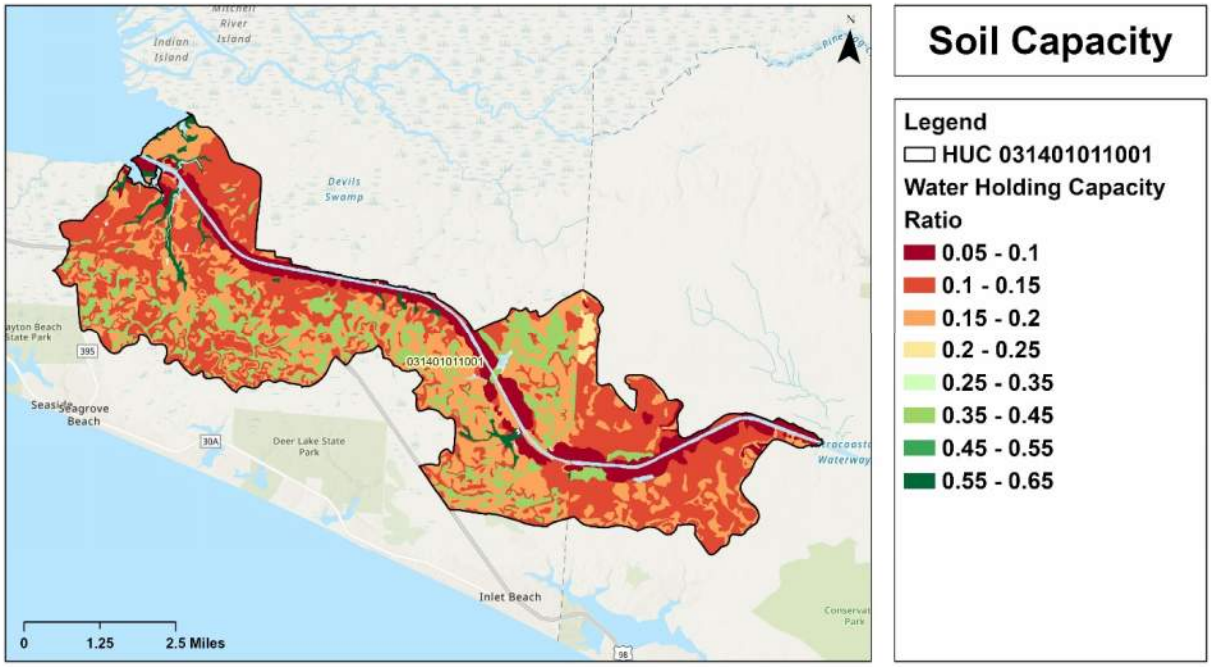

Figure 18. Water Holding Capacity (ratio) for the HUC 031401011001, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (Figure 19).

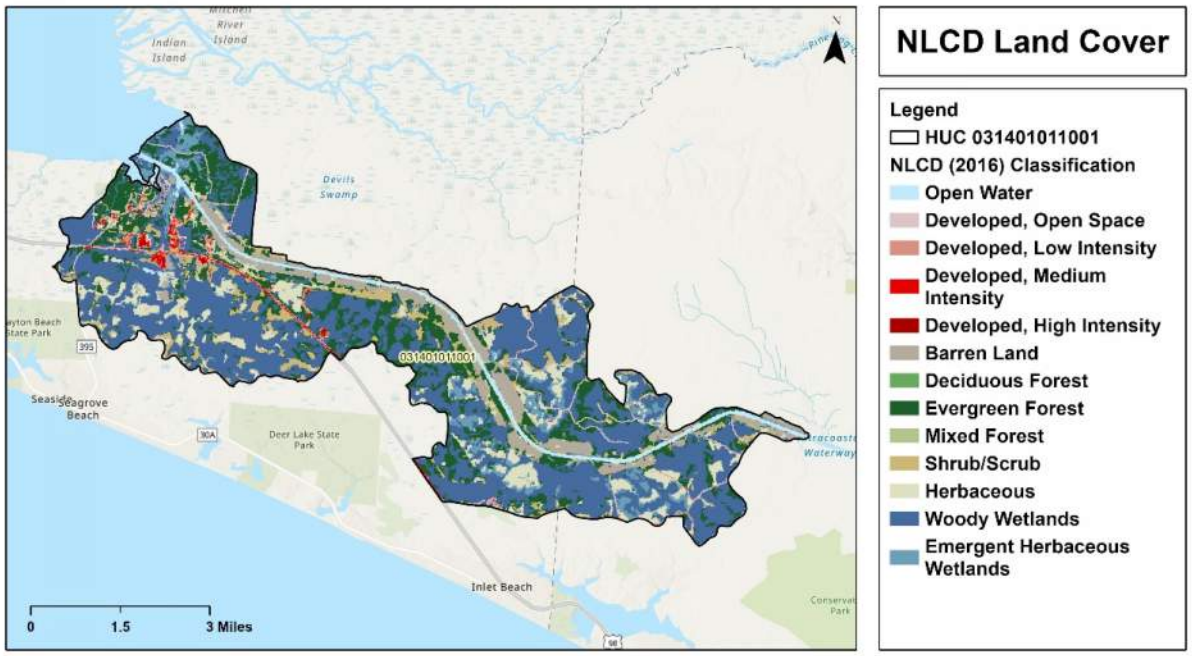

Figure 19. Land use in the HUC 031401011001 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in Figure 20. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

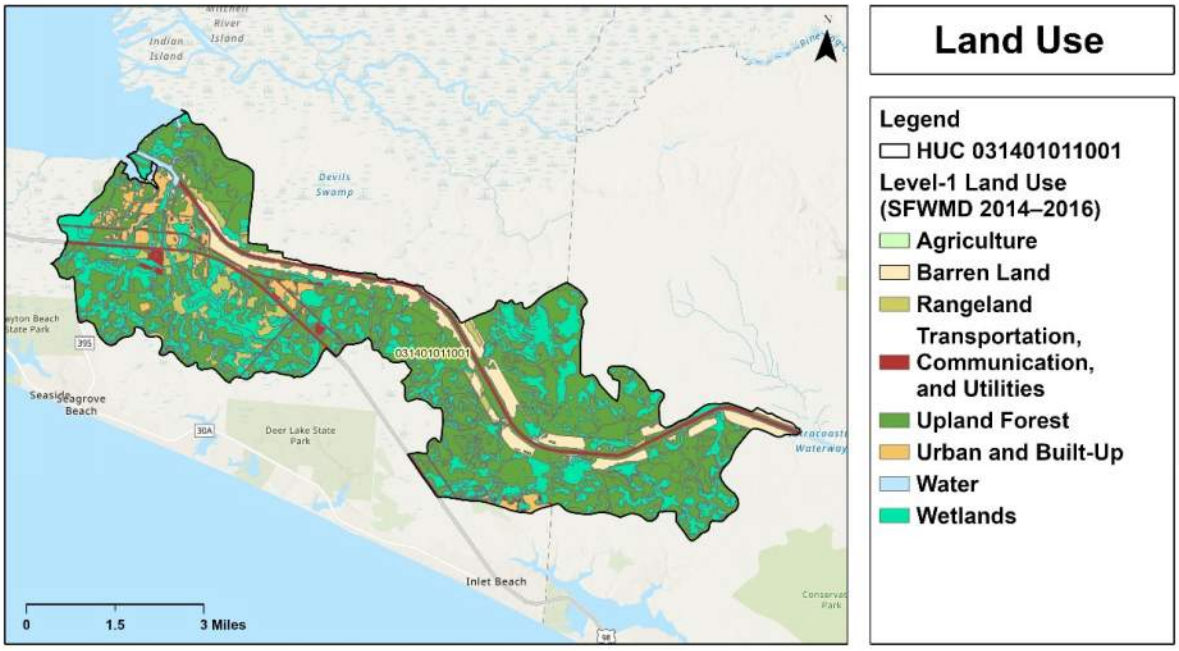

Figure 20. Land use in the HUC 031401011001 (from the 2023 Florida Geographic Data Library (FGDL) database), processed by FAU.

In the HUC 031401011001 subwatershed, most of the area is upland forest, wetlands and water, summing 83.09%. Although there is not much developed land in the HUC (only 2.73% is urban and built-up), there is a significant amount of transportation, communication, and utilities, with 5.79% of the total land, as shown in Table 3. Table 4 shows the roughness of the surface.

Table 3. Land use for HUC 031401011001 subwatershed

Level 1 Land Use Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	3.37	0.01%
Barren Land	1428.14	5.01%
Rangeland	958.76	3.37%
Transportation, Communication, and Utilities	1649.13	5.79%
Upland Forest	11974.07	42.04%
Urban and Built-Up	776.75	2.73%
Water	5009.00	17.58%
Wetlands	6685.57	23.47%
Grand Total:	**28484.79**	**100.00%**

(Source Data: 2023 Florida Geographic Data Library (FGDL) database))

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. Figure 22 to Figure 24 rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

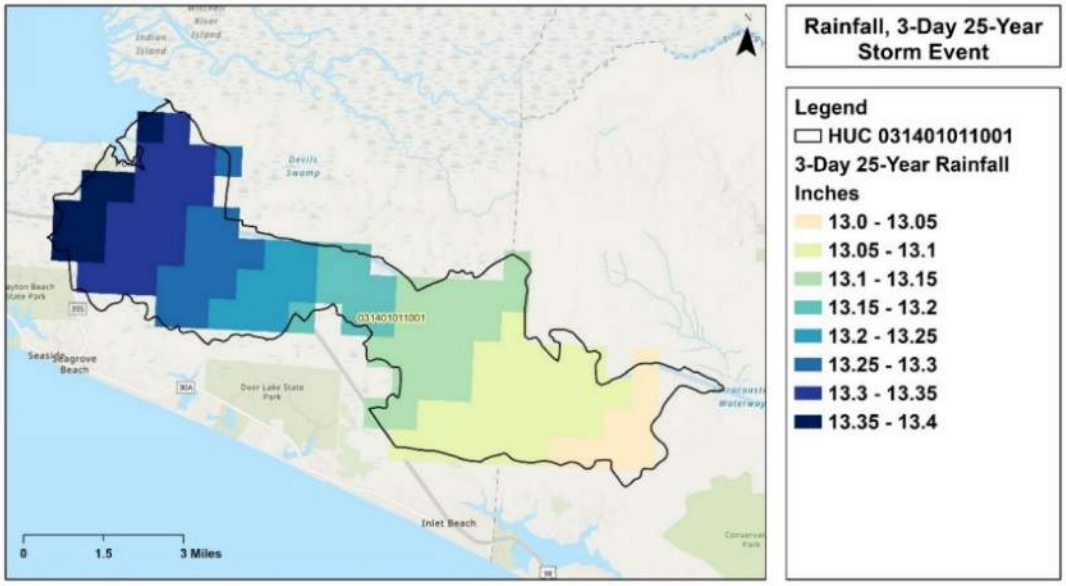

Figure 21. Rainfall distribution map across HUC 031401011001 sub-watershed, for 3-day 25-year storm event, processed by FAU.

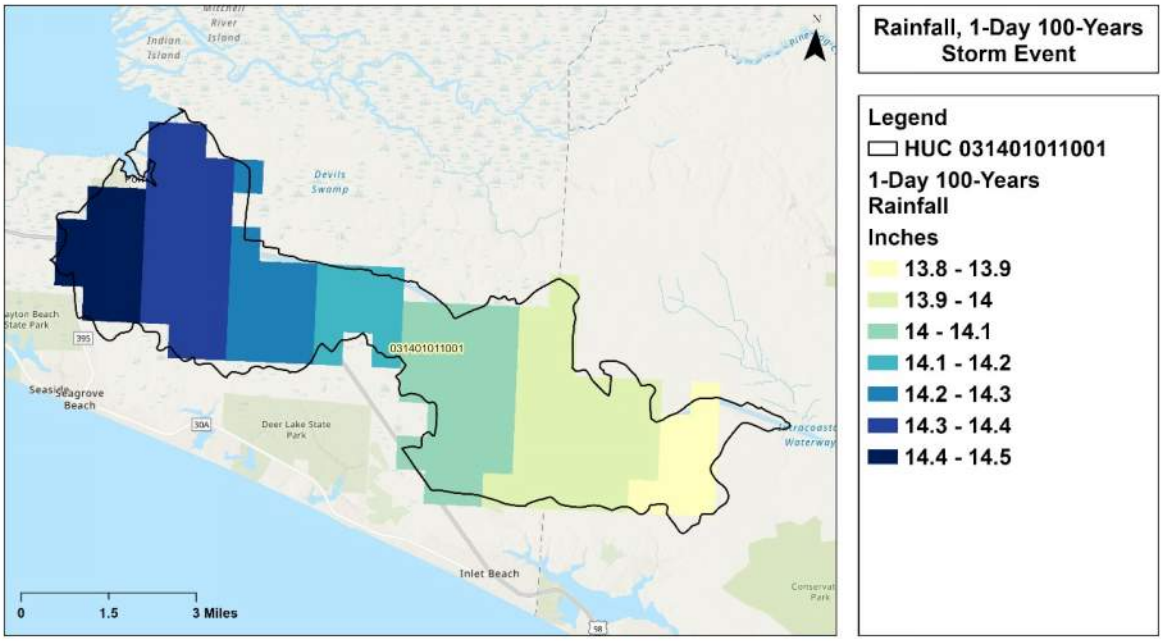

Figure 22. Rainfall distribution map across HUC 031401011001 sub-watershed, for 1-day 100-year storm event, processed by FAU.

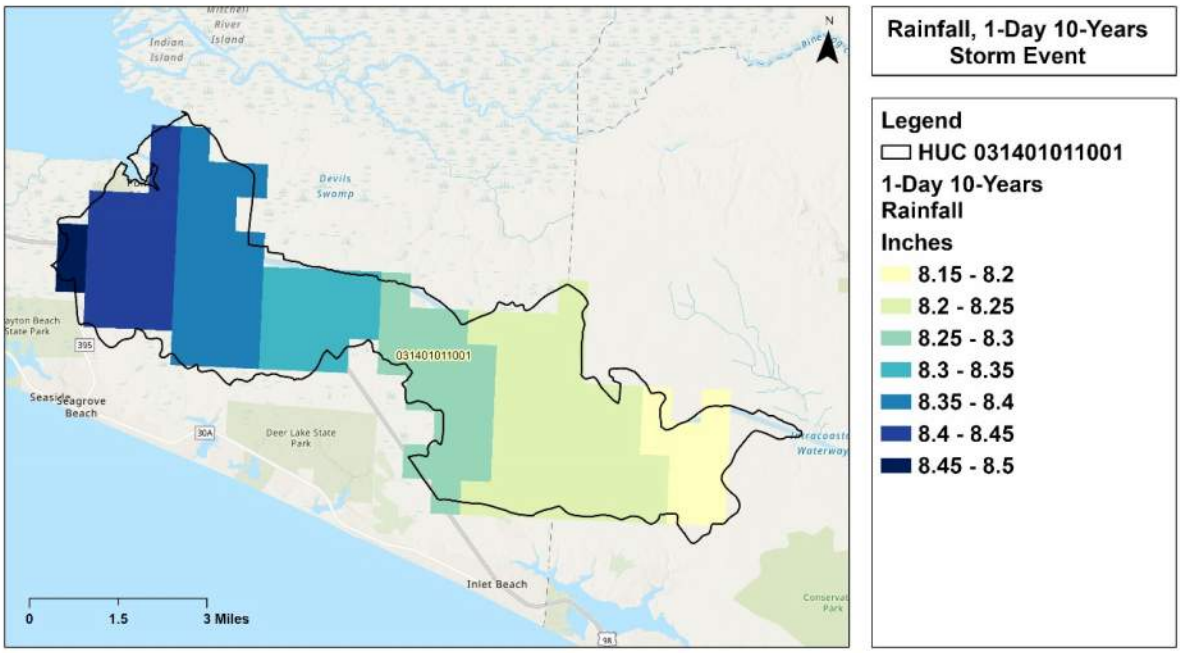

Figure 23. Rainfall distribution map across HUC 031401011001 sub-watershed, for 1-day 10-year storm event, processed by FAU.

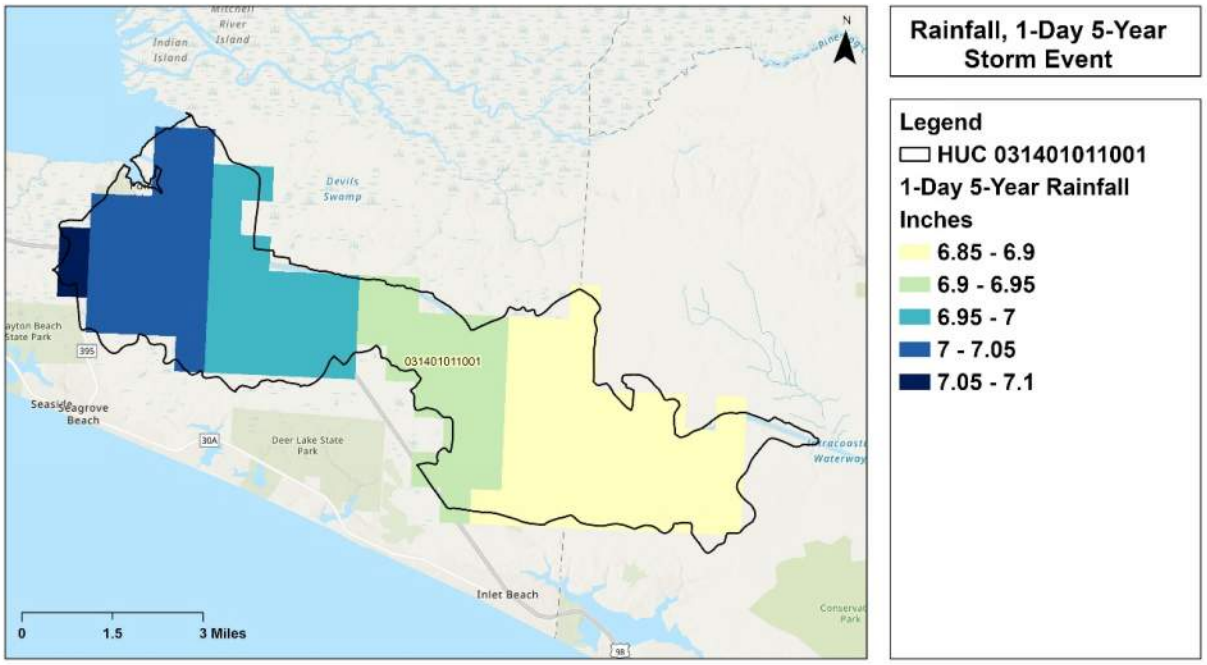

Figure 24. Rainfall distribution map across HUC 031401011001 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. Figure 25 shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

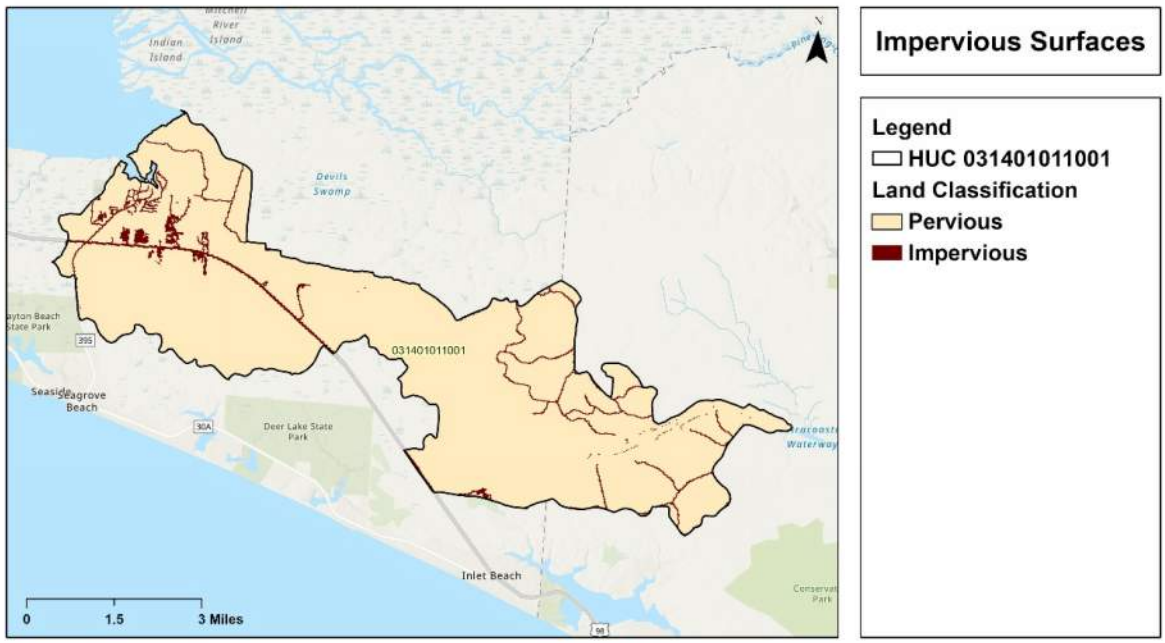

Figure 25. Impervious area map for the HUC 031401011001 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (Figure 26). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

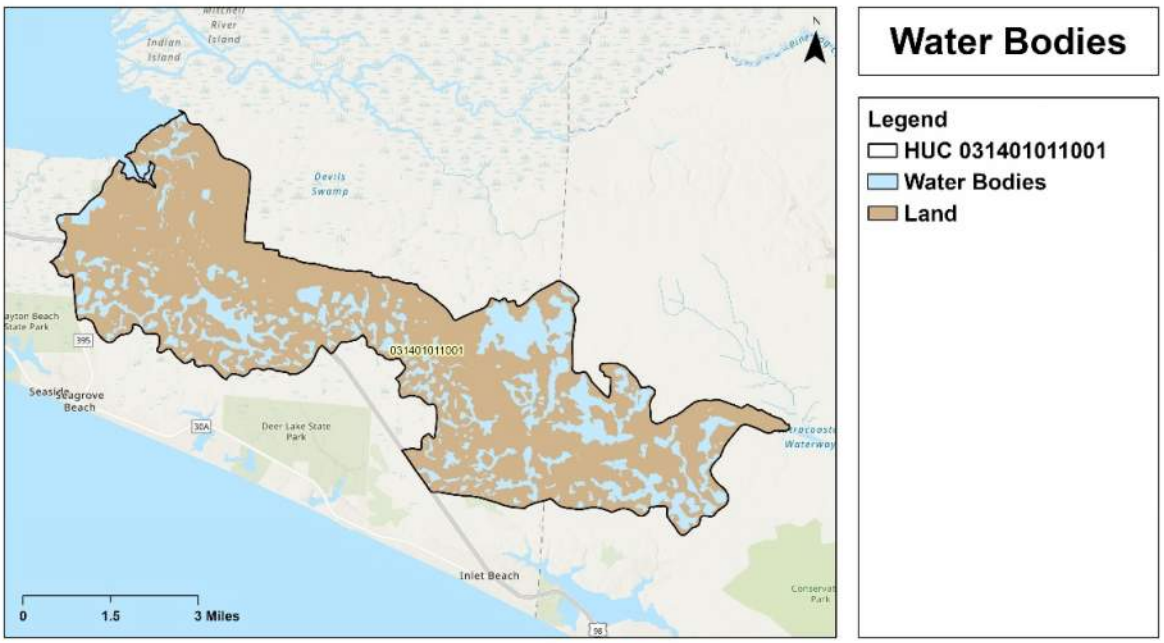

Figure 26. Water bodies map for the HUC 031401011001 sub-watershed, processed by FAU.

1.10. Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, Table 5 outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in Figure 27 and Figure 28, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

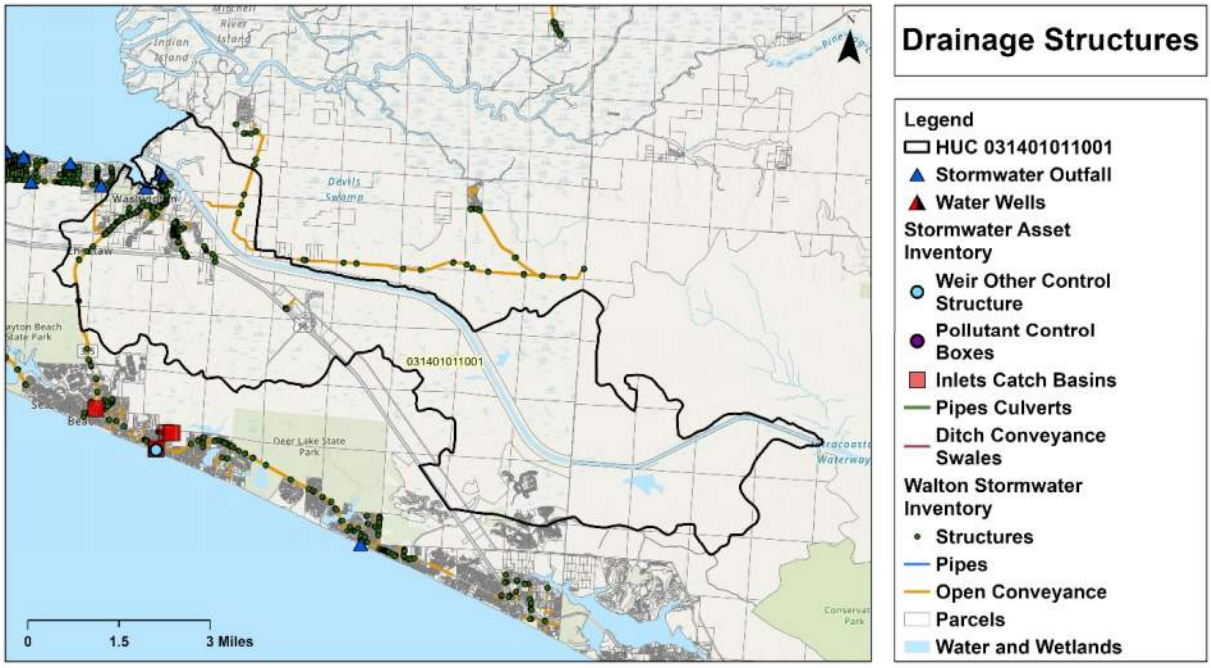

Figure 27. Stormwater Infrastructure for the HUC 031401011001. Processed by FAU.

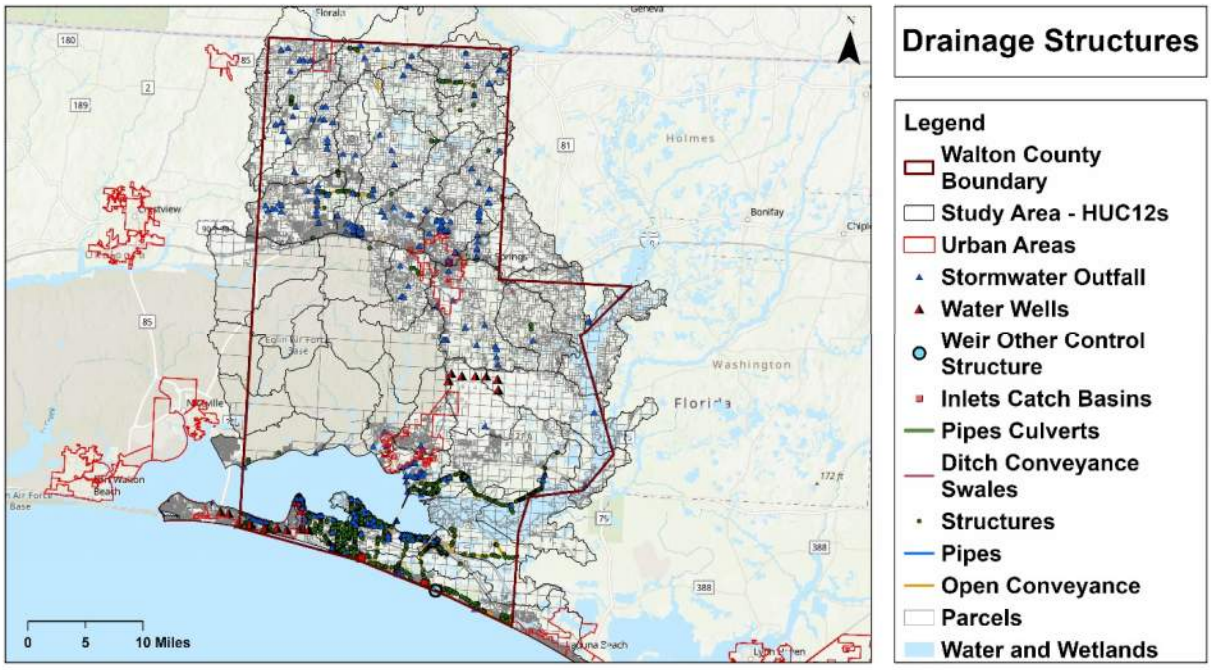

Figure 28. Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for a vulnerability assessment. These are included in Table 6. The data can be used to model the impacts of flood

routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapter 1, an analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401011001 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species

while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. Figure 29 shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

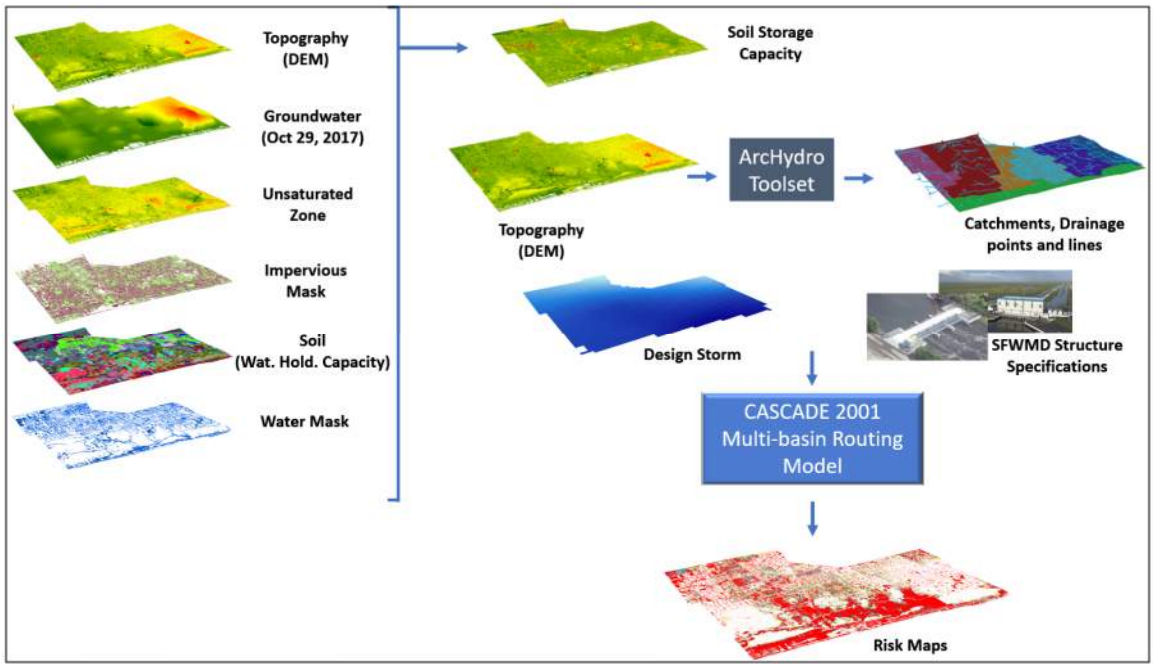

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are

critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (Figure 30), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

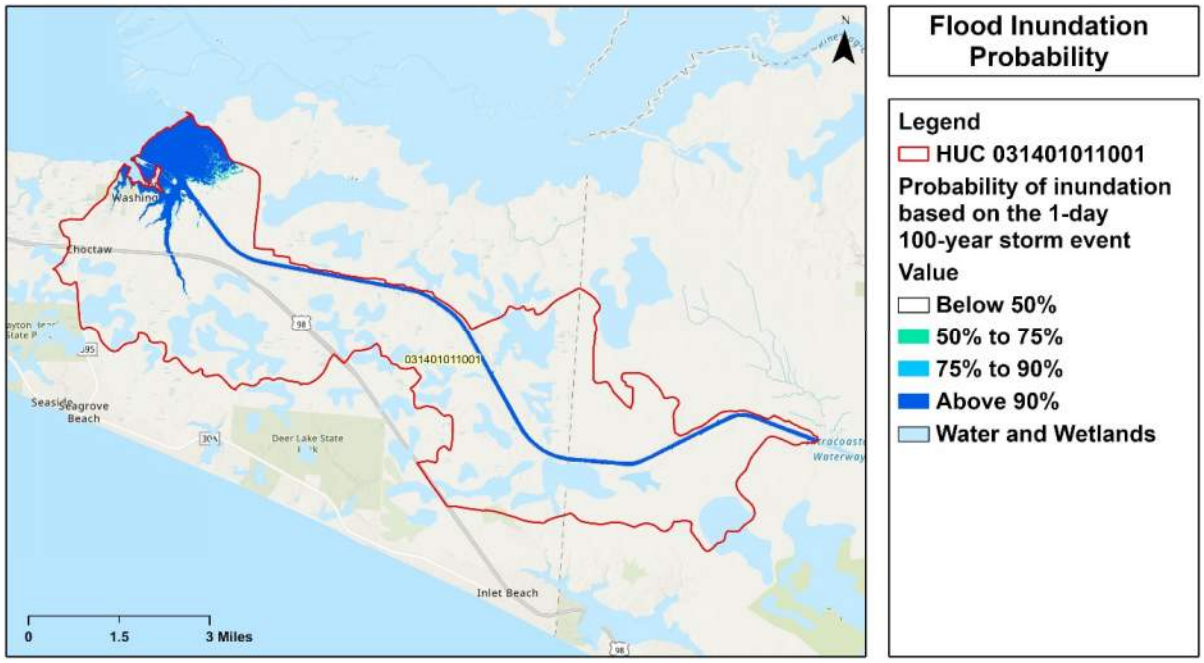

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401011001, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate

the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed later in this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not

eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Future Challenges of Sea Level Rise and Climate Change

Global observations from satellites and long-term data collection have made it possible to document and analyze patterns in the Earth's climate. Scientific analysis of the impact of these changes has helped to improve the understanding of future flood hazard driving forces and long-term impacts on human activities and watershed master planning (http://www.research.noaa.gov/climate/t_observing.html). Examples of impacts are rising global average air and ocean temperatures, increased and earlier snow and ice melt, shorter subtropical rainy seasons, shifted seasons, sea level rise and greater variations in temperature and precipitation (IPCC, 2013; Freas et al., 2008; Marshall et al., 2004; Bloetscher et al., 2010). Marshall et al. (2004) specifically focused on the Florida peninsula to predict changes in rainfall and warmer temperatures but interspersed lower low temperatures due to the potential loss of wetlands.

Future changes in climate will add to the existing impacts, at a time when the population of the state is expected to nearly double by 2030. Additional research and high-resolution climate modeling for the Florida peninsula and local jurisdictions is needed to help guide long-term plans like WMPs. Rainfall appears to be decreasing and temperatures rising (see Figure 31).

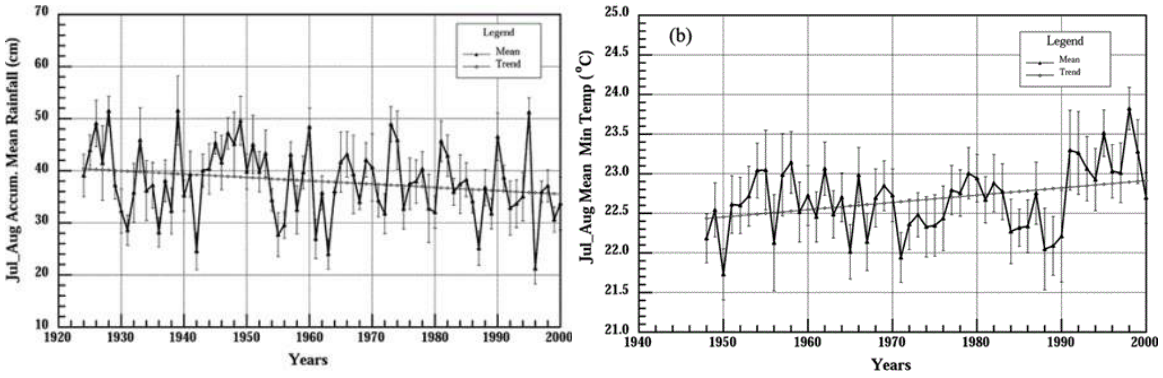

Figure 31. Change in average rainfall and change in average temp 1924 to 2000. Note the reversed trend, which means groundwater input variability is lessened. Source: Marshall et al., 2004.

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to

flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3 feet. Accompanying these drivers are potential changes in storm frequency and intensity, desertification, population migration, ocean acidification and coastal flooding (IPCC, 2007), exacerbated by the land cover and land use changes, which are substantially impacted by the fluxes, timing and quality of precipitation (Adrians et al., 2003; Scanlon et al., 2005; Marshall et al., 2004; Salmun and Molod, 2006), and leading to changes in the timing of peak flows and volumes (Richey and Costa-Cabral, 2006).

The results of these climatic changes are likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly An outcome of these climatic patterns is that during the past 140 years, an increase in sea levels has been observed (Bloetscher, 2012), a worrying pattern since sea level rise is a permanent phenomenon, that can be catastrophic to low lying areas in the long-term. The question is how much and how soon? Various studies (Bindoff et al., 2007; Domingues et al., 2008; Edwards, 2007; Gregory, 2008; Vermeer and Rahmstorf, 2009; Jevrejeva, Moore and Grinsted, 2010; Bloetscher, 2010, 2011; IPCC, 2007; Heimlich et al., 2009) indicate large uncertainty in projections of sea level rise by 2100. Gregory et al. (2012) note that during the last two decades, the global rate of sea level rise has been larger than the 20th-century time-mean, and Church et al. (2011) suggested that the cause was increased rates of thermal expansion, glacier mass loss, and ice discharge from icesheets. Gregory et al. (2012) suggested that there may also be increasing contributions to global sea level rise from the effects of groundwater depletion, reservoir impoundment, and loss of storage capacity in surface waters due to siltation. Measurements of Florida's east coast (Maul, 2008) show an average rate of sea level rise of 2.27 ± 0.04 mm per year from 1915 to 1992 based on tide gauge readings. Analyzing the tidal gauge readings for Florida shows that:

1. Florida average sea level rise is 2.10 ± 0.49 mm/yr

2. All but one location is within the 95% confidence limit range (the exception is Panama City where there is evidence of submergence and other land-based issues)
3. None of the Florida sea level rise rates differ statistically
4. Average global sea level rise for 1920-2000 was 2.0 mm/yr – within 95% confidence limit for Florida locations

From 1929 to 1992, over eight inches of sea, with another 6 inches added since 1992, which is already having significant impacts on coastal communities where population growth has increased the need for improved flood management strategies (Bloetscher, 2008; Parkinson, 2010; Zhang et al., 2011, 2011a; NFIP, 2011; Schmidt et al., 2011; Warner et al., 2012).

As a result, the SFRCCC (2015) adopted USACE's methodology to derive scenarios of sea level change intermediate to high rates of sea level rise for years 2030 (3" to 7") and 2060 (9" to 24") as the consensus projection to guide future planning. The path keeps increasing – now 14 inches since 1929 (Figure 32) caused by thermal expansion of the ocean and melting ice caps (Jevrejeva et al., 2010; Vermeer and Rahmstorf, 2009). Sea level rise is a major concern in Florida, including Walton County, since the majority of the state's population live on the coast, involving most major commercial, residential, and economic enterprises. Figure 32 demonstrate the estimated sea level change for Panama City, considering the predictions of NOAA 2017. For NOAA high scenario SLR change scenario, the estimated level change is higher than 8 ft., while for the intermediate and low scenarios are about 3.9 feet and 1.7 feet respectively.

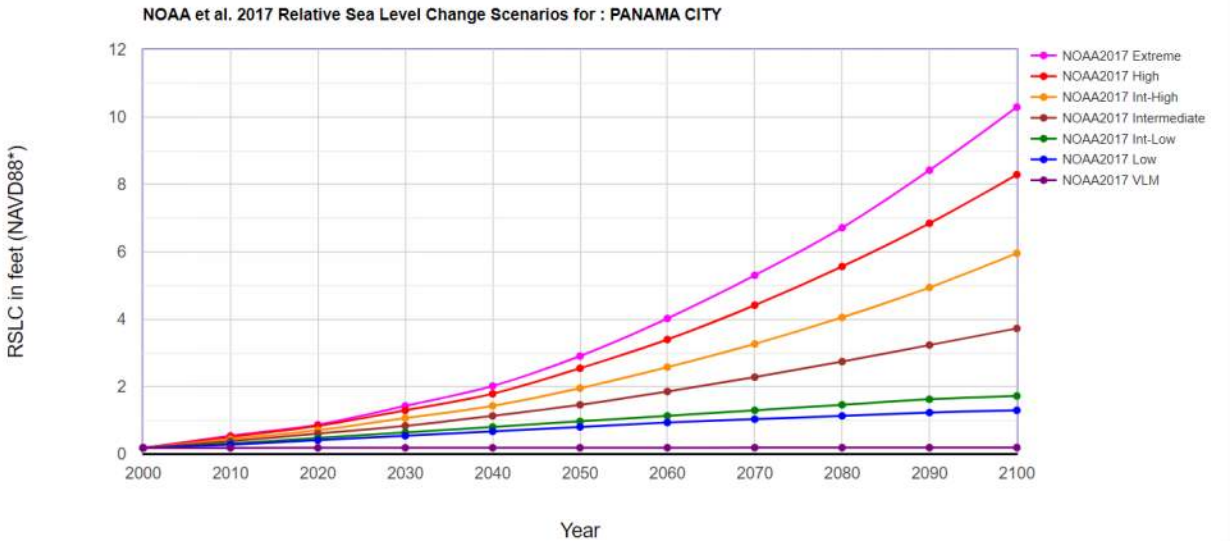

Figure 32. Relative Sea Level Change Scenarios for gauge 8729108, Panama City, FL. Source: NOAA, 2017 (https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html).

NOAA (2017) outlines five scenarios for sea level rise. The NFIP proposes the use of the intermediate high projection, which is 1.2 meters or 4 ft globally from current sea level elevations (Figure 33).

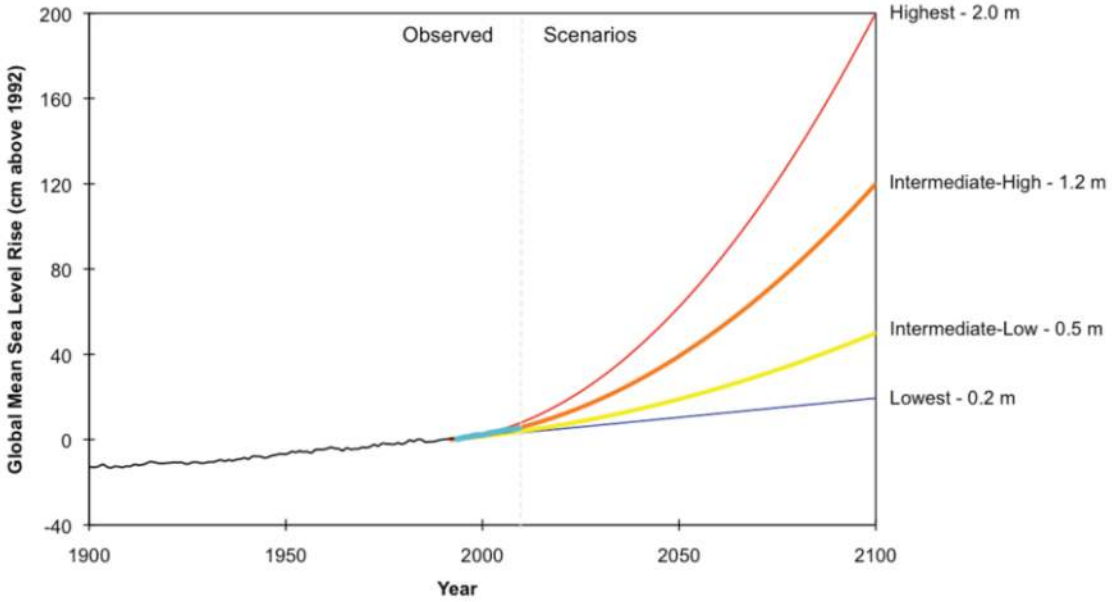

Figure 33. Graphic of global sea level rise projections.
Source: NOAA, 2017
(https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf)

As sea level rises, access to roads, bridges, rail, and transit could be at risk of flooding, causing the effects of sea level rise to spread indirectly throughout the entire transportation network, affecting the overall system performance. For example, the flooding of a critical road or facility access can cause a shifting of traffic flow causing congested conditions in other roadways that are not actually flooded. Since the roadway network would be unable to carry the traffic demand, the system would experience operational failure; as a result, causing travel times and delays. Moreover, the inundation of a critical access could cause transportation connectivity problems to essential infrastructure like ports or airports. Transportation infrastructure relies on the effectiveness of flood control and stormwater drainage systems for the transportation corridors. Road integrity relies on adequate drainage. The increased risk of severe flooding in Florida's low-lying terrain can adversely affect transportation infrastructure along the coastline; roads can be inundated, and roadway beds can be damaged. Sea level rise will cause increased water table levels (FDOT, 2012), as regional water tables cannot exist naturally below mean high tide (2 feet in Florida). Adding 3 feet of sea level rise on top of groundwater would compound the risk of flooding in low-lying areas. Road bases below 5 feet NVGD would become saturated under this scenario,

likely causing premature base failure. As soil storage capacity is diminished due to rising groundwater elevations associated with sea level rise, the potential for more frequently flooded roadways would likely damage pavements (FDOT, 2012). Hence sea level rise must be accounted for in WMPs in coastal areas. To allow flexibility in the analysis due to the range of increases within the different time periods, an approach that uses incremental increases of 1, 2, and 3 feet of sea level rise is suggested for modeling. The increments can work as threshold values in planning considerations in terms of allowing planners the ability to know ahead of time where the next set of vulnerable areas will be, to allow for a proactive response approach that can be matched to the observed future rates. Sea level rise is a major concern since nearly half the US population lives within 50 miles of the coast, involving most major commercial, residential, and economic enterprises. The effects of 5 ft sea level rise, King tide, and 1-day 100-year storm event are shown in Figure 34.

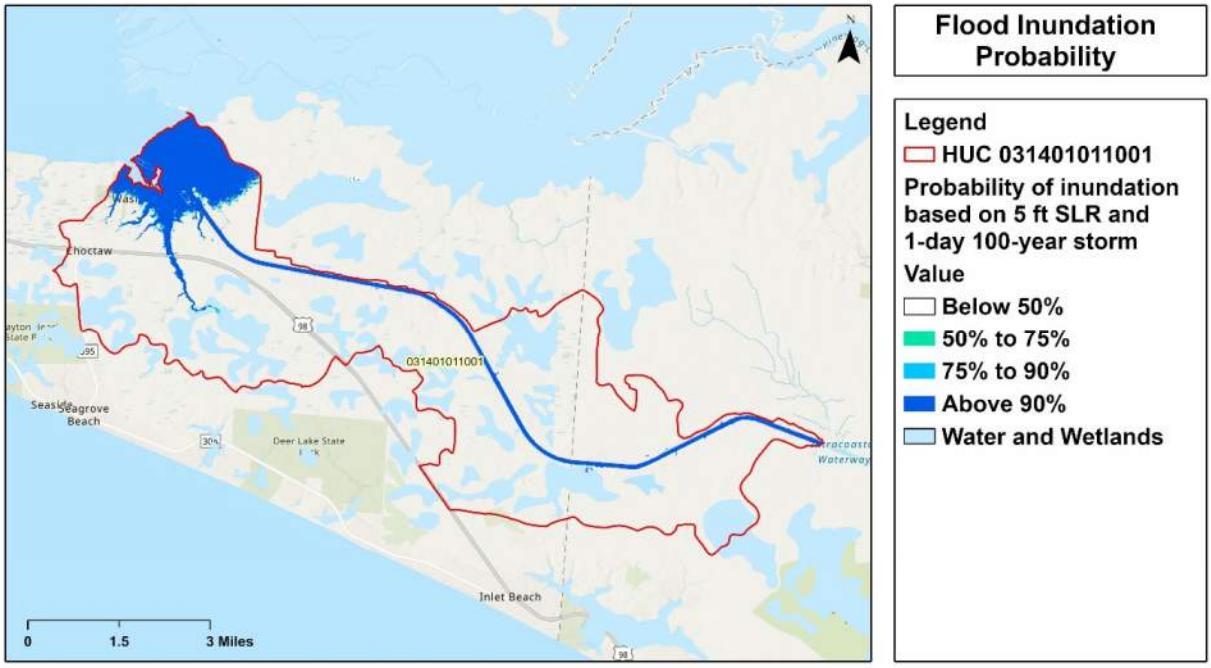

Figure 34. Flood Inundation Probability for a Sea level rise of 5 ft + 1-day 100-year storm event for HUC 031401011001 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Dark blue is area under 5 ft NAVD88 and potentially inundated at the 99th percentile tidal conditions. Processed by FAU.

2.4 Modeling Results

Figure 35 to Figure 58 are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. **3-day 25-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 35)
2. **1-day 100-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 36)
3. **1-day 10-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 37)
4. **1-day 5-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 38)
5. **Sea level rise of 1 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 39)
6. **Sea level rise of 1 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations storm (Figure 40)
7. **Sea level rise of 1 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 41)
8. **Sea level rise of 1 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 42)
9. **Sea level rise of 2 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 43)
10. **Sea level rise of 2 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 44)
11. **Sea level rise of 2 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 45)
12. **Sea level rise of 2 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 46)
13. **Sea level rise of 3 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 47)
14. **Sea level rise of 3 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 48)

15. **Sea level rise of 3 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 49)
16. **Sea level rise of 3 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 50)
17. **Sea level rise of 4 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 51)
18. **Sea level rise of 4 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 52)
19. **Sea level rise of 4 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 53)
20. **Sea level rise of 4 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 54)
21. **Sea level rise of 5 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 55)
22. **Sea level rise of 5 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 56)
23. **Sea level rise of 5 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 57)
24. **Sea level rise of 5 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 58)

In all cases, a significant amount of flooding is noted near Choctawhatchee Bay and along the Intracoastal Waterway. As this basin connects to the ocean though Choctawhatchee Bay, SLR scenarios plays an important hole, implying a considered growth as the projected scenario of rising tides rises.

The design storm simulation determined that approximately 8.1% of the HUC total area or 2.38 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 8.3% of the HUC's total area, or 2.43 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 7.4% of the HUC's total area, or 2.17 mi^2, would

be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 7% of the HUC's total area, or 2.06 mi², would be expected to be inundated during the 1-day 5-year storm. Table 7 compares the four storm events.

Table 7. HUC 031401011001 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	27.03	2.38	91.9%	8.1%
1-day 100-year	26.99	2.43	91.7%	8.3%
1-day 10-year	27.24	2.17	92.6%	7.4%
1-day 5-year	27.36	2.06	93.0%	7.0%

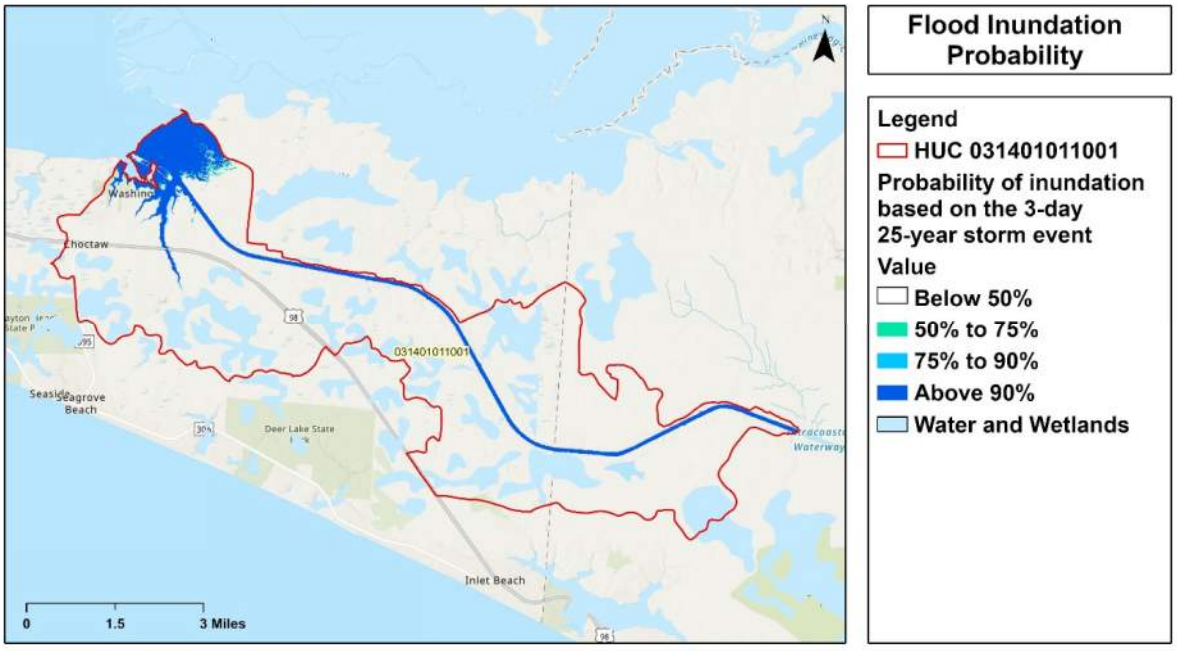

Figure 35. 3-day 25-year storm event for HUC 031401011001 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

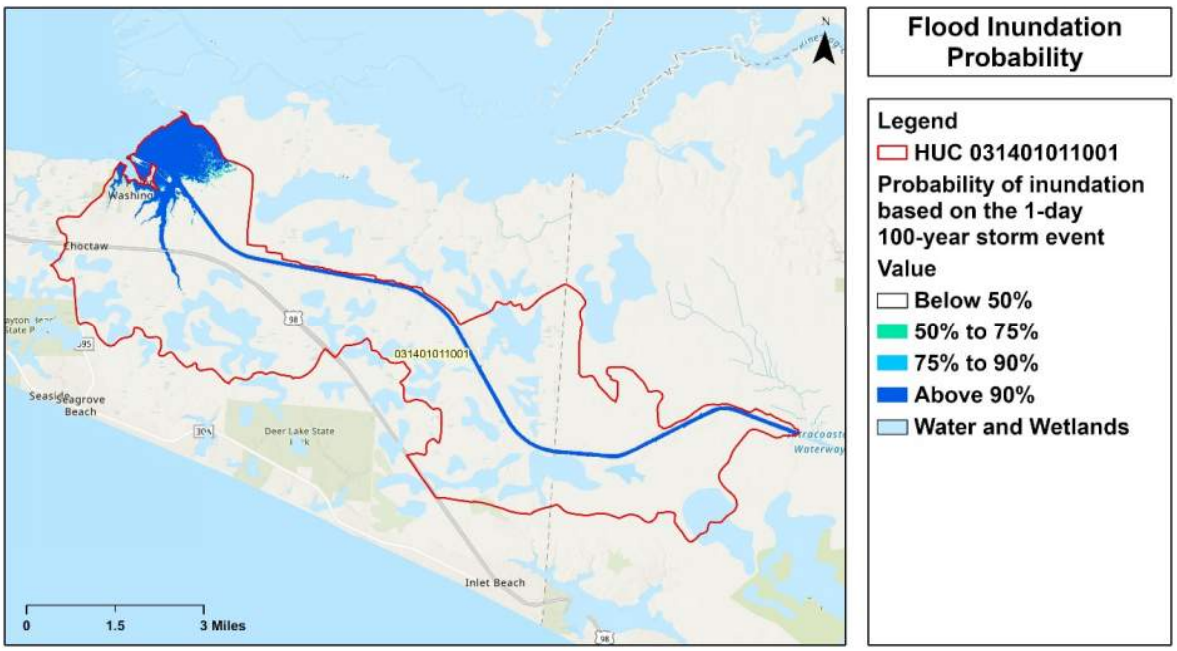

Figure 36. 1-day 100-year storm event for HUC 031401011001 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

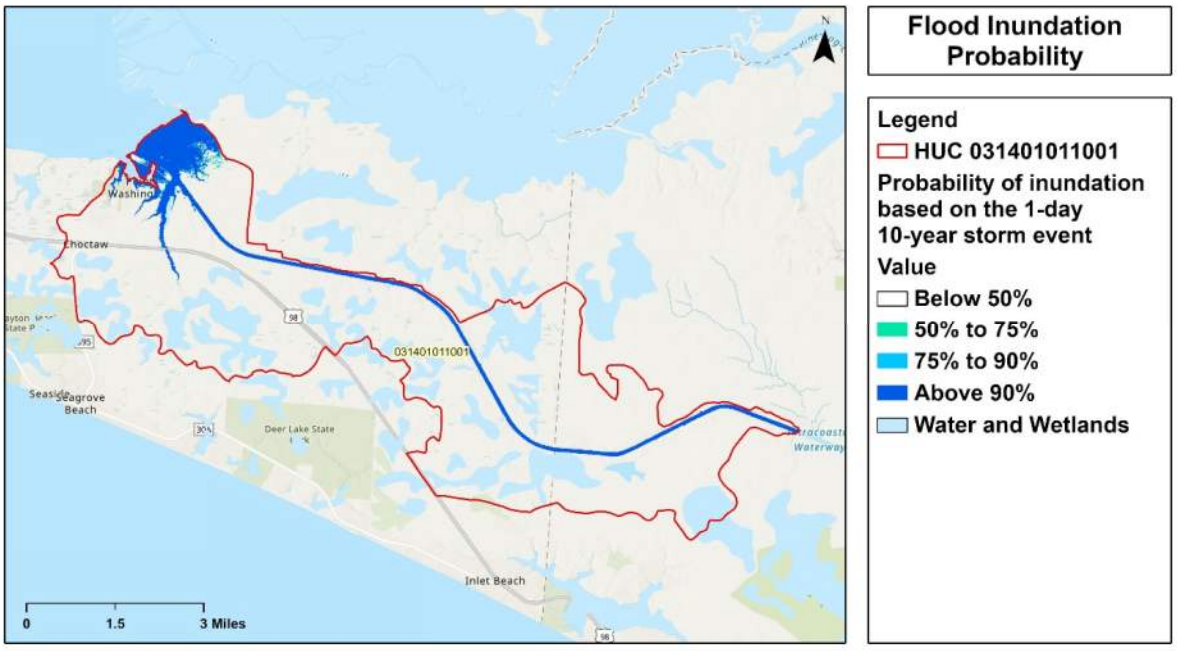

Figure 37. 1-day 10-year storm event for HUC 031401011001 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

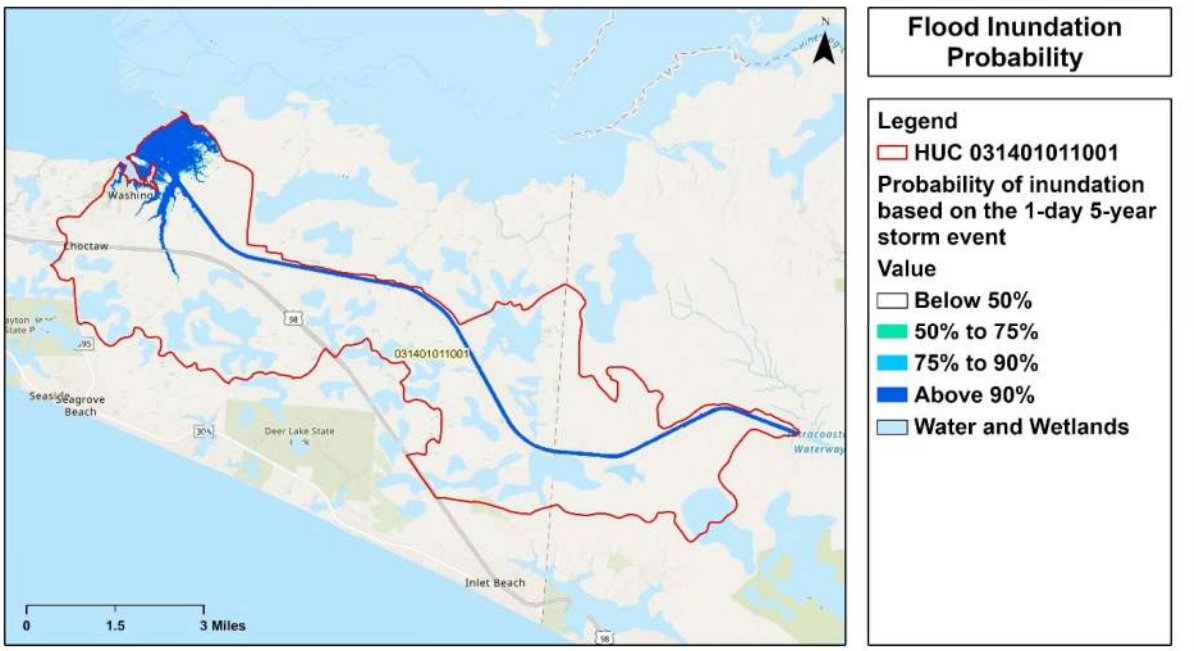

Figure 38. 1-day 5-year storm event for HUC 031401011001 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

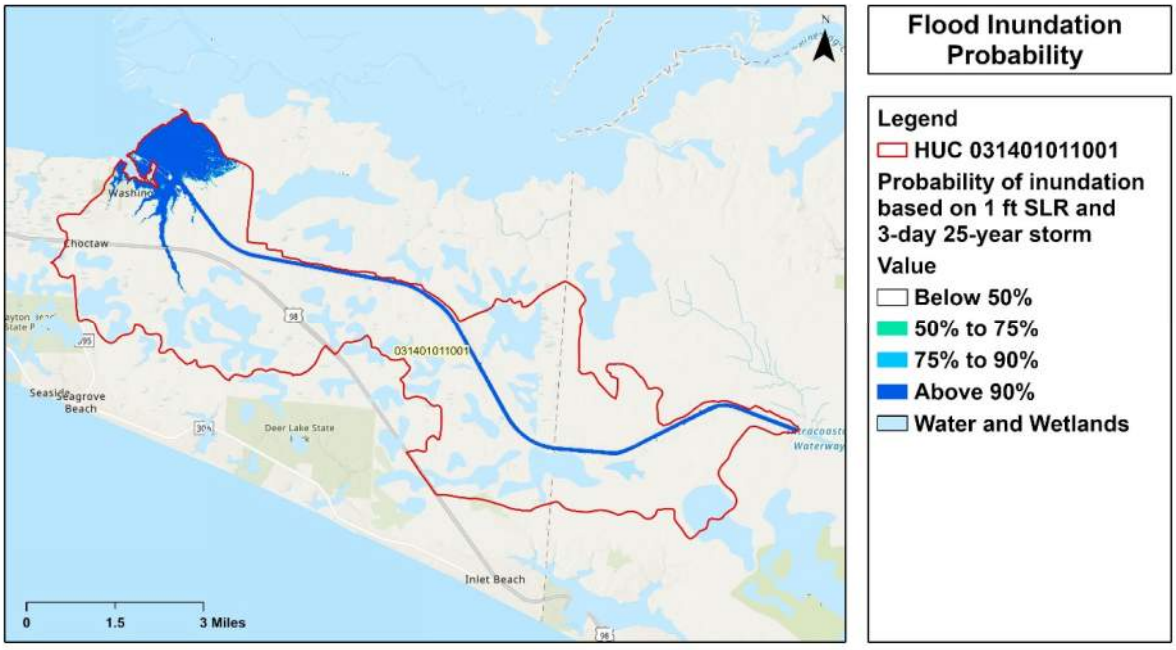

Figure 39. Sea level rise of 1 ft + 3-day 25-year storm for HUC 031401011001 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

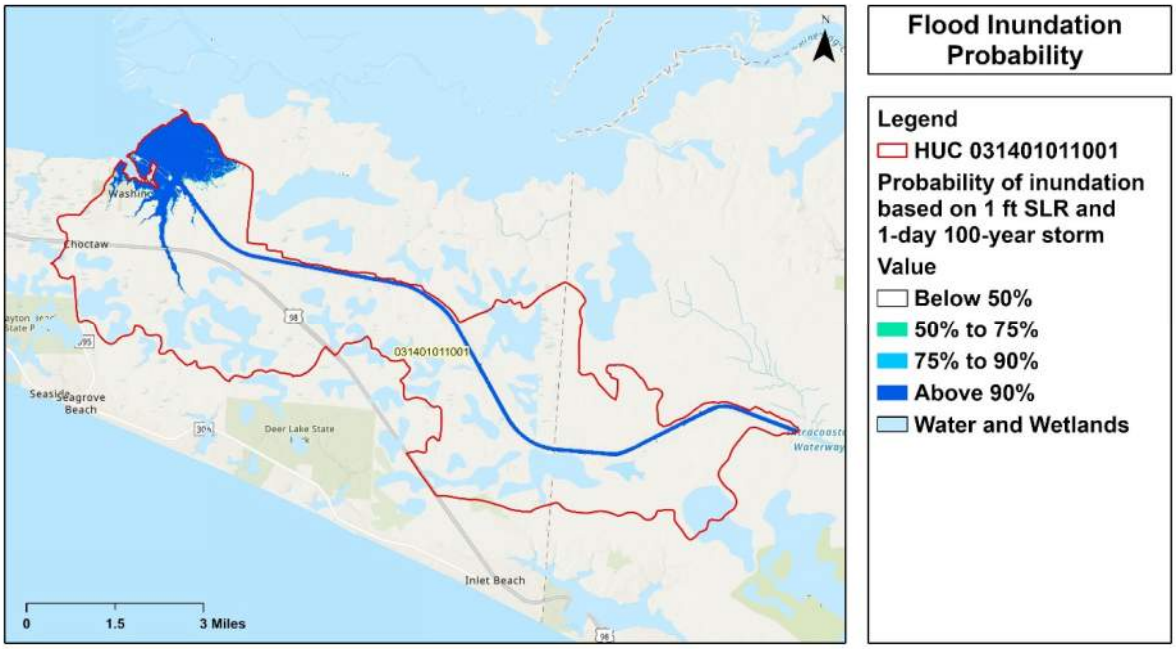

Figure 40. Sea level rise of 1 ft + 1-day 100-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

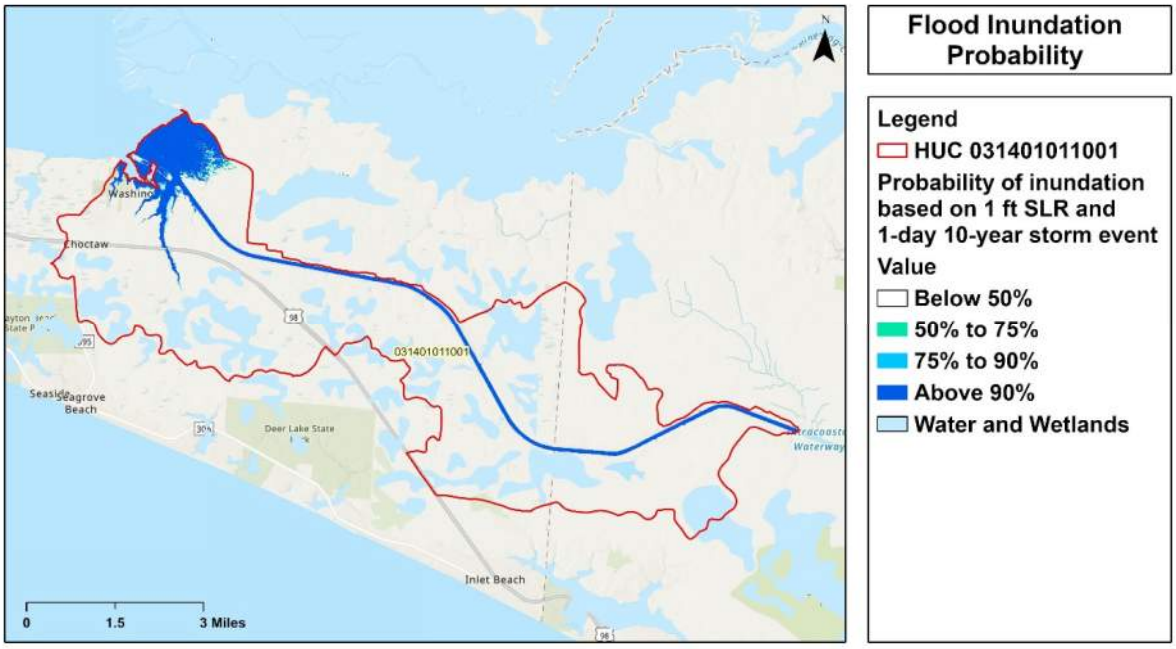

Figure 41. Sea level rise of 1 ft + 1-day 10-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

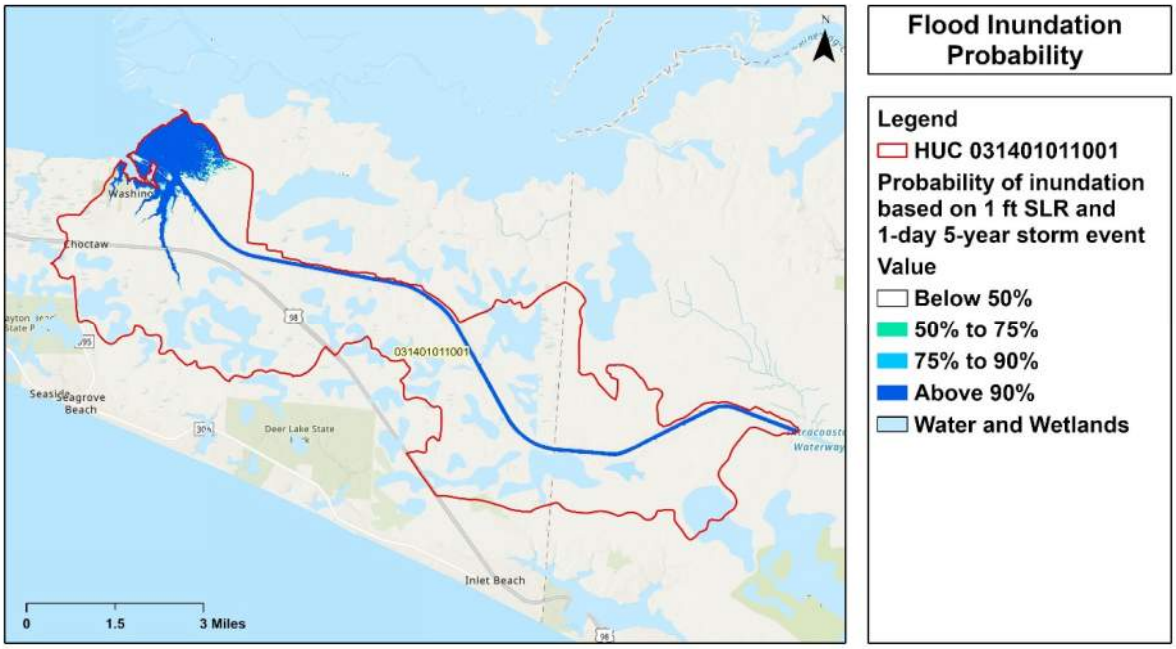

Figure 42. Sea level rise of 1 ft + 1-day 5-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

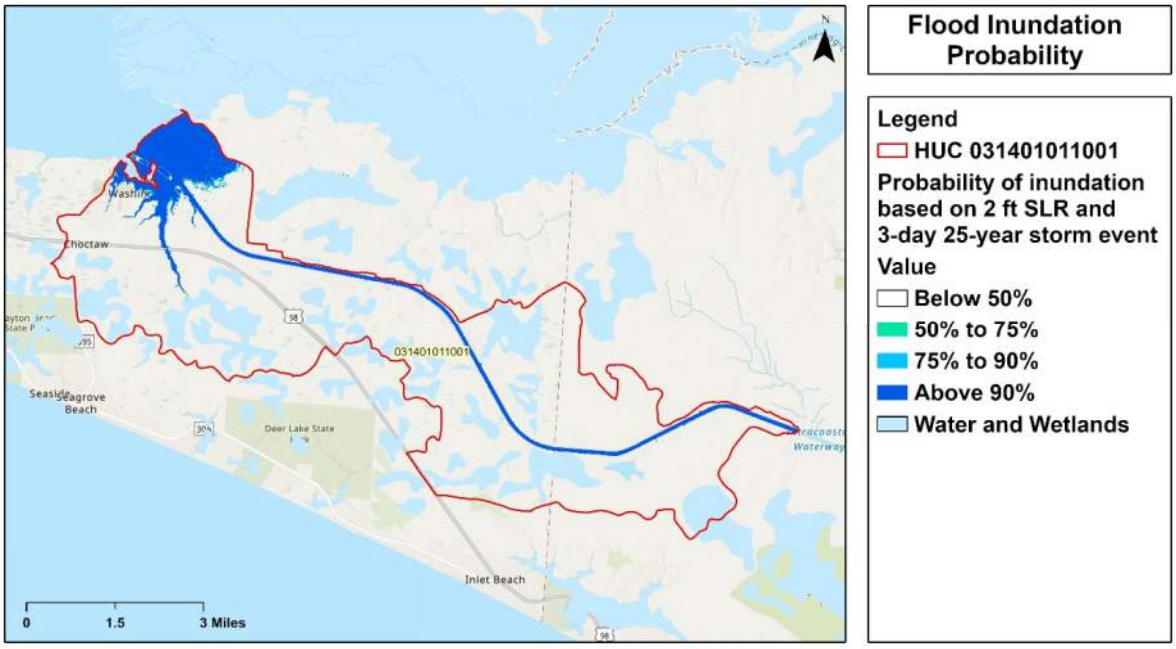

Figure 43. Sea level rise of 2 ft + 3-day 25-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

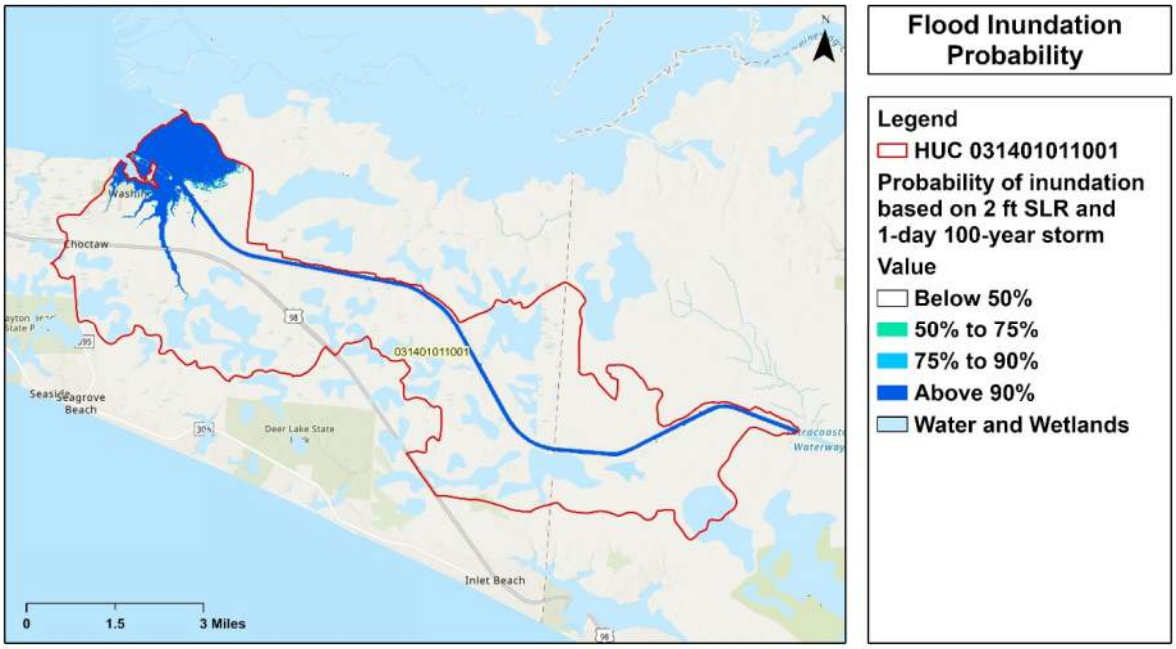

Figure 44. Sea level rise of 2 ft + 1-day 100-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

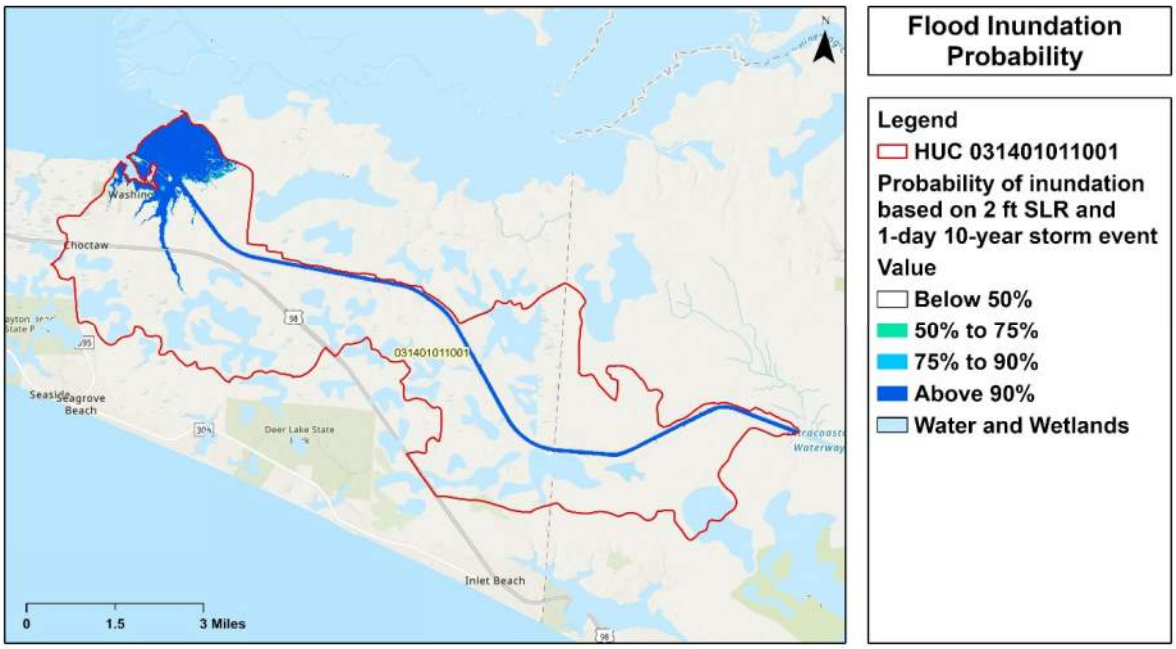

Figure 45. Sea level rise of 2 ft + 1-day 10-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

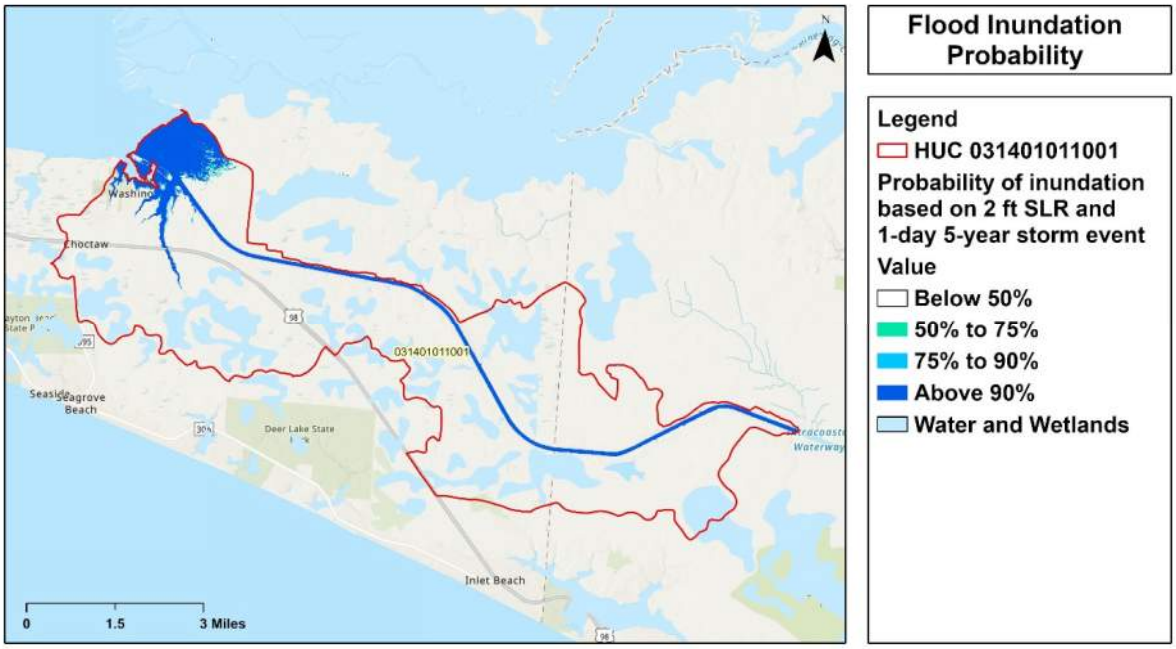

Figure 46. Sea level rise of 2 ft + 1-day 5-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

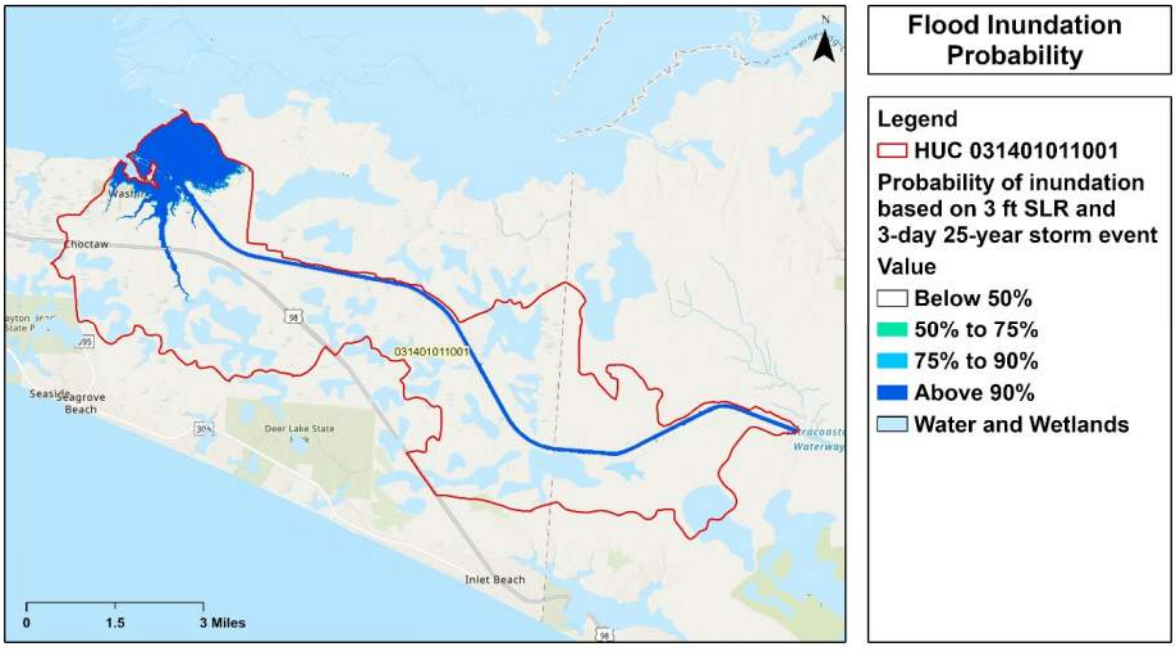

Figure 47. Sea level rise of 3 ft + 3-day 25-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

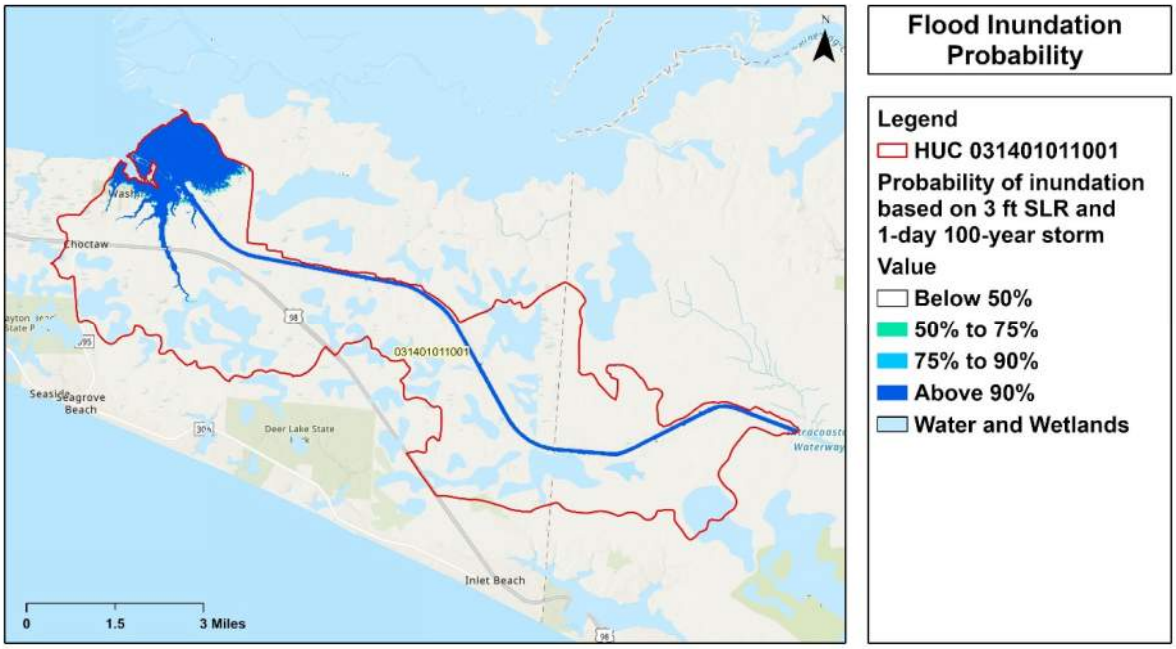

Figure 48. Sea level rise of 3 ft + 1-day 100-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

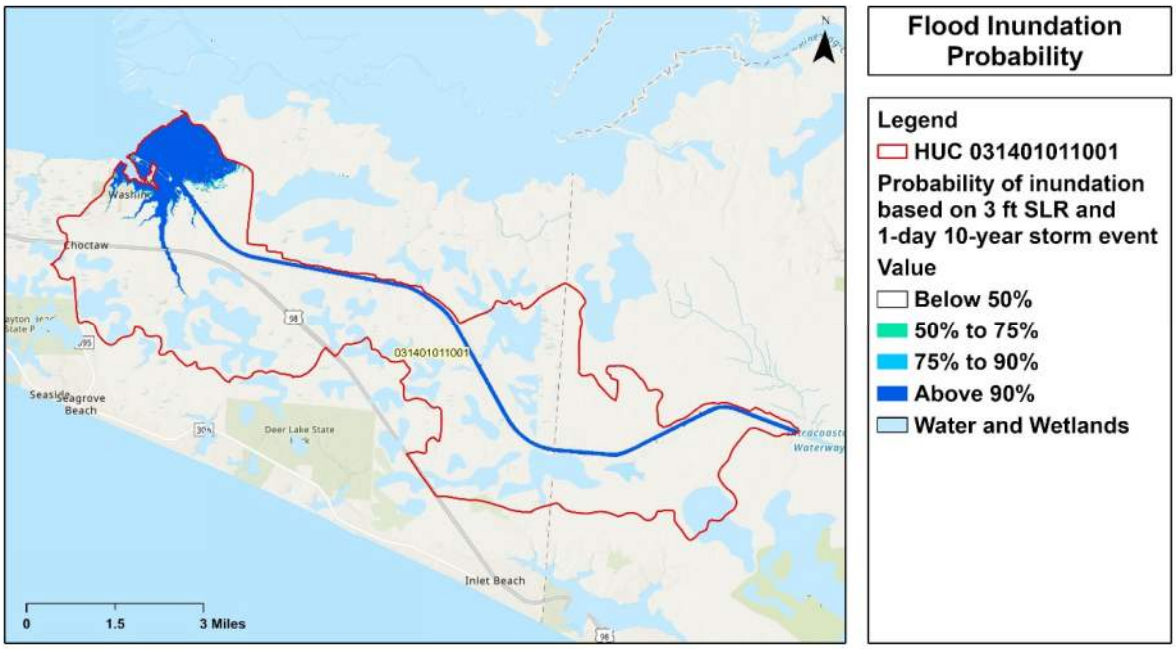

Figure 49. Sea level rise of 3 ft + 1-day 10-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

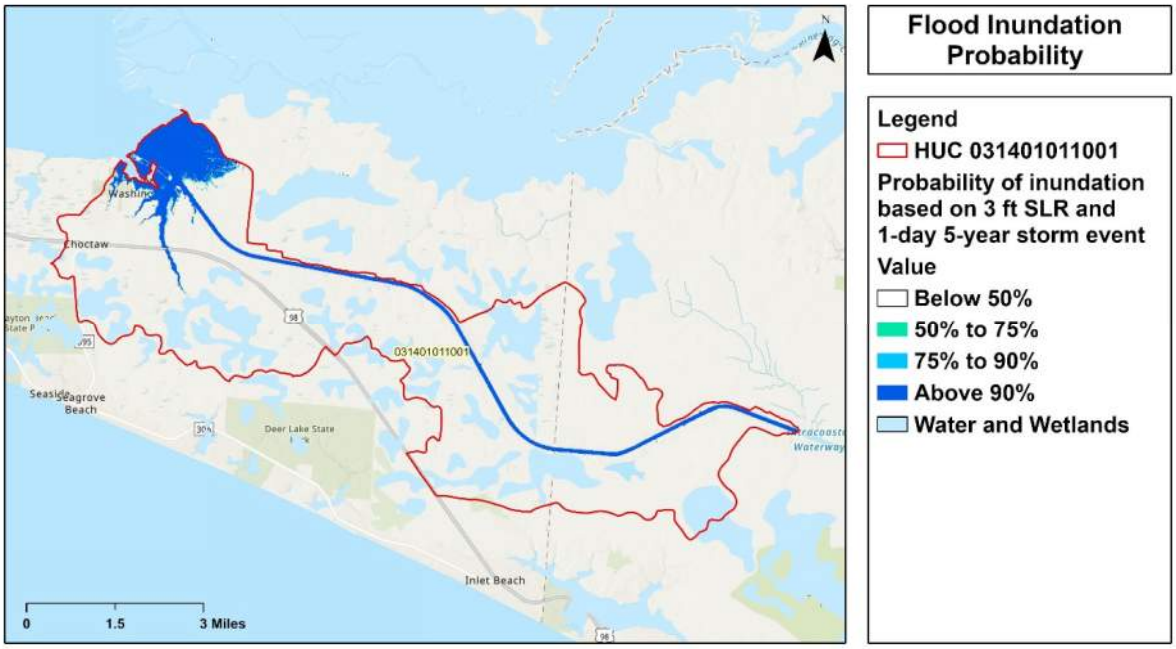

Figure 50. Sea level rise of 3 ft + 1-day 5-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

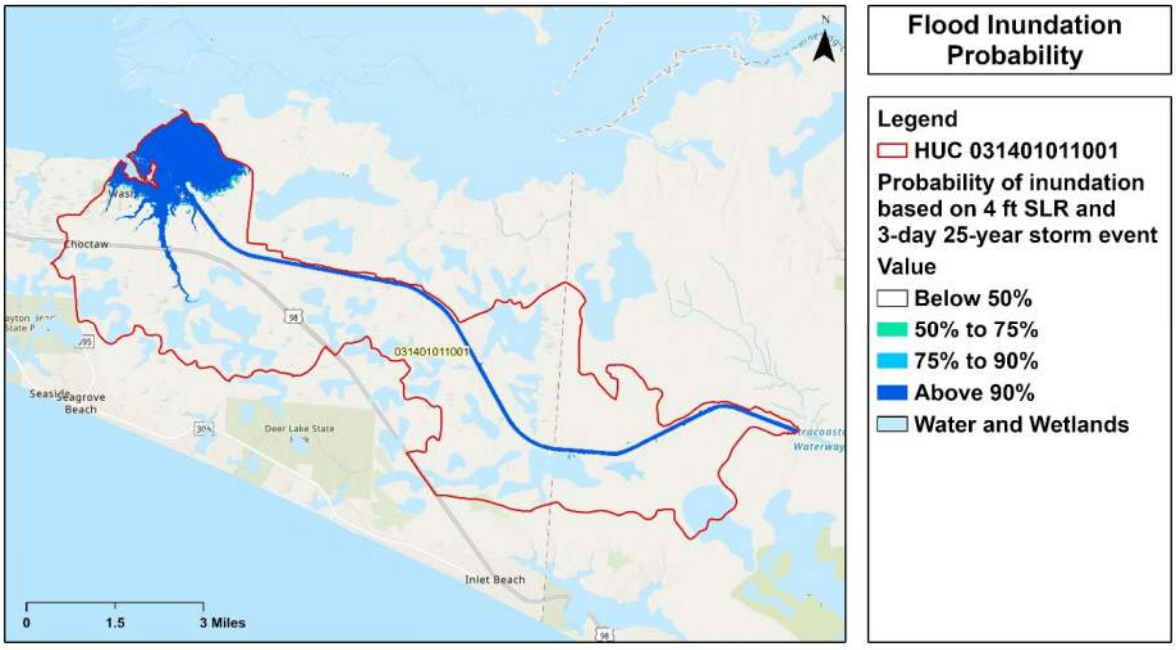

Figure 51. Sea level rise of 4 ft + 3-day 25-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

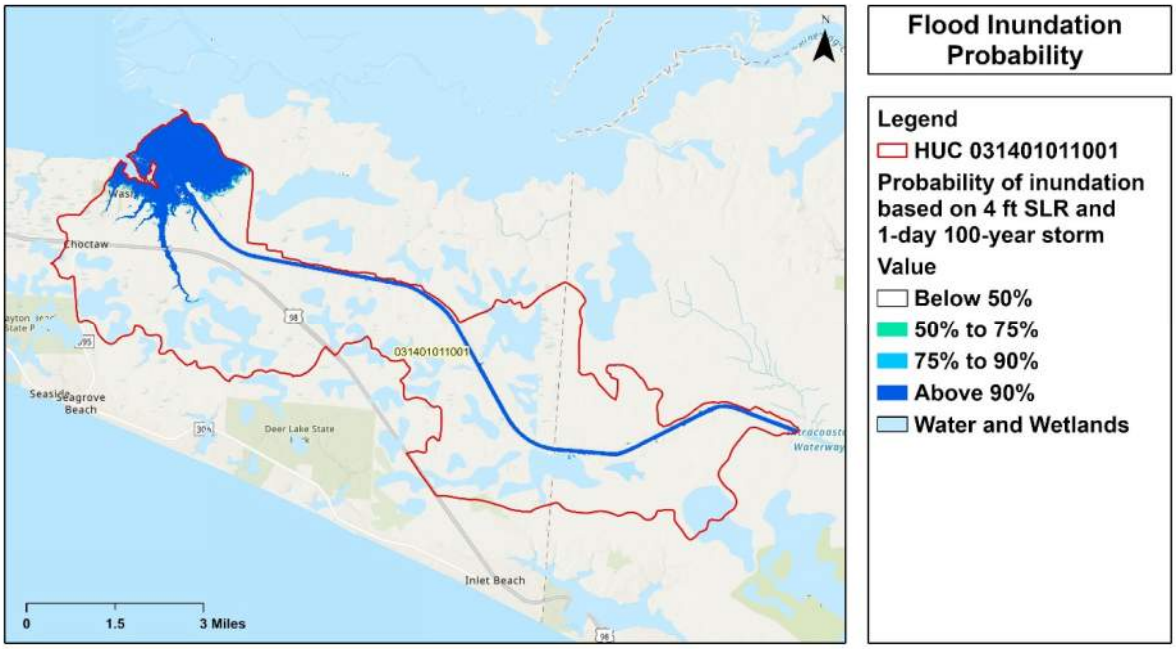

Figure 52. Sea level rise of 4 ft + 1-day 100-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

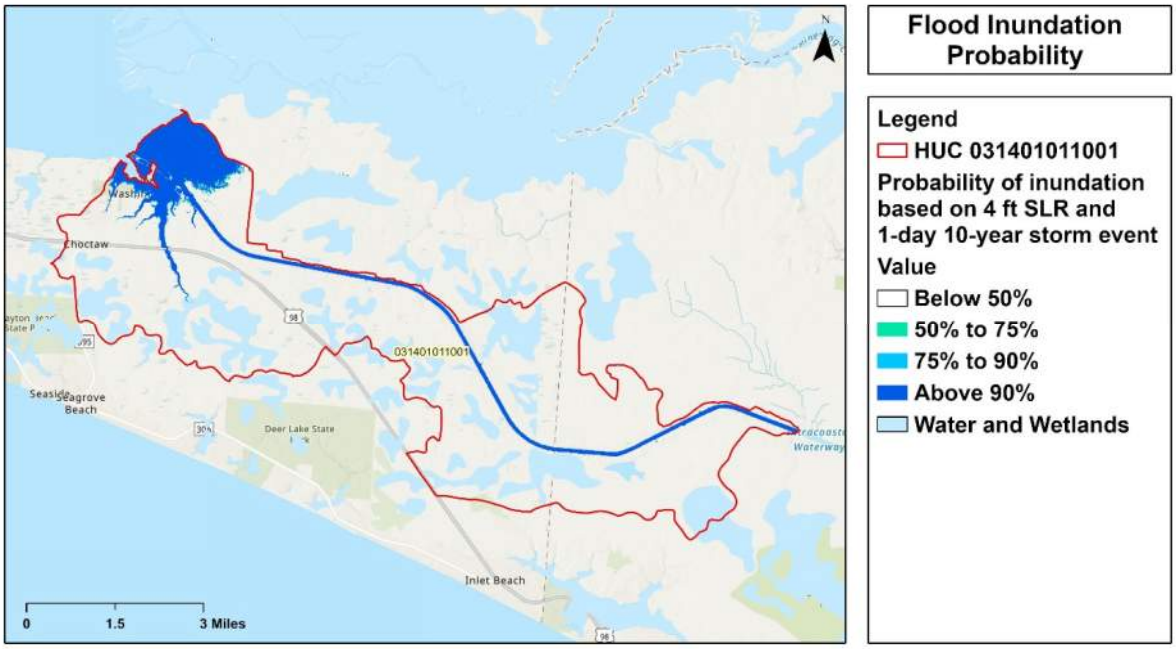

Figure 53. Sea level rise of 4 ft + 1-day 10-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

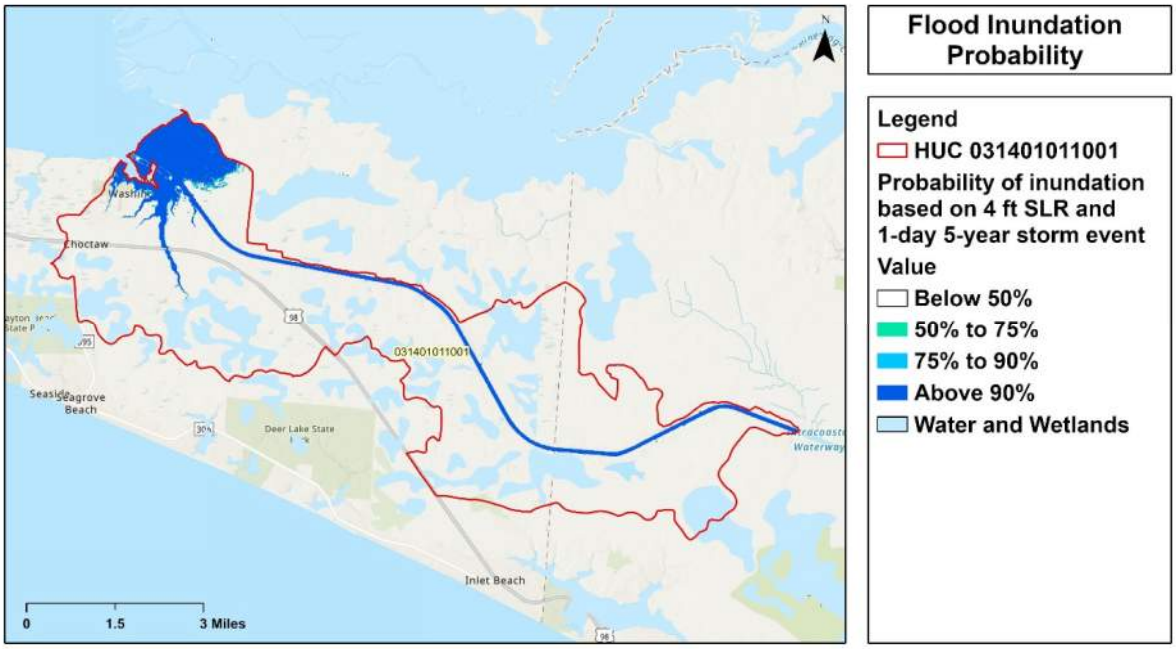

Figure 54. Sea level rise of 4 ft + 1-day 5-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

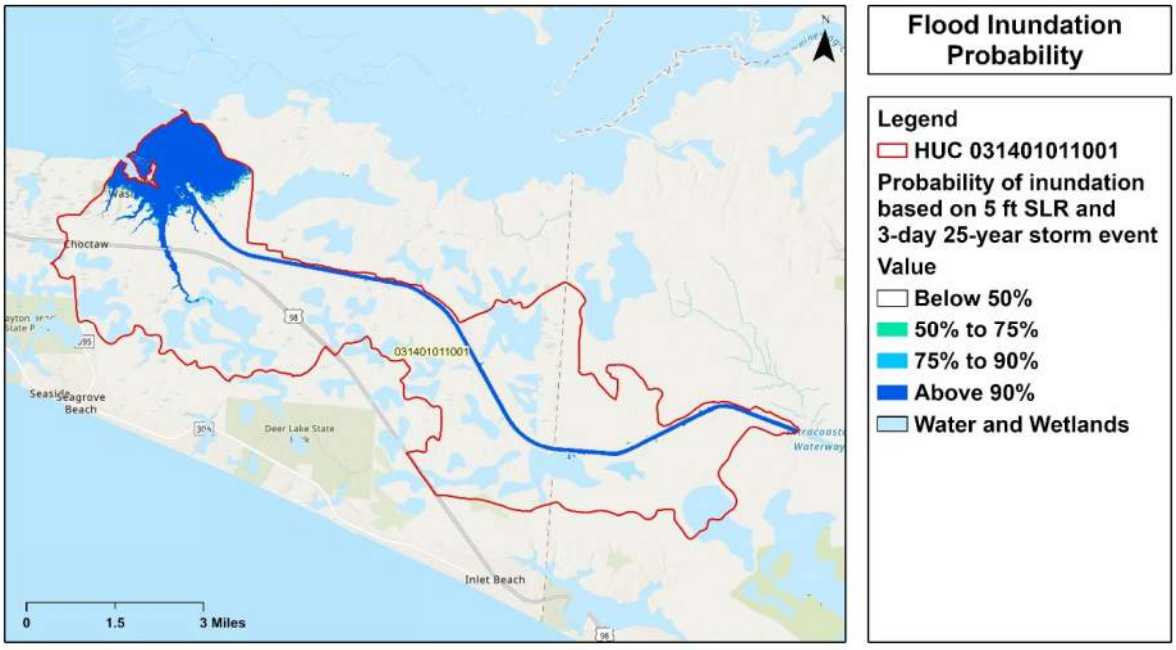

Figure 55. Sea level rise of 5 ft + 3-day 25-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

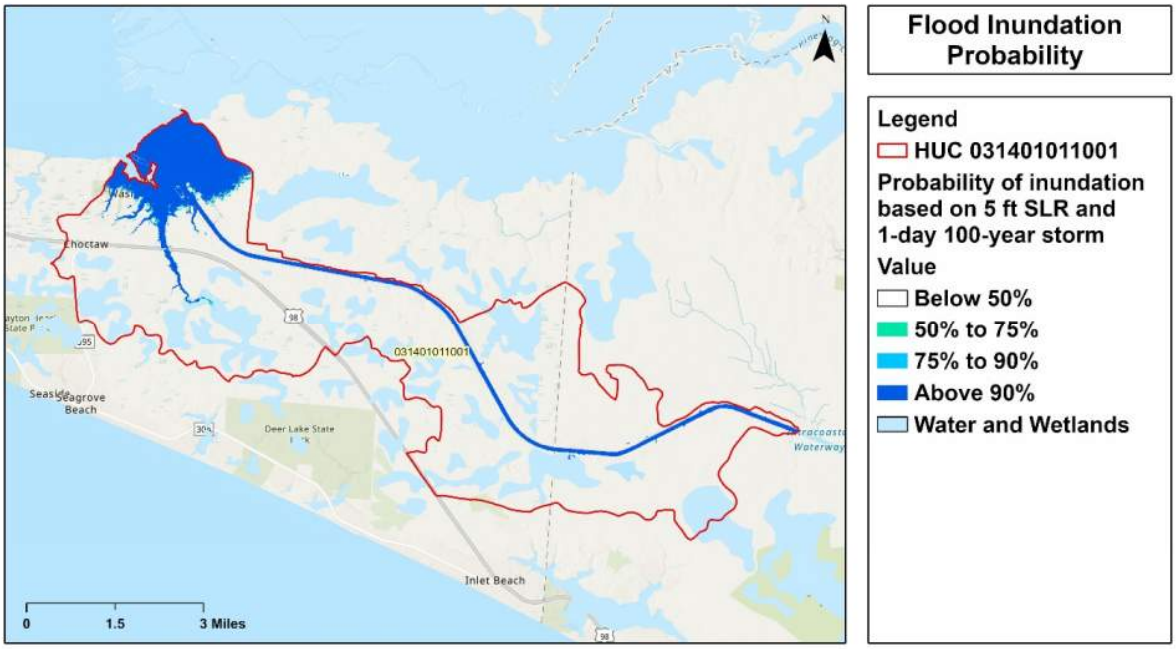

Figure 56. Sea level rise of 5 ft + 1-day 100-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

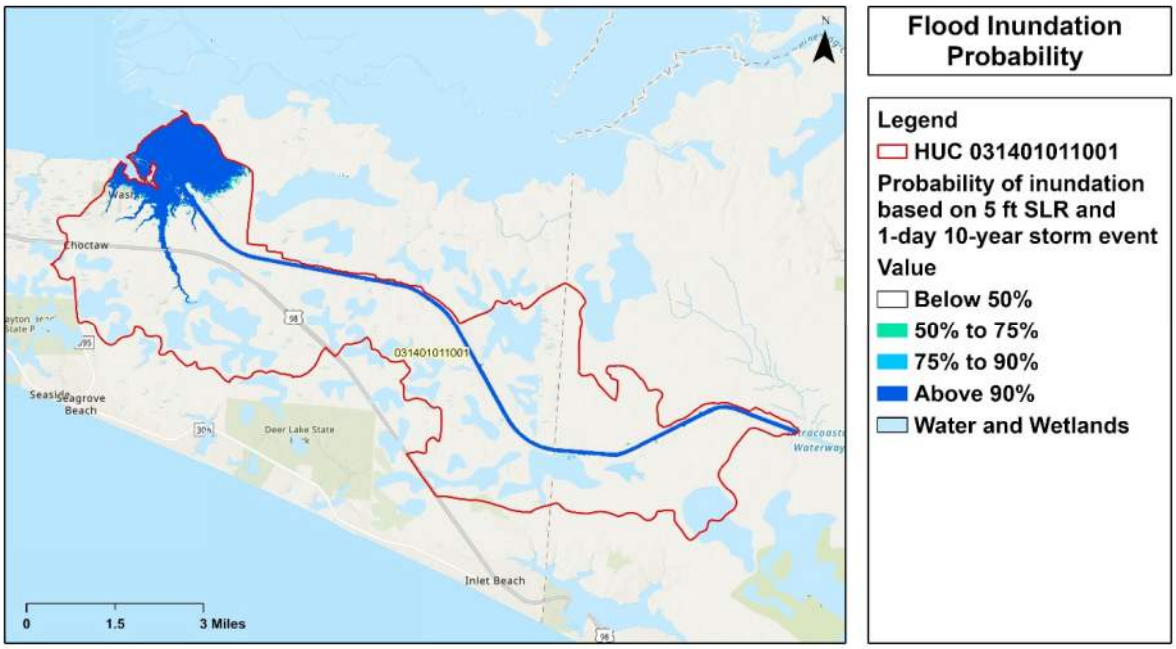

Figure 57. Sea level rise of 5 ft + 1-day 10-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

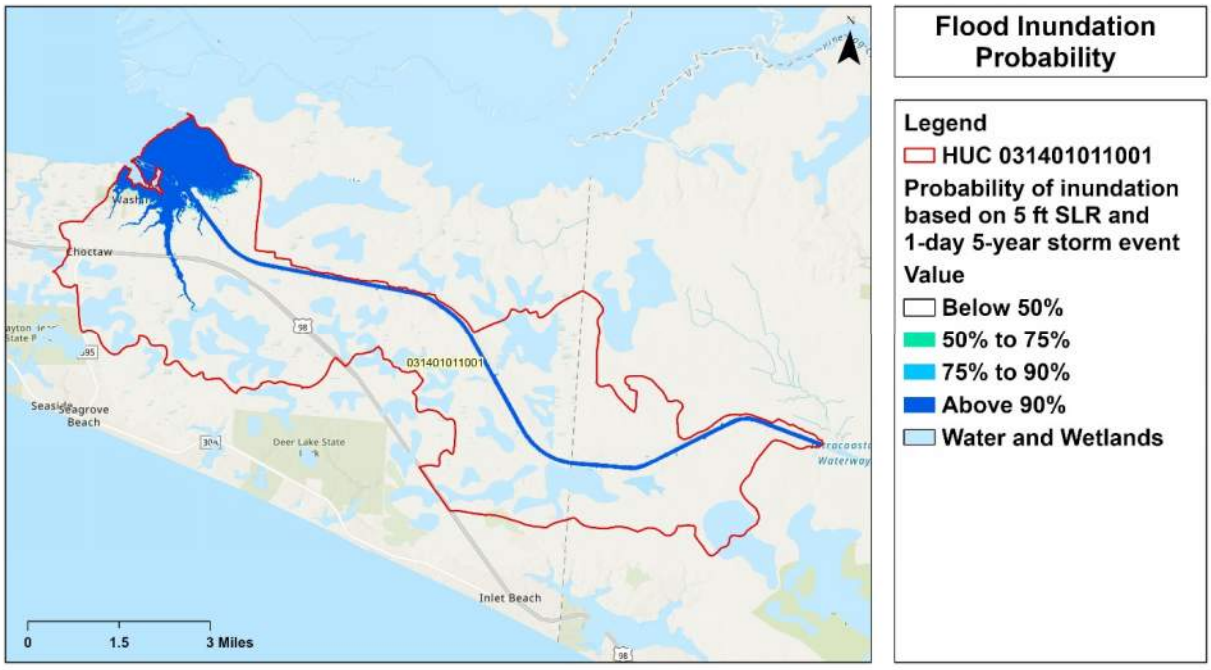

Figure 58. Sea level rise of 5 ft + 1-day 5-year storm for HUC 031401011001 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.5 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Table 8 outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would

have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3

25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6

53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6

88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, as shown in Table 9.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.5.1 Results

Figure 59 to Figure 61 depict the HUC 031401011001 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (Figure 59) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 60) overlays critical facilities onto the 1-day 100-year storm event scenario, while the third map (Figure 61) represents the same overlay within the context of 5 feet of sea level rise (SLR) combined with the 1-day 100-year storm event. Figure 62 is a mosaic showing critical facilities overlaid in the 5 feet SLR + 1-day 100-year storm event for the whole county.

Additionally, Figure 61 and Figure 62 illustrate the composite score for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Figure 63 represents the calculation for composite score based on 1-day 100-year storm event, while Figure 64 shows the calculation for composite score for the same storm event, but including a 5 feet of Sea Level Rise scenario. Figure 65 shows the same area zoomed out.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will

be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

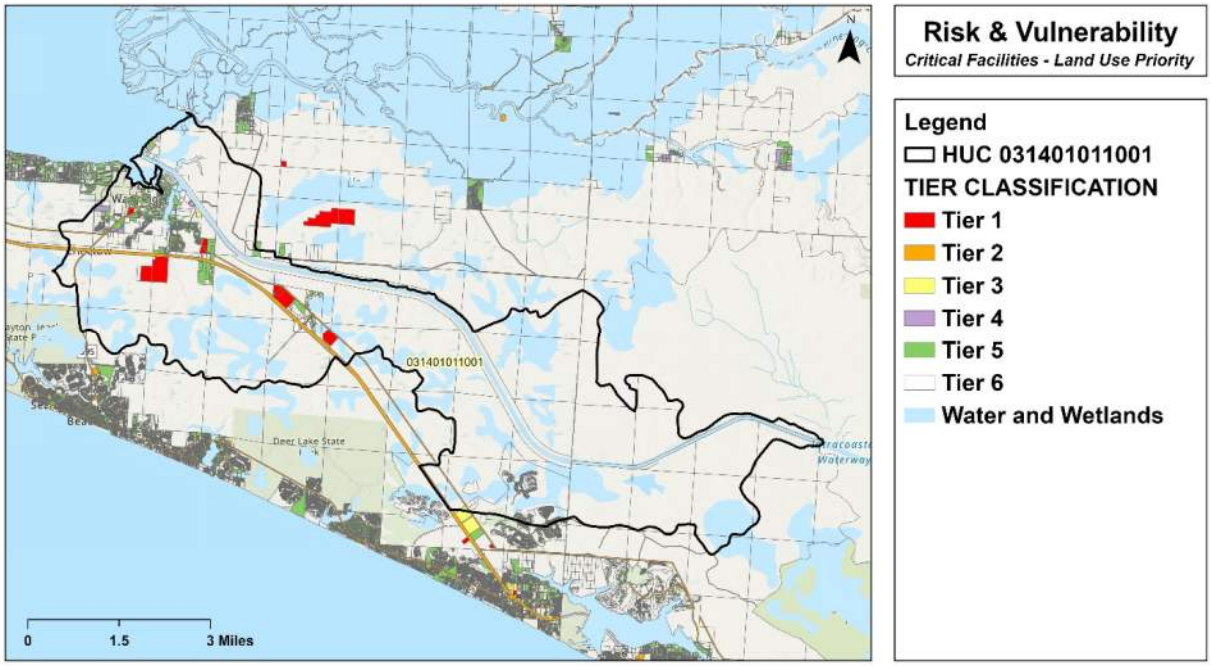

Figure 59. HUC 031401011001 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

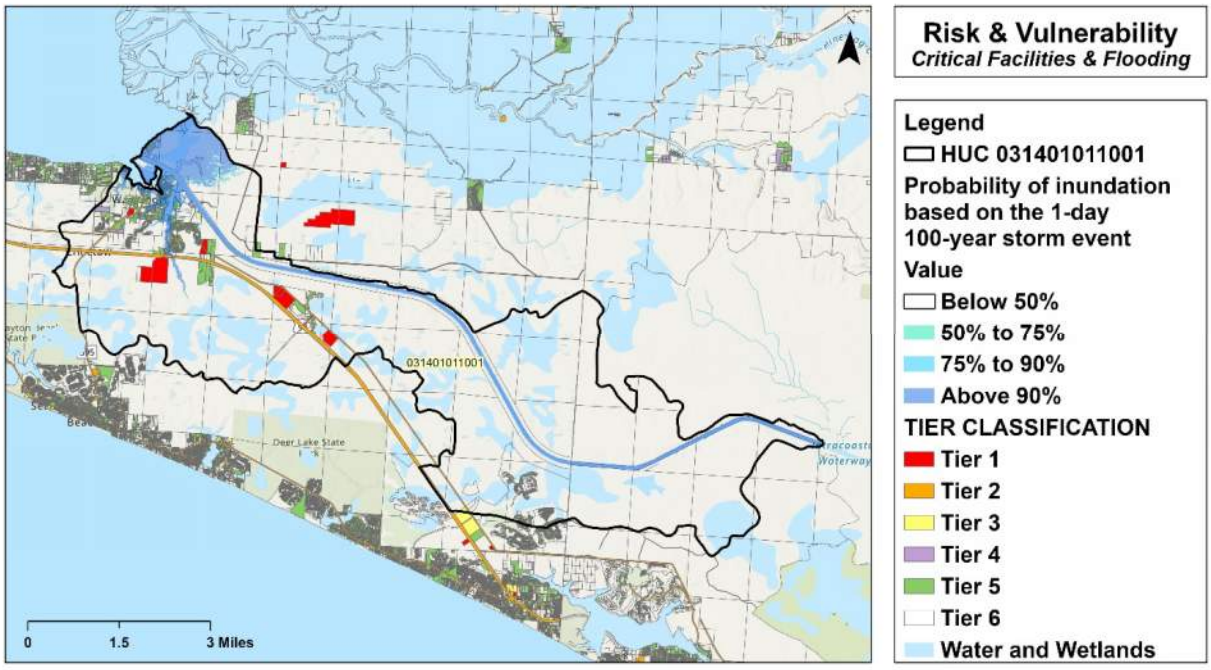

Figure 60. HUC 031401011001 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

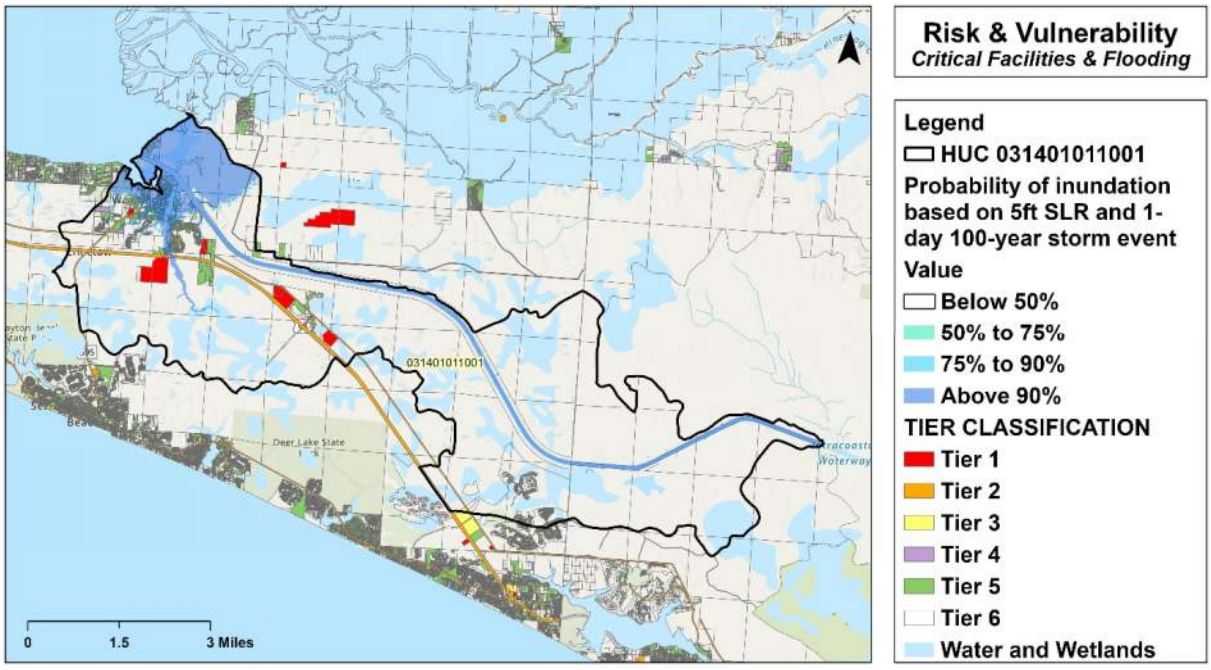

Figure 61. HUC 031401011001 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

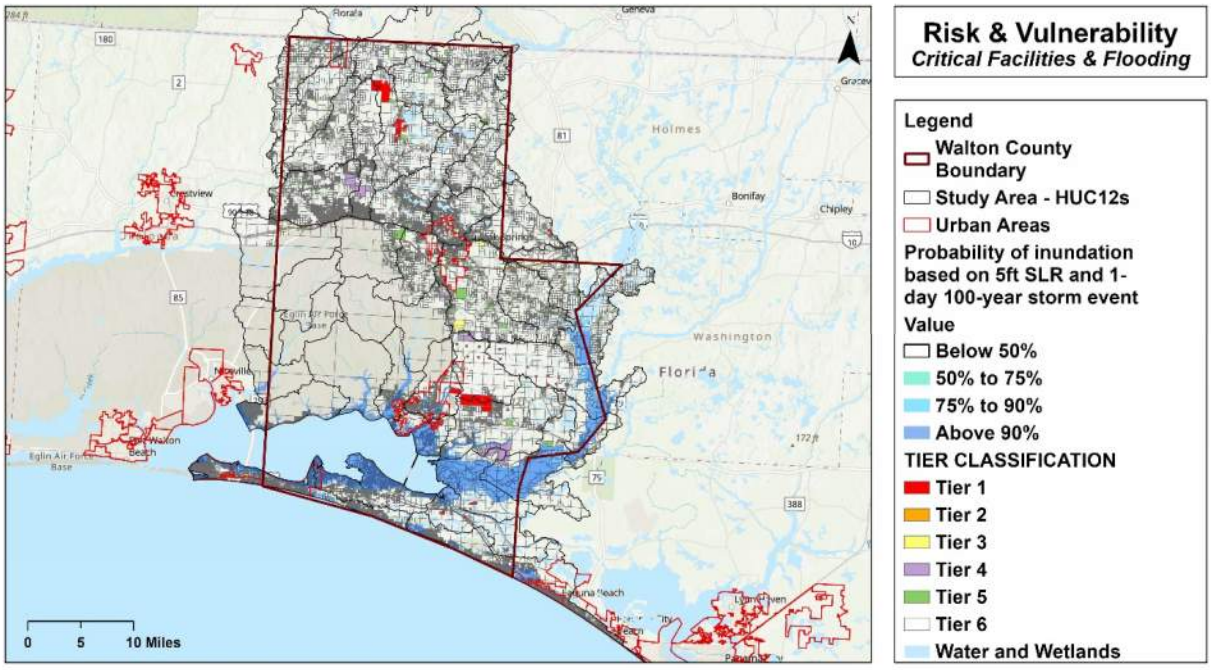

Figure 62. Walton County (mosaic) - Critical Facilities (priority of land uses) map, overlaid on the 1-day 100-year storm event + 5 ft. SLR probability of inundation for Walton County. Processed by FAU.

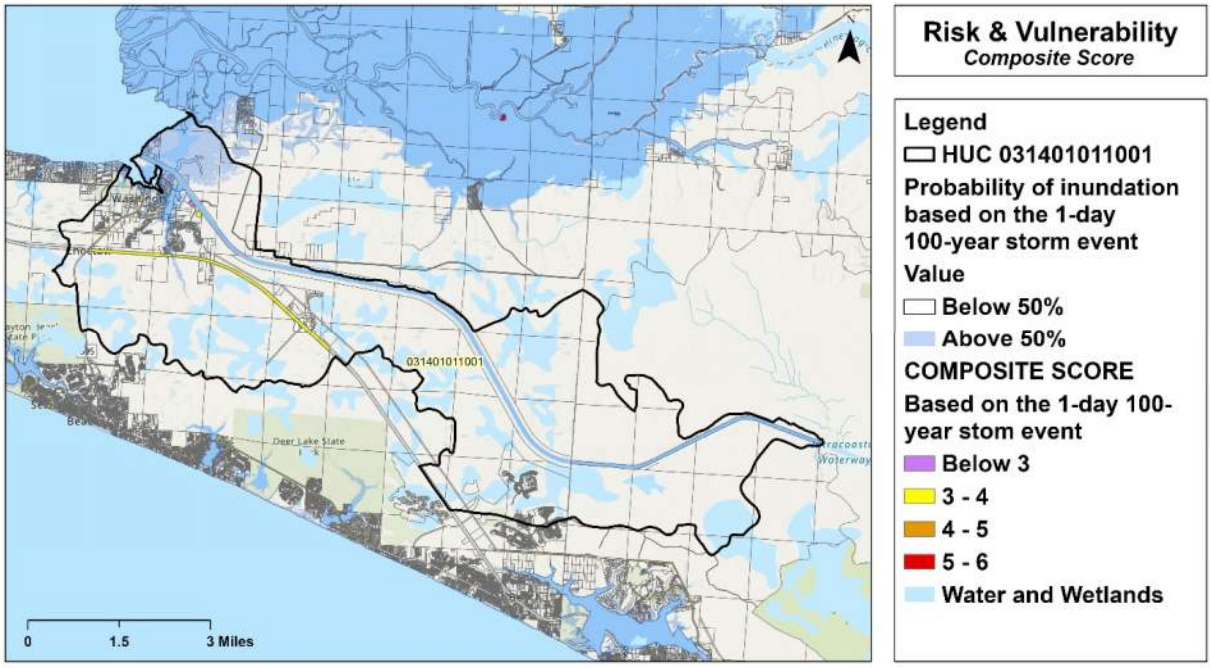

Figure 63. HUC 031401011001 sub-watershed Composite Score Risk map based on the 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation. Processed by FAU.

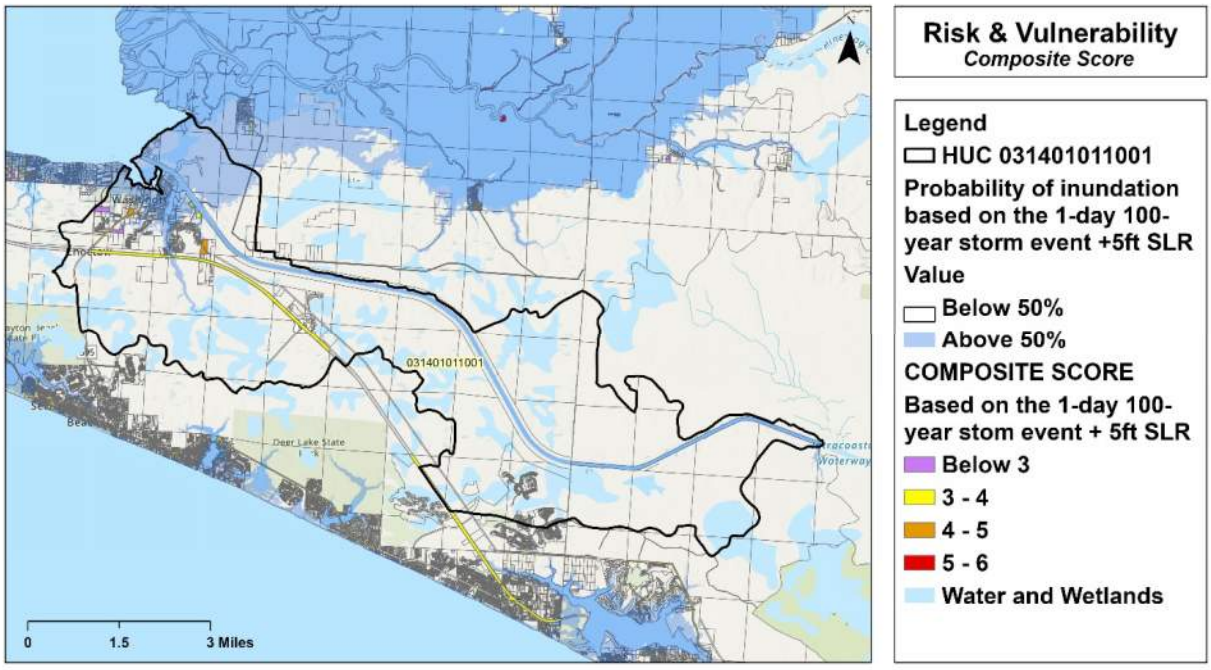

Figure 64. HUC 031401011001 sub-watershed Composite Score Risk map based on 1-day 100-year storm event + 5 ft. SRL, overlaid on the 1-day 100-year + 5 ft. SLR probability of inundation. Processed by FAU.

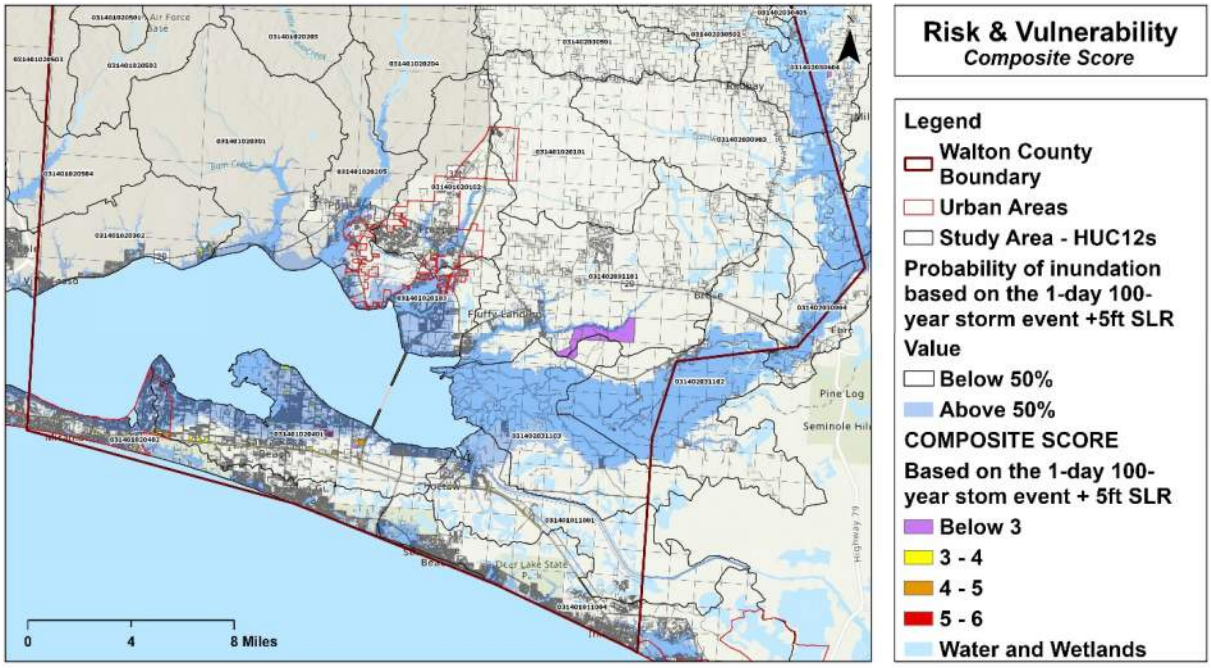

Figure 65. Coastal Area of Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

2.5.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401011001. A summary of these flood mitigation strategies is listed in Table 10. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.5.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see Table 11).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401011001. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401011001	18826.93
All of the 1-day 100-year storm event inundation	**1554.50**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	219.24
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	74.90
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.99
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	1335.26
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	1259.37

2.5.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. Figure 66 indicates the results

from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

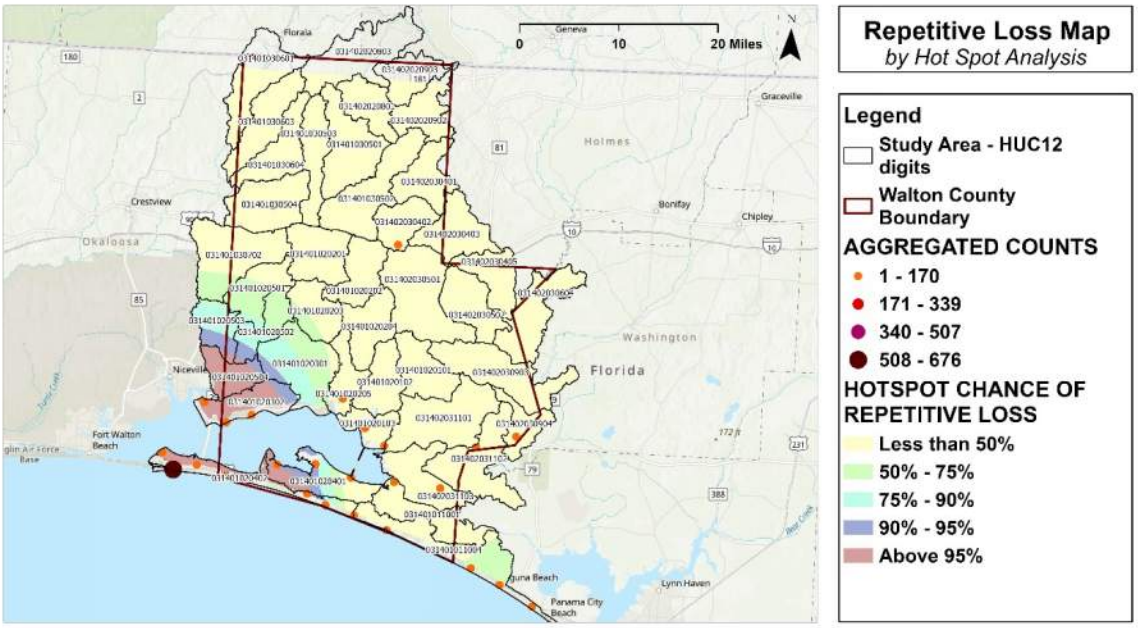

Figure 66. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.5.5 Priority Projects

There are a good number of properties located within the flood zones for both the 1-day 100-year and 1-day 100-year + 5ft SLR scenarios, taking into account critical facilities. However, the majority of these parcels fall under tiers 5 and 6, signifying a lower priority for intervention. A few parcels are classified under tiers 3 and 4, but the most critical concern lies with segments of essential roads, specifically N CO Highway 395 and US Highway 98, both categorized as tier 2.

When evaluating the composite score, three parcels stand out with scores below 3, all of which are mobile homes (DOR code 002). Additionally, a few parcels and roads fall within the score range of 3 to 4, including N CO Highway 395, US Highway 98, and others. Apart from roads, parcels within this score range are primarily utilities (DOR code 091), mobile homes (DOR code 002), with one exception being light manufacturing (DOR code 041).

Moving into the score range of 4 to 5, there are three significant parcels that need priority. One is a public school (DOR code 083), another is a private school (DOR code 072), and the third is a utility (DOR code 091). This category also encompasses several local streets that need attention.

Further, local roads with a score between 5 to 6 are identified as priority areas for projects. These roads share a common classification as 'parcels with no values (row),' under DOR code 101, and

are situated in proximity to Point Washington. The parcel names, extracted from the 'PARCELID' field in the Property Appraisal Data, include:

- Eden Dr
- Eve Cir
- Doghobble Ln
- Garden Court Ln
- Apple Ct

More detail about flood solutions are described in the community plan and in Section 5.5 where drilldown to specific neighborhoods is outlined.

APPENDIX C

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401011004

EASTERN LAKE-PHILLIPS INLET FRONTAL

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401011004) is highlighted among all the HUCs to help identifying its location.

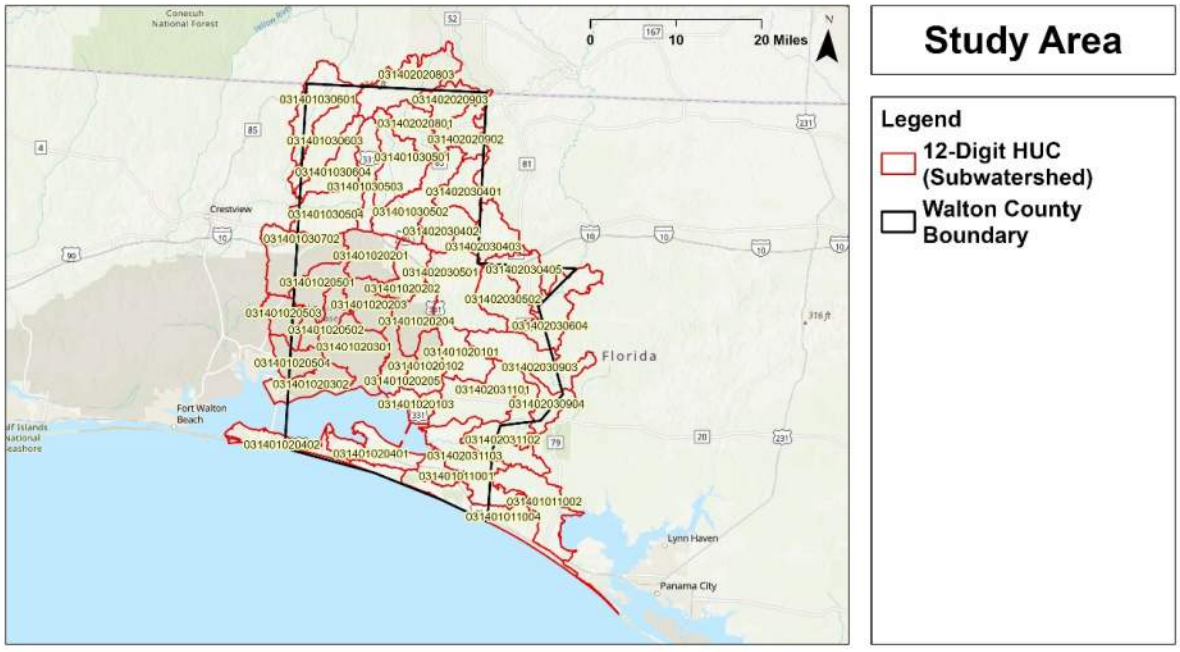

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

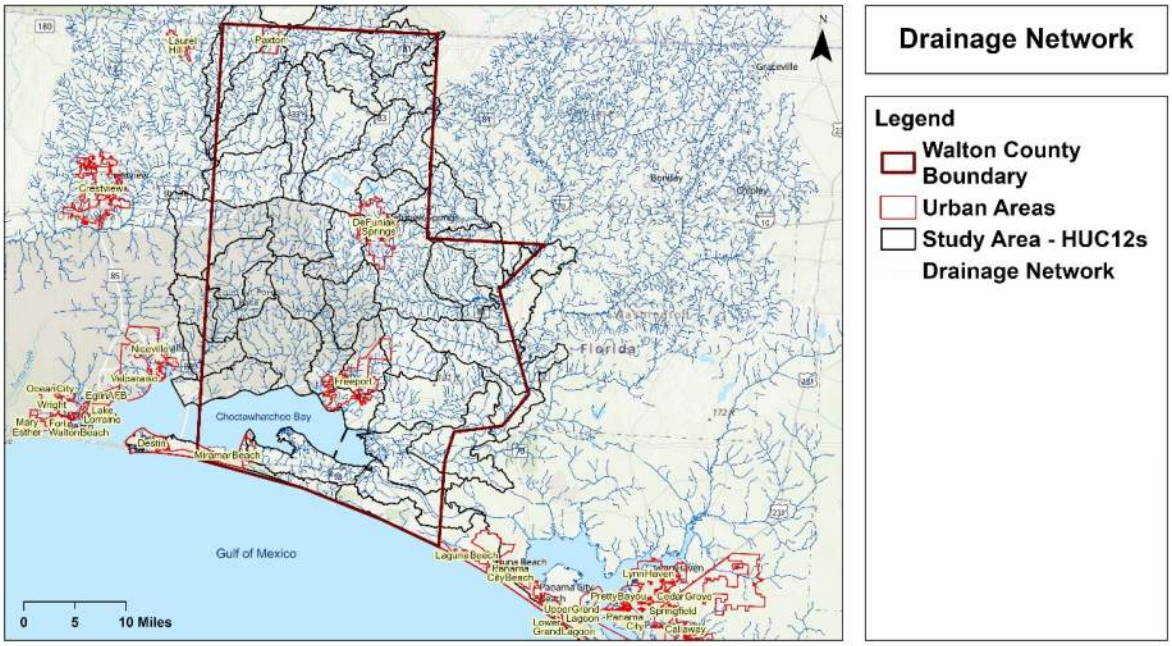

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

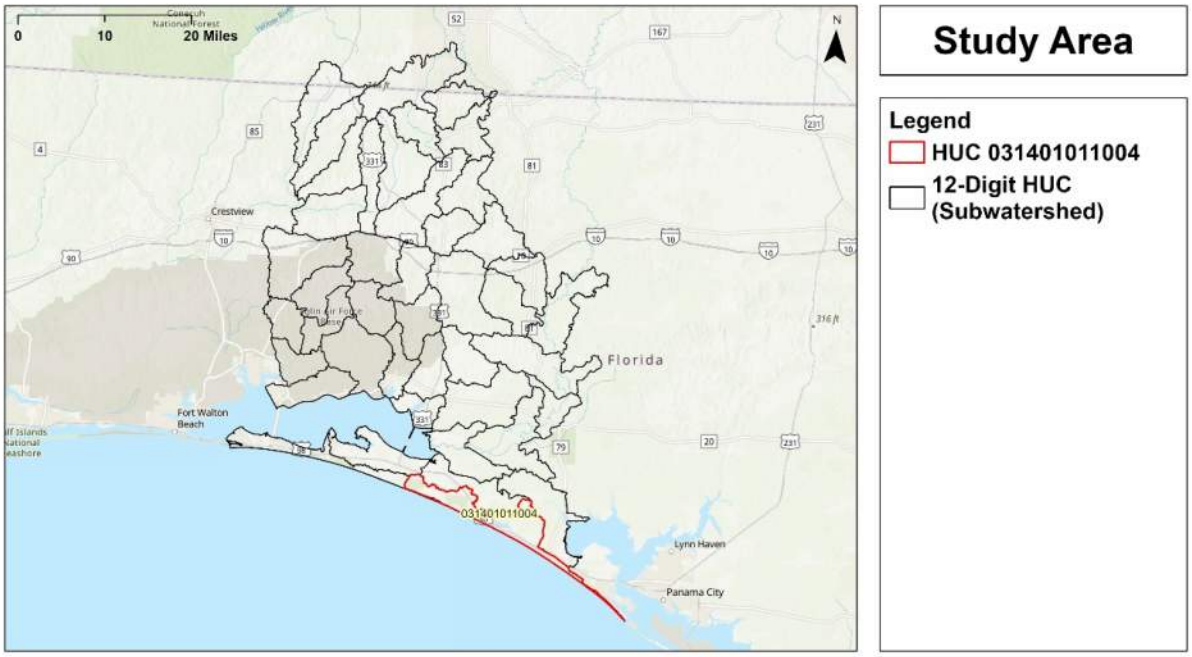

Figure 3. HUC 031401011004 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Figures 12 and 13 in the county-wide report show the current and projected land use for the County. Based on the 2017 future land use map for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land Use in Walton County (Prepared by FAU from future land use map) versus land use in the entire watershed (2023 Florida Geographic Data Library (FGDL))

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

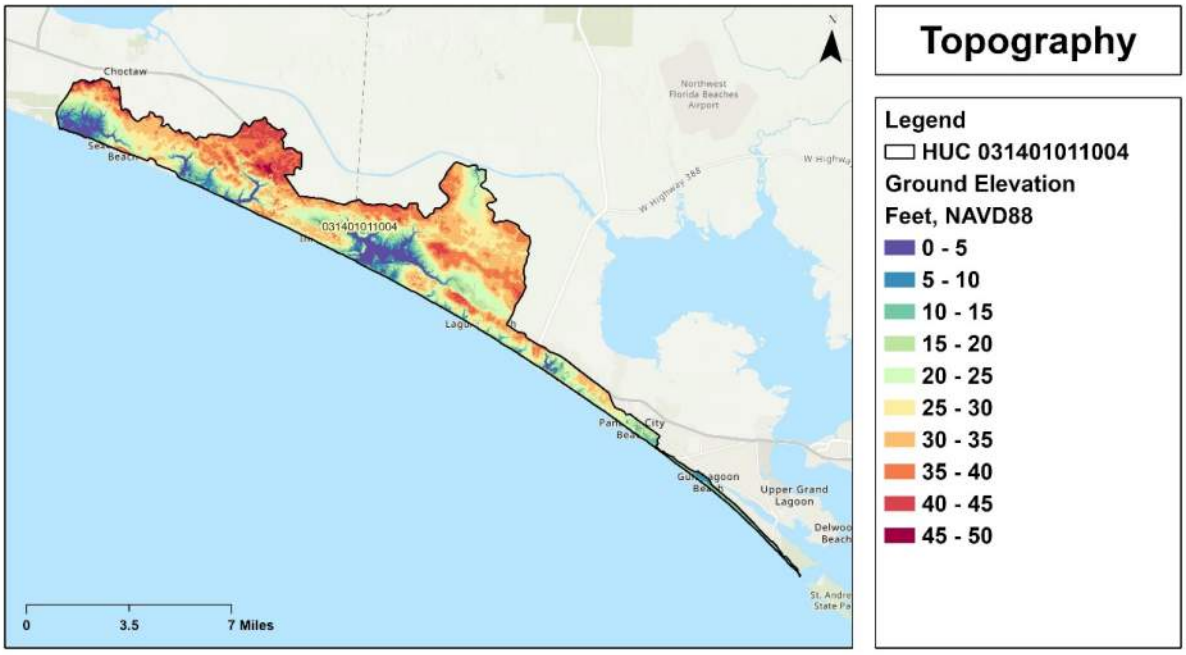

Figure 4. Topographic map of the HUC 031401011004 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401011004 sub-watershed is shown in **Error! Reference source not found.**.

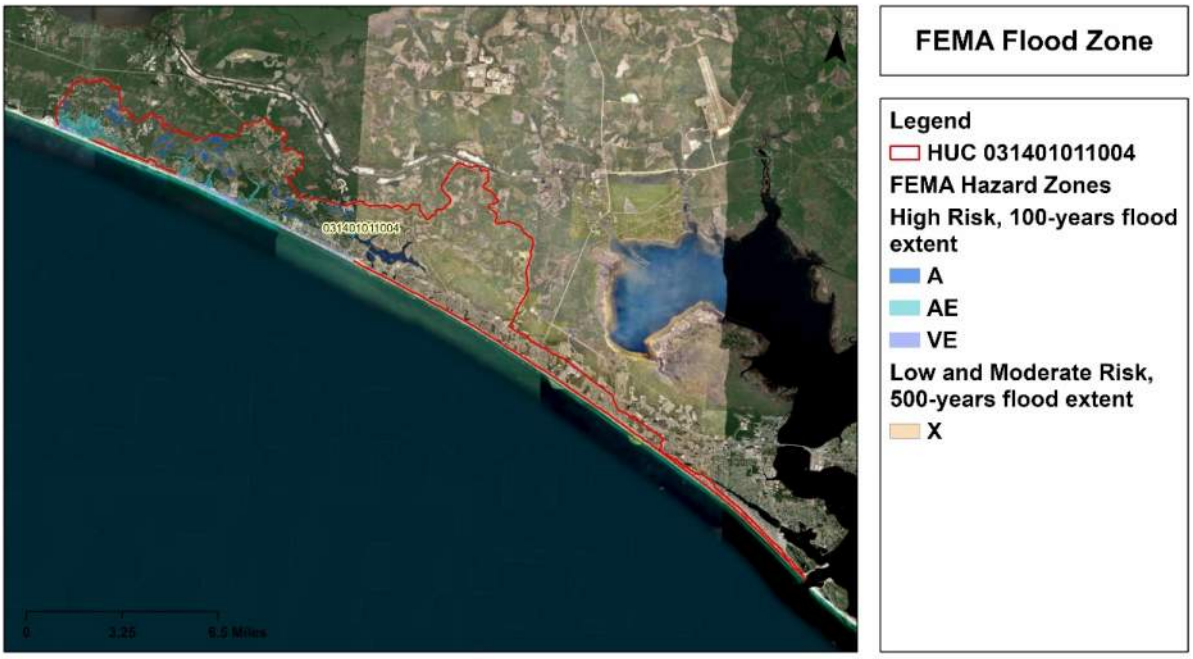

Figure 5. FEMA Flood Zone map (2020) for HUC 031401011004 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401011004 as it will reach the area through Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

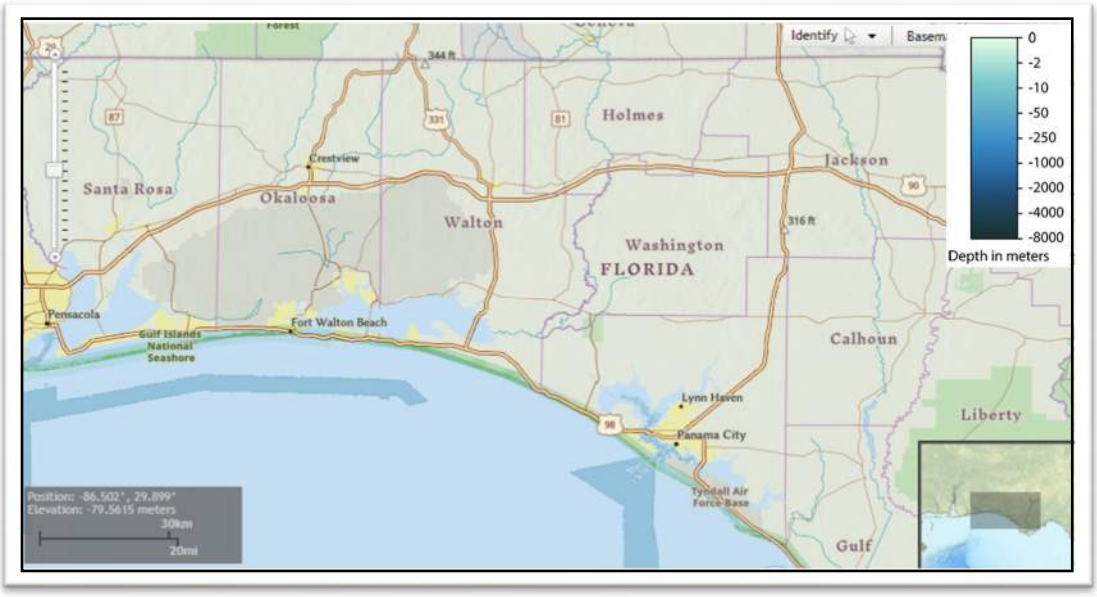

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

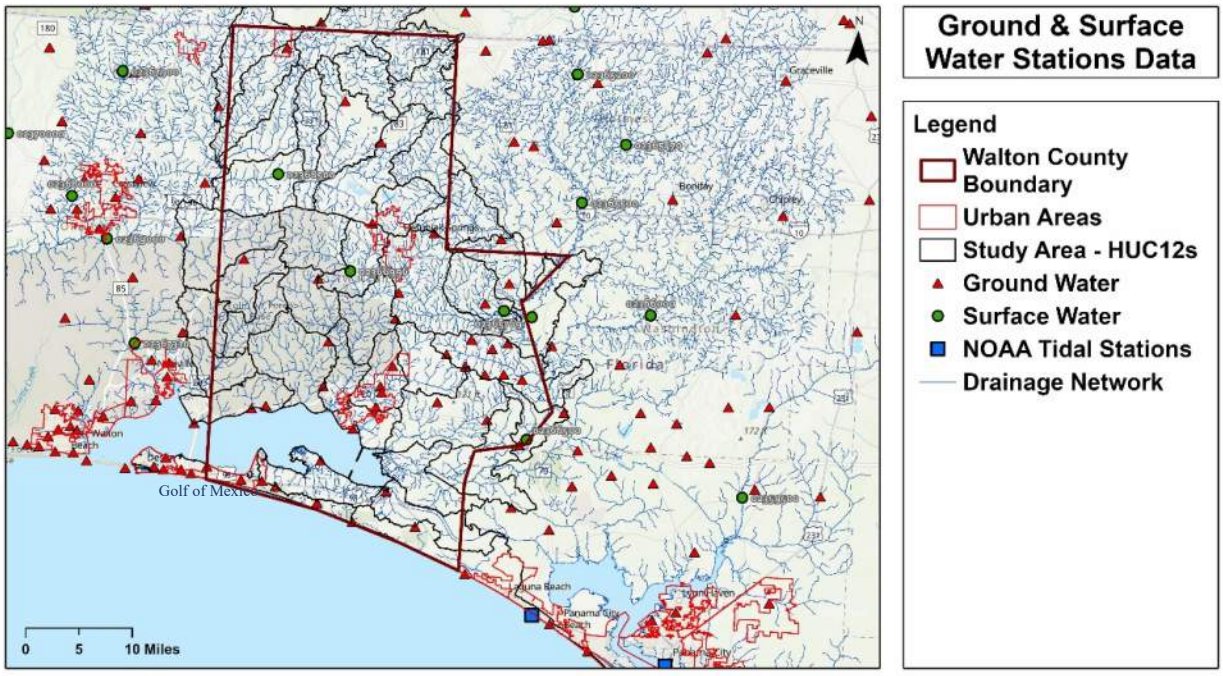

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called sub-basins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031401011004 is a coastal area, therefore it is connected to the Gulf of Mexico at the south side. There are no other major waterbodies, rivers or canals.

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366500.

However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401011004, which is USGS 02366500 Choctawhatchee River NR Bruce FLA.

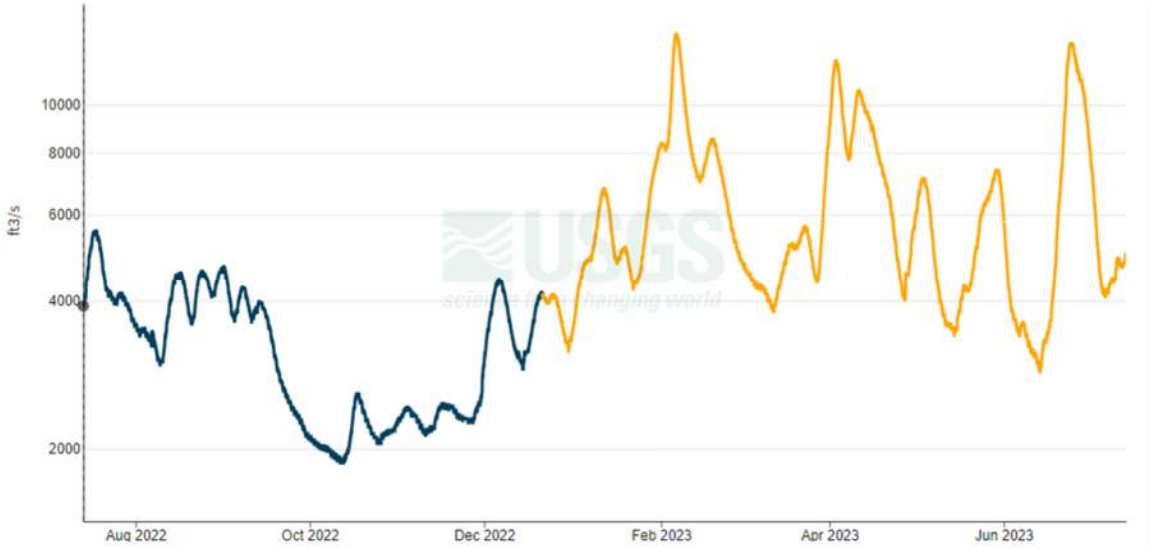

Figure 8. Average streamflow for Choctawhatchee River NR Bruce FLA (USGS 02366500 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366500/#parameterCode=00065&period=P365D)

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401011004 and points out the location of the ground water station in the surroundings. A NOAA tidal station is identified. A groundwater-surface layer for the HUC 031401011004 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

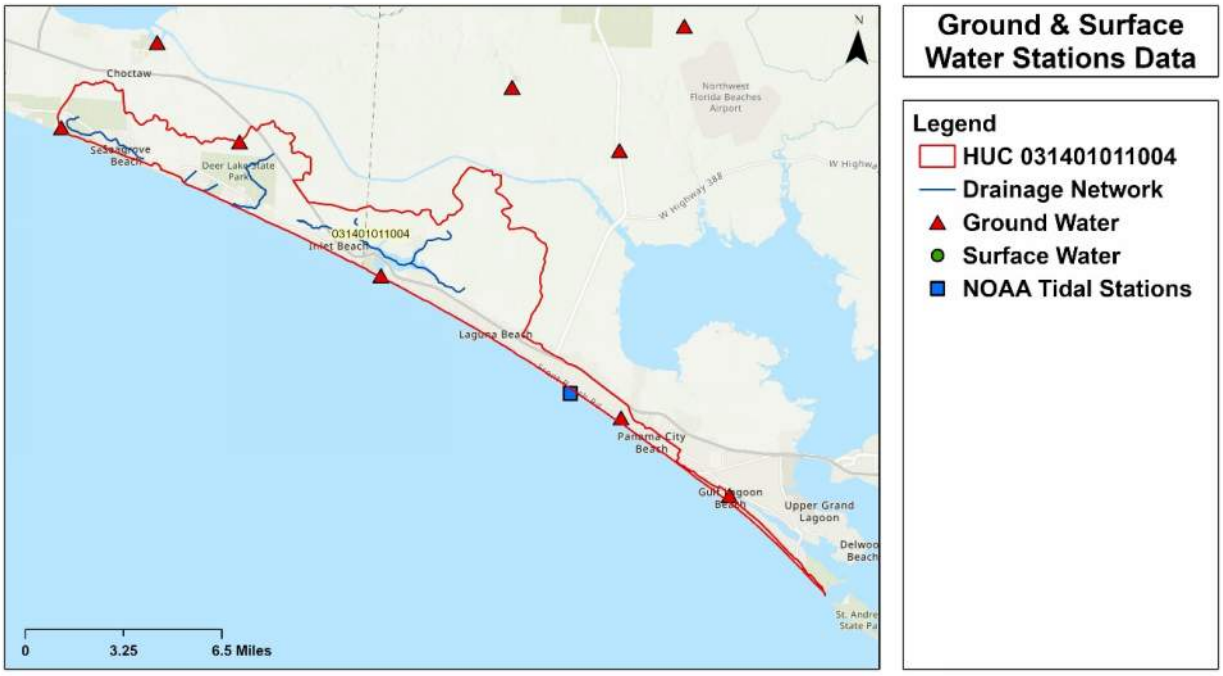

Figure 9. Ground and Surface Water Stations in the HUC 031401011004 sub-watershed, processed by FAU.

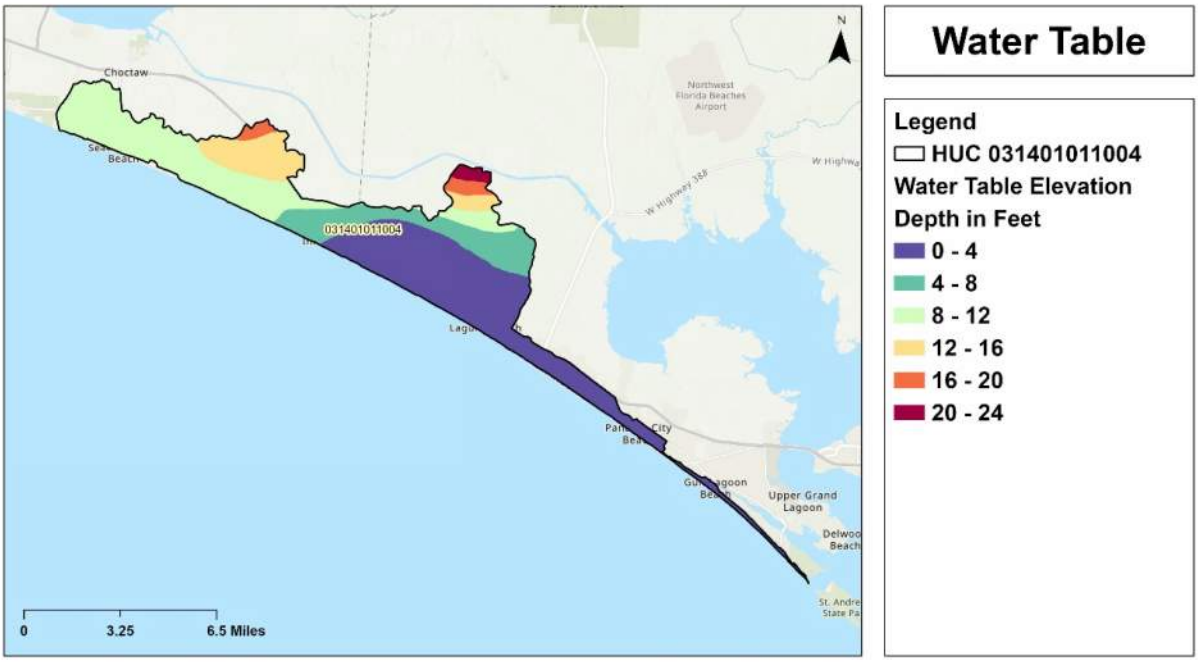

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401011004 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

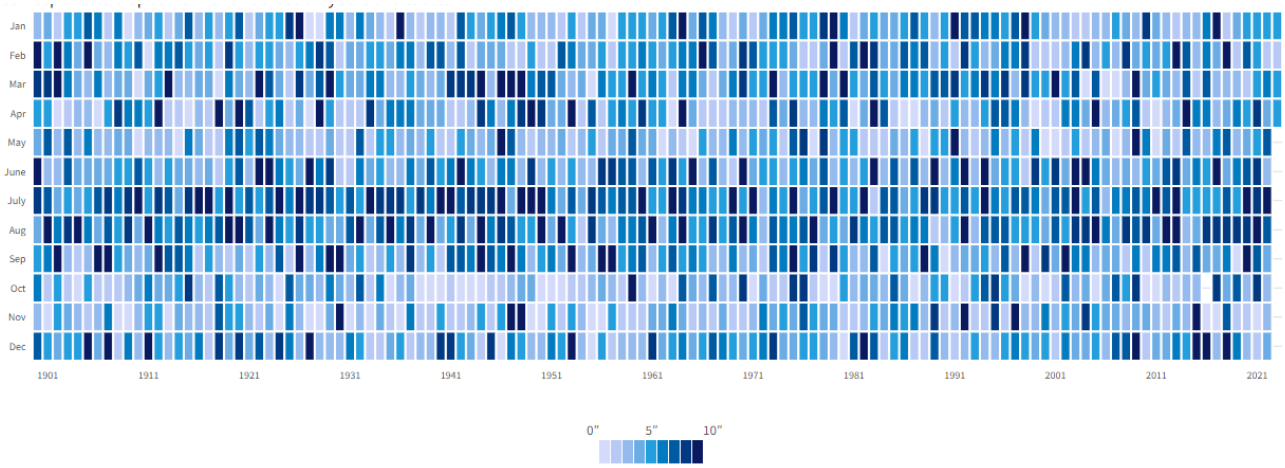

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation)

While the topography (Section 2.1) and native soil (Section 2.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there are no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

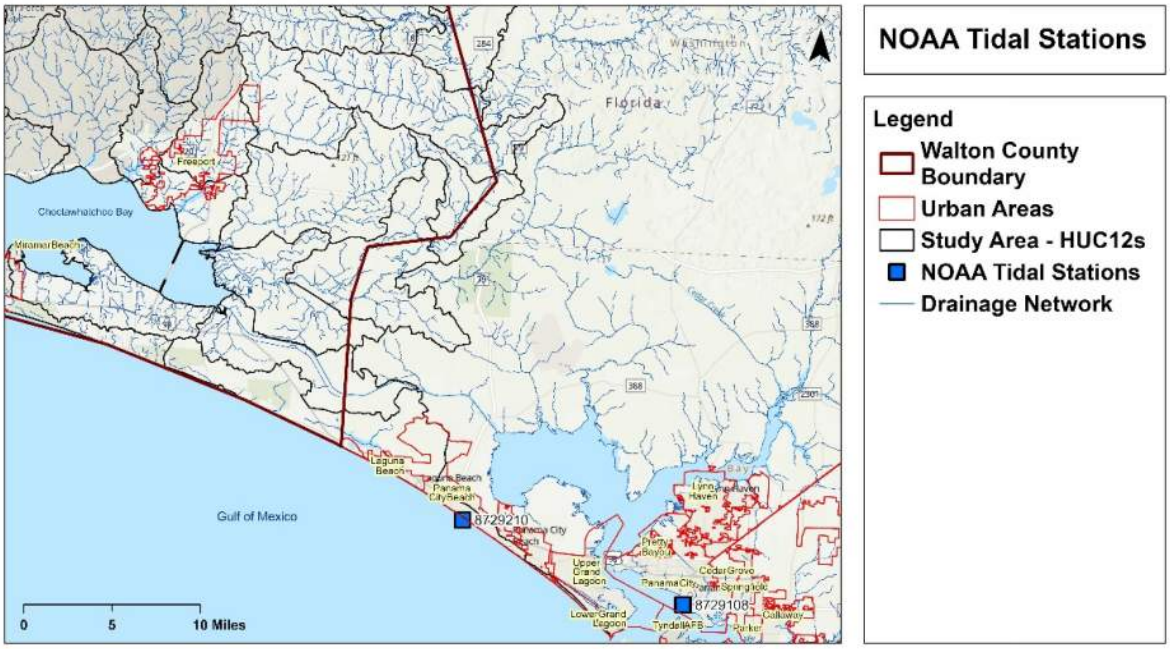

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

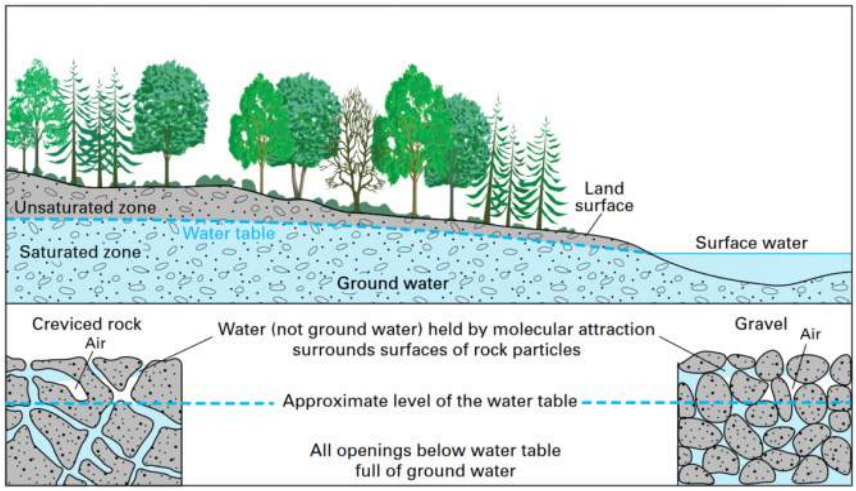

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

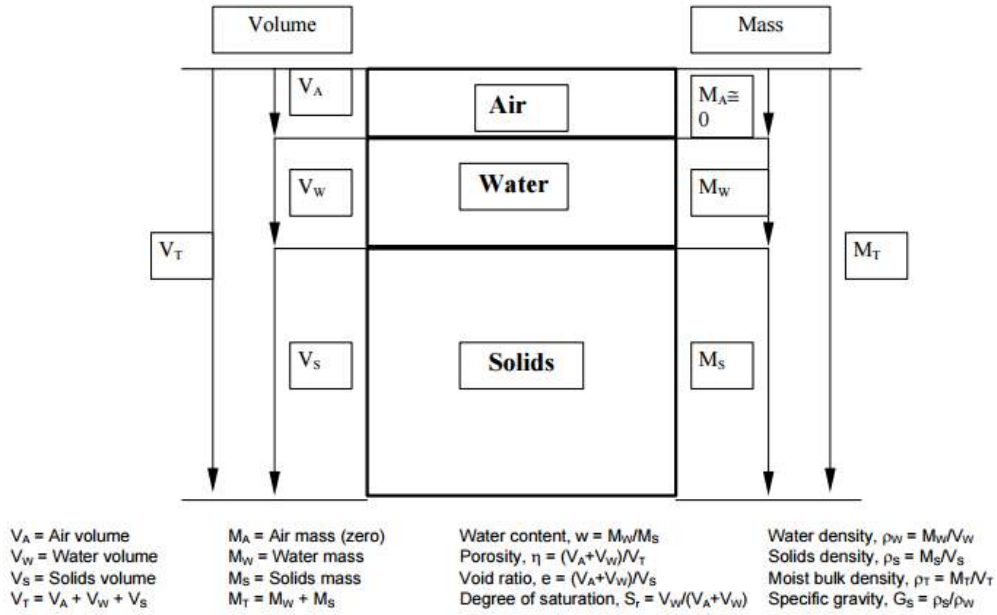

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

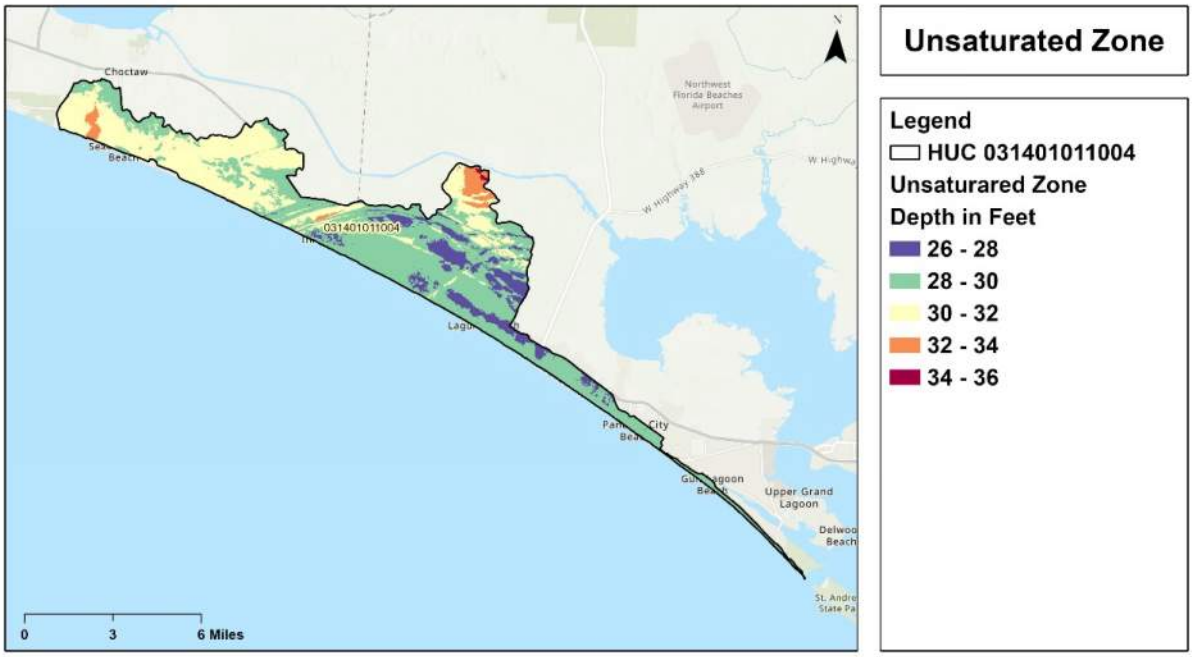

Figure 15. Unsaturated zone map for HUC 031401011004, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. Much of the basin has a medium amount of soil storage capacity, ranging between 30 to 33 inches of capacity left.

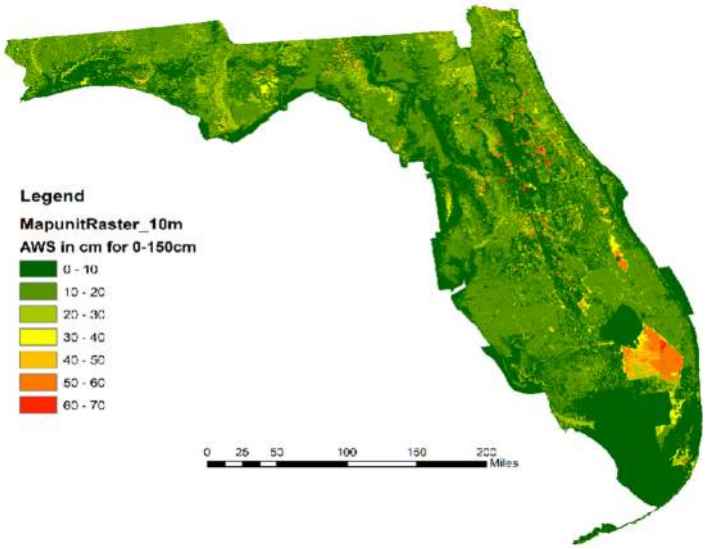

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

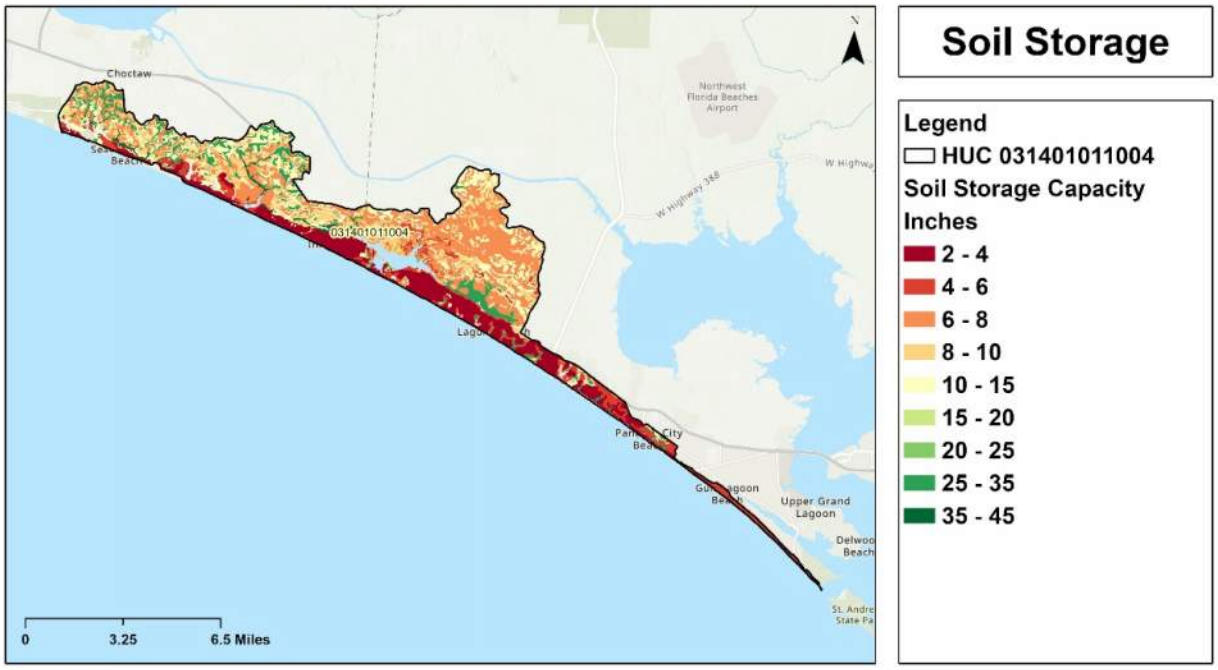

Figure 17. Water storage capacity of soil for the HUC 031401011004 (inches), processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

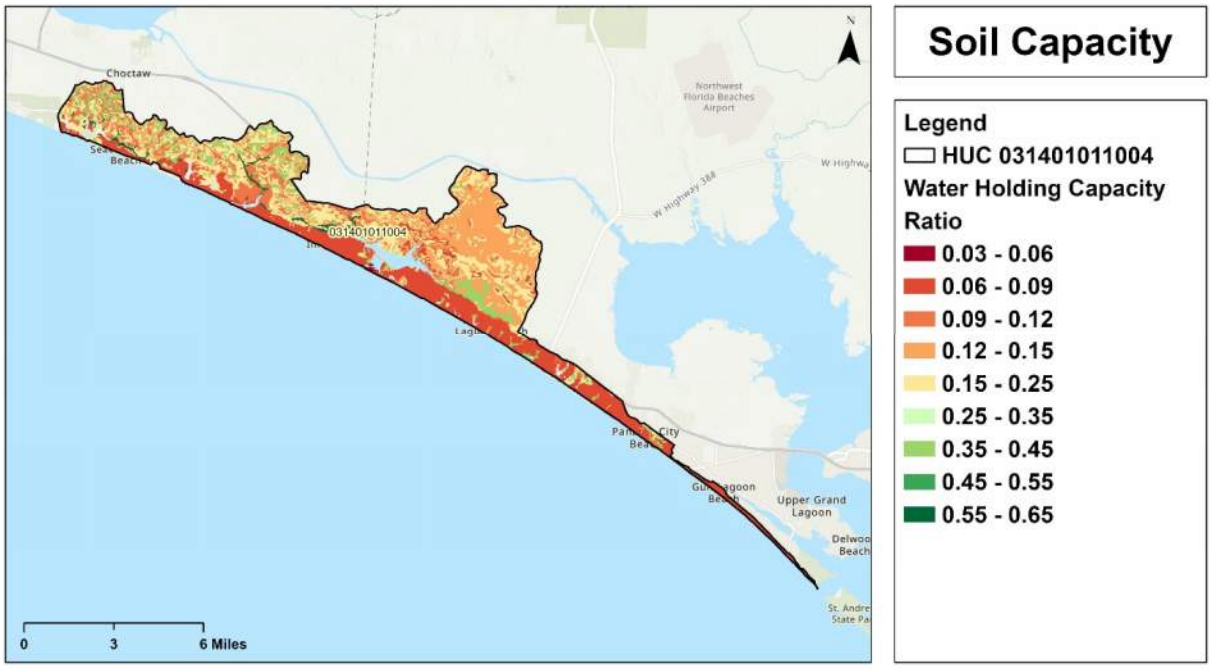

Figure 18. Water Holding Capacity (ratio) for the HUC 031401011004, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

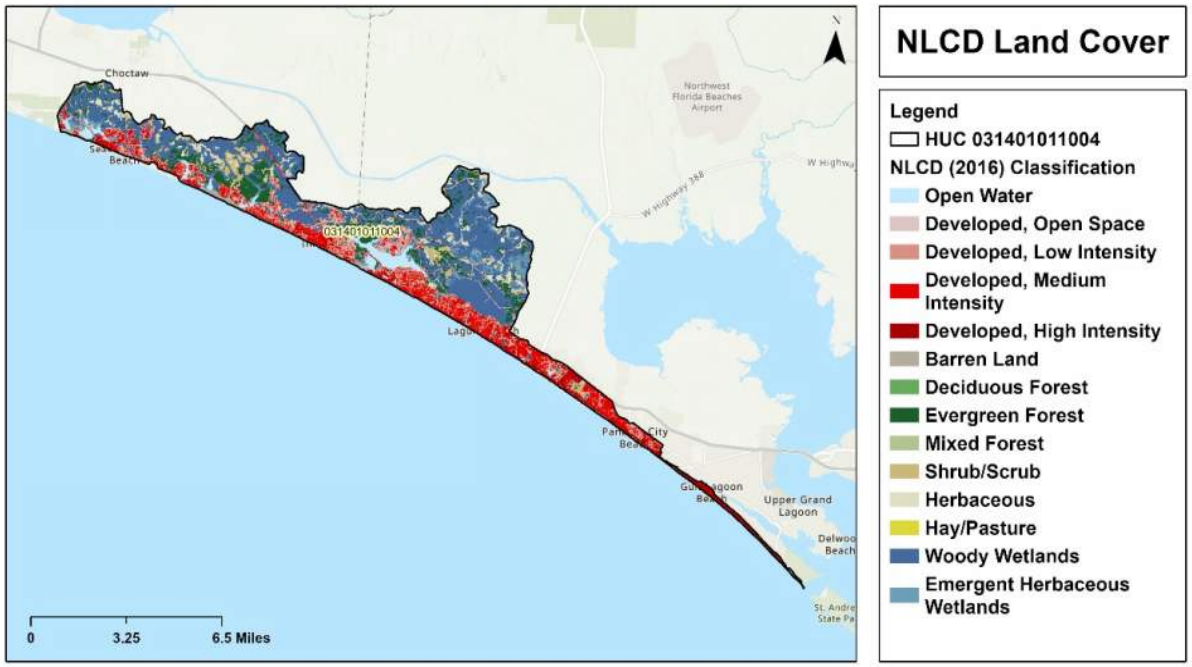

Figure 19. Land use in the HUC 031401011004 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

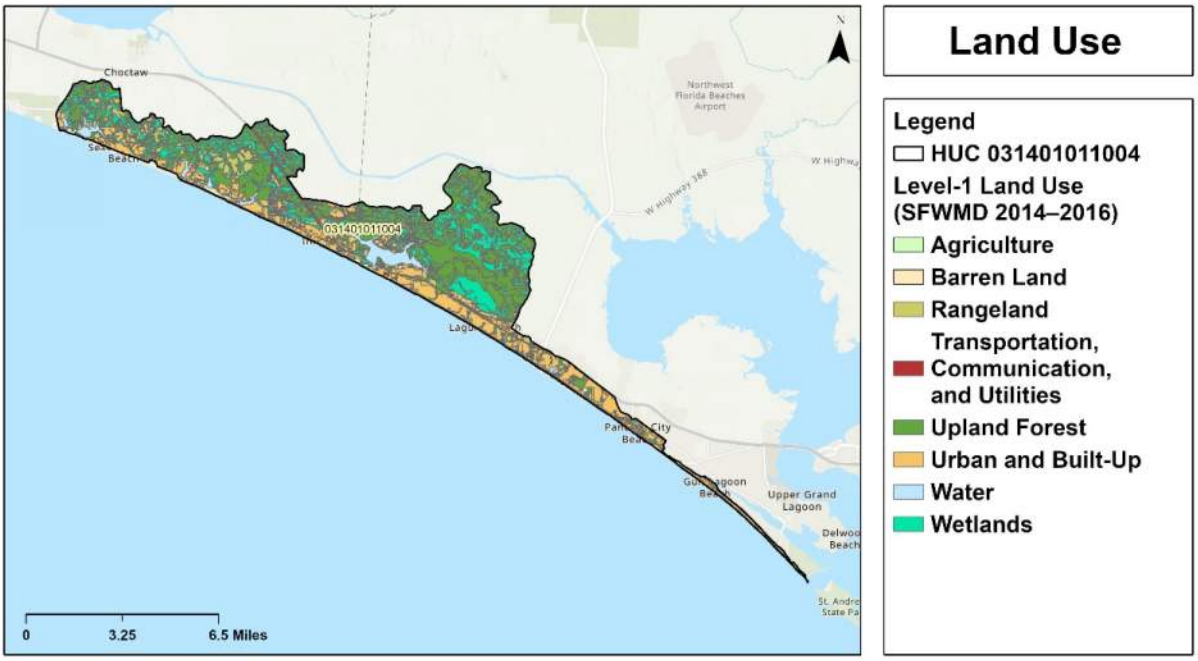

Figure 20. Land use in the HUC 031401011004 (from the 2023 Florida Geographic Data Library (FGDL)), processed by FAU.

In the 031401011004 sub-watershed, the predominant land cover is upland forest, accounting for 62.90% of the area. Urban and built-up comes in second at 13.92%, followed by wetlands at 10.80%, and rangeland at 9.73%, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

The unusual significant amount of developed land in the HUC is due to being a coastal area, encompassing communities such as Grayaton Beach, Seaside, Seacrest, Rosemary Beach, Sunnyside, Laguna Beach and a very small portion of Panama City Beach.

Table 3. Land use for HUC 031401011004 subwatershed (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	0.00	0.00%
Barren Land	593.35	1.82%
Rangeland	1342.70	4.11%
Transportation, Communication, and Utilities	1597.75	4.89%
Upland Forest	12822.04	39.25%
Urban and Built-Up	7227.06	22.12%
Water	1208.65	3.70%
Wetlands	7875.64	24.11%
Grand Total:	**32667.19**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

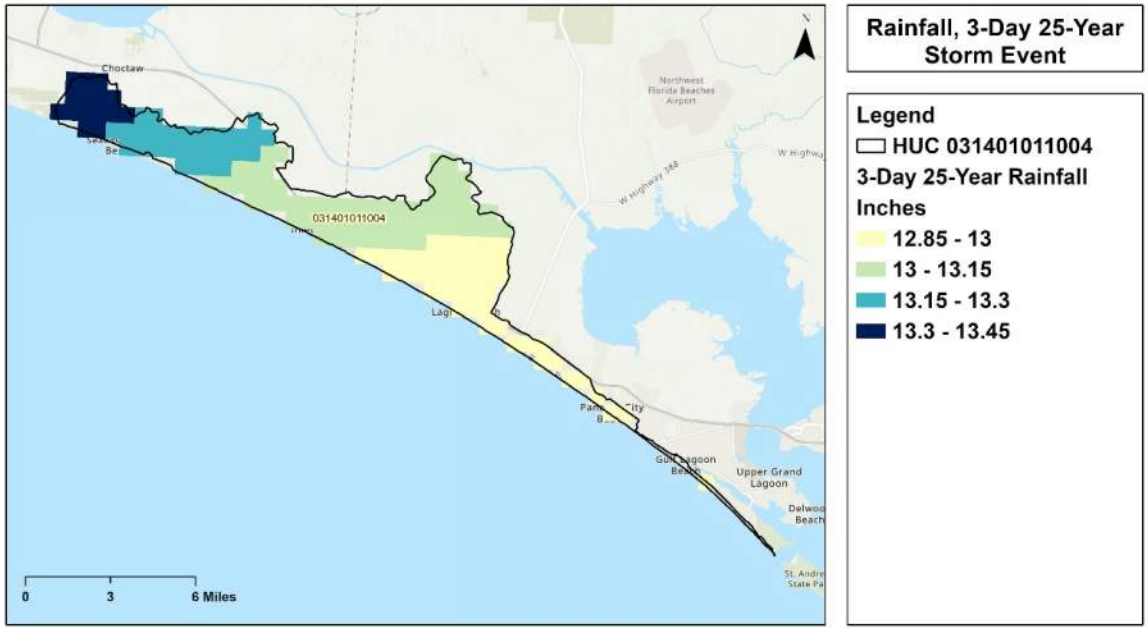

Figure 21. Rainfall distribution map across HUC 031401011004 sub-watershed, for 3-day 25-year storm event, processed by FAU.

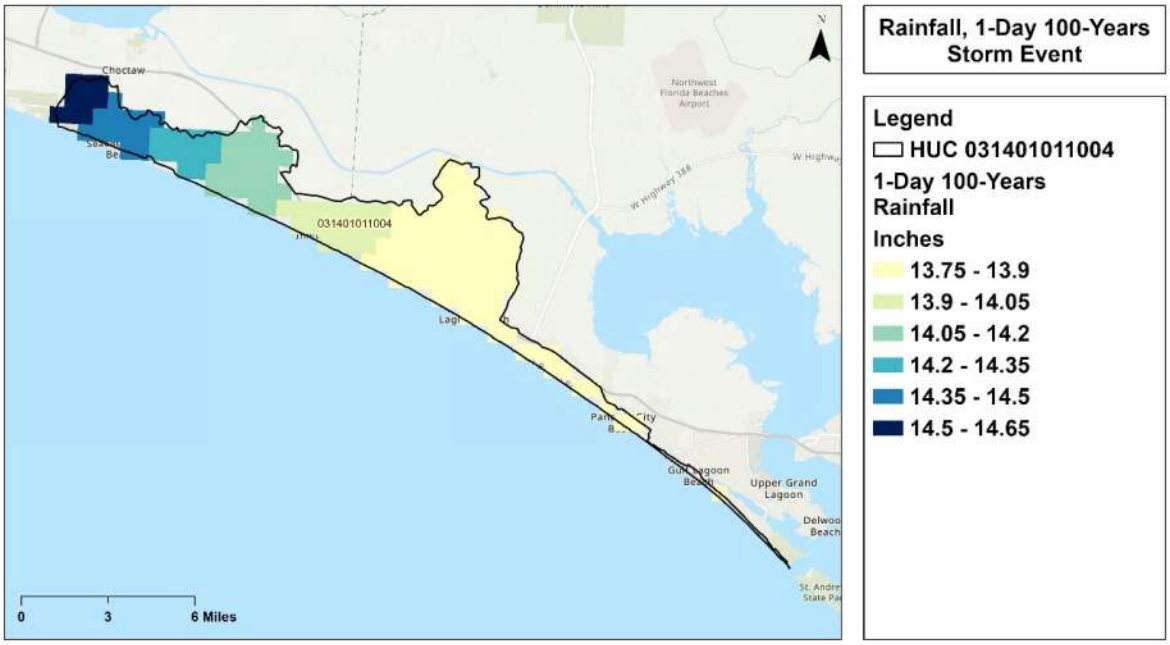

Figure 22. Rainfall distribution map across HUC 031401011004 sub-watershed, for 1-day 100-year storm event, processed by FAU.

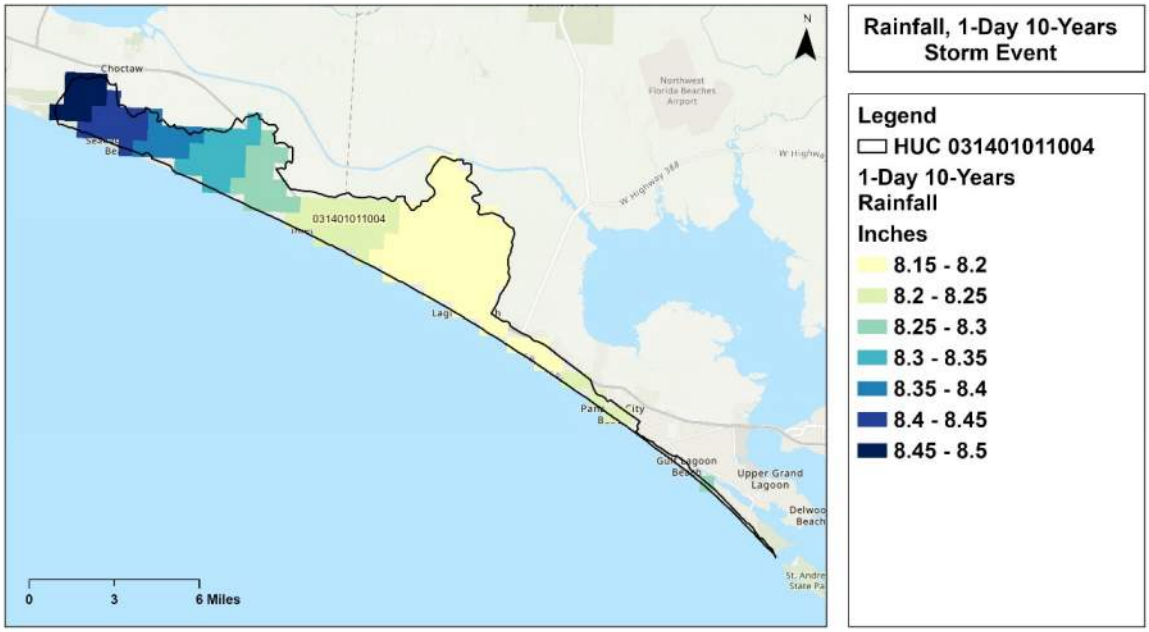

Figure 23. Rainfall distribution map across HUC 031401011004 sub-watershed, for 1-day 10-year storm event, processed by FAU.

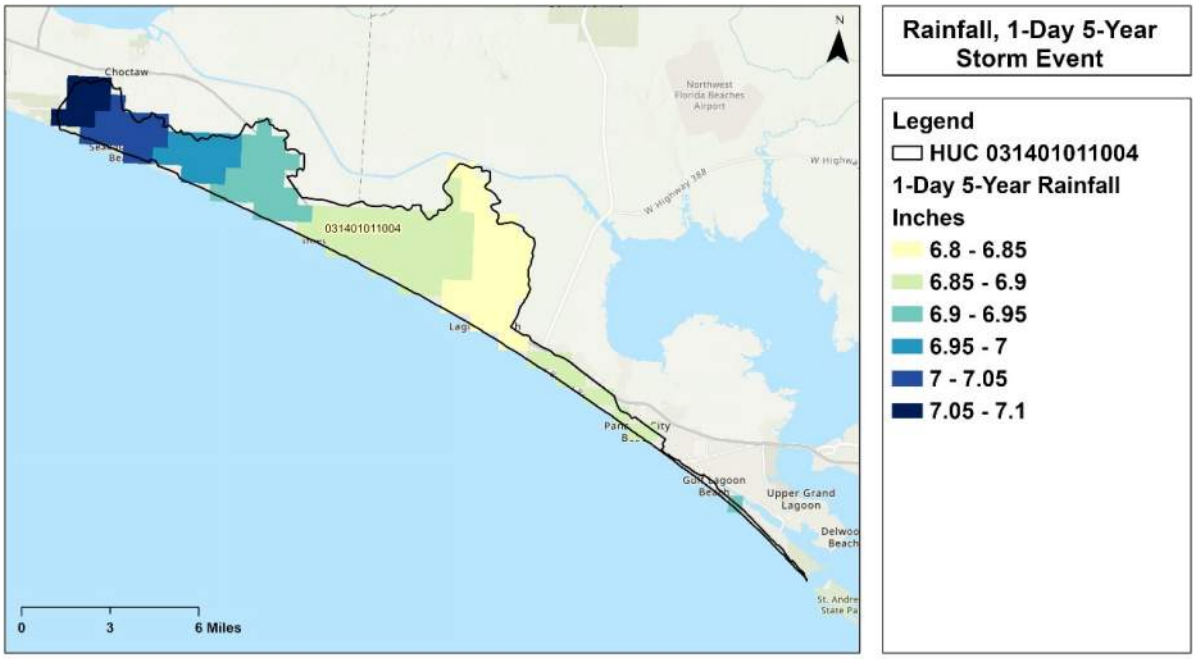

Figure 24. Rainfall distribution map across HUC 031401011004 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land

cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

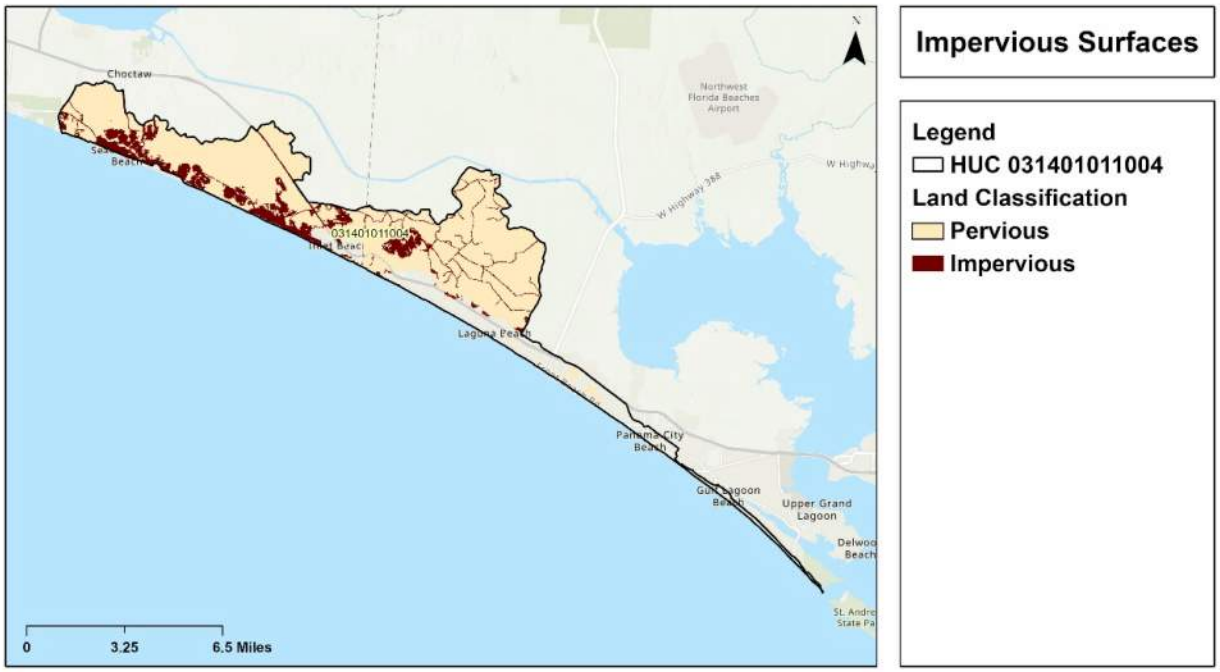

Figure 25. Impervious area map for the HUC 031401011004 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

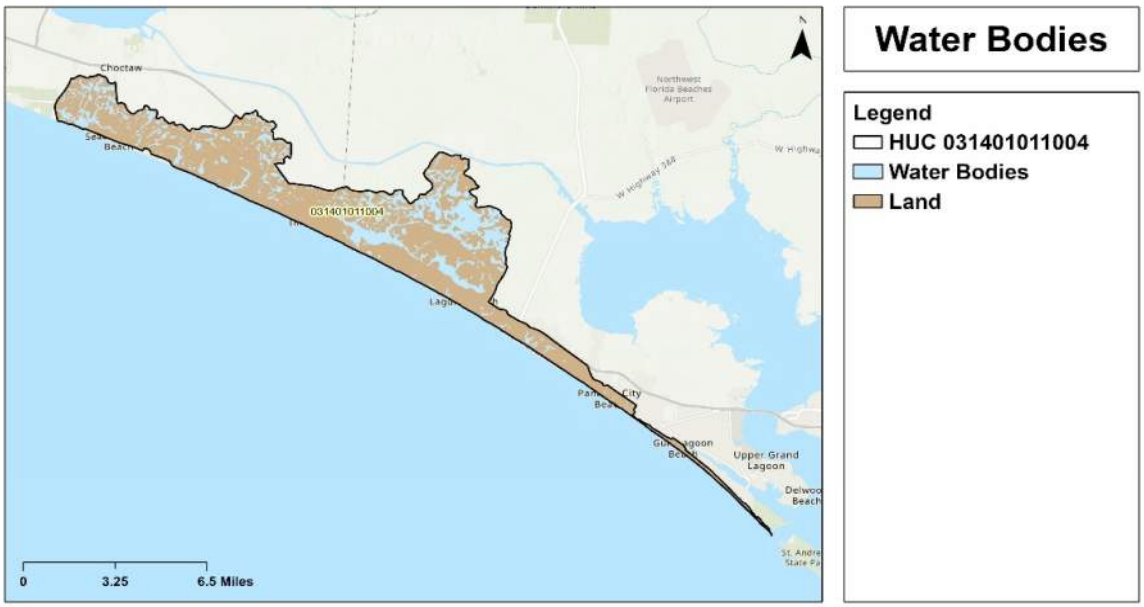

Figure 26. Water bodies map for HUC 031401011004 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

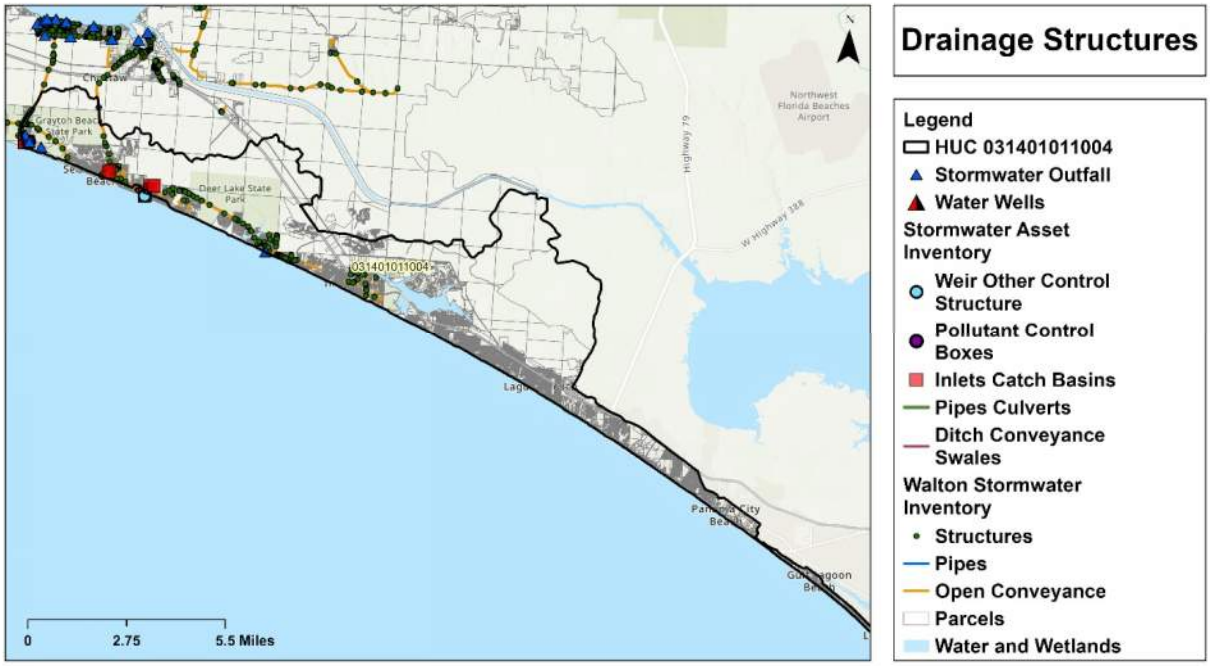

Figure 27. Stormwater Infrastructure for the HUC 031401011004. Processed by FAU.

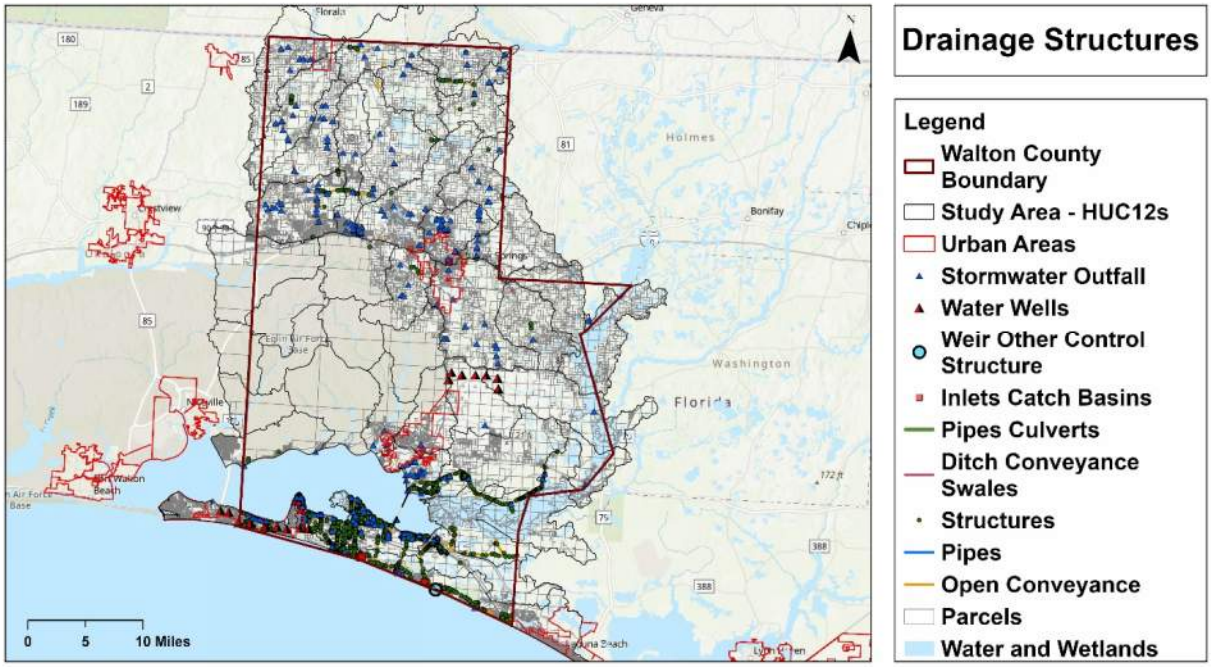

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapter 1, and analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the 031401011004 HUC12 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species

while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. Figure 29 shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

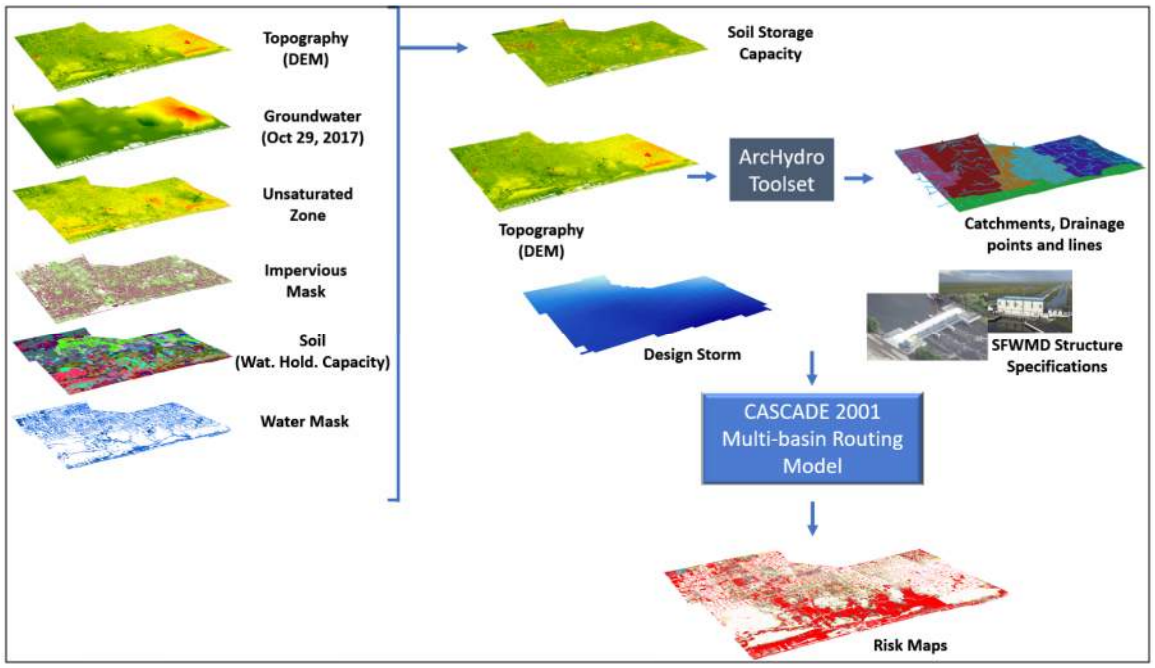

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

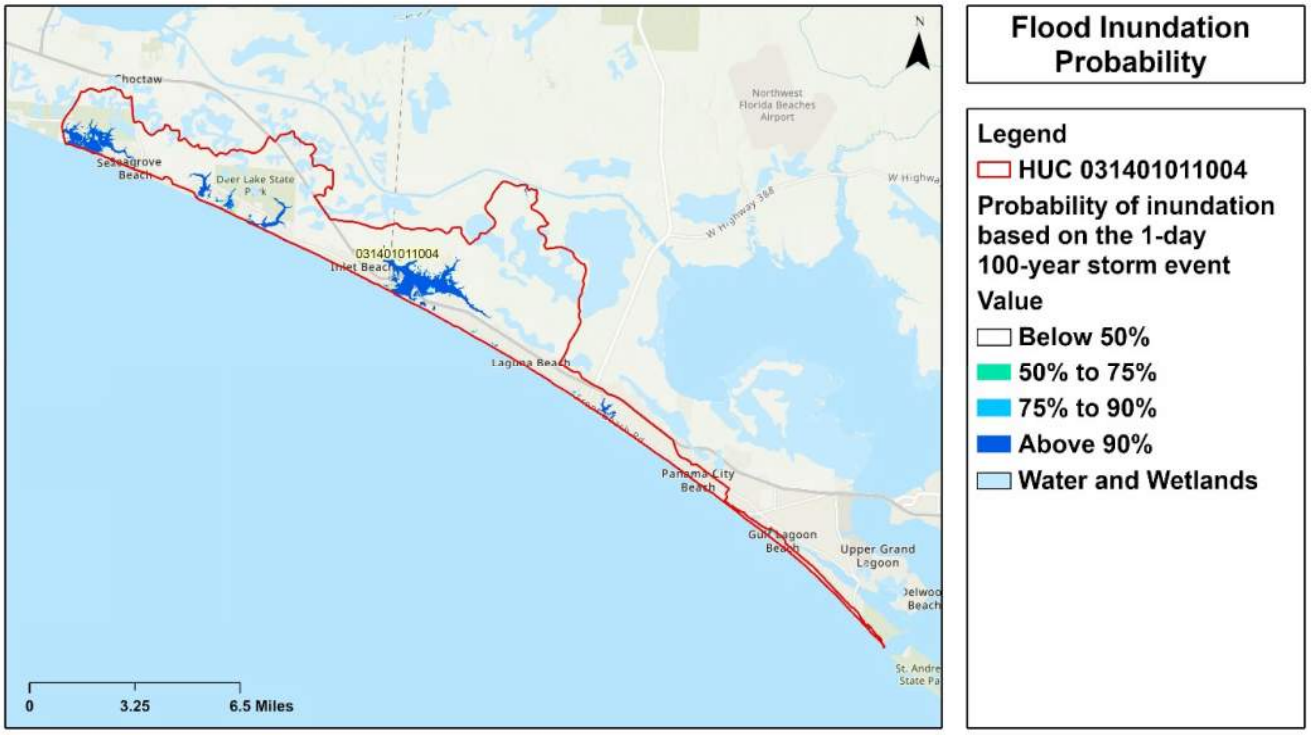

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401011004, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate

the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed later in this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not

eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Future Challenges of Sea Level Rise and Climate Change

Global observations from satellites and long-term data collection have made it possible to document and analyze patterns in the Earth's climate. Scientific analysis of the impact of these changes has helped to improve the understanding of future flood hazard driving forces and long-term impacts on human activities and watershed master planning (http://www.research.noaa.gov/climate/t_observing.html). Examples of impacts are rising global average air and ocean temperatures, increased and earlier snow and ice melt, shorter subtropical rainy seasons, shifted seasons, sea level rise and greater variations in temperature and precipitation (IPCC, 2013; Freas et al., 2008; Marshall et al., 2004; Bloetscher et al., 2010). Marshall et al. (2004) specifically focused on the Florida peninsula to predict changes in rainfall and warmer temperatures but interspersed lower low temperatures due to the potential loss of wetlands.

Future changes in climate will add to the existing impacts, at a time when the population of the state is expected to nearly double by 2030. Additional research and high-resolution climate modeling for the Florida peninsula and local jurisdictions is needed to help guide long-term plans like WMPs. Rainfall appears to be decreasing and temperatures rising (see **Error! Reference source not found.**).

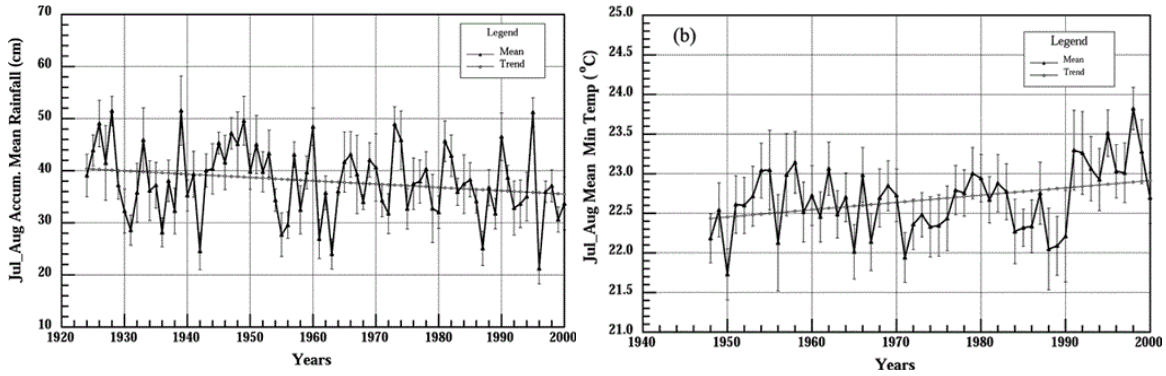

Figure 31. Change in average rainfall and change in average temp 1924 to 2000. Note the reversed trend, which means groundwater input variability is lessened. Source: Marshall et al., 2004.

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water

gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3 feet. Accompanying these drivers are potential changes in storm frequency and intensity, desertification, population migration, ocean acidification and coastal flooding (IPCC, 2007), exacerbated by the land cover and land use changes, which are substantially impacted by the fluxes, timing and quality of precipitation (Adrians et al., 2003; Scanlon et al., 2005; Marshall et al., 2004; Salmun and Molod, 2006), and leading to changes in the timing of peak flows and volumes (Richey and Costa-Cabral, 2006).

The results of these climatic changes are likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly An outcome of these climatic patterns is that during the past 140 years, an increase in sea levels has been observed (Bloetscher, 2012), a worrying pattern since sea level rise is a permanent phenomenon, that can be catastrophic to low lying areas in the long-term. The question is how much and how soon? Various studies (Bindoff et al., 2007; Domingues et al., 2008; Edwards, 2007; Gregory, 2008; Vermeer and Rahmstorf, 2009; Jevrejeva, Moore and Grinsted, 2010; Bloetscher, 2010, 2011; IPCC, 2007; Heimlich et al., 2009) indicate large uncertainty in projections of sea level rise by 2100. Gregory et al. (2012) note that during the last two decades, the global rate of sea level rise has been larger than the 20th-century time-mean, and Church et al. (2011) suggested that the cause was increased rates of thermal expansion, glacier mass loss, and ice discharge from icesheets. Gregory et al. (2012) suggested that there may also be increasing contributions to global sea level rise from the effects of groundwater depletion, reservoir impoundment, and loss of storage capacity in surface waters due to siltation. Measurements of Florida's east coast (Maul, 2008) show an average rate of sea level rise of 2.27 ± 0.04 mm per year from 1915 to 1992 based on tide gauge readings. Analyzing the tidal gauge readings for Florida shows that:

1. Florida average sea level rise is 2.10 ± 0.49 mm/yr
2. All but one location is within the 95% confidence limit range (the exception is Panama City where there is evidence of submergence and other land-based issues)
3. None of the Florida sea level rise rates differ statistically

4. Average global sea level rise for 1920-2000 was 2.0 mm/yr – within 95% confidence limit for Florida locations

From 1929 to 1992, over eight inches of sea, with another 6 inches added since 1992, which is already having significant impacts on coastal communities where population growth has increased the need for improved flood management strategies (Bloetscher, 2008; Parkinson, 2010; Zhang et al., 2011, 2011a; NFIP, 2011; Schmidt et al., 2011; Warner et al., 2012).

As a result, the SFRCCC (2015) adopted USACE's methodology to derive scenarios of sea level change intermediate to high rates of sea level rise for years 2030 (3" to 7") and 2060 (9" to 24") as the consensus projection to guide future planning. The path keeps increasing – now 14 inches since 1929 (**Error! Reference source not found.**) caused by thermal expansion of the ocean and melting ice caps (Jevrejeva et al., 2010; Vermeer and Rahmstorf, 2009). Sea level rise is a major concern in Florida, including Walton County, since the majority of the state's population live on the coast, involving most major commercial, residential, and economic enterprises. Figure 32demonstrate the estimated sea level change for Panama City, considering the predictions of NOAA 2017. For NOAA high scenario SLR change scenario, the estimated level change is higher than 8 ft., while for the intermediate and low scenarios are about 3.9 feet and 1.7 feet respectively.

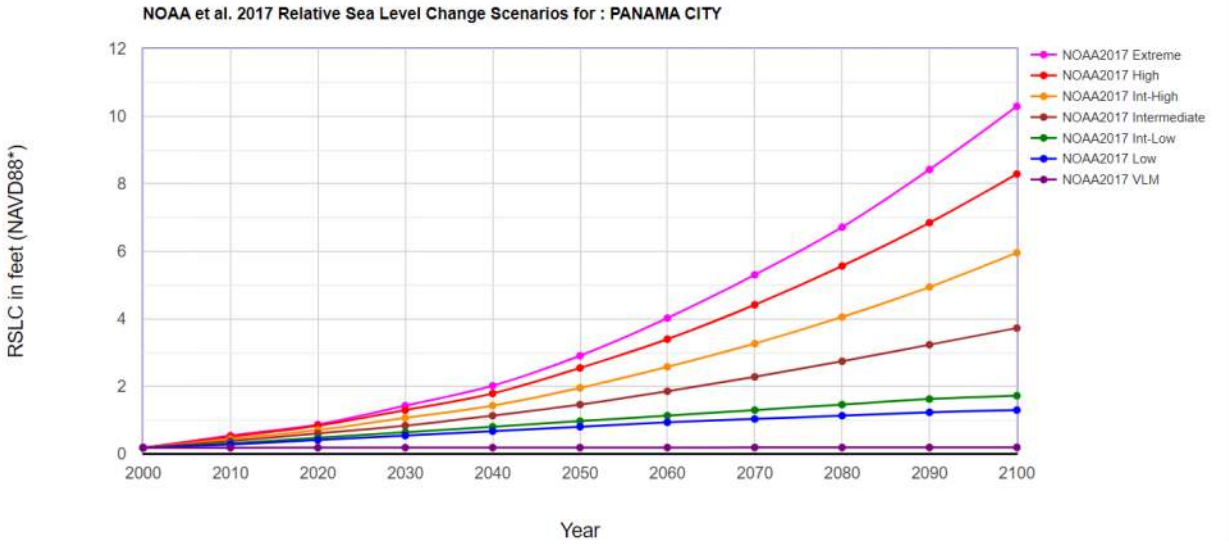

Figure 32. Relative Sea Level Change Scenarios for gauge 8729108, Panama City, FL. Source: NOAA, 2017 (https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html).

NOAA (2017) outlines five scenarios for sea level rise. The NFIP proposes the use of the intermediate high projection, which is 1.2 meters or 4 ft globally from current sea level elevations (**Error! Reference source not found.**).

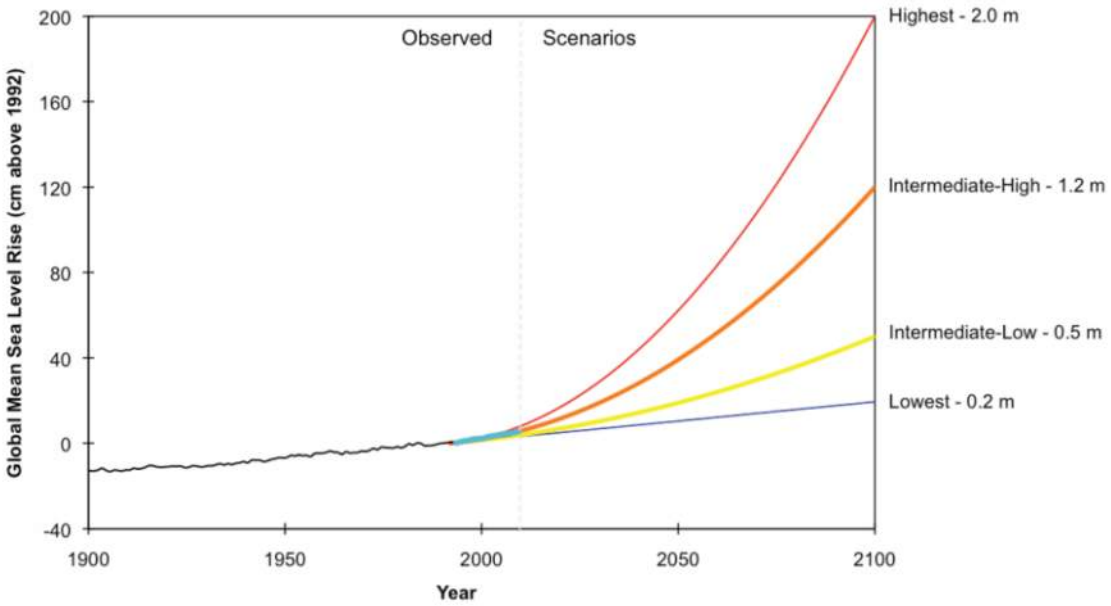

Figure 33. Graphic of global sea level rise projections.
Source: NOAA, 2017
(https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf)

As sea level rises, access to roads, bridges, rail, and transit could be at risk of flooding, causing the effects of sea level rise to spread indirectly throughout the entire transportation network, affecting the overall system performance. For example, the flooding of a critical road or facility access can cause a shifting of traffic flow causing congested conditions in other roadways that are not actually flooded. Since the roadway network would be unable to carry the traffic demand, the system would experience operational failure; as a result, causing travel times and delays. Moreover, the inundation of a critical access could cause transportation connectivity problems to essential infrastructure like ports or airports. Transportation infrastructure relies on the effectiveness of flood control and stormwater drainage systems for the transportation corridors. Road integrity relies on adequate drainage. The increased risk of severe flooding in Florida's low-lying terrain can adversely affect transportation infrastructure along the coastline; roads can be inundated, and roadway beds can be damaged. Sea level rise will cause increased water table levels (FDOT, 2012), as regional water tables cannot exist naturally below mean high tide (2 feet in Florida). Adding 3 feet of sea level rise on top of groundwater would compound the risk of flooding in low-lying areas. Road bases below 5 feet NVGD would become saturated under this scenario, likely causing premature base failure. As soil storage capacity is diminished due to rising groundwater elevations associated with sea level rise, the potential for more frequently flooded roadways would likely damage pavements (FDOT, 2012). Hence sea level rise must be accounted for in WMPs in coastal areas. To allow flexibility in the analysis due to the range of increases within the different time periods, an approach that uses incremental increases of 1, 2, and 3 feet of

sea level rise is suggested for modeling. The increments can work as threshold values in planning considerations in terms of allowing planners the ability to know ahead of time where the next set of vulnerable areas will be, to allow for a proactive response approach that can be matched to the observed future rates. Sea level rise is a major concern since nearly half the US population lives within 50 miles of the coast, involving most major commercial, residential, and economic enterprises. The effects of 5 ft sea level rise, King tide, and 1-day 100-year storm event are shown in **Error! Reference source not found.**.

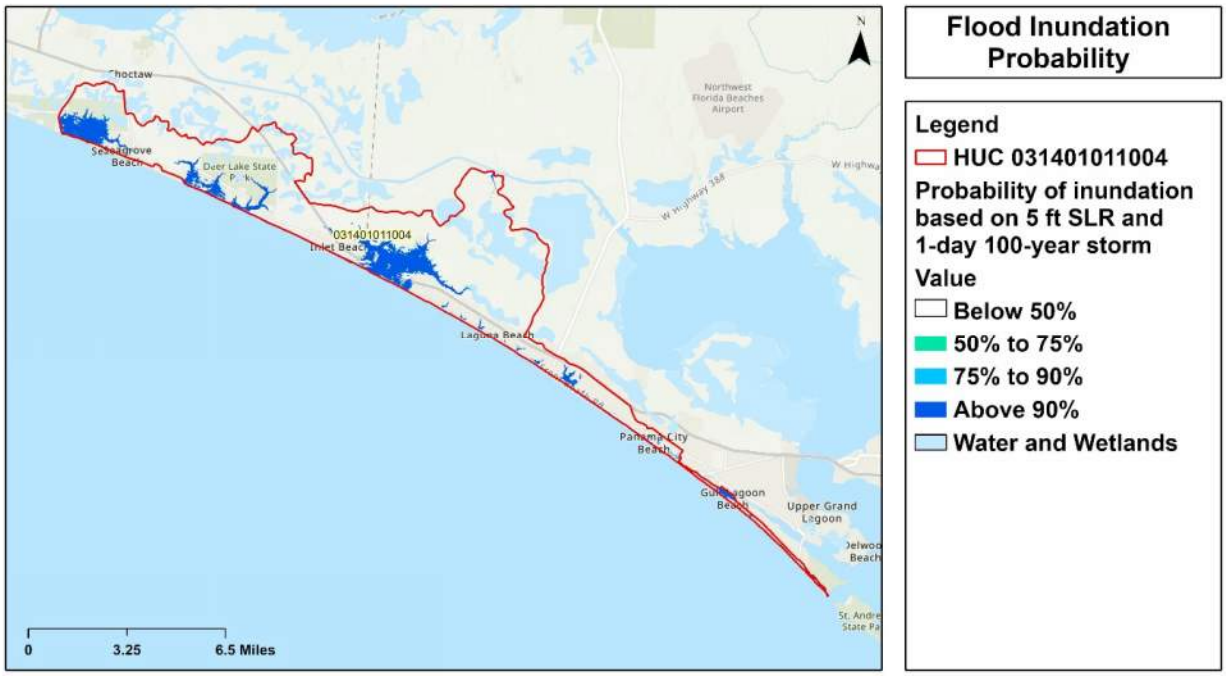

Figure 34. Flood Inundation Probability for a Sea level rise of 5 ft + 1-day 100-year storm event for HUC 031401011004 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Dark blue is area under 5 ft NAVD88 and potentially inundated at the 99th percentile tidal conditions. Processed by FAU.

2.4 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. **3-day 25-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 35)
2. **1-day 100-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 36)

3. **1-day 10-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 37)
4. **1-day 5-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 38)
5. **Sea level rise of 1 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 39)
6. **Sea level rise of 1 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations storm (Figure 40)
7. **Sea level rise of 1 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 41)
8. **Sea level rise of 1 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 42)
9. **Sea level rise of 2 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 43)
10. **Sea level rise of 2 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 44)
11. **Sea level rise of 2 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 45)
12. **Sea level rise of 2 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 46)
13. **Sea level rise of 3 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 47)
14. **Sea level rise of 3 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 48)
15. **Sea level rise of 3 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 49)
16. **Sea level rise of 3 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 50)

17. **Sea level rise of 4 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 51)
18. **Sea level rise of 4 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 52)
19. **Sea level rise of 4 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 53)
20. **Sea level rise of 4 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 54)
21. **Sea level rise of 5 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 55)
22. **Sea level rise of 5 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 56)
23. **Sea level rise of 5 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 57)
24. **Sea level rise of 5 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 58)

In all cases, a good amount of flooding is noted along the major waterbodies. As this basin connects to the ocean though Gulf of Mexico, SLR scenarios plays an important hole, implying a considered growth as the projected scenario of rising tides rises.

The design storm simulation determined that approximately 7.0% of the HUC total area or 3.10 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 7.3% of the HUC's total area, or 3.22 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 6.6% of the HUC's total area, or 2.94 mi^2, would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 6.5% of the HUC's total area, or 2.87 mi^2, would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401011004 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	41.11	3.10	93.0%	7.0%
1-day 100-year	40.99	3.22	92.7%	7.3%
1-day 10-year	41.28	2.94	93.4%	6.6%
1-day 5-year	41.34	2.87	93.5%	6.5%

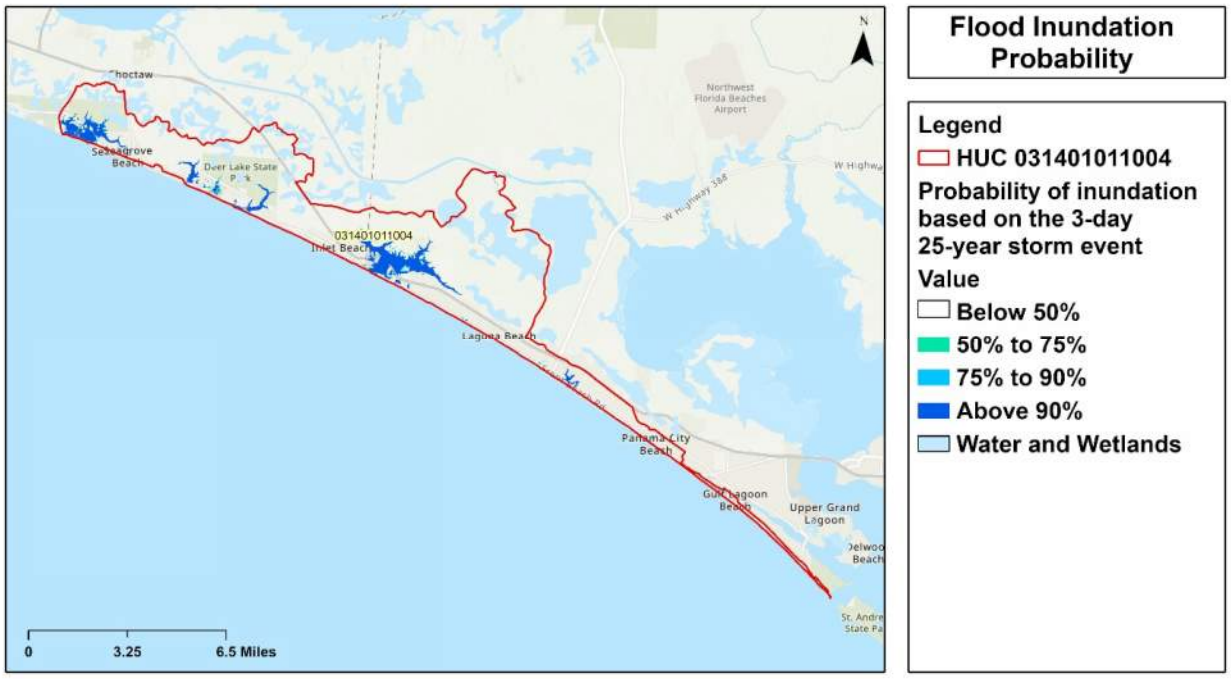

Figure 35. 3-day 25-year storm event for HUC 031401011004 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

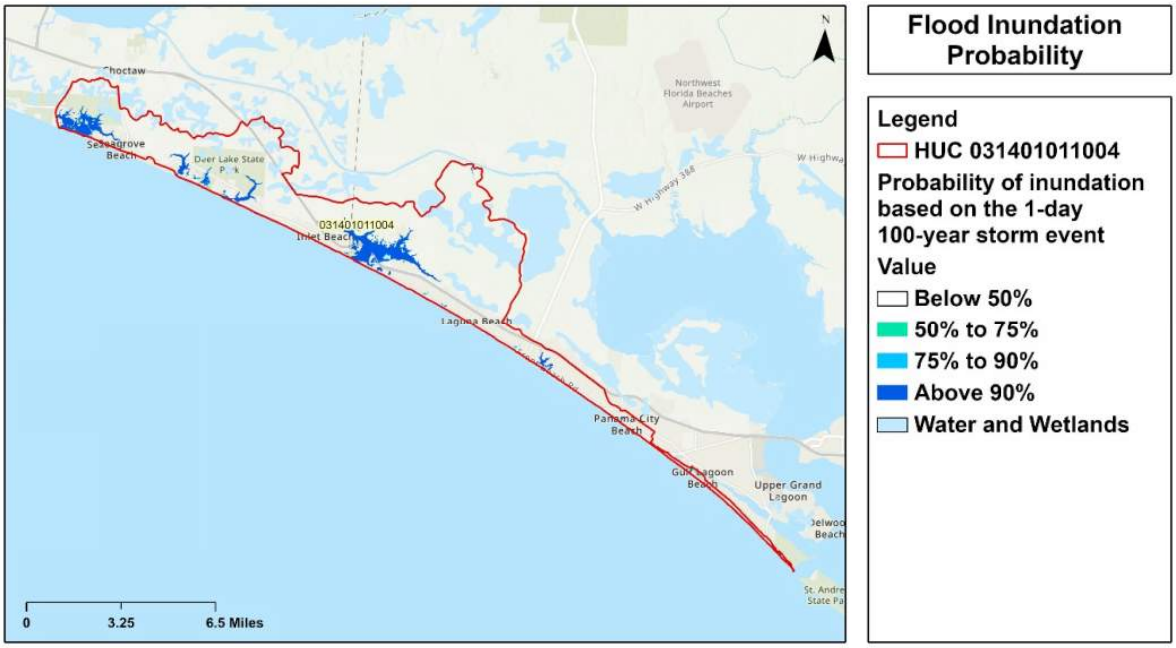

Figure 36. 1-day 100-year storm event for HUC 031401011004 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

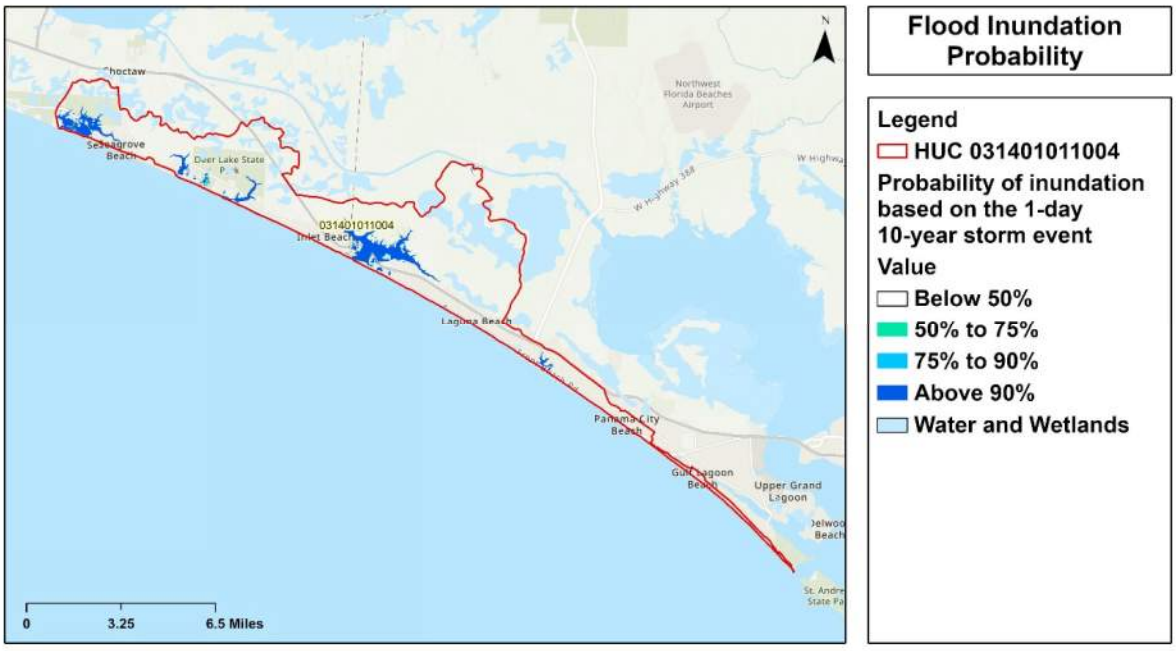

Figure 37. 1-day 10-year storm event for HUC 031401011004 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

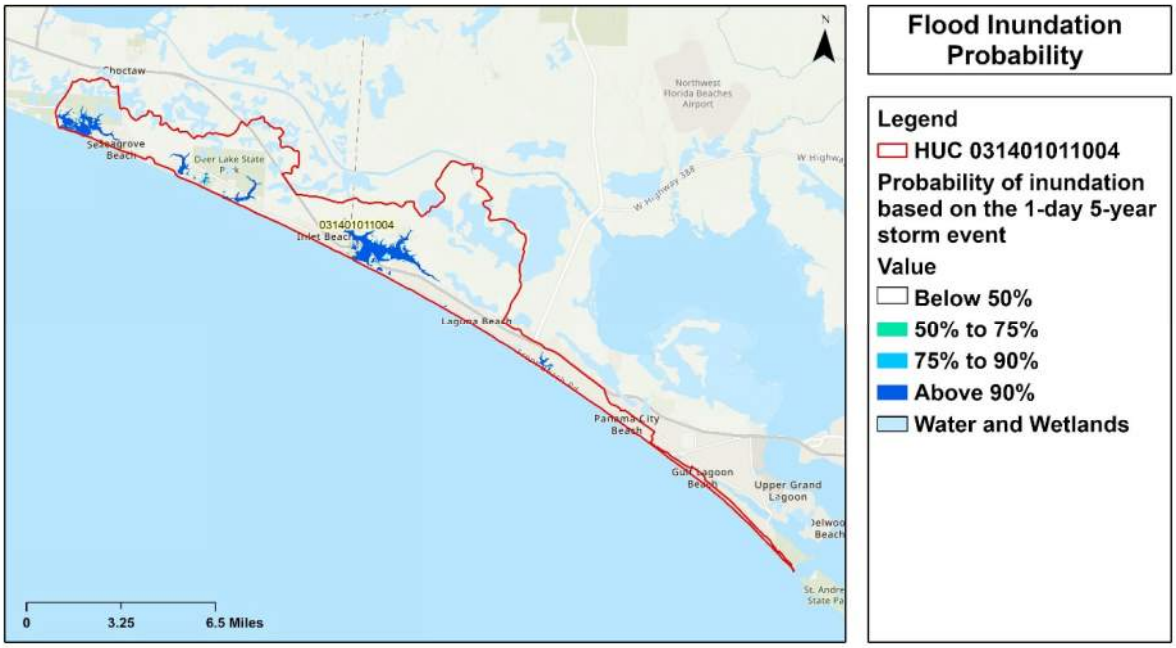

Figure 38. 1-day 5-year storm event for HUC 031401011004 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

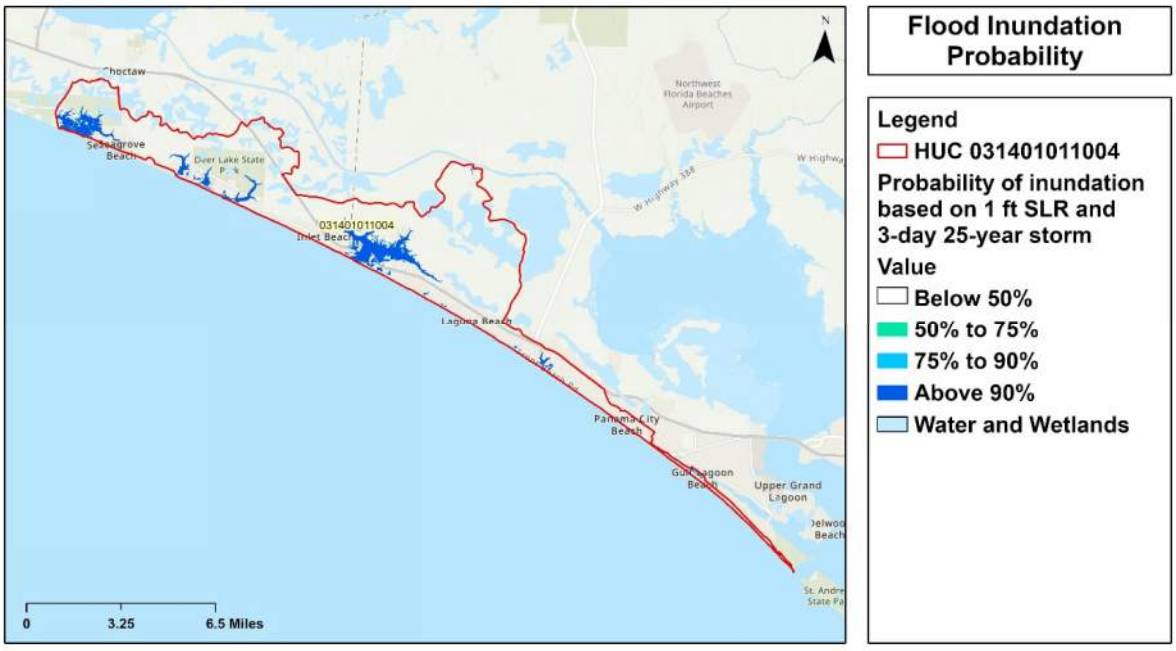

Figure 39. Sea level rise of 1 ft + 3-day 25-year storm for HUC 031401011004 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

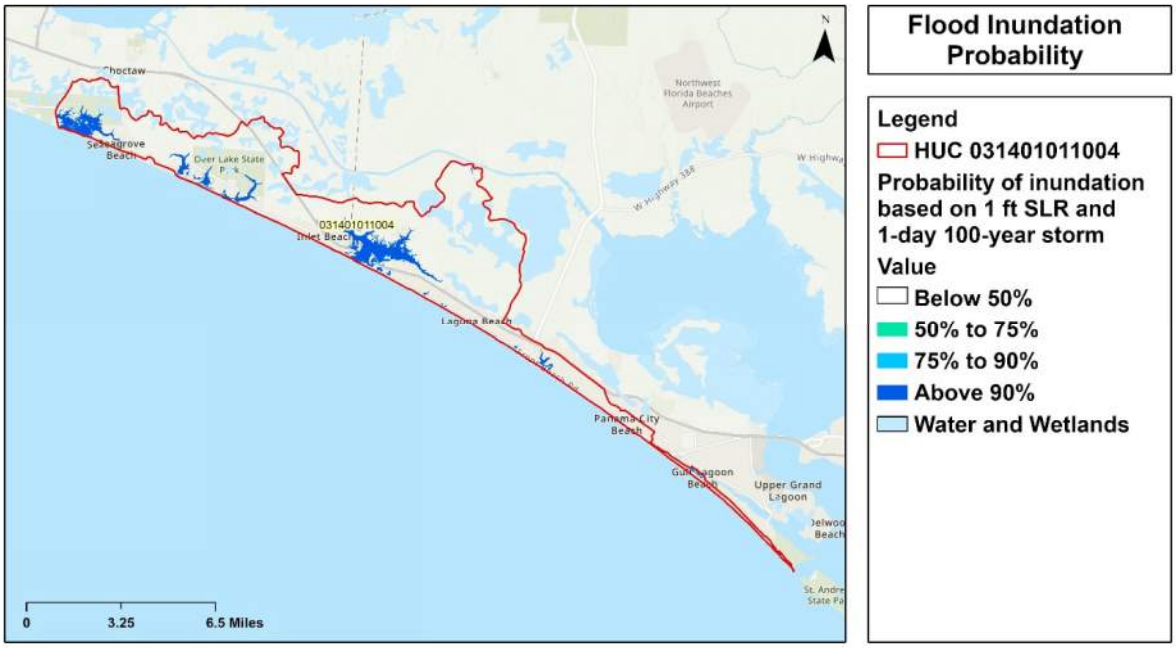

Figure 40. Sea level rise of 1 ft + 1-day 100-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

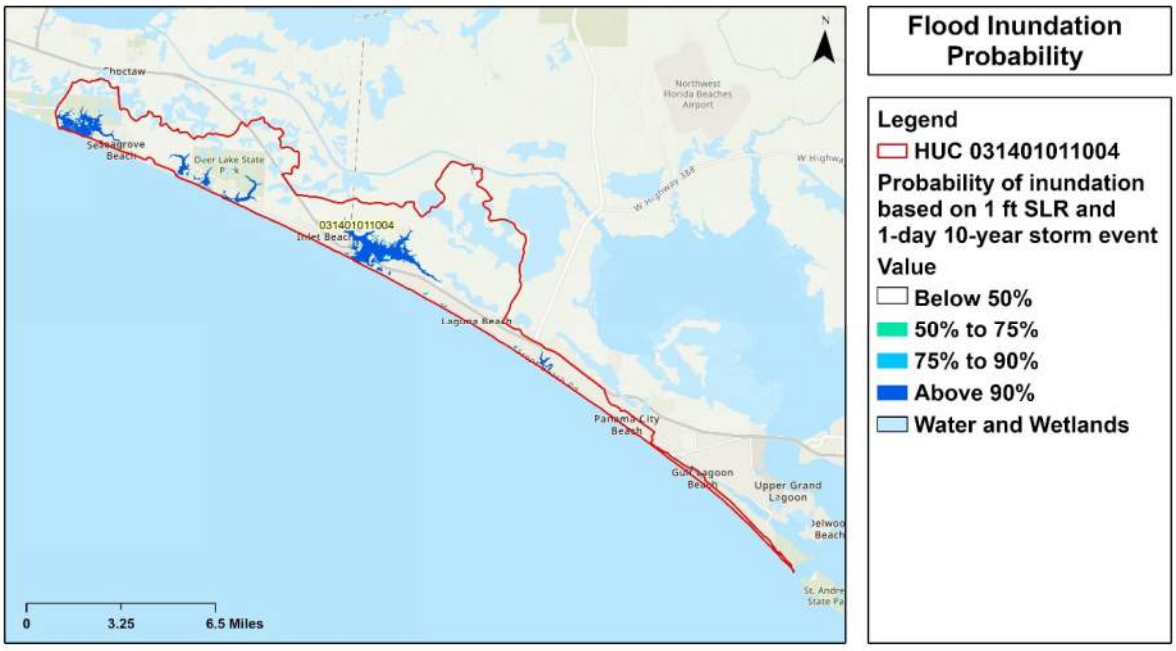

Figure 41. Sea level rise of 1 ft + 1-day 10-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

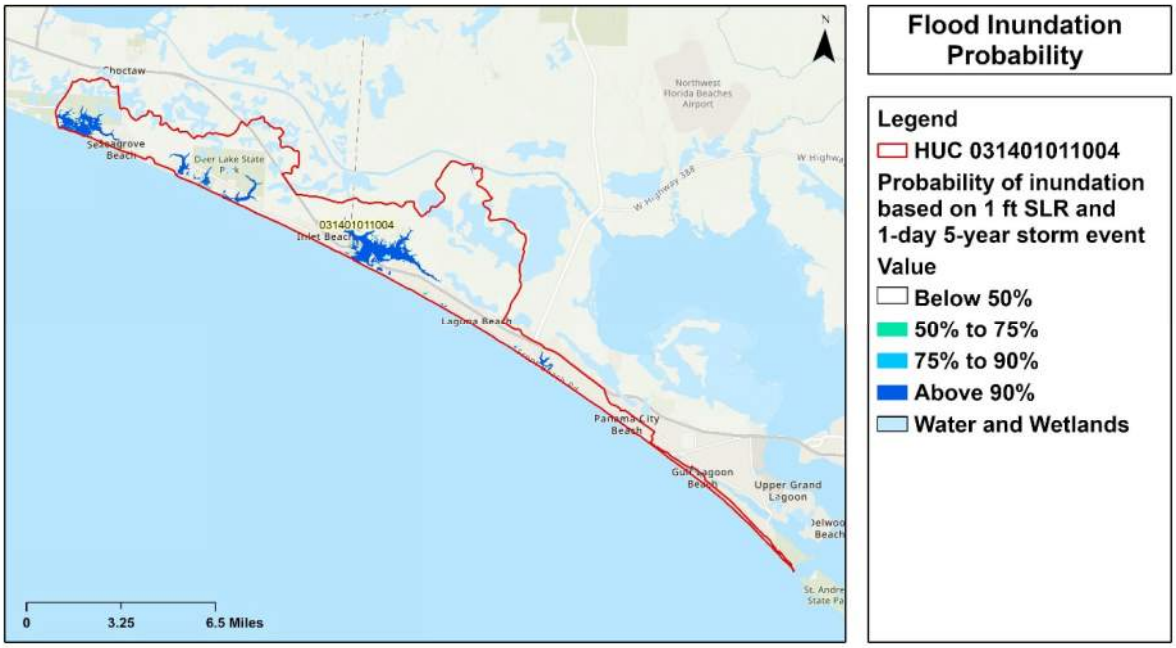

Figure 42. Sea level rise of 1 ft + 1-day 5-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

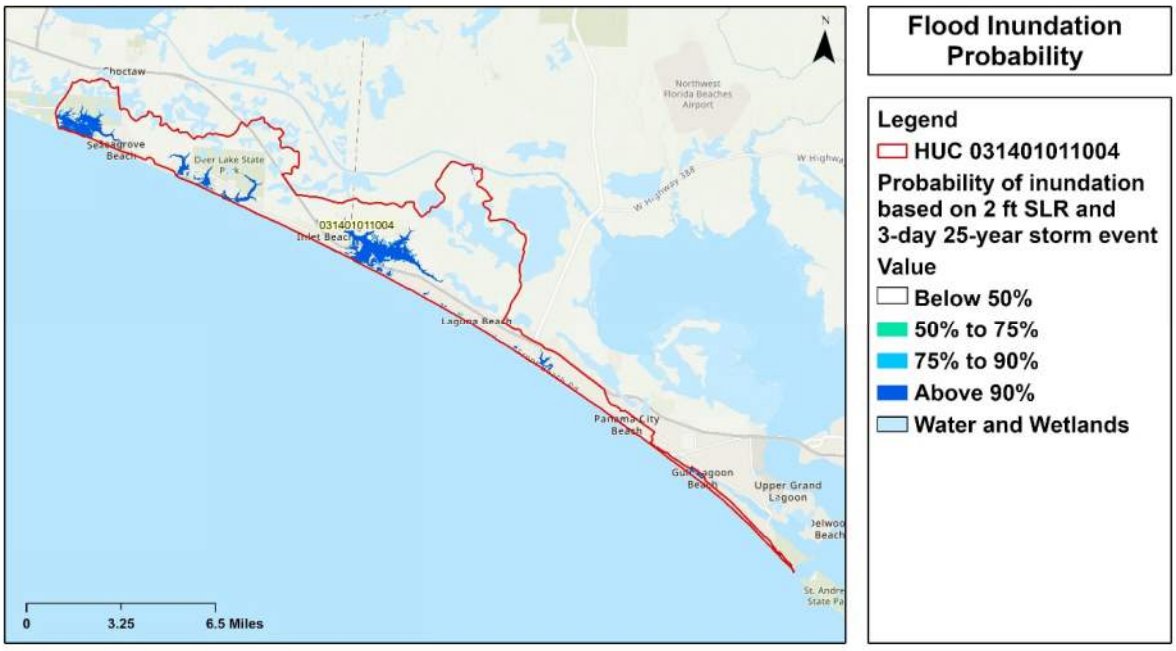

Figure 43. Sea level rise of 2 ft + 3-day 25-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

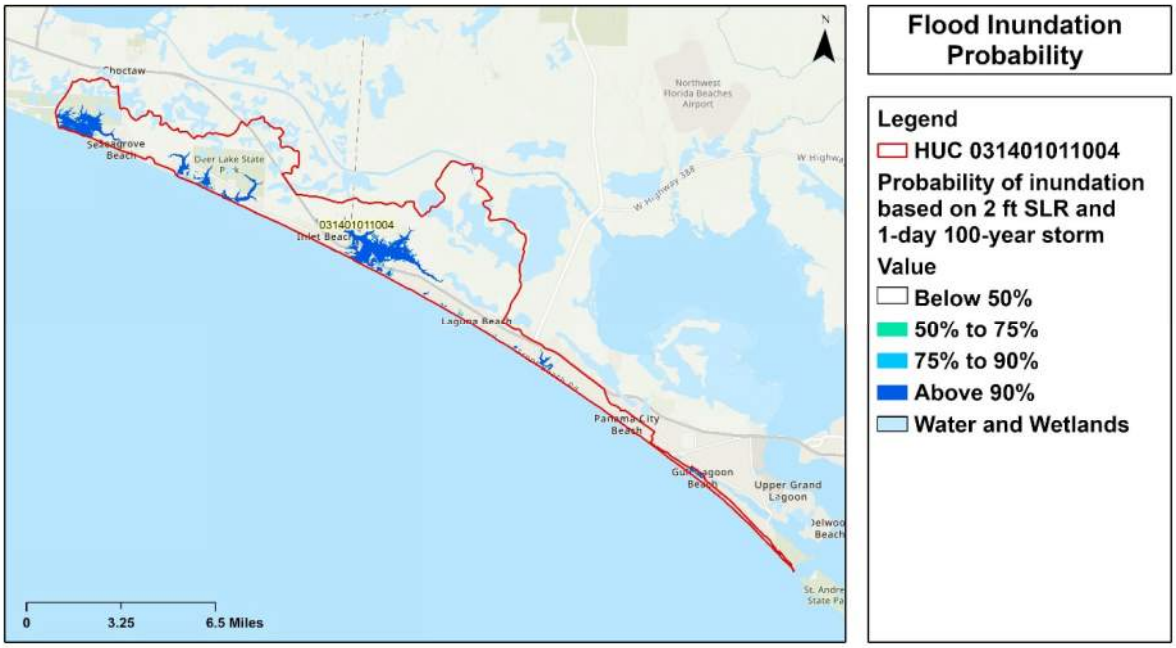

Figure 44. Sea level rise of 2 ft + 1-day 100-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

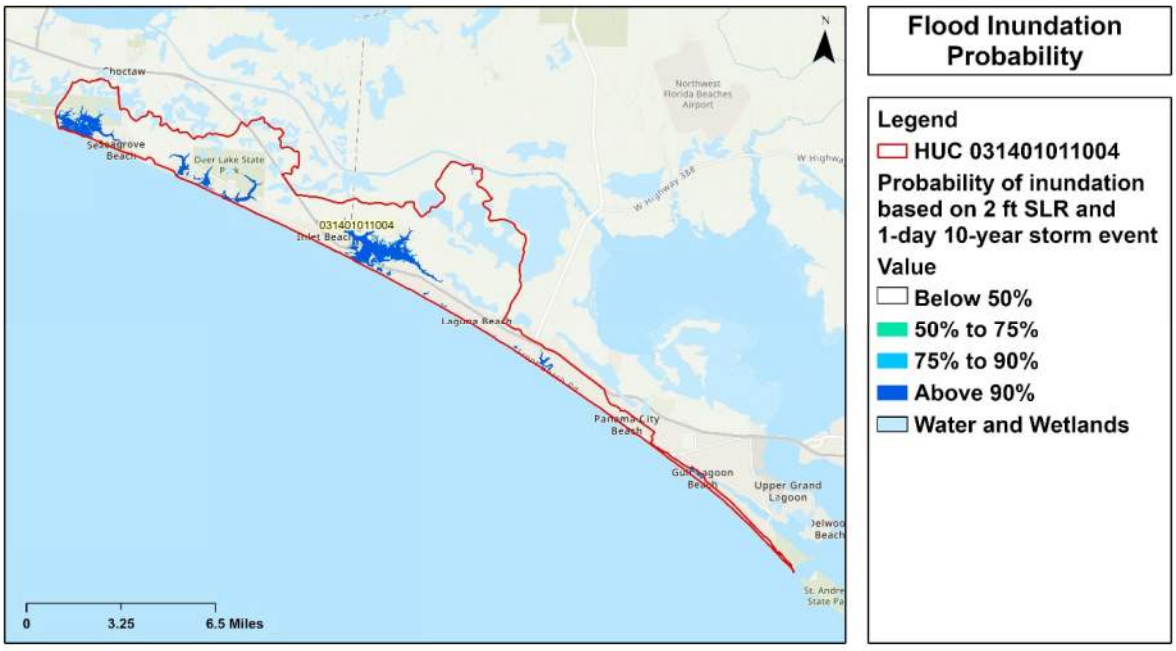

Figure 45. Sea level rise of 2 ft + 1-day 10-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

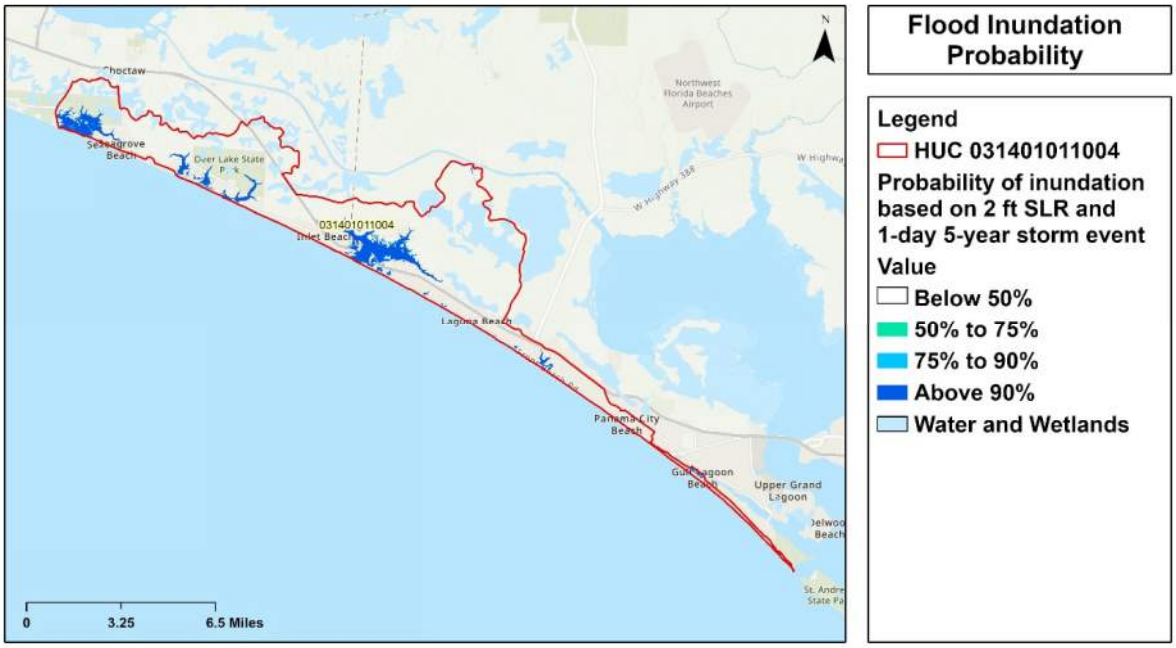

Figure 46. Sea level rise of 2 ft + 1-day 5-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

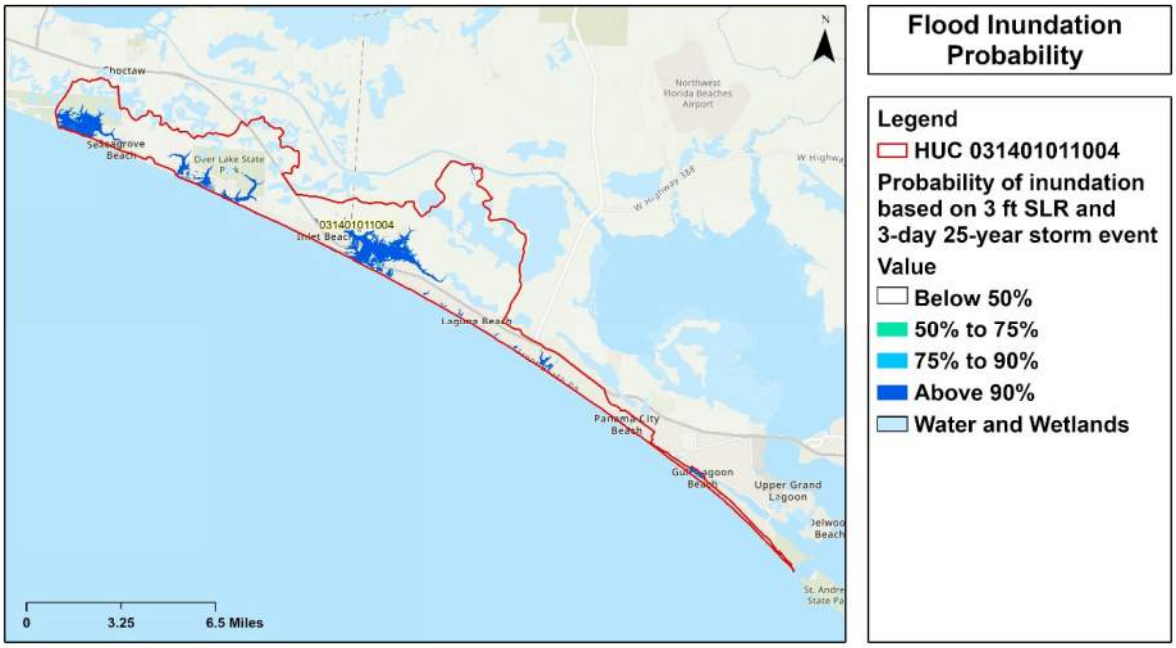

Figure 47. Sea level rise of 3 ft + 3-day 25-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

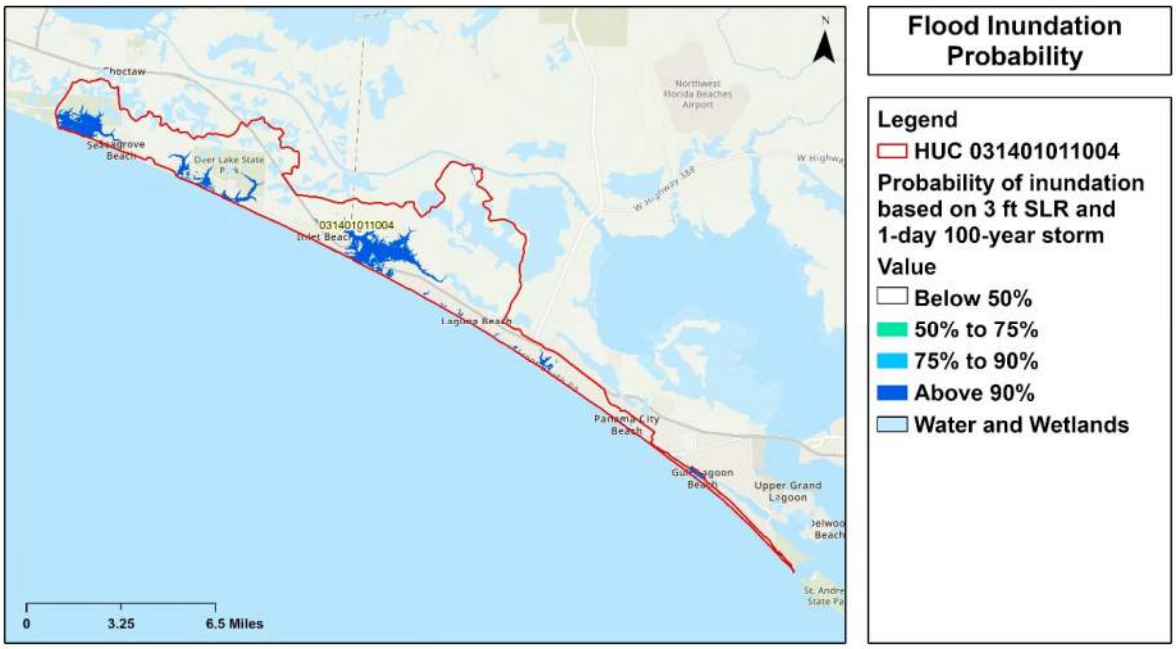

Figure 48. Sea level rise of 3 ft + 1-day 100-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

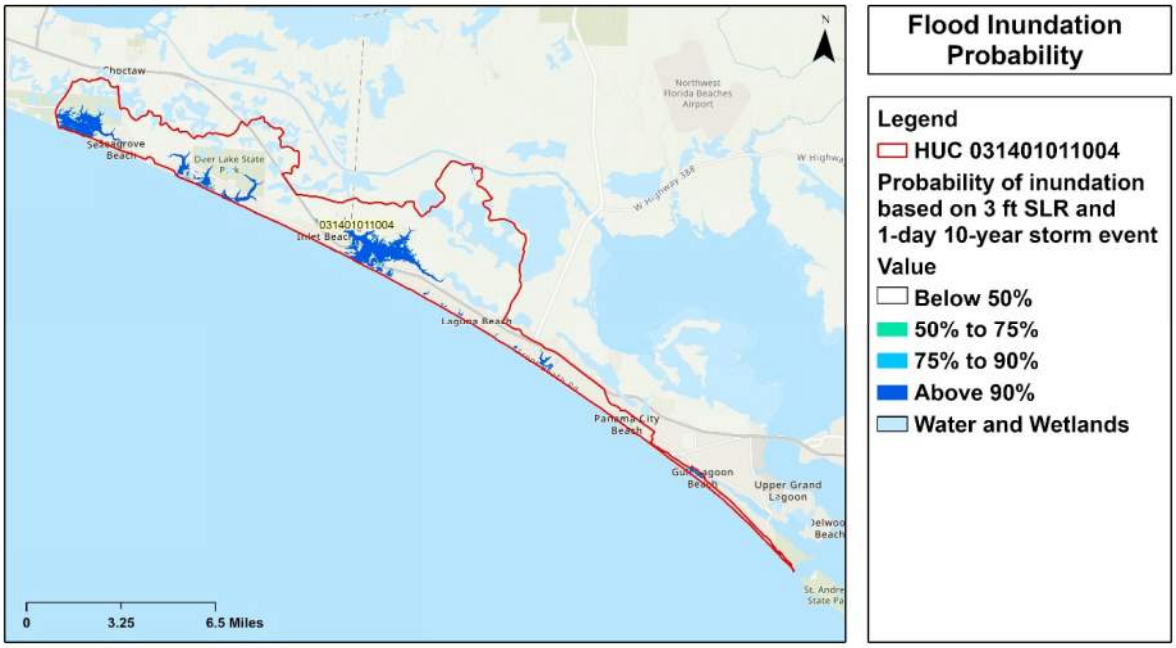

Figure 49. Sea level rise of 3 ft + 1-day 10-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

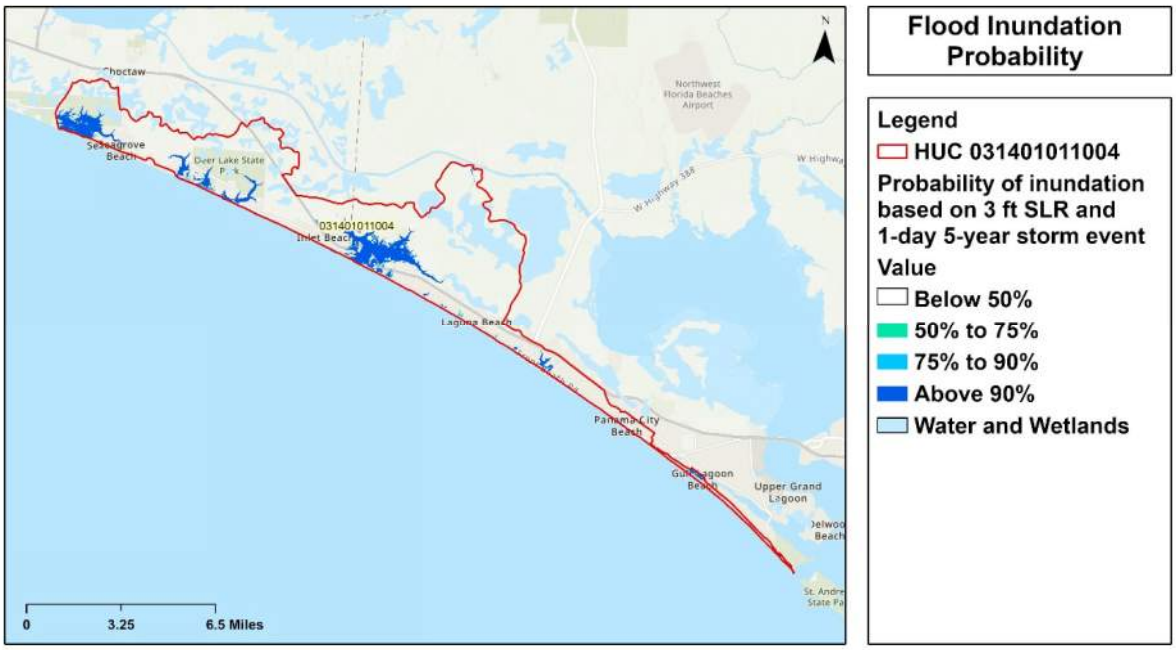

Figure 50. Sea level rise of 3 ft + 1-day 5-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

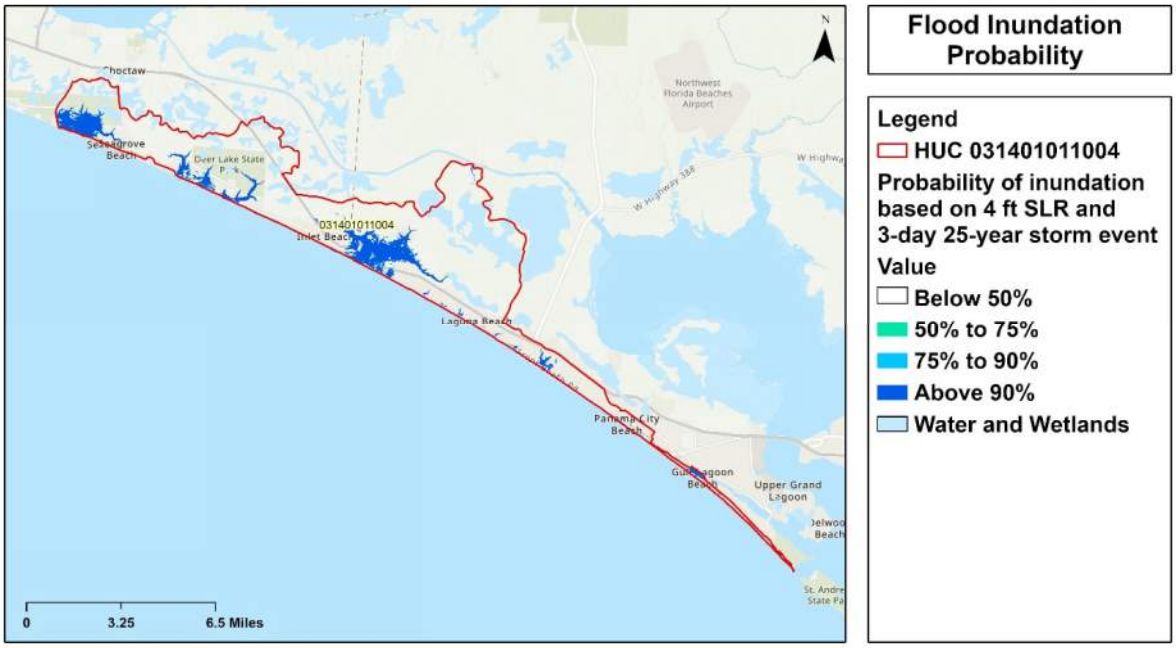

Figure 51. Sea level rise of 4 ft + 3-day 25-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

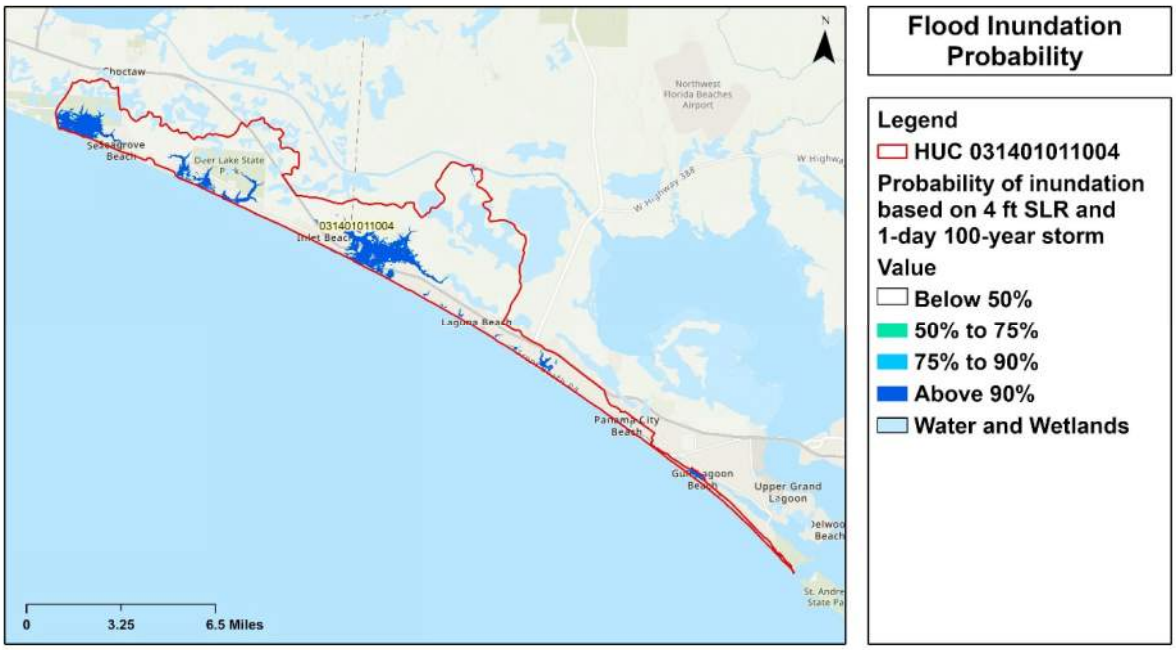

Figure 52. Sea level rise of 4 ft + 1-day 100-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

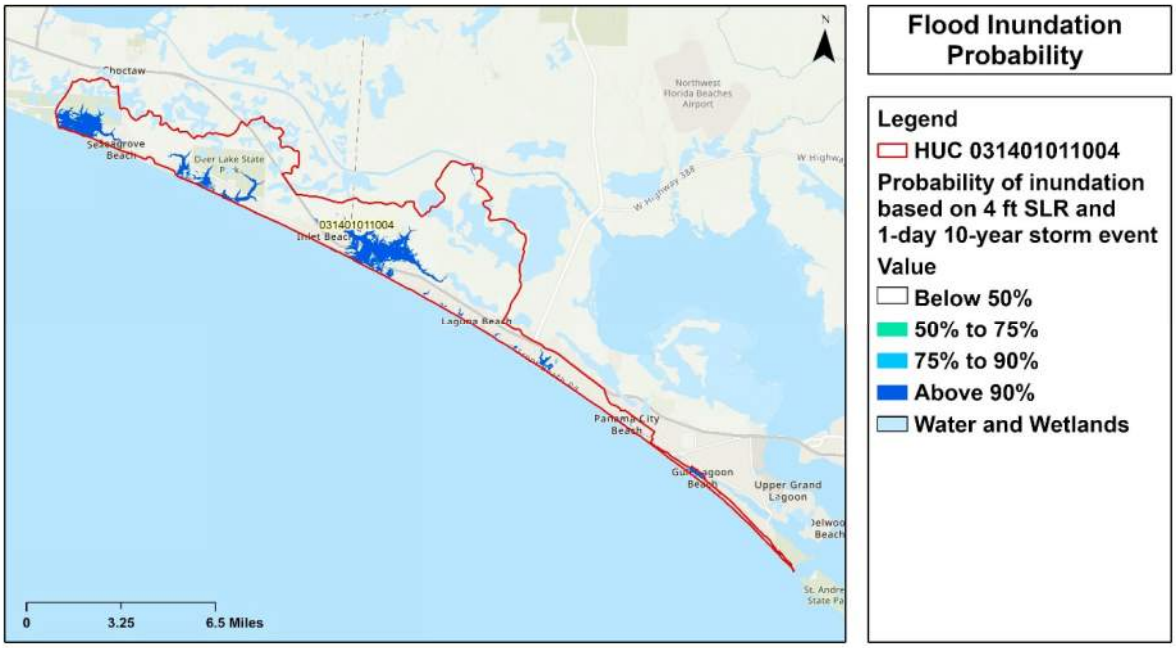

Figure 53. Sea level rise of 4 ft + 1-day 10-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

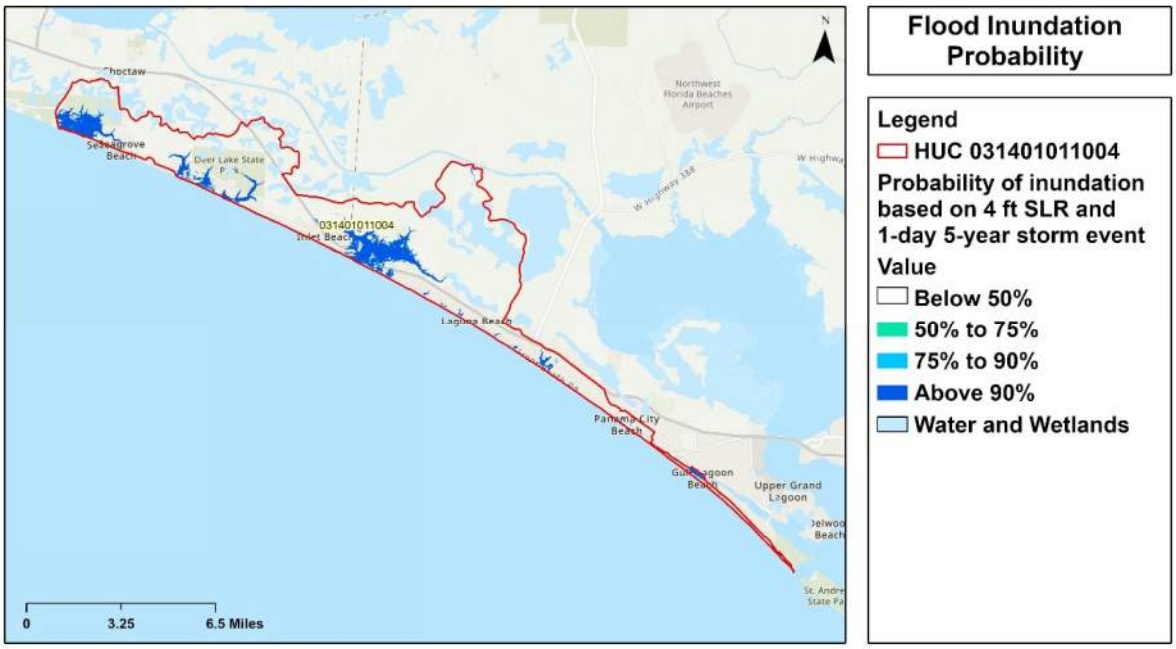

Figure 54. Sea level rise of 4 ft + 1-day 5-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

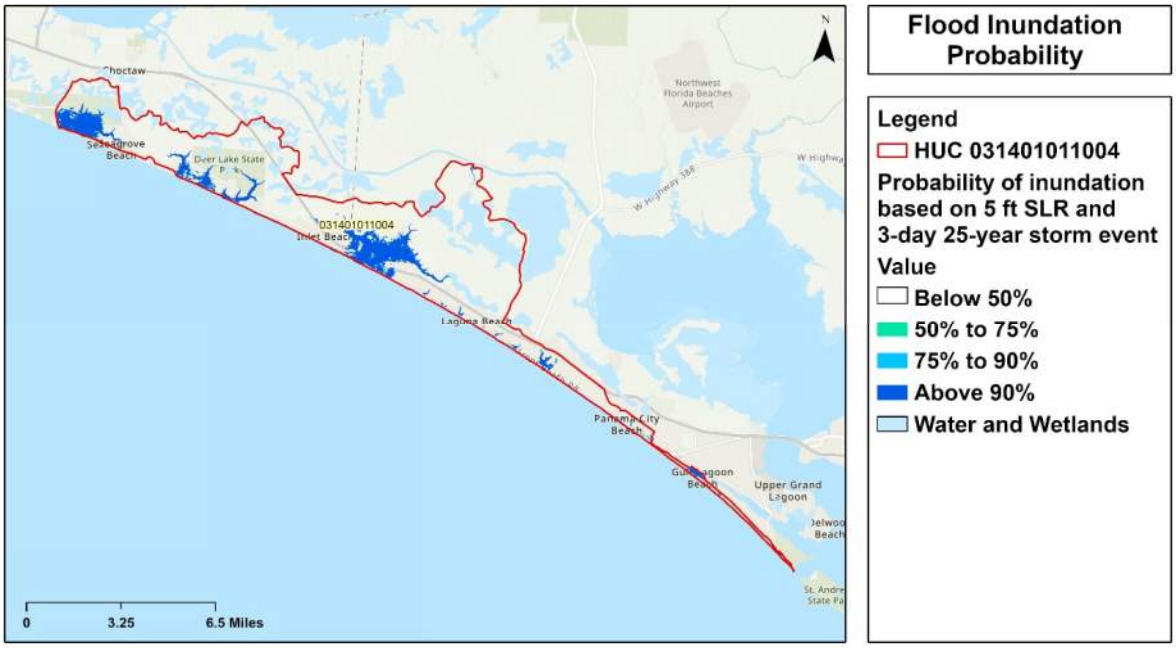

Figure 55. Sea level rise of 5 ft + 3-day 25-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

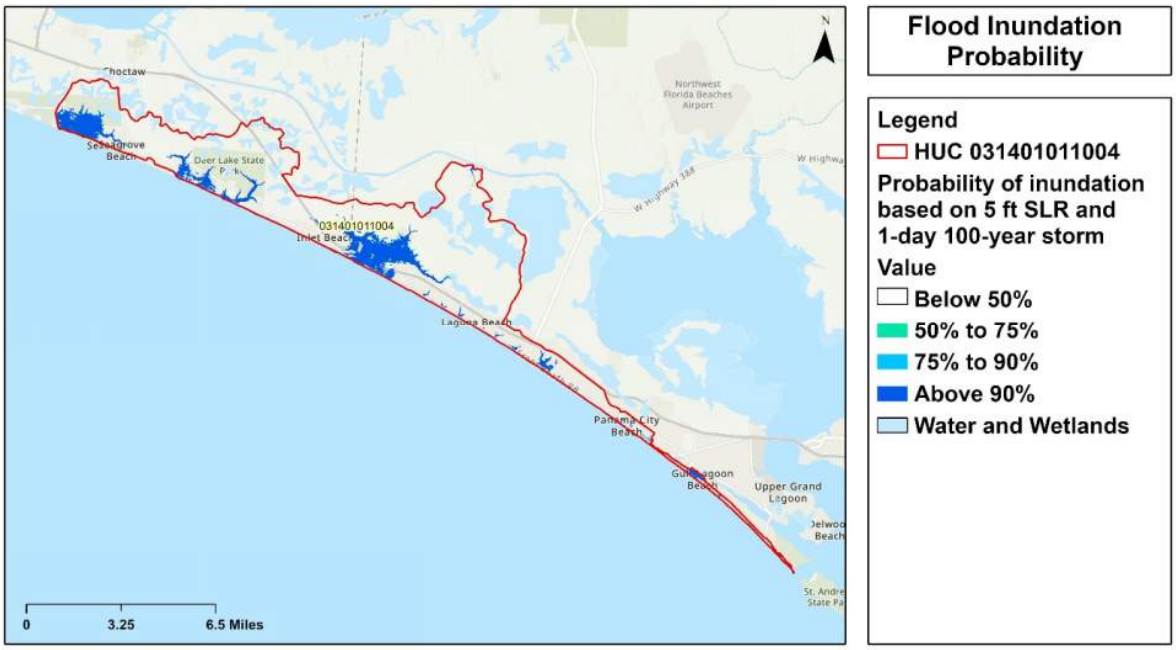

Figure 56. Sea level rise of 5 ft + 1-day 100-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

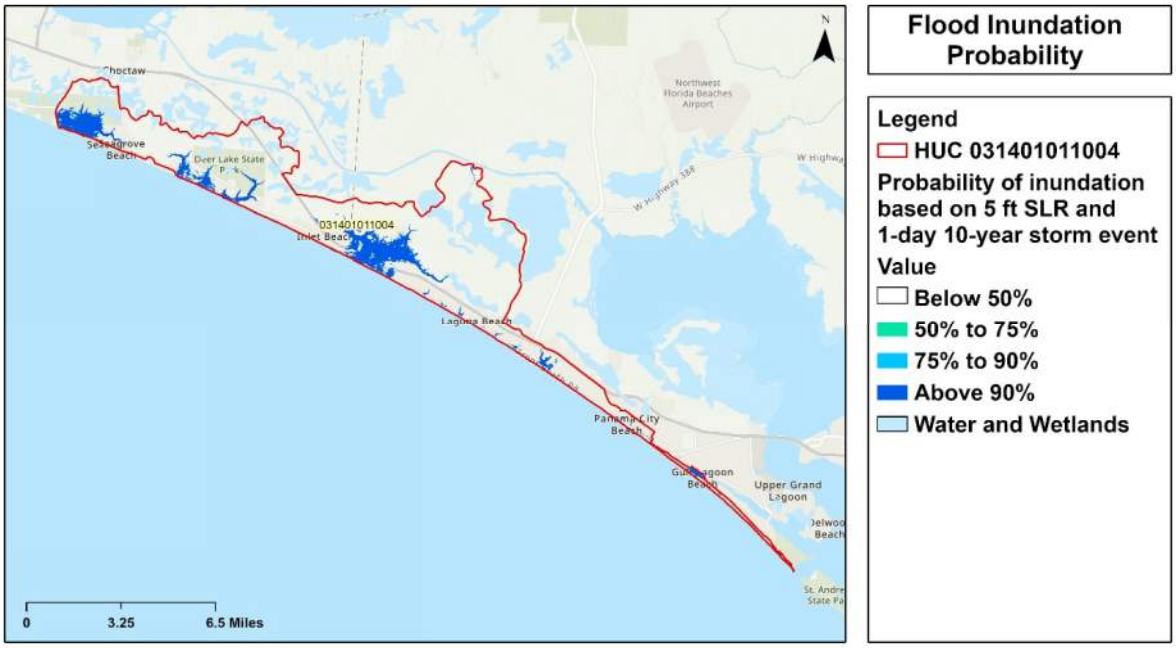

Figure 57. Sea level rise of 5 ft + 1-day 10-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

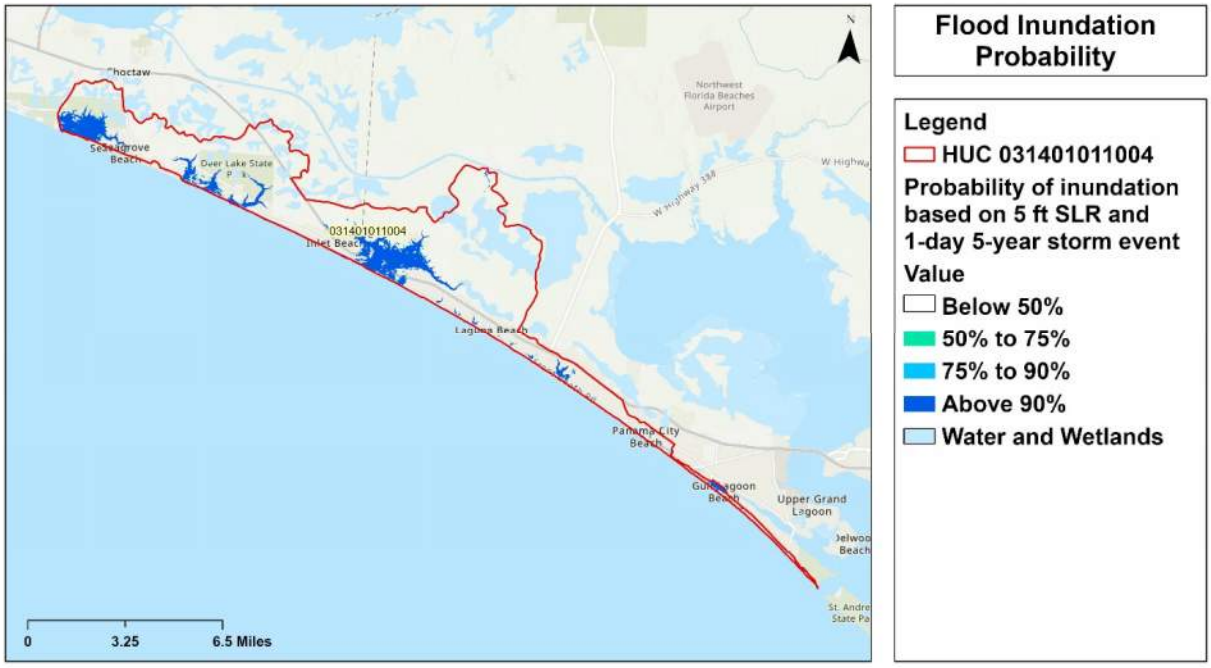

Figure 58. Sea level rise of 5 ft + 1-day 5-year storm for HUC 031401011004 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

2.5 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5

12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6

44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6

77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.5.1 Results

Error! Reference source not found. to **Error! Reference source not found.** depict the HUC 031401011004 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (Figure 59) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 60) overlays critical facilities onto the 1-day 100-year storm event scenario, while the third map (**Error! Reference source not found.**) represents the same overlay within the context of 5 feet of sea level rise (SLR) combined with the 1-day 100-year storm event. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 5 feet SLR + 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** and **Error! Reference source not found.** illustrate the composite score for the HUC, which is the result of the calculations explained above,

pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. **Error! Reference source not found.** represents the calculation for composite score based on 1-day 100-year storm event, while **Error! Reference source not found.** shows the calculation for composite score for the same storm event, but including a 5 feet of Sea Level Rise scenario. **Error! Reference source not found.** shows the same area zoomed out.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

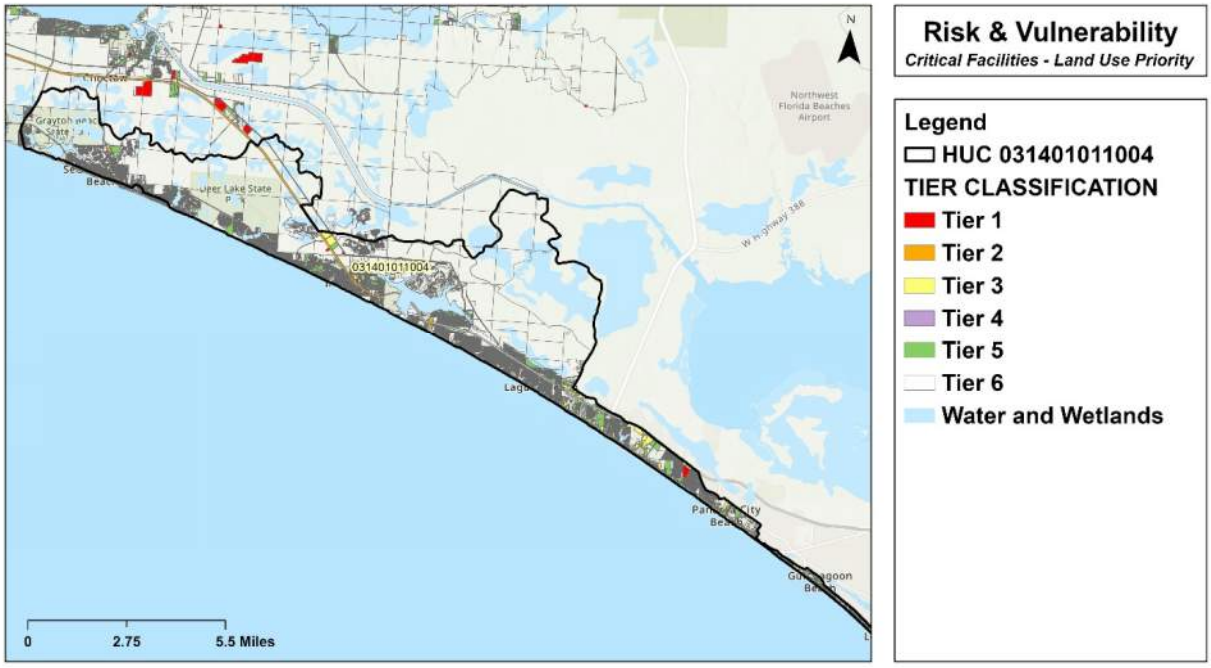

Figure 59. HUC 031401011004 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

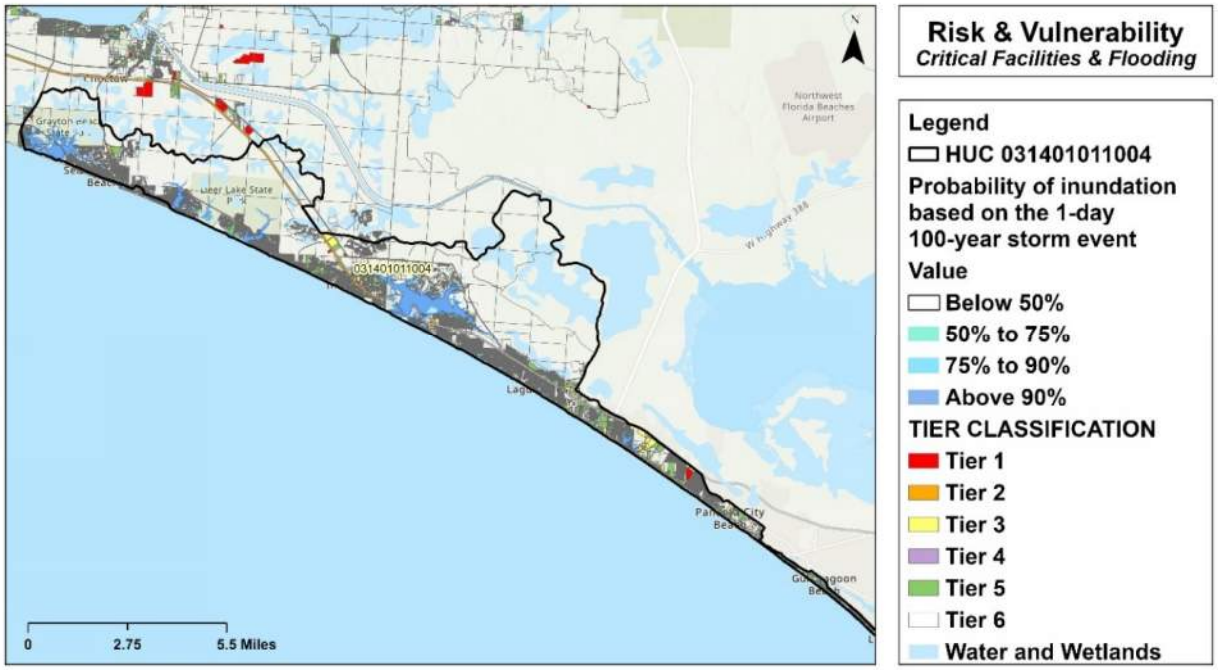

Figure 60. HUC 031401011004 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

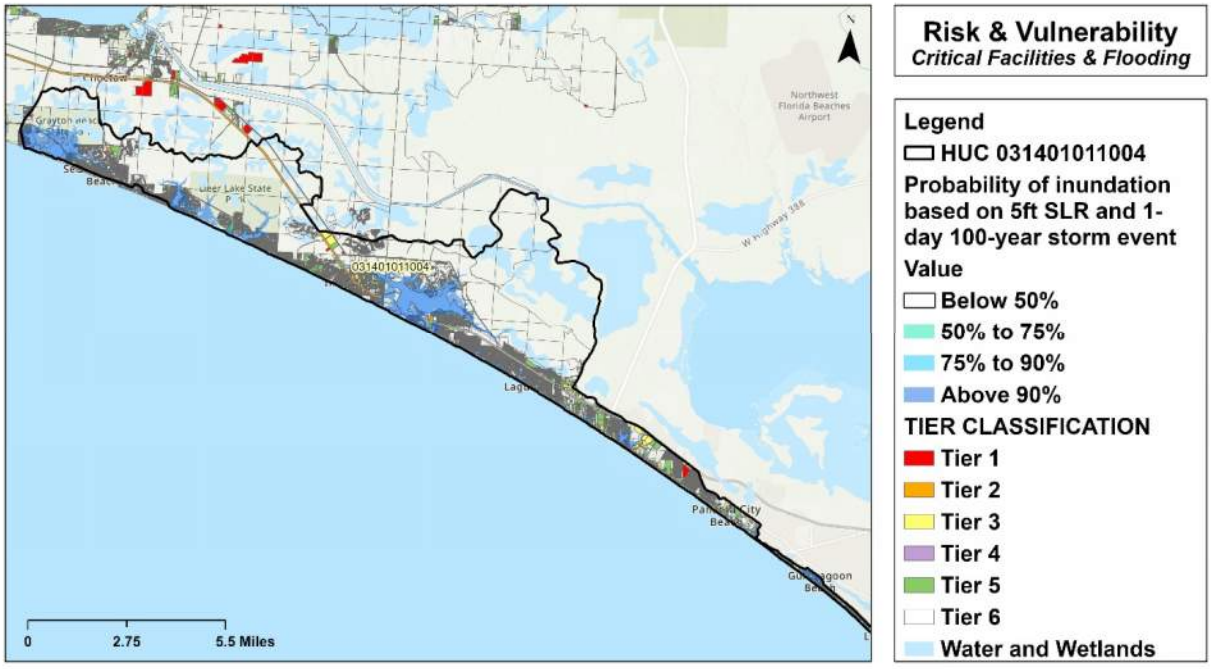

Figure 61. HUC 031401011004 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event + 5 ft SLR probability of inundation. Processed by FAU.

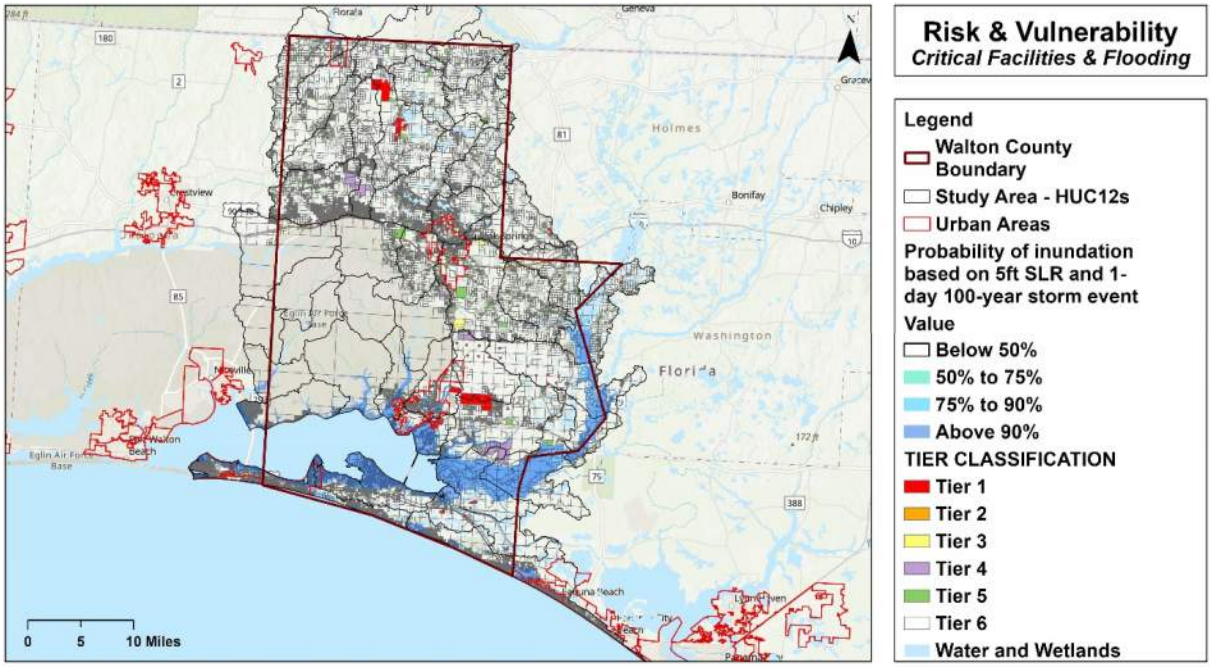

Figure 62. Walton County (mosaic) - Critical Facilities (priority of land uses) map, overlaid on the 1-day 100-year storm event + 5 ft SLR probability of inundation for Walton County. Processed by FAU.

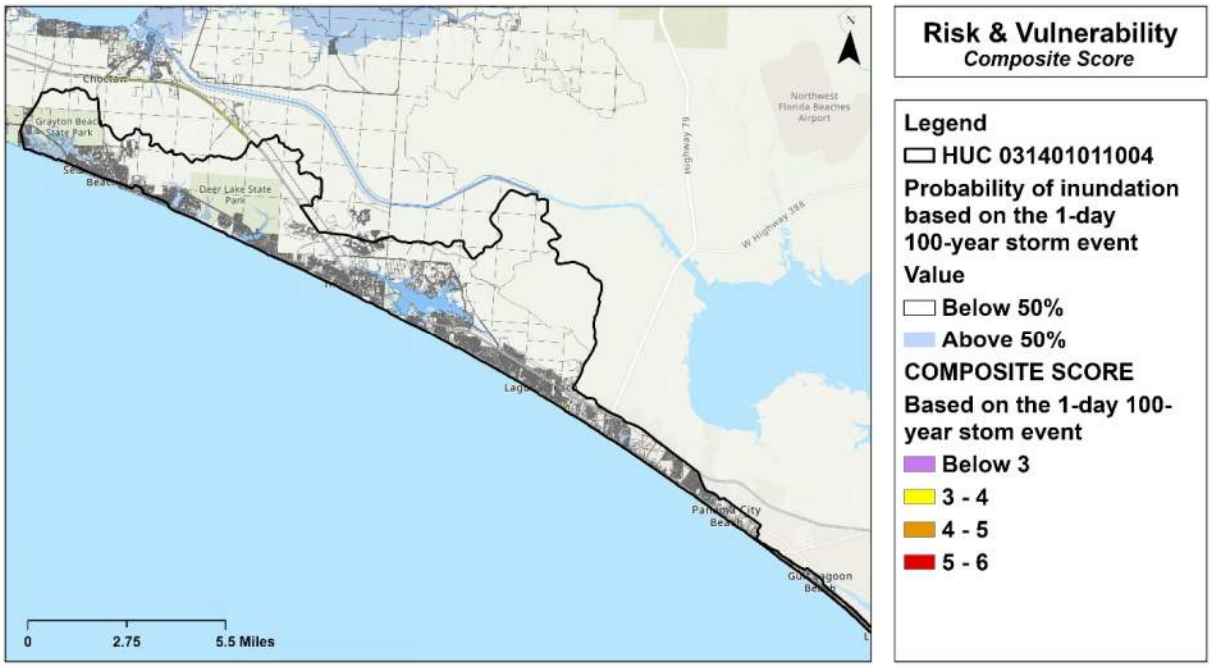

Figure 63. HUC 031401011004 sub-watershed Composite Score Risk map based on the 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation. Processed by FAU.

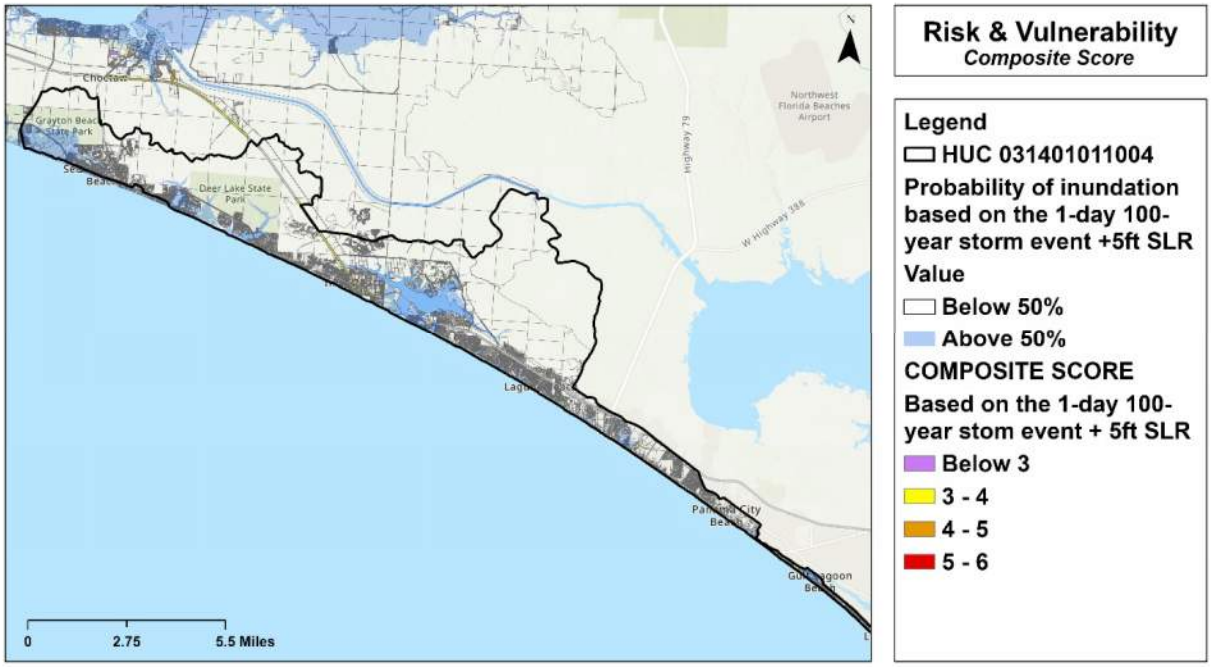

Figure 64. HUC 031401011004 sub-watershed Composite Score Risk map based on 1-day 100-year storm event + 5 ft SRL, overlaid on the 1-day 100-year + 5 ft SLR probability of inundation. Processed by FAU.

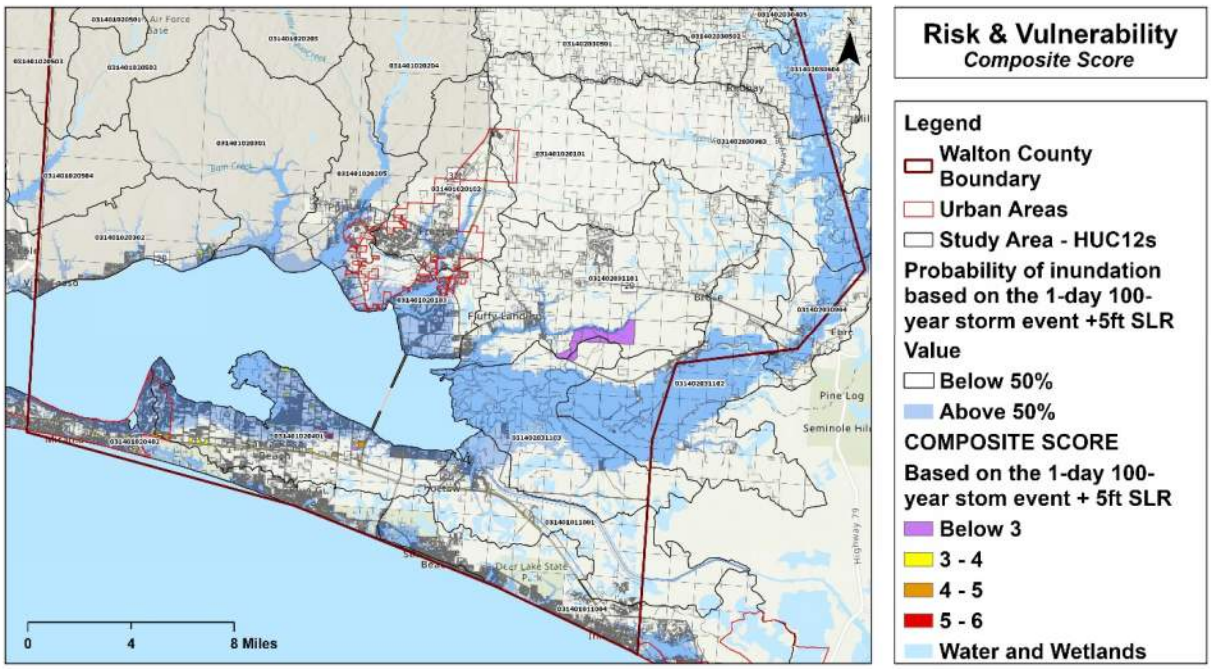

Figure 65. Coastal Area of Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event + 5 ft SLR probability of inundation. Processed by FAU.

2.5.2 Drill-down – Urban Areas

For enhanced visualization of the urban areas within this HUC 031401011004, Figure 66 to Figure 80 illustrate the same results for critical facilities (land use priorities) and composite scores, but on a zoomed in scale, which better facilitates the examination of finer details within the urban areas (Grayton Beach, Seaside, Seagrove Beach, Seacrest, and Rosemary Beach). These maps cover both the 1-day 100-year scenario and the 1-day 100-year + 5 feet SLR scenario.

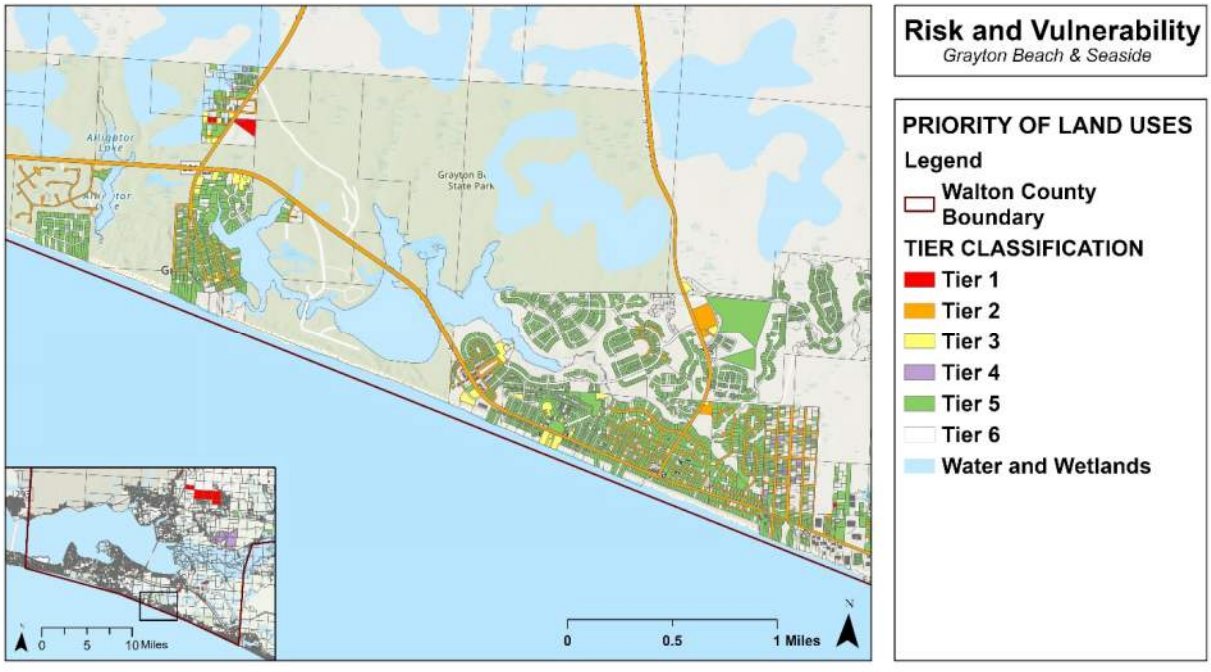

Figure 66. Critical Facilities (priority of land uses) map for Grayton Beach. Processed by FAU.

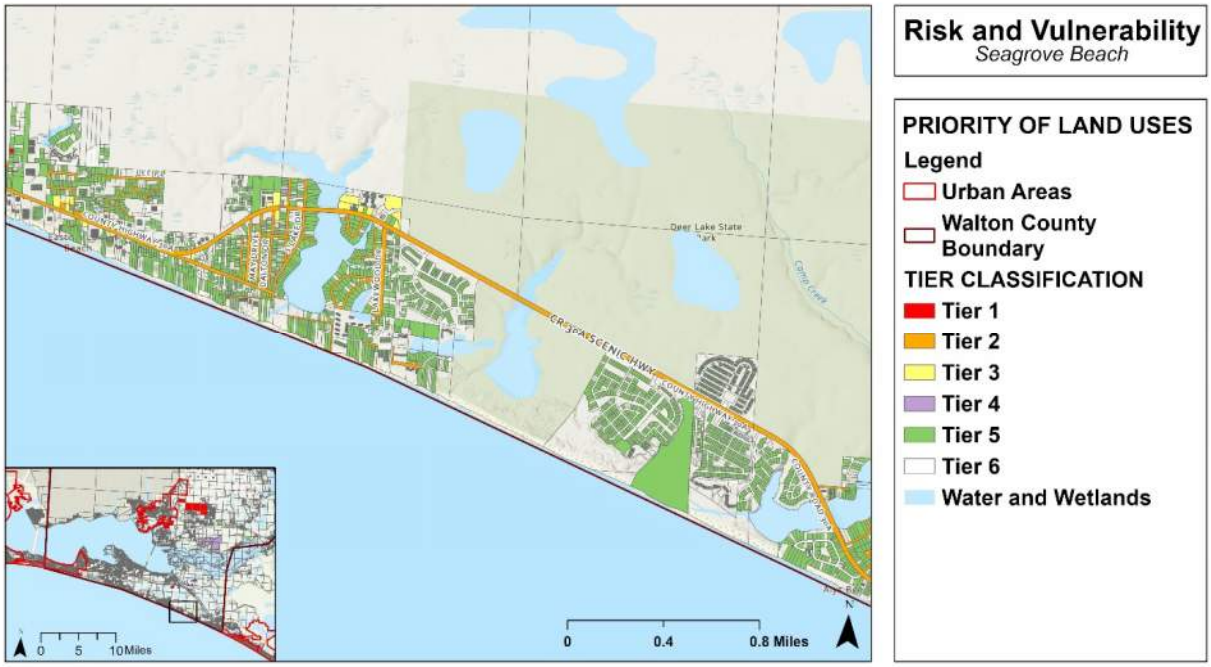

Figure 67. Critical Facilities (priority of land uses) map for Seagrove Beach. Processed by FAU.

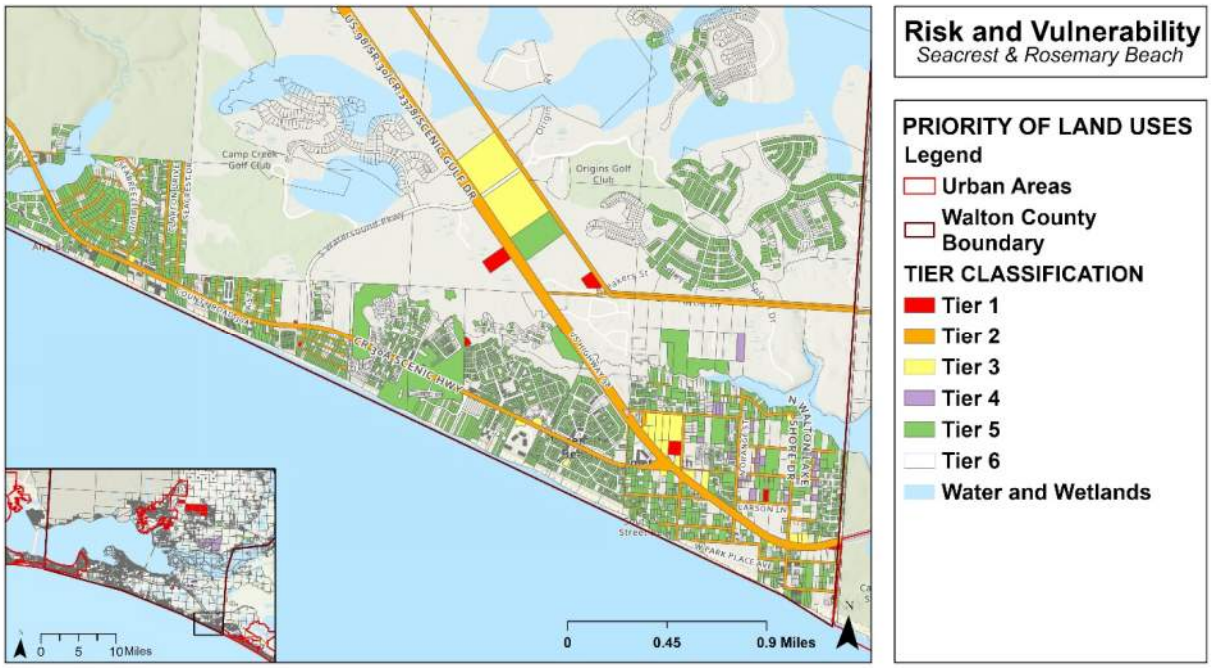

Figure 68. Critical Facilities (priority of land uses) map for Seacrest and Rosemary Beach. Processed by FAU.

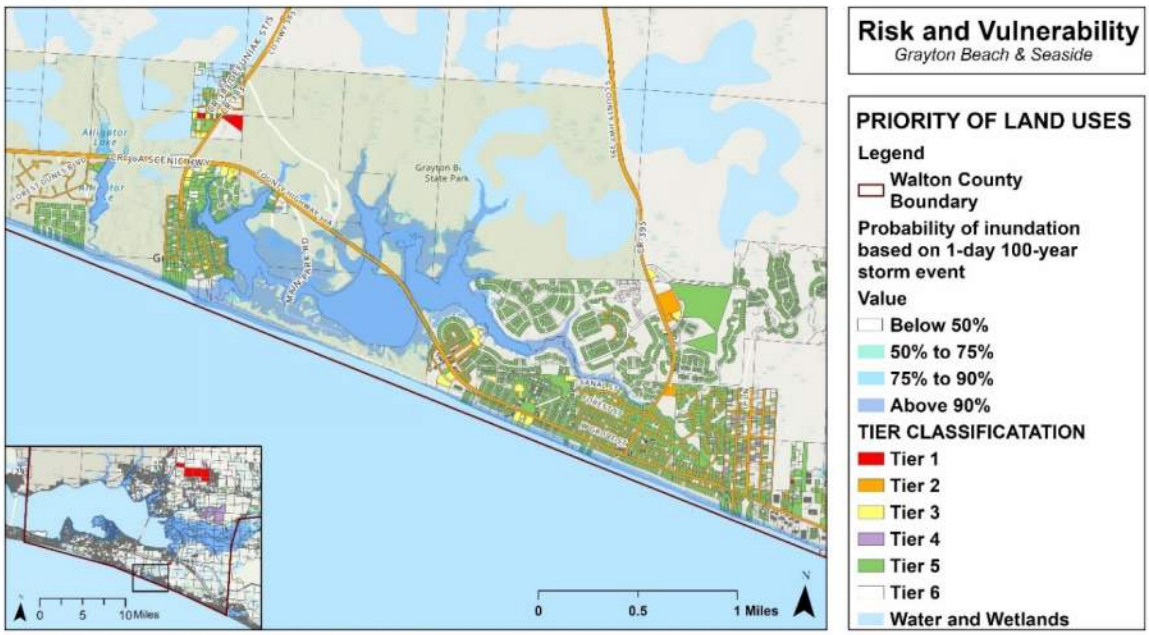

Figure 69. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event for Grayton Beach and Seaside. Processed by FAU.

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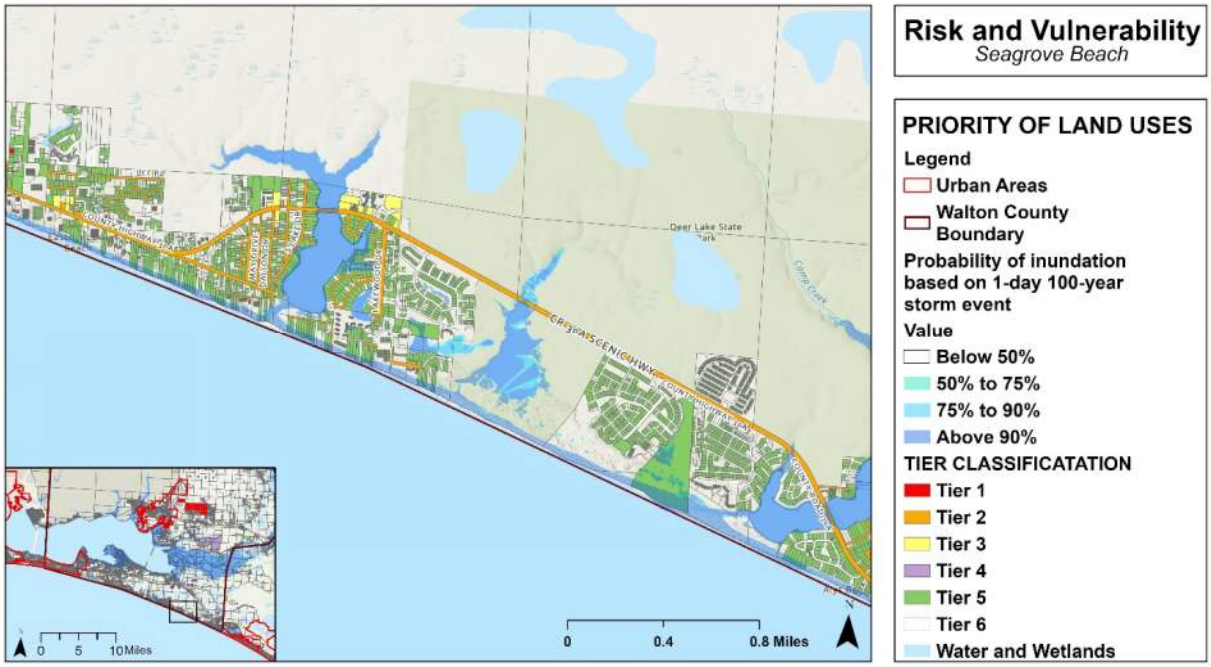

Figure 70. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event for Seagrove Beach. Processed by FAU.

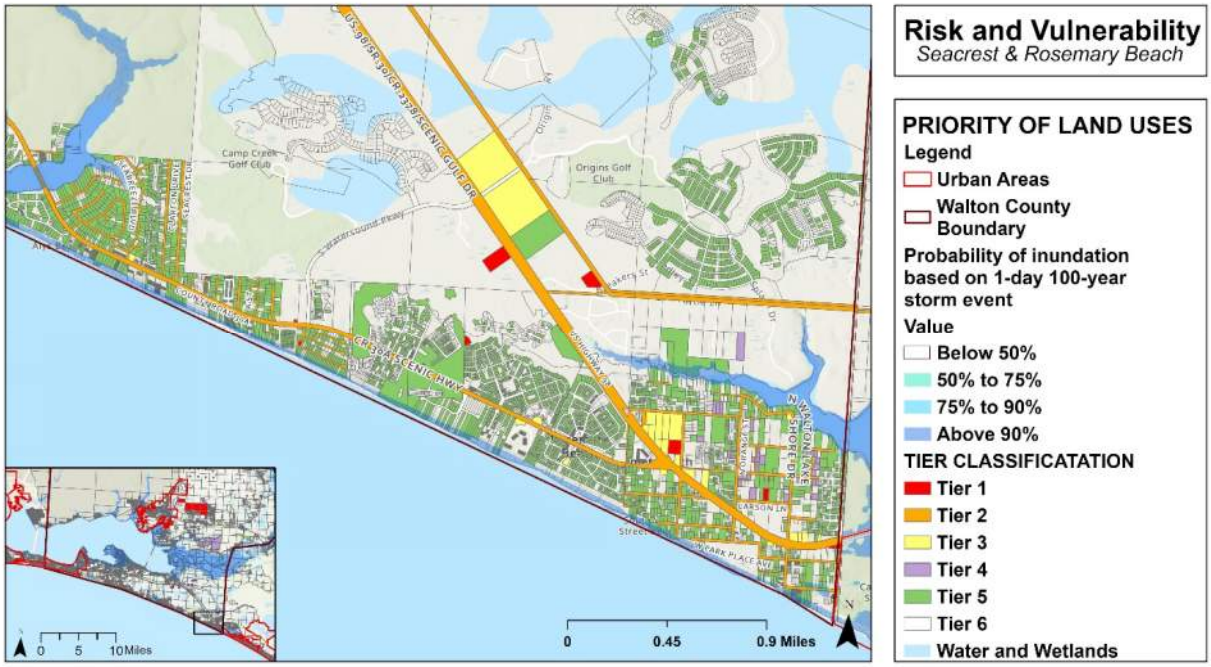

Figure 71. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event for Seacrest and Rosemary Beach. Processed by FAU.

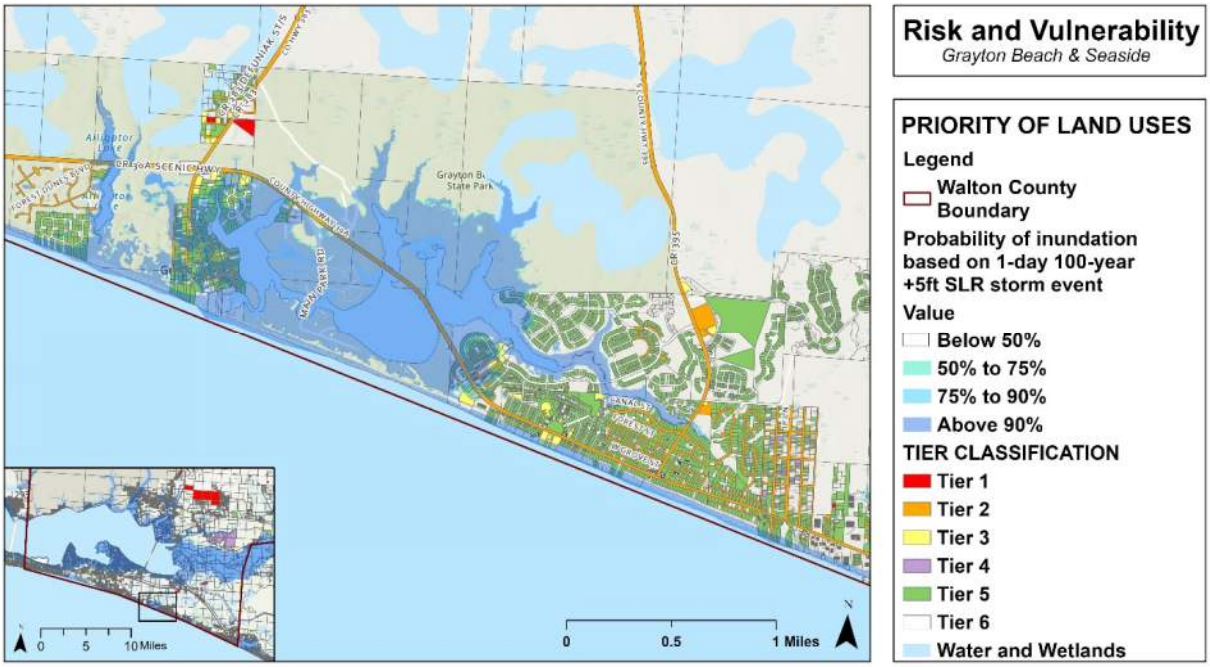

Figure 72. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event + 5 ft SLR for Grayton Beach and Seaside. Processed by FAU.

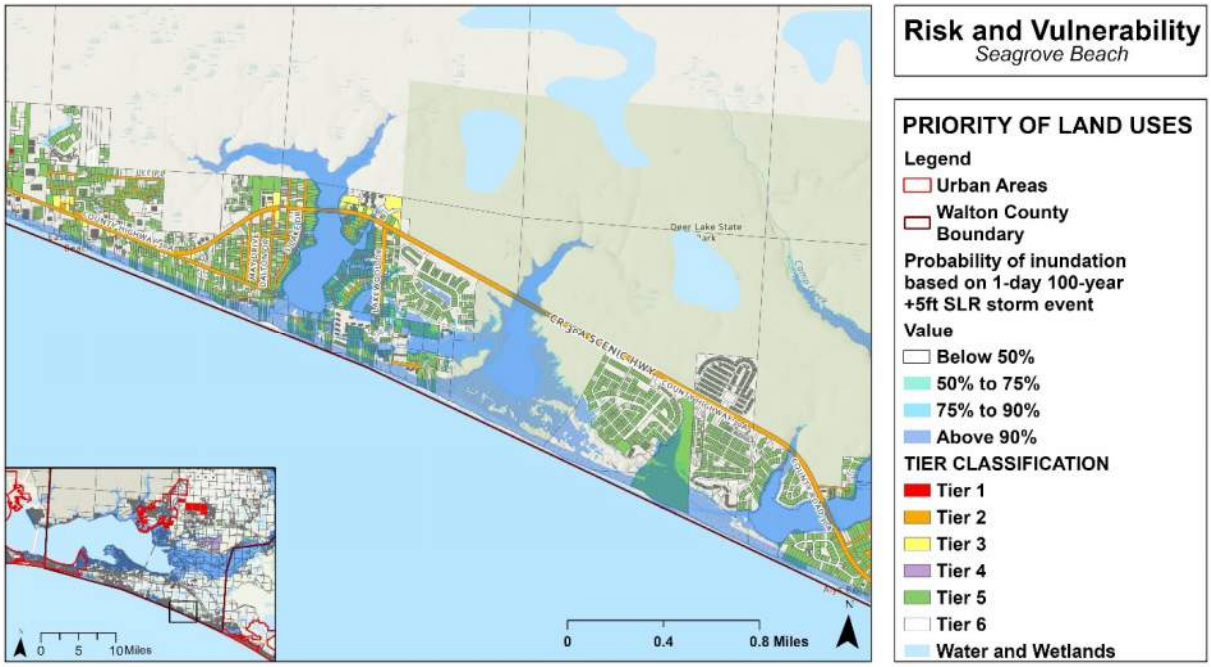

Figure 73. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event + 5 feet SLR for Seagrove Beach . Processed by FAU.

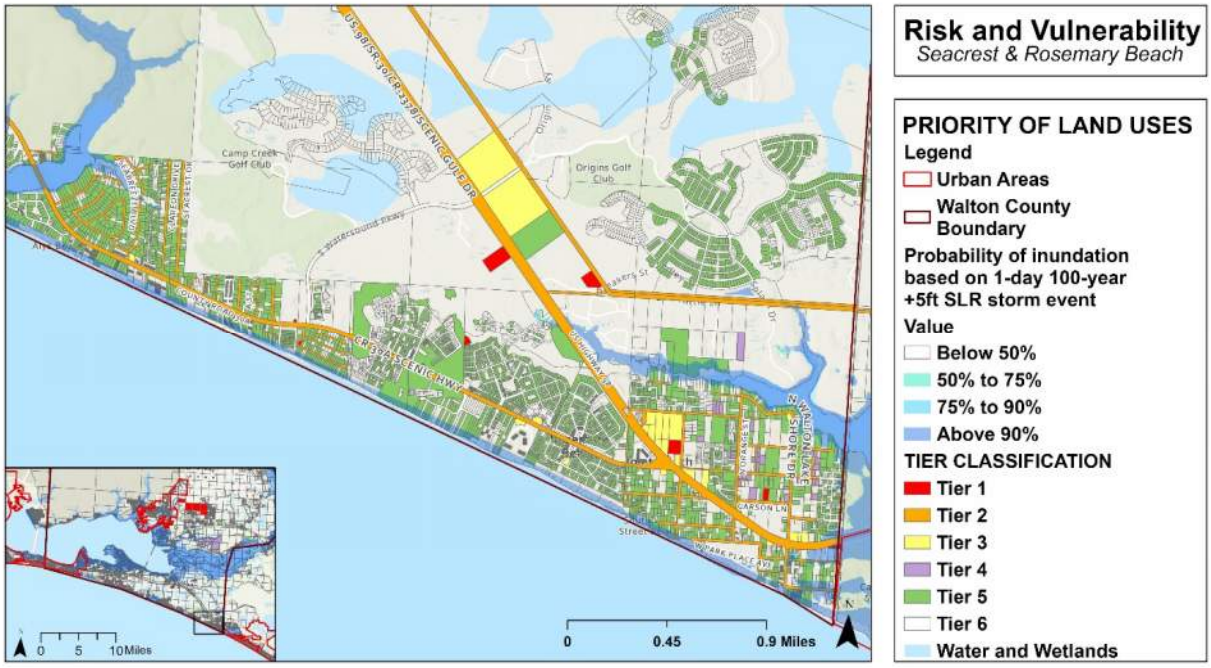

Figure 74. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event + 5 feet SLR for Seacrest and Rosemary Beach . Processed by FAU.

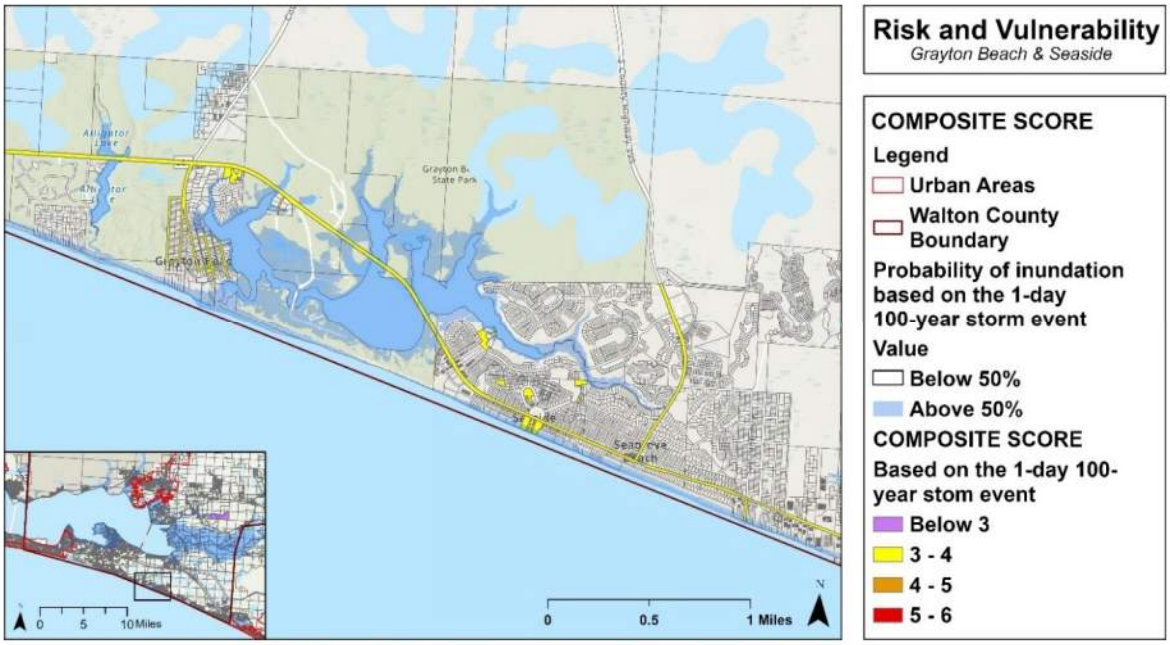

Figure 75. Composite Score map, based on 1-day 100-year storm event, overlaid in the flooding layer, for Grayton Beach and Seaside. Processed by FAU.

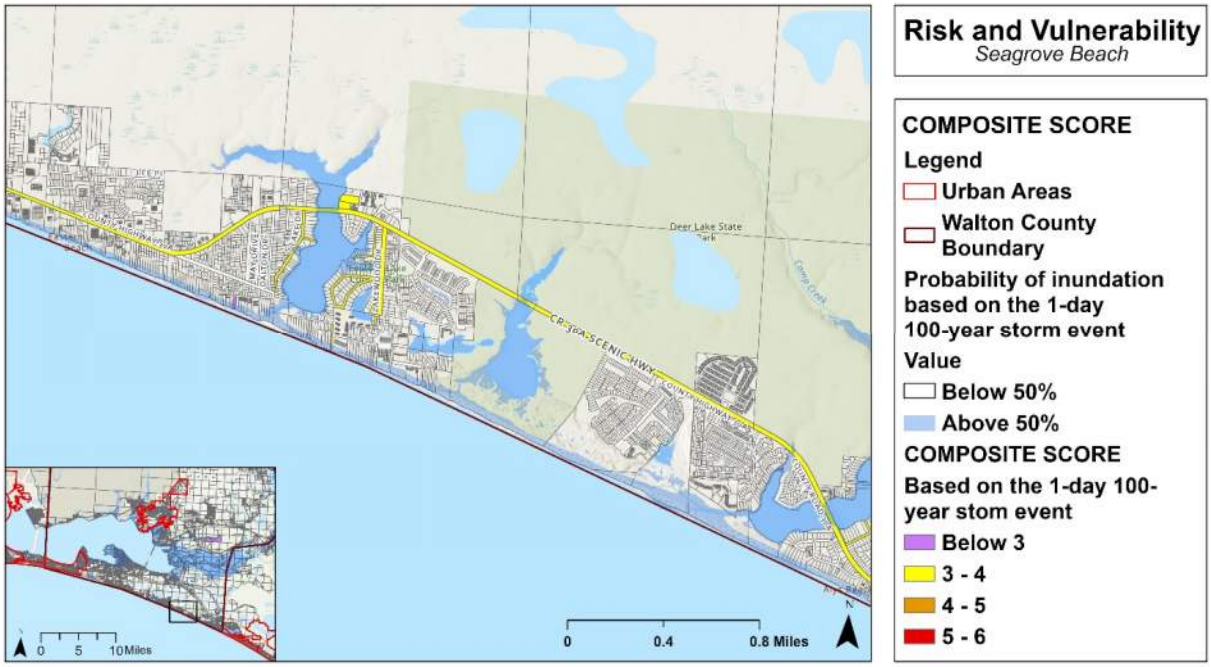

Figure 76. Composite Score map, based on 1-day 100-year storm event, overlaid in the flooding layer, for Seagrove Beach. Processed by FAU.

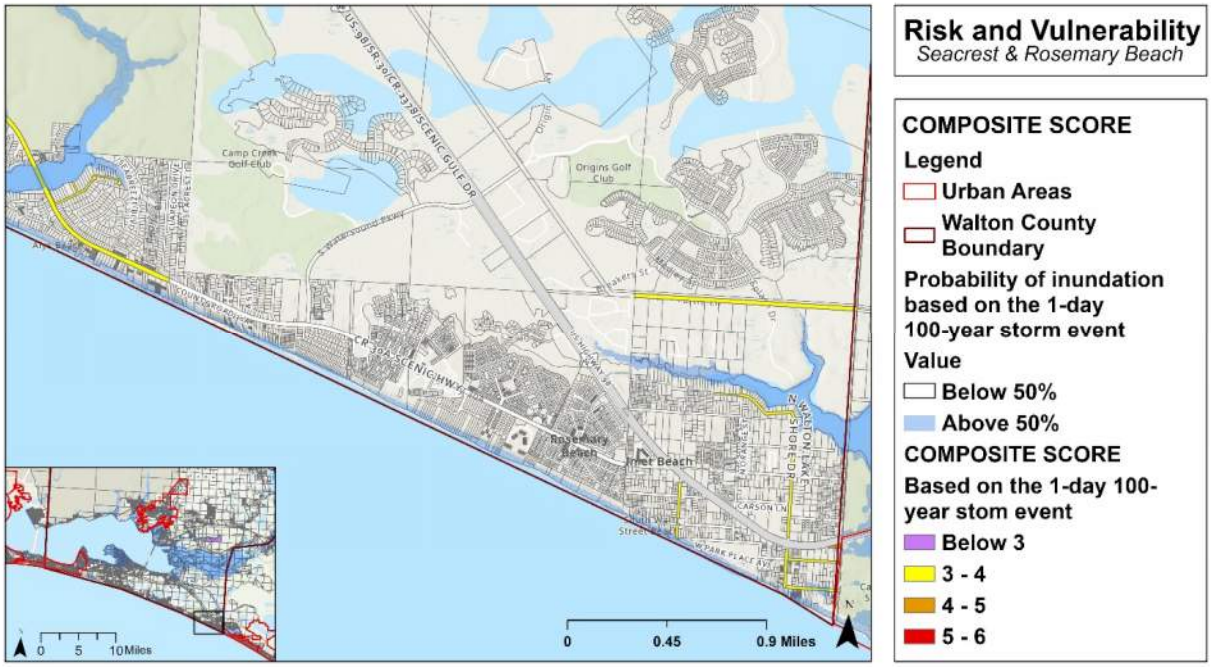

Figure 77. Composite Score map, based on 1-day 100-year storm event, overlaid in the flooding layer, for Seacrest and Rosemary Beach. Processed by FAU.

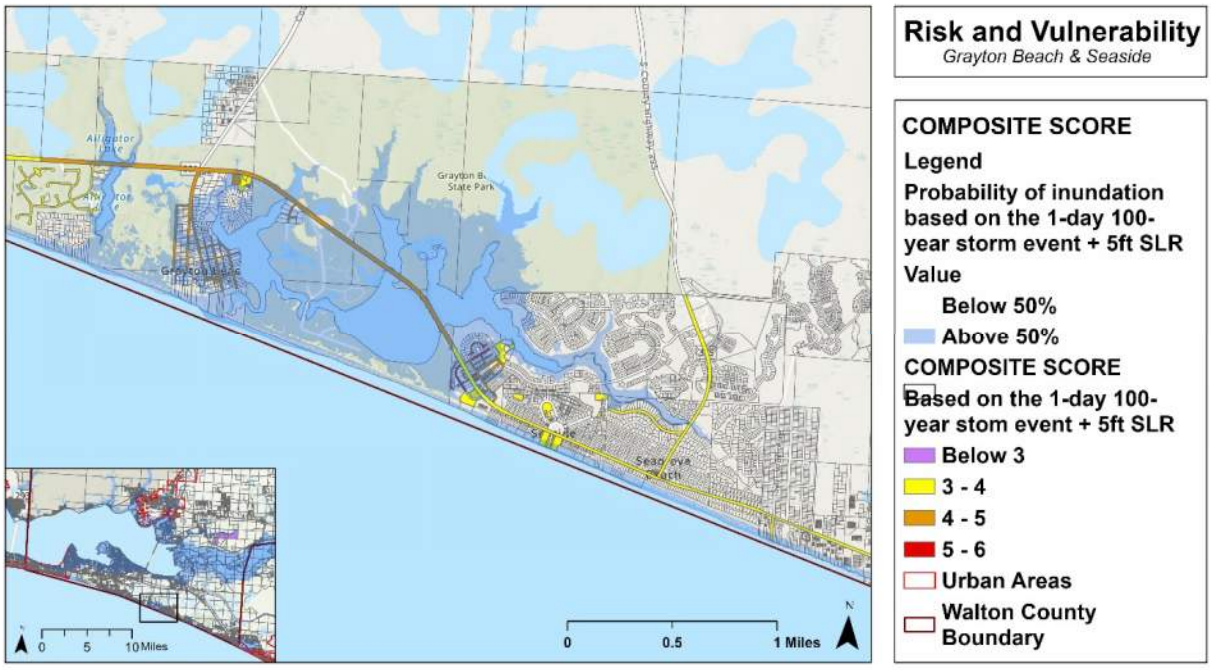

Figure 78. Composite Score map, based on 1-day 100-year storm event + 5 ft SLR, overlaid in the flooding layer, for Grayton Beach and Seaside. Processed by FAU.

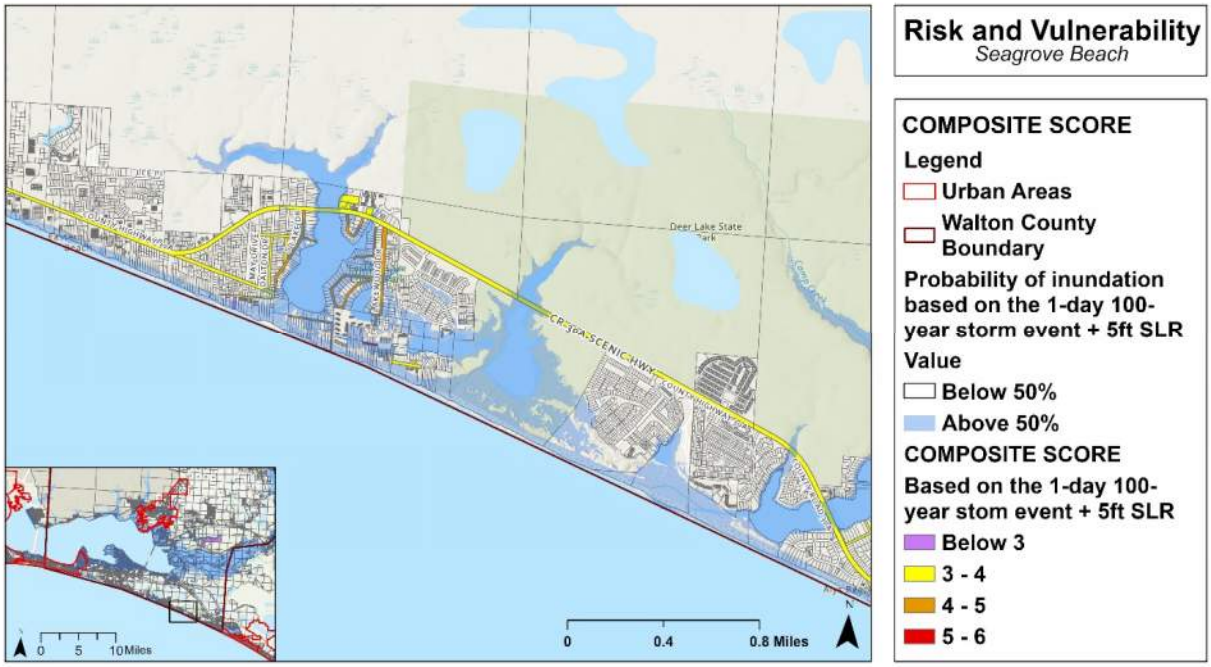

Figure 79. Composite Score map, based on 1-day 100-year storm event + 5 ft SLR, overlaid in the flooding layer, for Seagrove Beach. Processed by FAU.

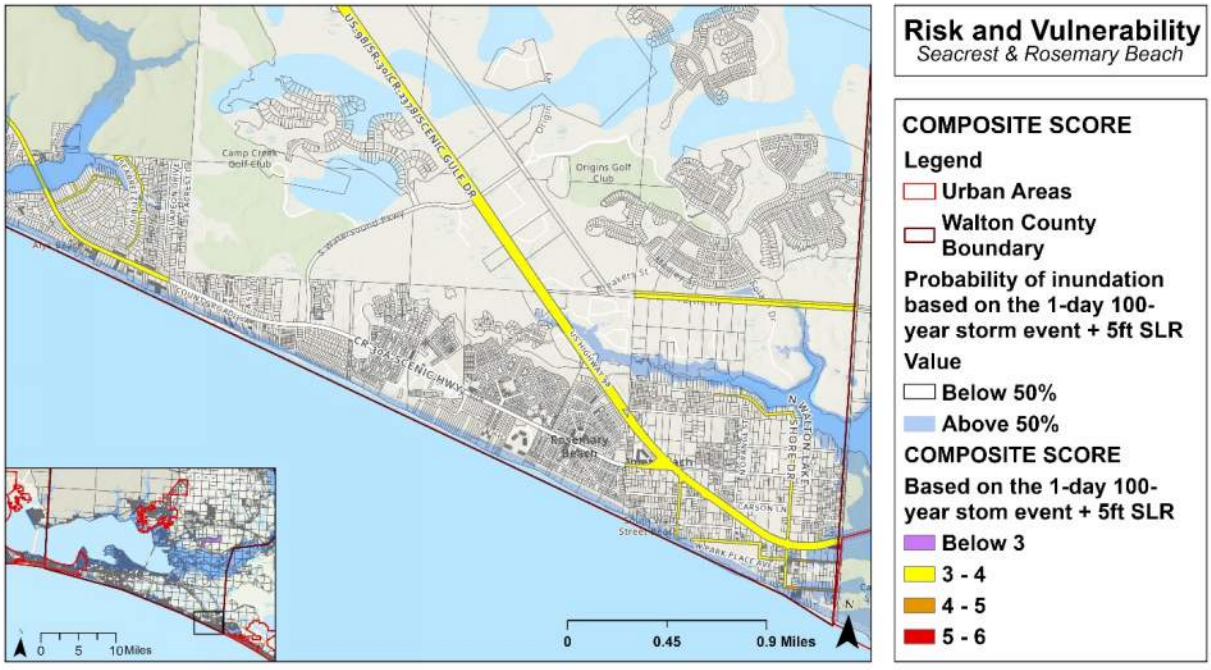

Figure 80. Composite Score map, based on 1-day 100-year storm event + 5 ft SLR, overlaid in the flooding layer, for Seacrest and Rosemary Beach. Processed by FAU.

2.5.3 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401011004. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.5.4 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401011004. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401011004	28300.11
All of the 1-day 100-year storm event inundation	**2061.69**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	971.91
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	397.52
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.01
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	1089.77
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	692.24

2.5.5 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. Figure 81 indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

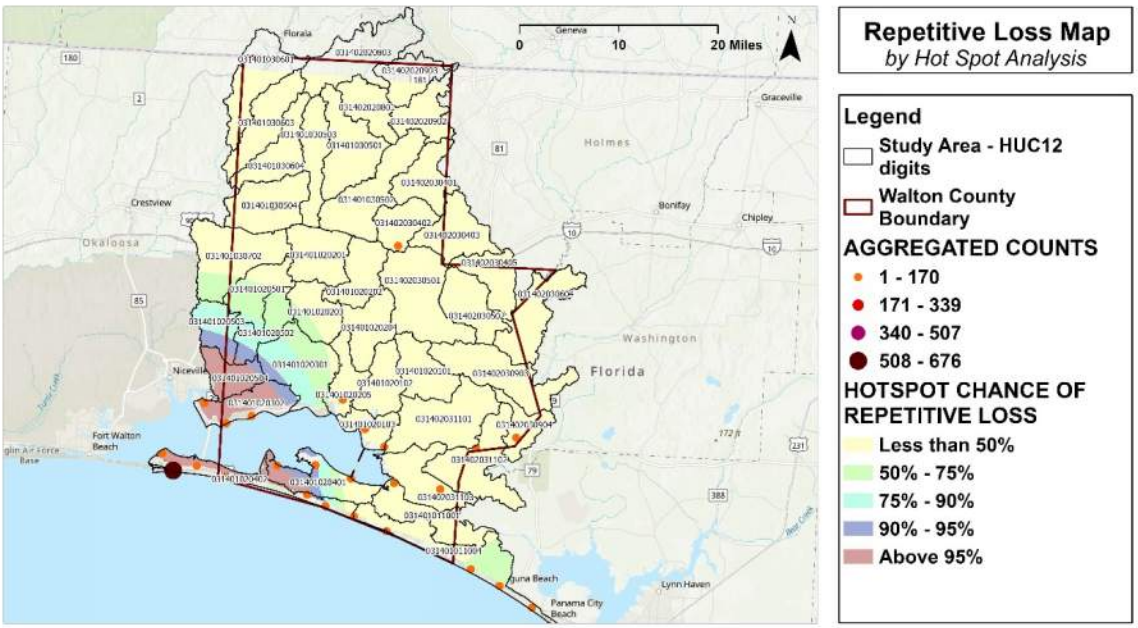

Figure 81. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.5.6 Priority Projects

Numerous properties situated along the coast, encompassing areas like Grayton Beach, Seaside, Seagrove Beach, Seacrest Beach, and Rosemary Beach, find themselves within flood zones for both the 1-day 100-year and 1-day 100-year + 5ft SLR scenarios. However, when focusing in critical facilities and land use priority, only some parcels fall within the high-priority tiers of 1 and 2. Specifically, there are 23 coastal parcels that fall within flood zones and fall under tier 1. Among these, three are public schools (DOR code 083), while the remainder are utilities (DOR code 091).

Examining the composite scores allows us to pinpoint areas that require immediate attention, and these priority projects are categorized by community, as follows:

Grayton Beach:

Score 4-5: W County Hwy 30A and local roads

Seaside:

Score 3-4: County Highway 30A, 1 Hotel/motel (DOR code 039), 2 Restaurants, cafeterias (DOR code 021), 2 Community Shopping Centers (DOR code 016)

Score 4-5: Watercolor Blvd N and County Highway 30A

Score 5-6: Buttercup St, Sunset Ridge Ln, Park Row Ln, Goldenrod Cir

Seagrove Beach:

Score 3-4: Canal St, S County Hwy 395, County Highway 30a, Center Ave W, Eastern Lake Road, Dalton Dr, S Gulf Dr, Beachfront Trl

Score 4-5: Lakewood Dr, S Lake Dr, Lake Pointe Dr, Beachside Drive, San Roy Rd

Score 5-6: Chivas Ln

Rosemary Beach/Inlet Beach:

Score 3-4: Us Highway 98, N Walton Lakeshore Dr, S Wall Street, W Park Place Ave, E Park Place Ave, S Walton Lakeshore Dr, Hotel/Motel (Dor code 039), 1 mobile home (DOR code 002)

Score 4-5: E Park Place Ave, Walton Magnolia Ln, 1 supermarket (DOR code 014), 1 office building (DOR code 017), 2 restaurants/cafeterias (DOR code 021), 1 professional service building (DOR code 019)

Score 5-6: 2 utility parcels (DOR code 091)

Additionally, numerous small parcels within the HUC boundary, although outside Walton County limits, are susceptible to flooding. These parcels generally fall within the score ranges below 3 and 3-4, and they are situated in coastal areas encompassing Laguna Beach and a portion of Panama City Beach.

APPENDIX D

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401020101

MAGNOLIA CREEK

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Research Assistant: Leticia Sabio

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401020101) is highlighted among all the HUCs to help identifying its location.

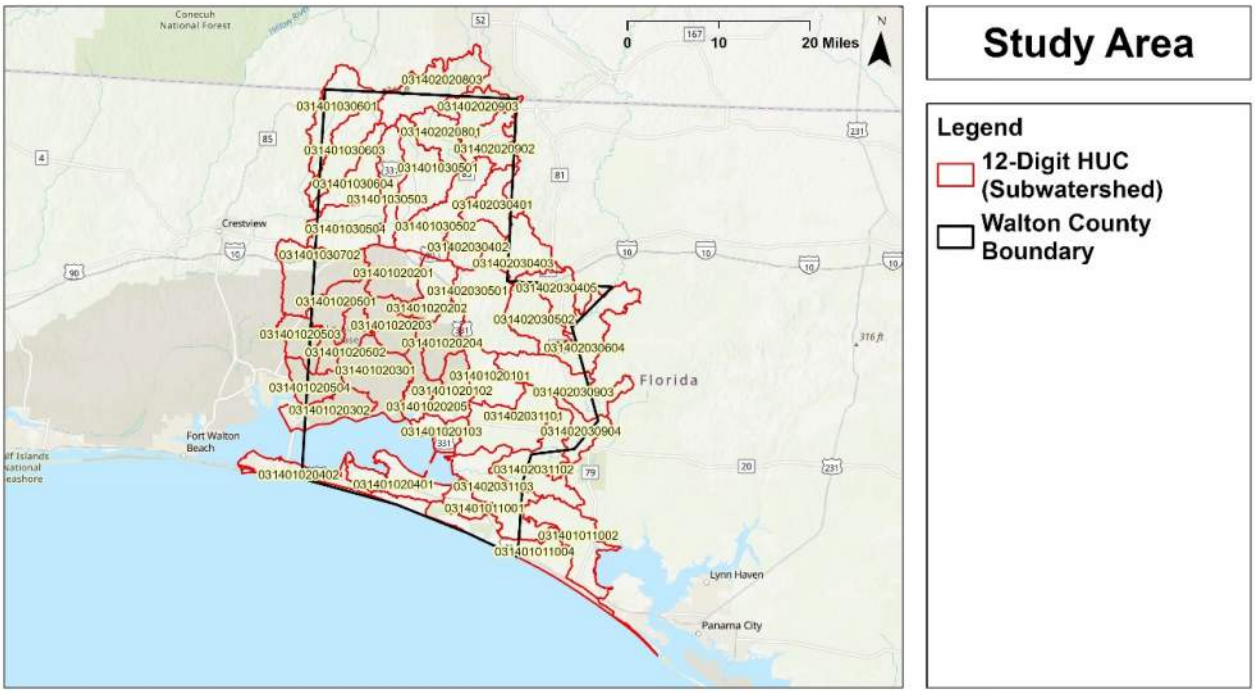

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

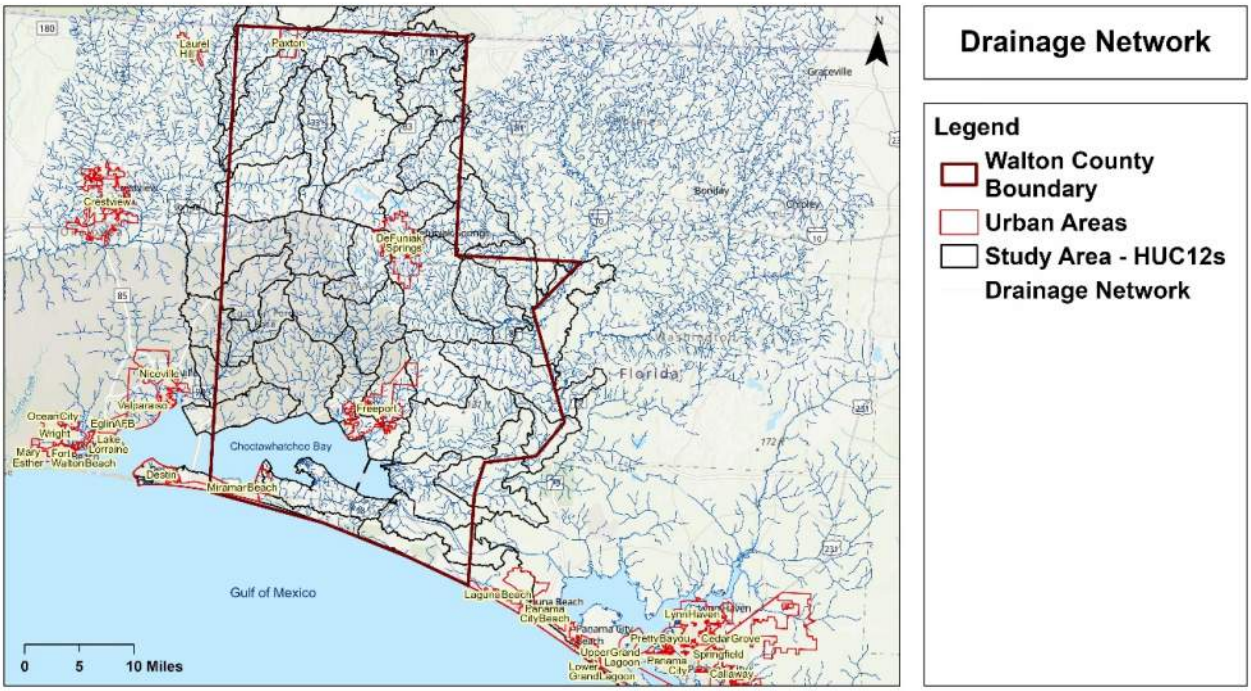

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

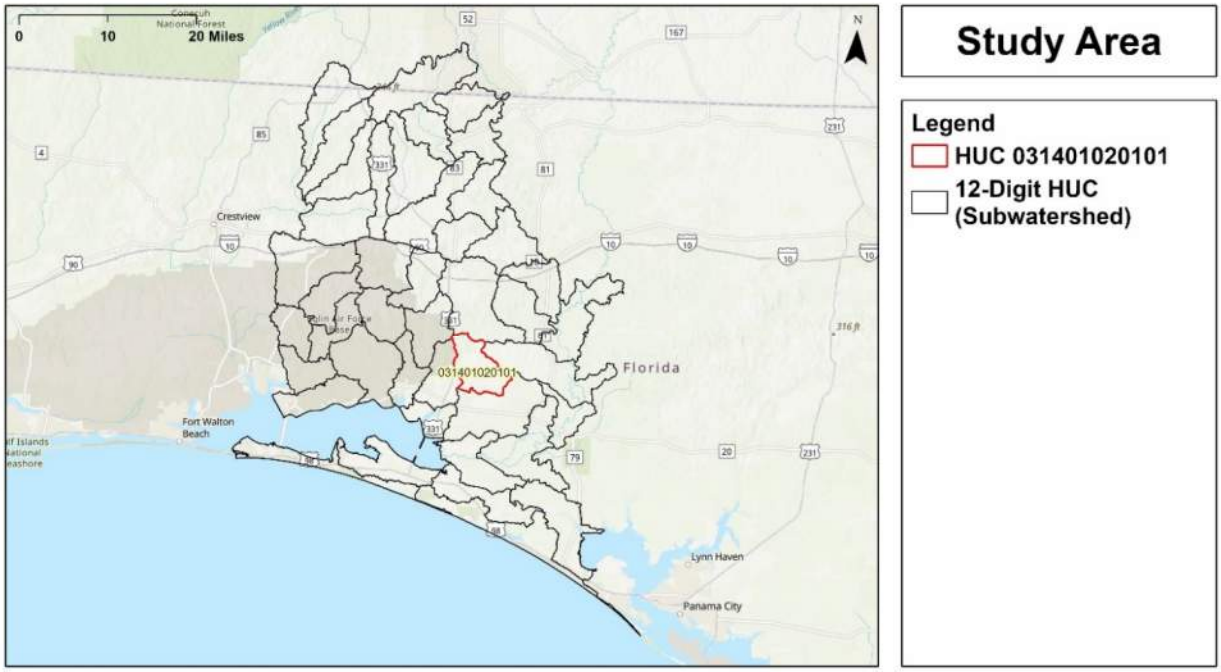

Figure 3. HUC 031401020101 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas,

including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

Figures 12 and 13 in the county-wide report show the current and projected land use for the County. Based on the 2017 future land use map for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land Use in Walton County (Prepared by FAU from future land use map) versus land use in the entire watershed (2023 Florida Geographic Data Library (FGDL))

Level 1 Land Use-Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of

Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

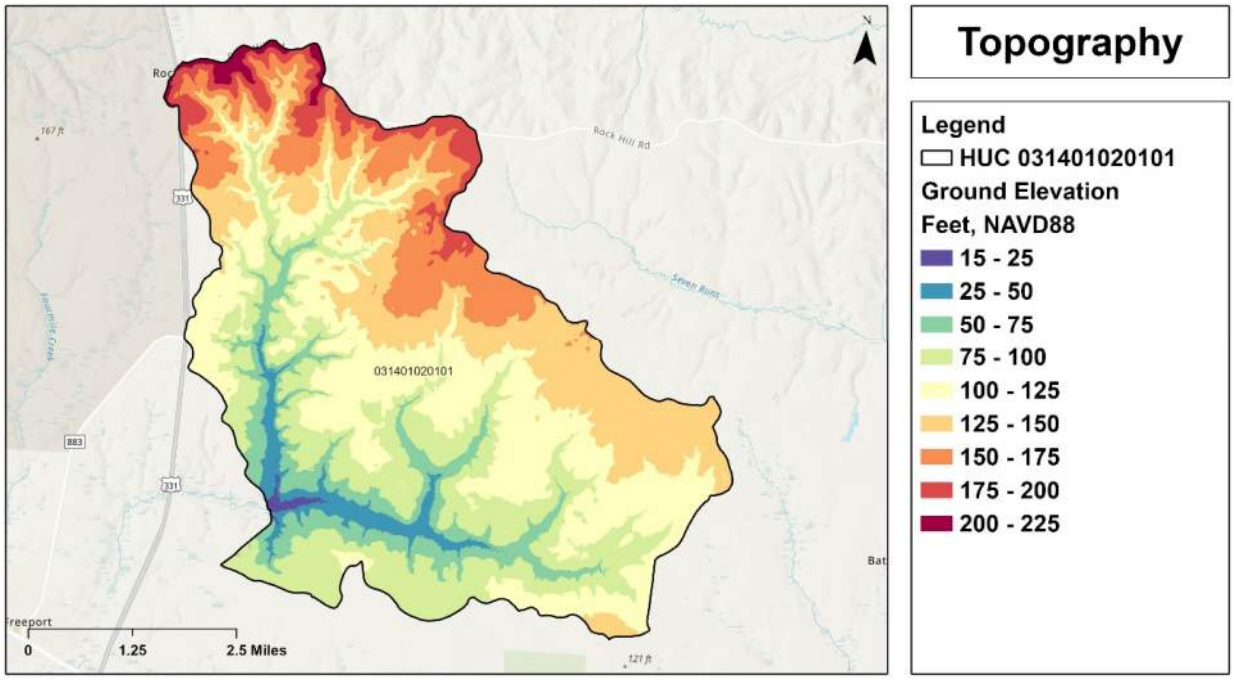

Figure 4. Topographic map of the HUC 031401020101 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401020101 sub-watershed is shown in **Error! Reference source not found.**.

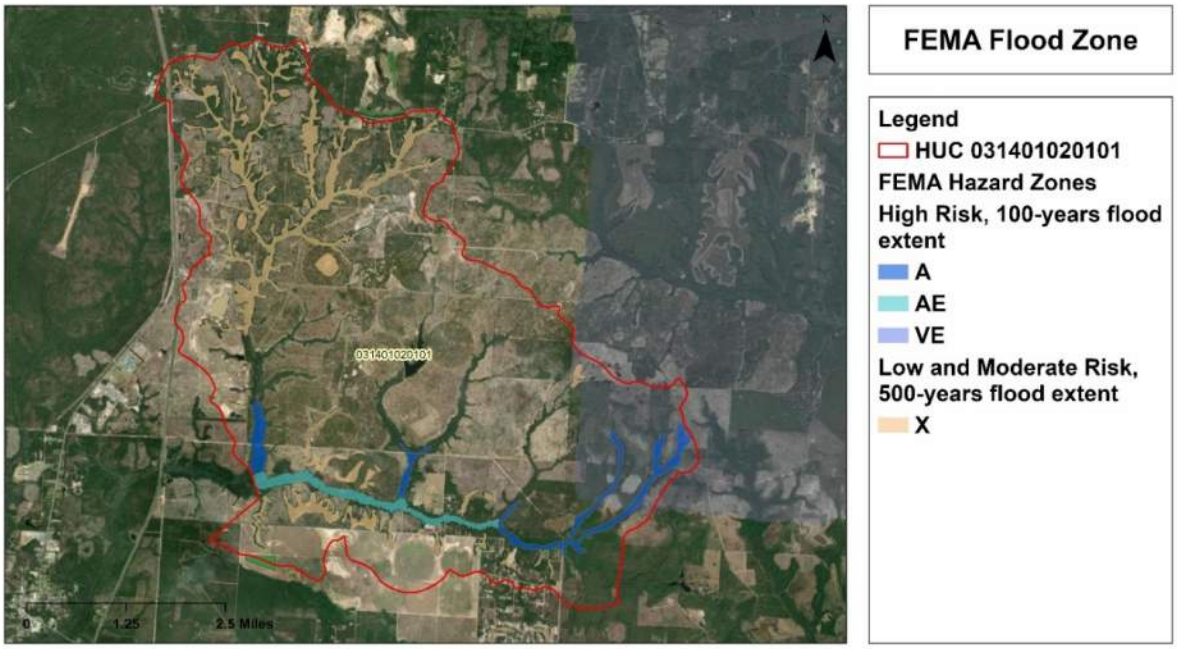

Figure 5. FEMA Flood Zone map (2020) for HUC 031401020101 sub-watershed, processed by FAU

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401020101 as it will reach the area through Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall

biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

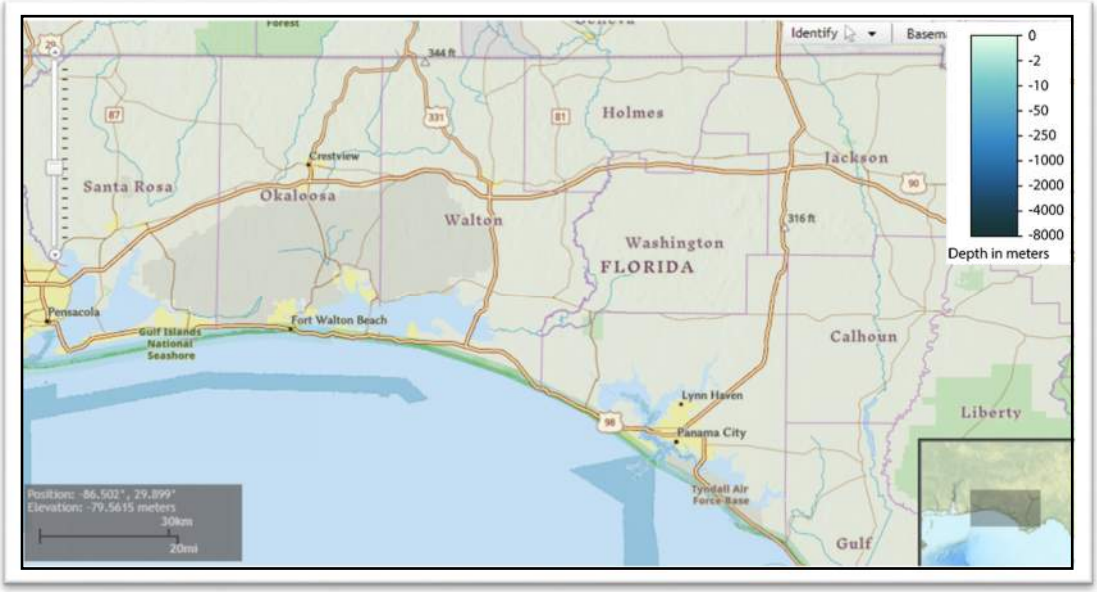

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

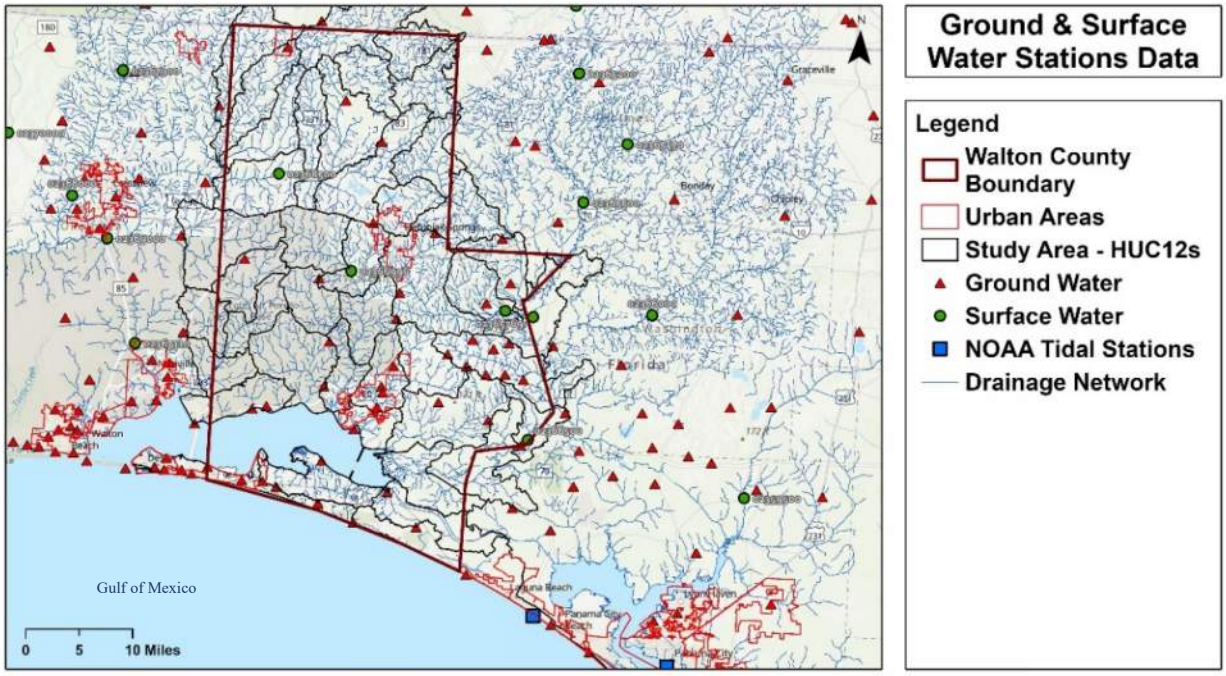

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031401020101 has no major rivers and canals, but creeks, include:

- Magnolia Creek
- Lafayetee Creek

- Wolf Creek
- White Branch

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401020101, which is USGS 02366500 Choctawhatchee River NR Bruce FLA.

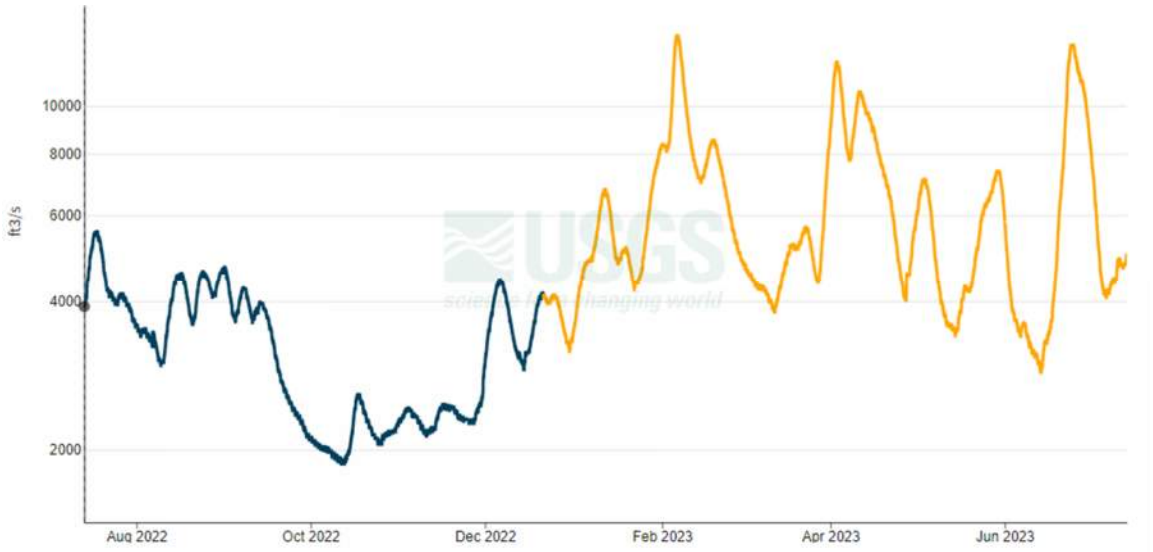

Figure 8. Average streamflow for Choctawhatchee River NR Bruce FLA (USGS 02366500 Surface-Water, June 2022 to July 2023).
Data retrieved from USGS Water Data Services: https://waterdata.usgs.gov/monitoring-location/02366500/#parameterCode=00065&period=P365D.

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are

estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401020101 and points out the location of the ground water station in the surroundings. A groundwater-surface layer for the HUC 031401020101 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

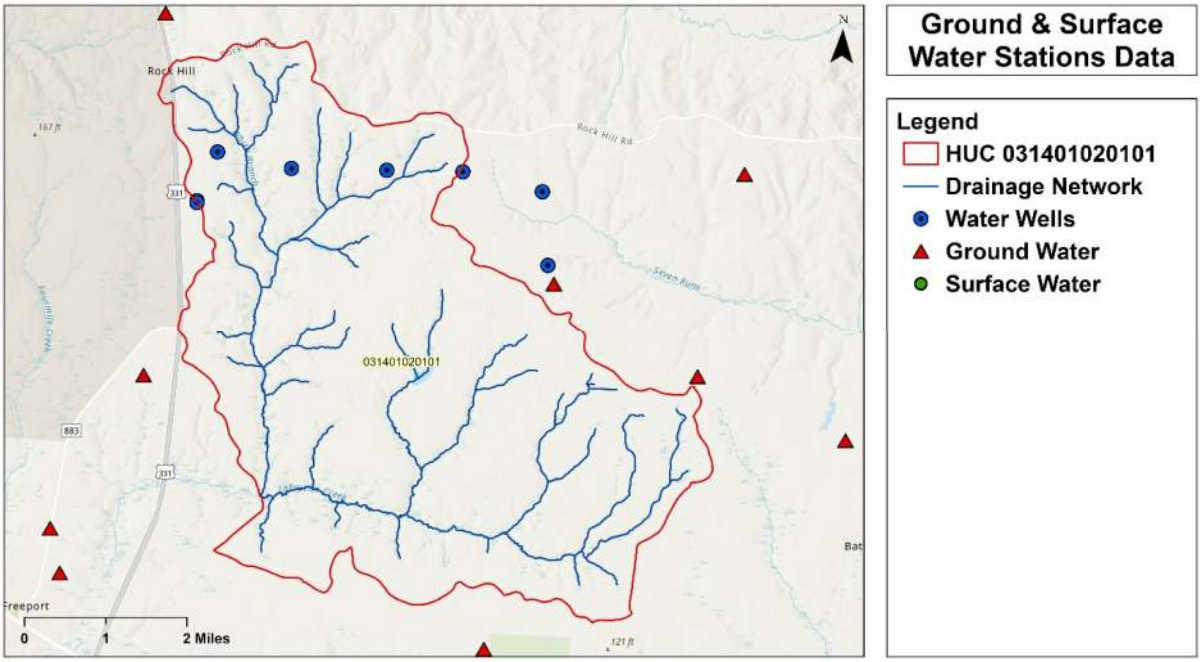

Figure 9. Ground and Surface Water Stations in the HUC 031401020101 sub-watershed, processed by FAU.

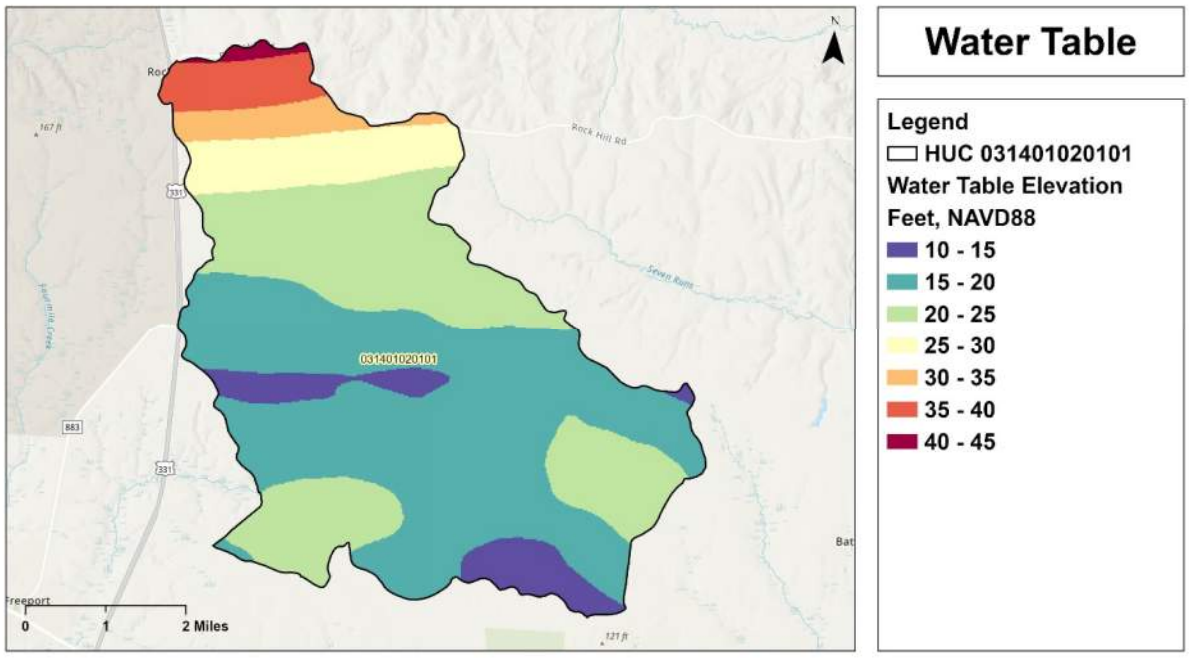

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401020101 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

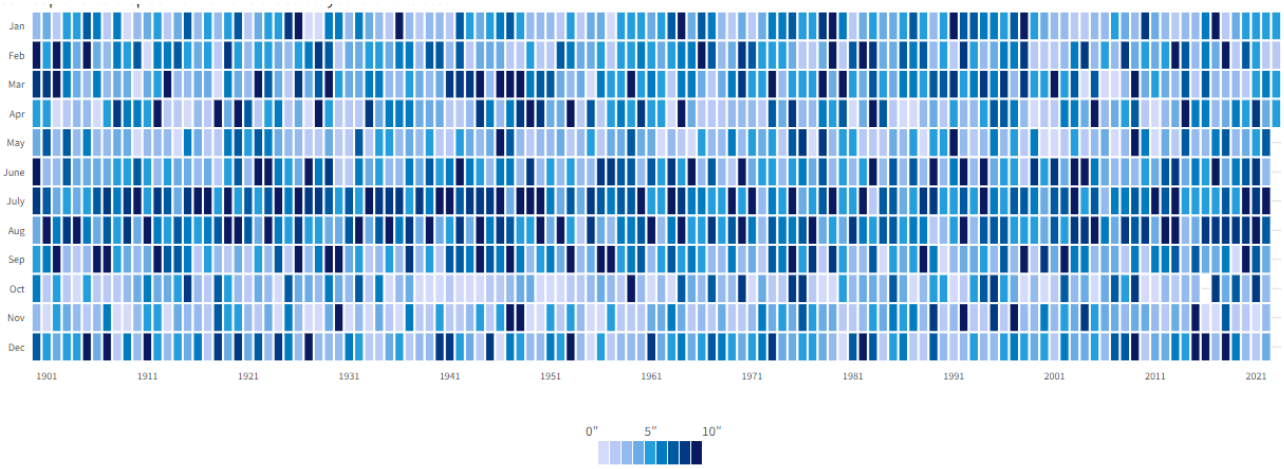

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/

While the topography (Section 2.1) and native soil (Section 2.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there are no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

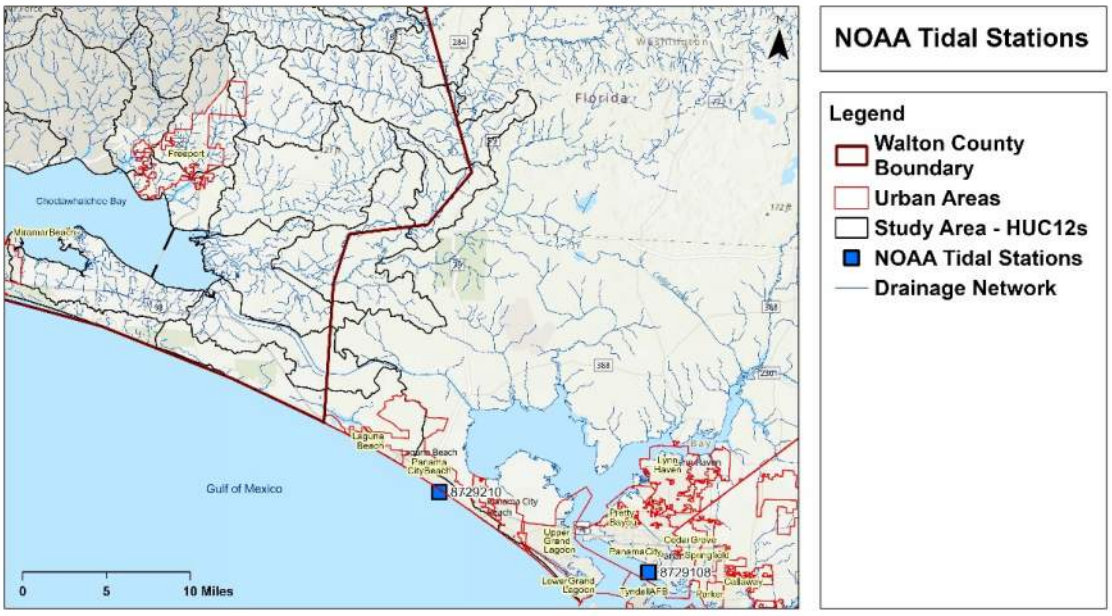

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

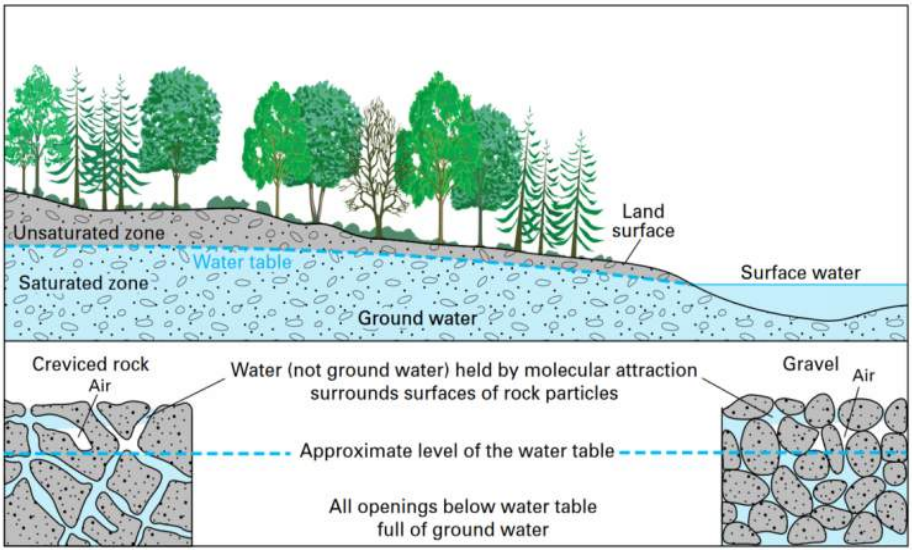

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

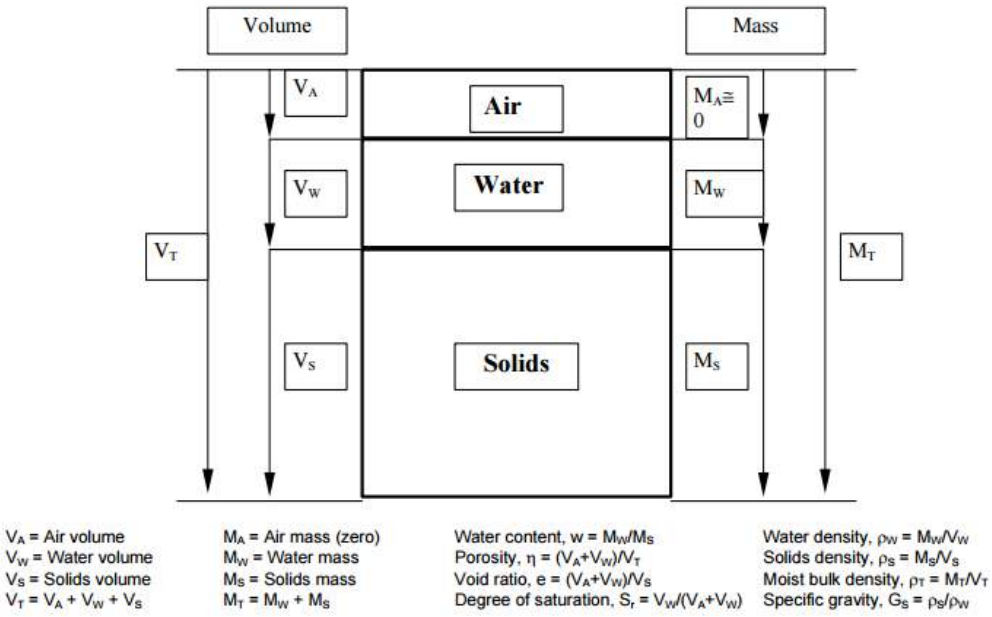

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

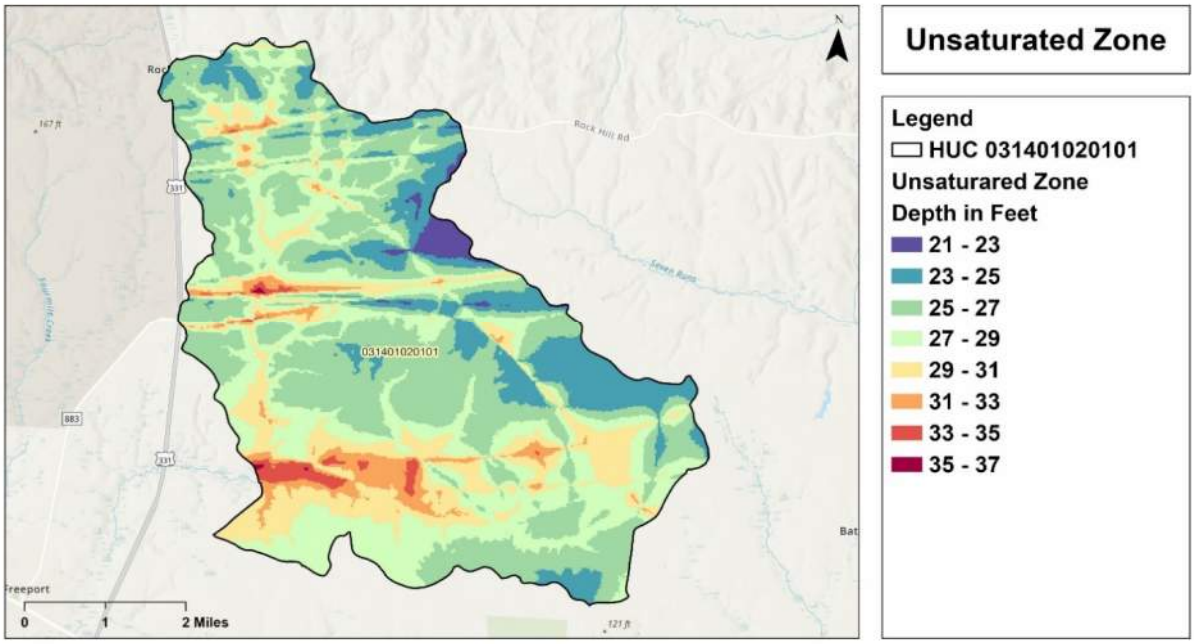

Figure 15. Unsaturated zone map for HUC 031401020101, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. Much of the basin has a medium amount of soil storage capacity, ranging between 30 to 33 inches of capacity left.

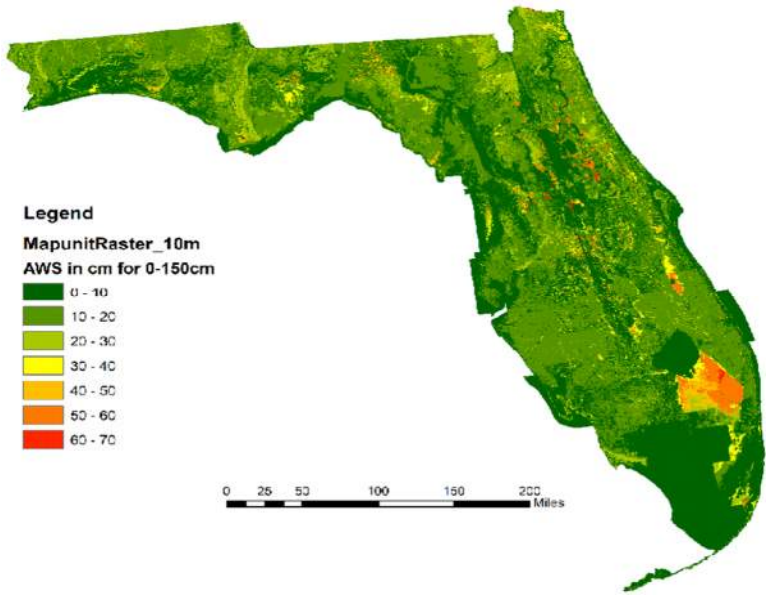

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

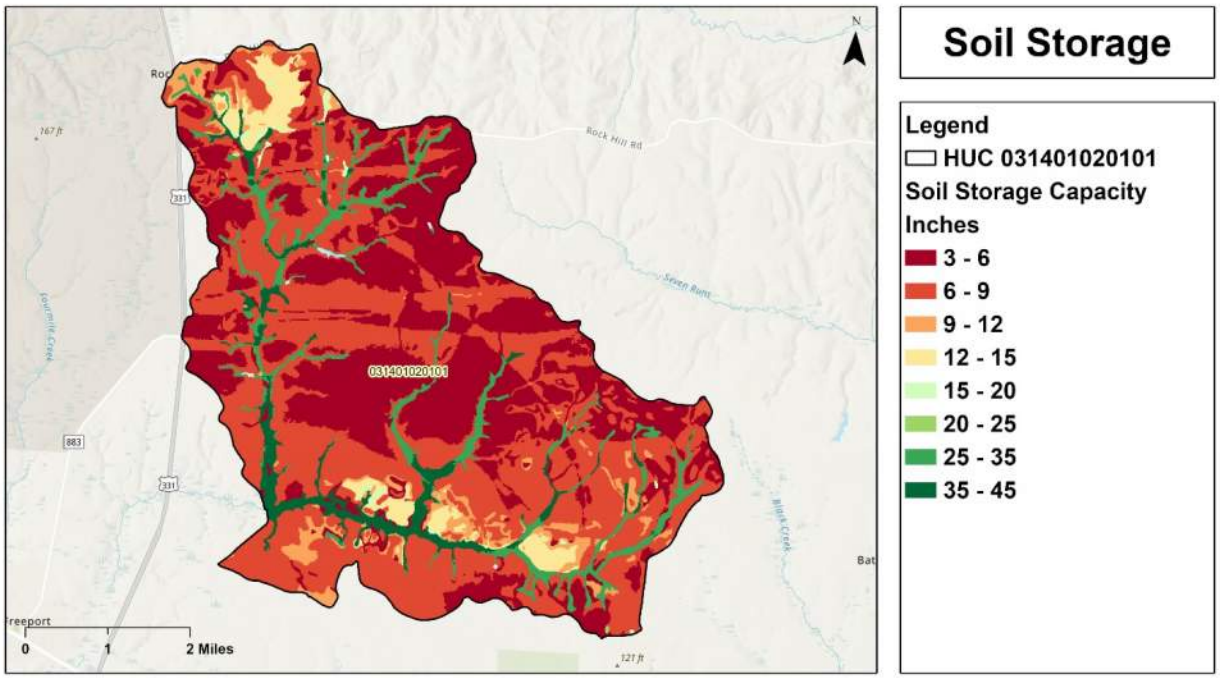

Figure 17. Water storage capacity of soil for the HUC 031401020101, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

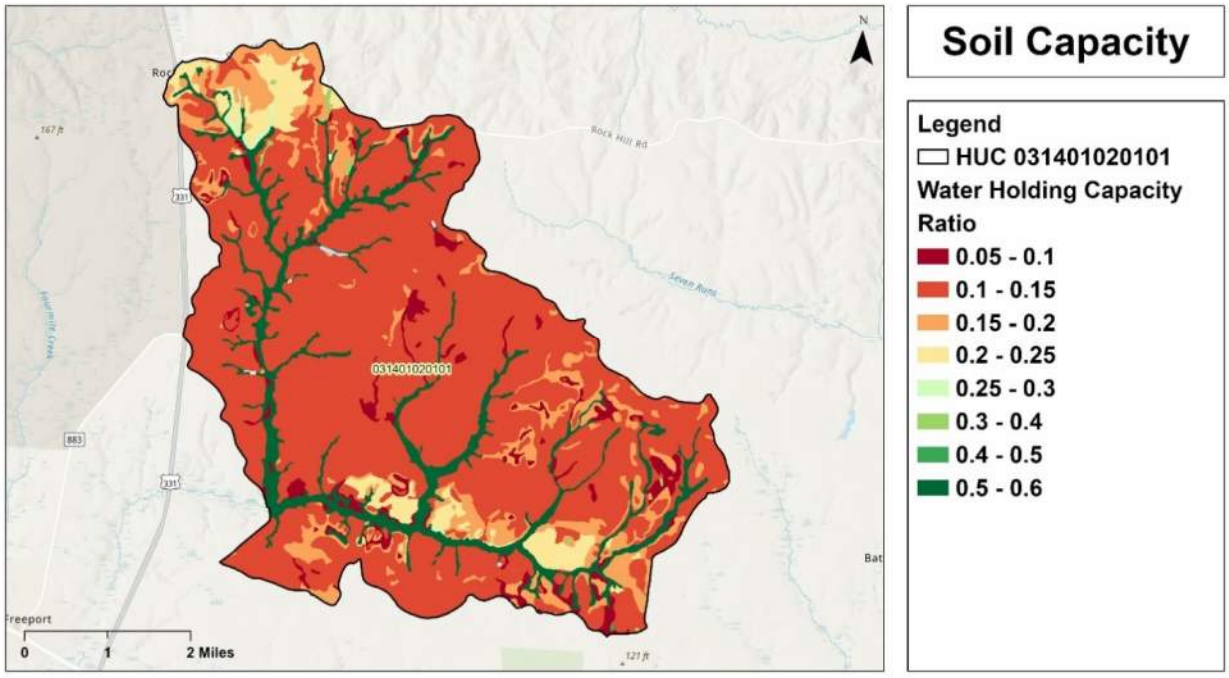

Figure 18. Water Holding Capacity (ratio) for the HUC 031401020101, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

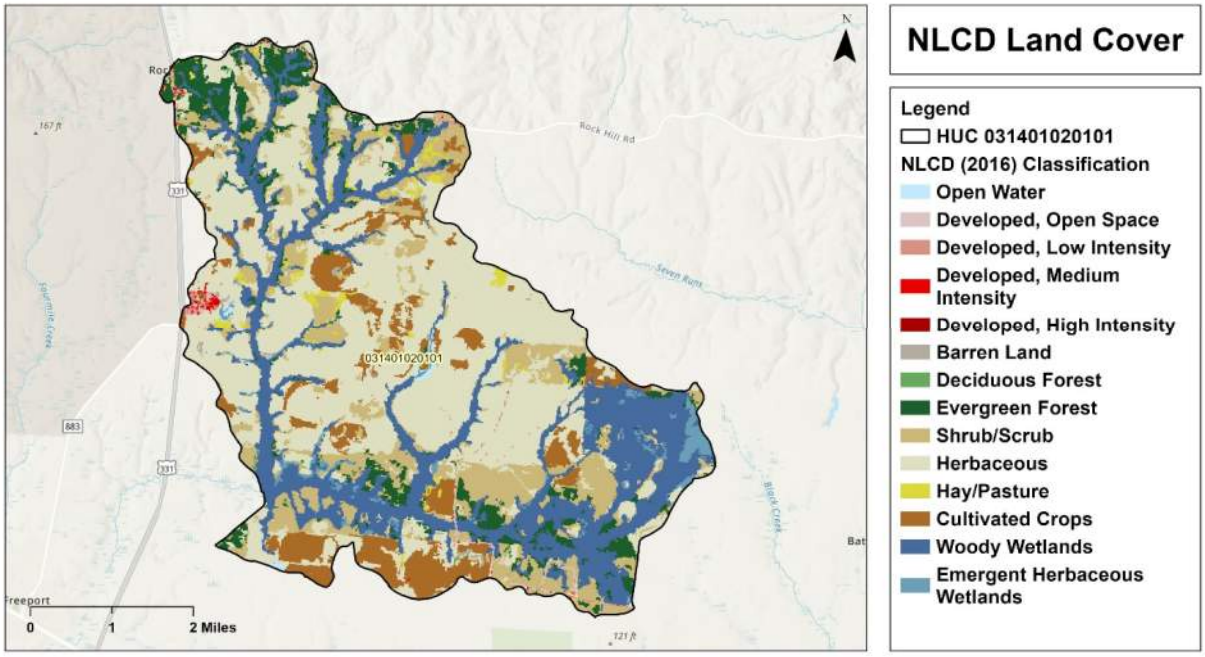

Figure 19. Land use in the HUC 031401020101 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps were used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

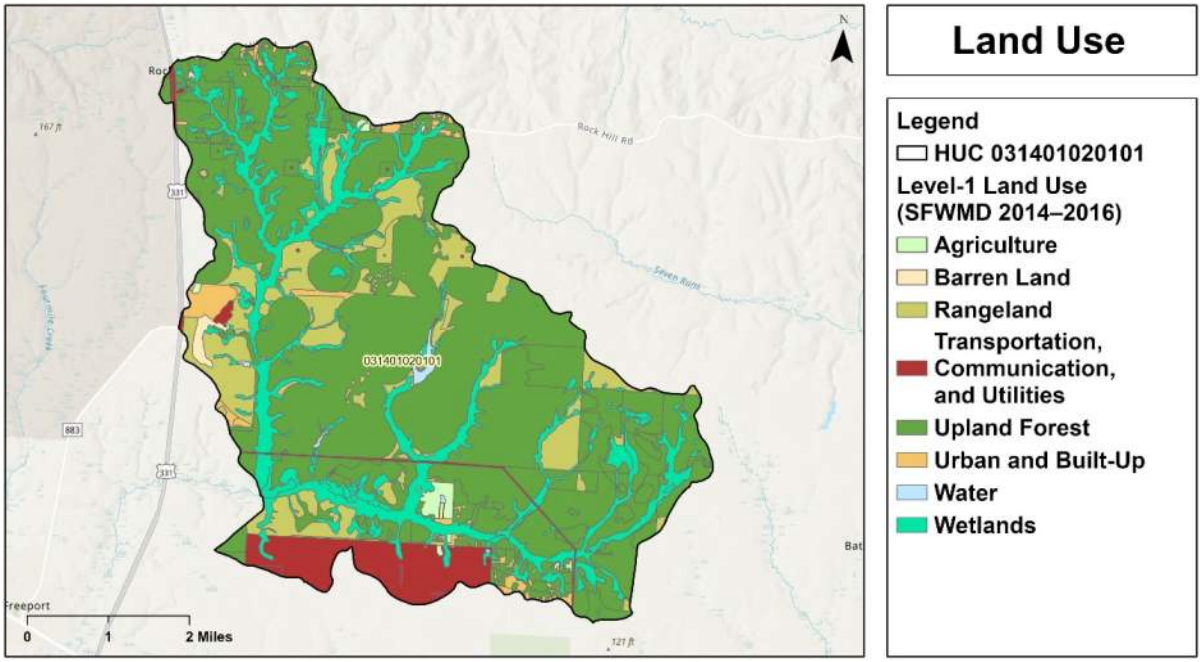

Figure 20. Land use in the HUC 031401020101 (from the 2023 Florida Geographic Data Library (FGDL) database), processed by FAU.

In the HUC 031401020203 sub-watershed, the predominant land cover is upland forest, accounting for 62.90% of the area. Urban and built-up comes in second at 13.92%, followed by wetlands at 10.80%, and rangeland at 9.73%, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031401020101 subwatershed (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	121.92	0.42%
Barren Land	75.01	0.26%
Rangeland	2849.14	9.93%
Transportation, Communication, and Utilities	4662.31	16.24%
Upland Forest	17254.18	60.11%
Urban and Built-Up	620.10	2.16%
Water	66.22	0.23%
Wetlands	3055.21	10.64%
Grand Total:	**28704.07**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

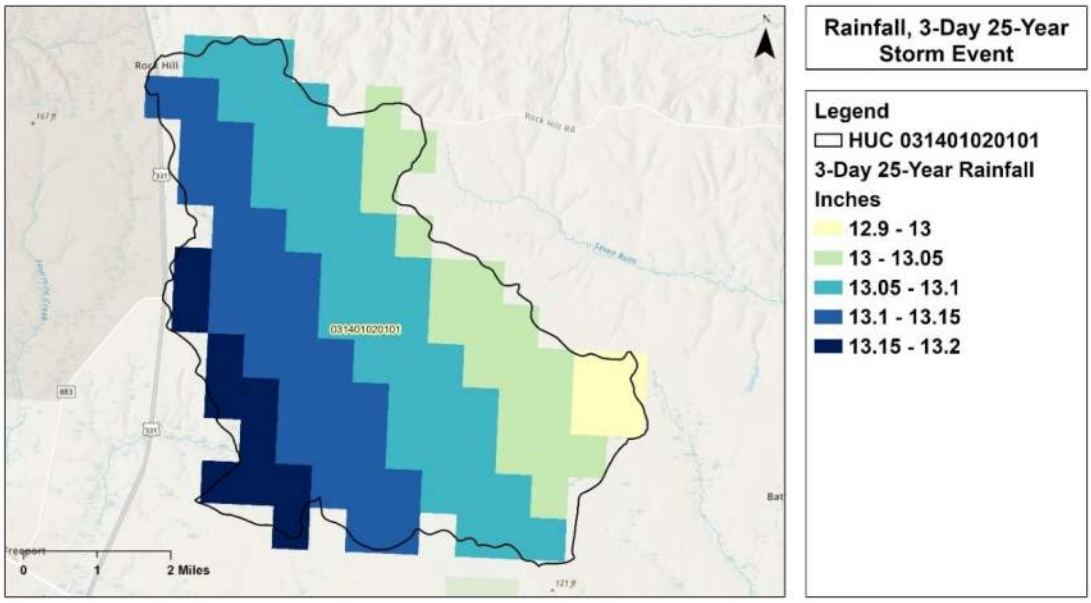

Figure 21. Rainfall distribution map across HUC 031401020101 sub-watershed, for 3-day 25-year storm event, processed by FAU.

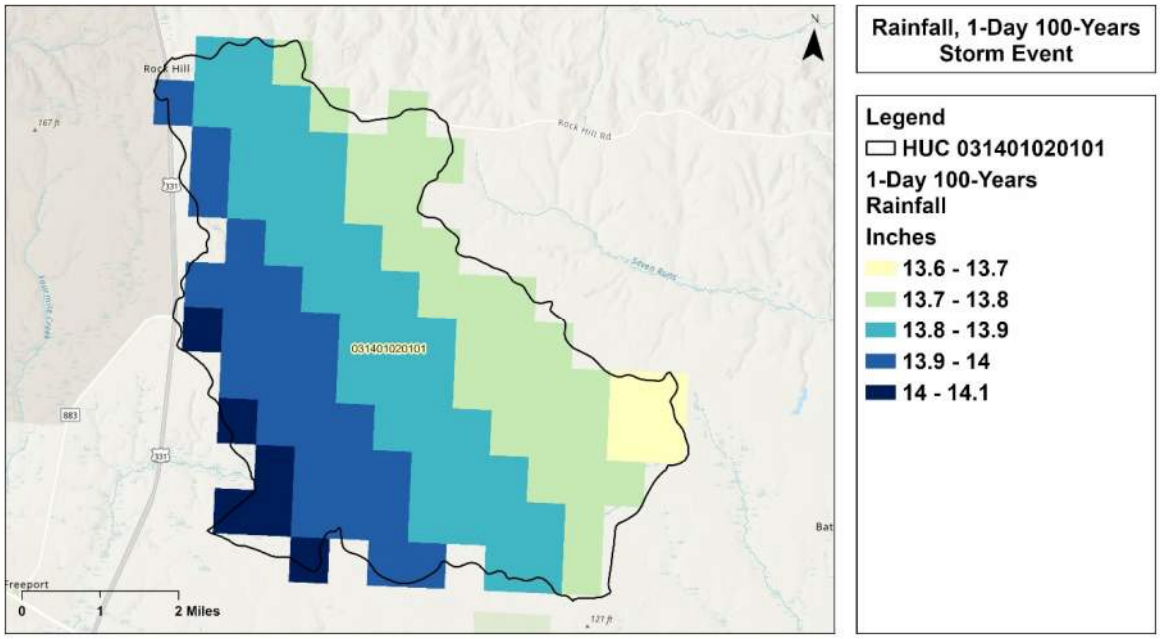

Figure 22. Rainfall distribution map across HUC 031401020101 sub-watershed, for 1-day 100-year storm event, processed by FAU.

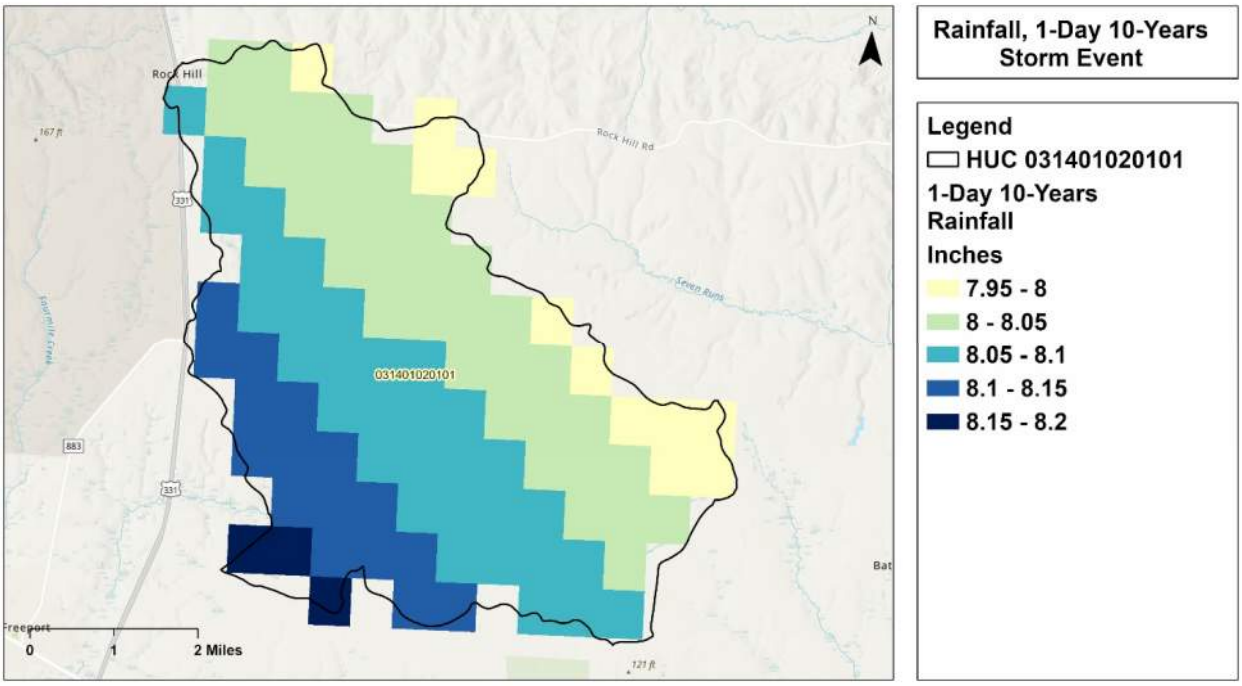

Figure 23. Rainfall distribution map across HUC 031401020101 sub-watershed, for 1-day 10-year storm event, processed by FAU.

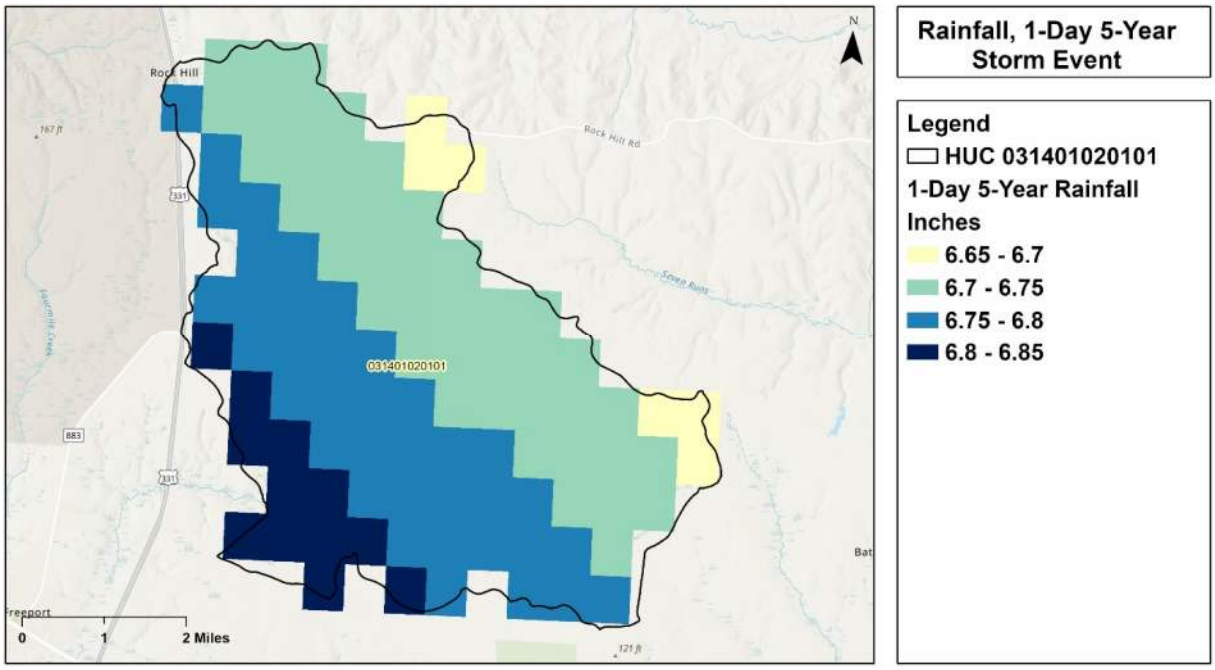

Figure 24. Rainfall distribution map across HUC 031401020101 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically

aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

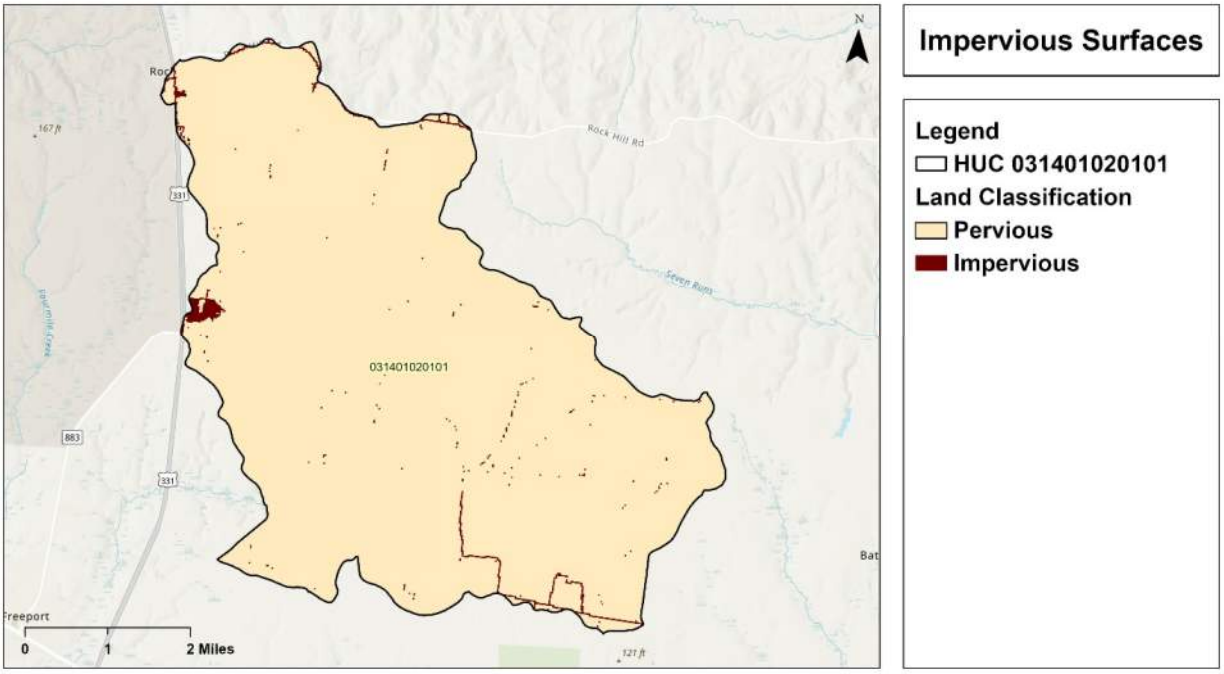

Figure 25. Impervious area map for the HUC 031401020101 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

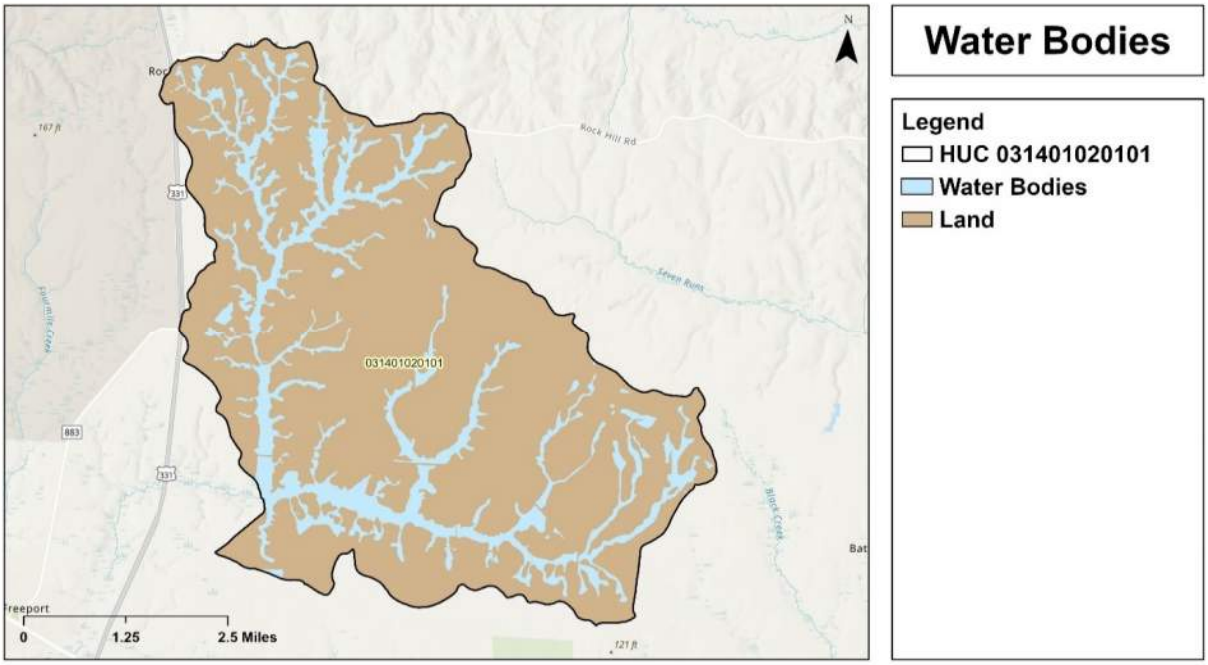

Figure 26. Water bodies map for the HUC 031401020101 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs,

property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County. Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.
** Census Designated Place

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

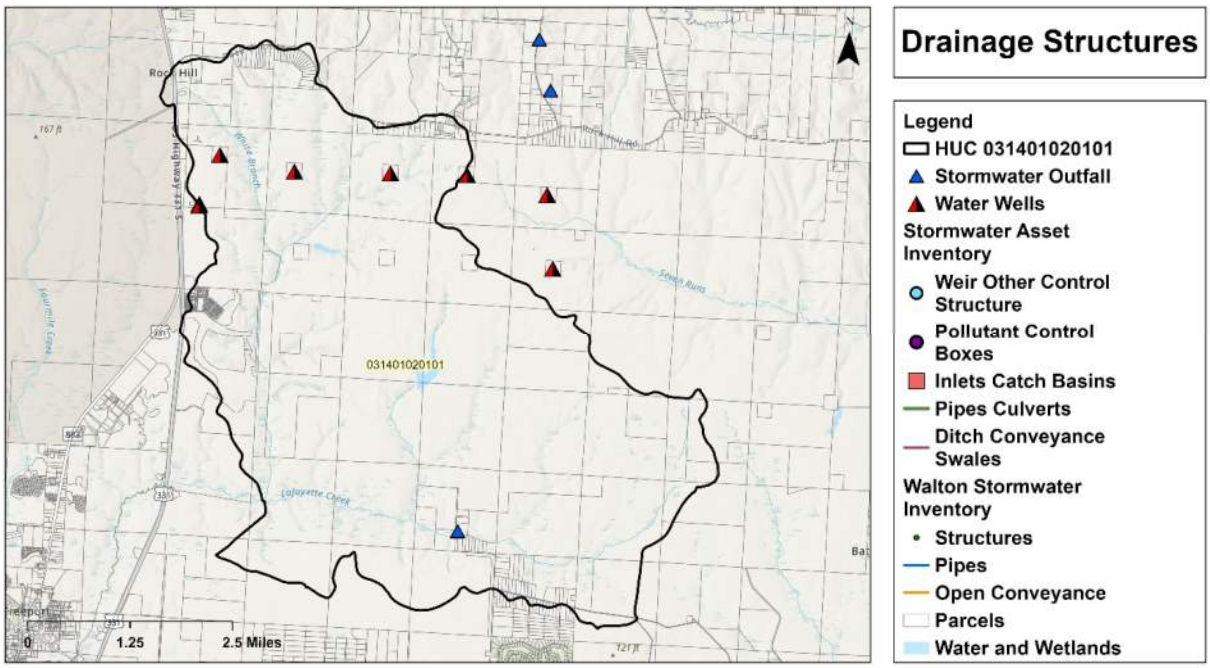

Figure 27. Stormwater Infrastructure for the HUC 031401020101. Processed by FAU.

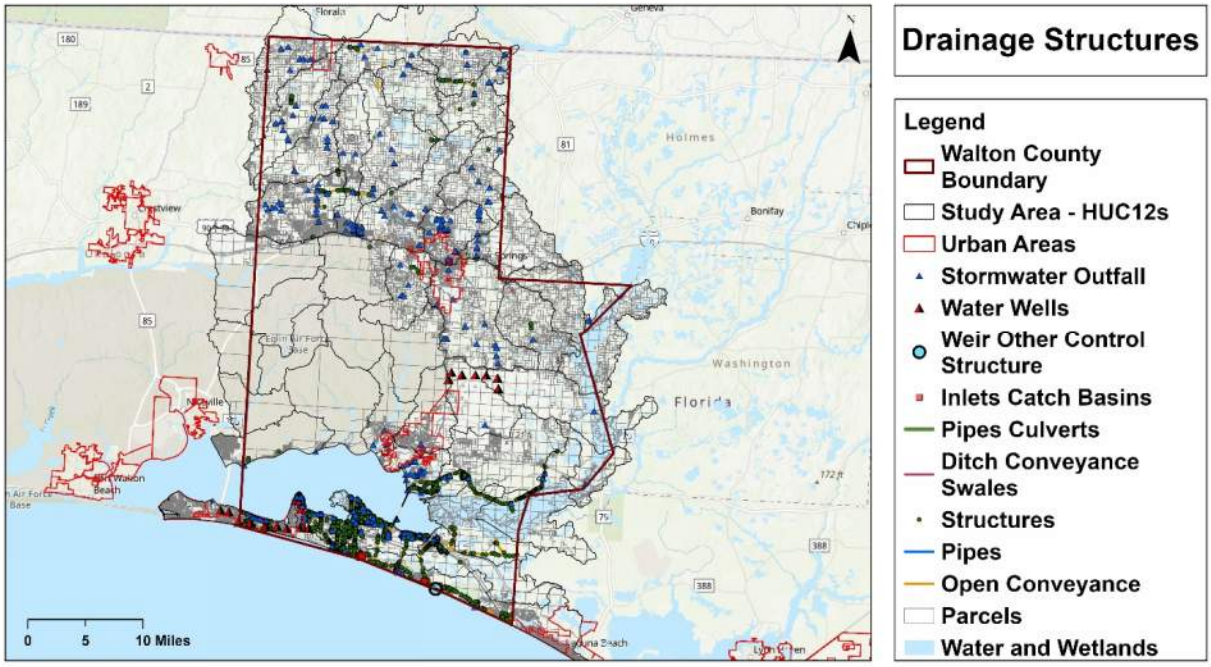

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapter 1, and analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401020101 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species

while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. Figure 29 shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

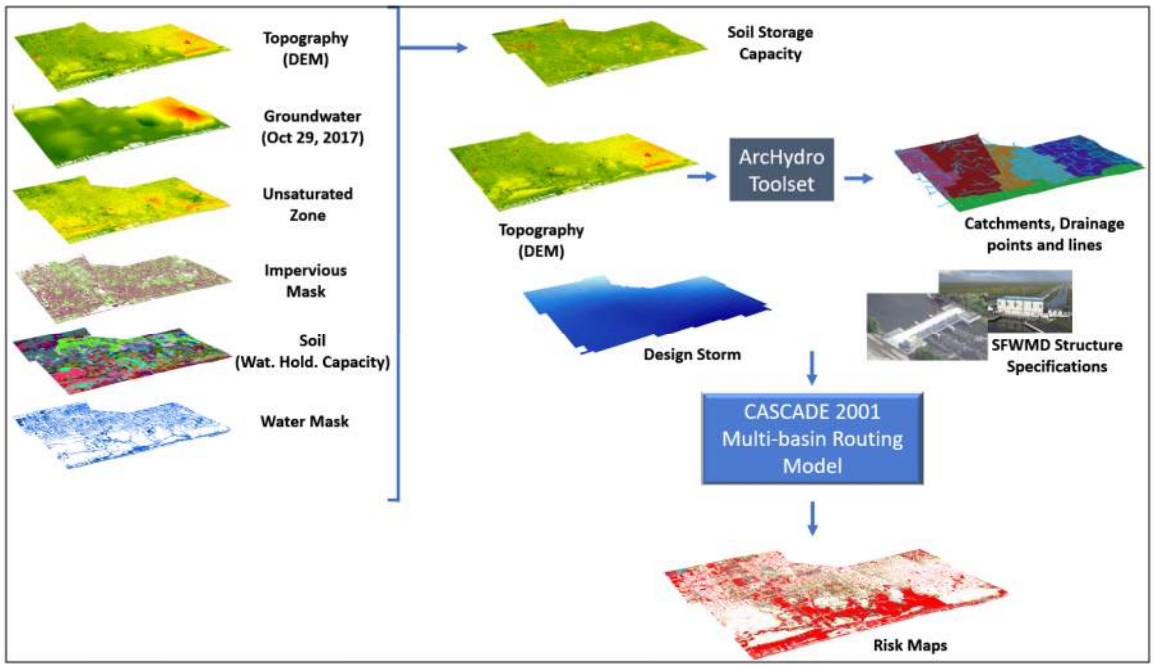

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are

critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

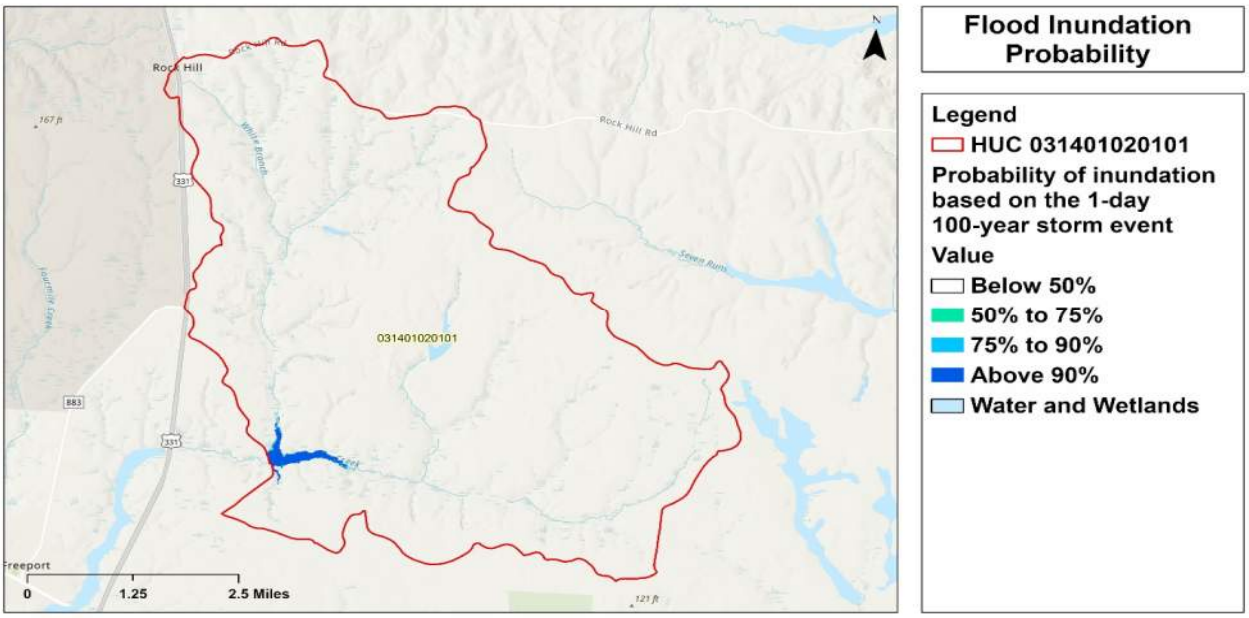

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401020101, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is

used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed later in this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not

eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a very small portion of flooding is noted at the entrance to the creek into the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, sea level rise should not impact the HUC, therefore SLR scenarios were not calculated.

The design storm simulation determined that approximately 0.5% of the HUC total area or 0.14 mi² has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 0.5% of the HUC's total area, or 0.14 mi² would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.3% of the HUC's total area, or 0.09 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0.3% of the HUC's total area, or 0.08 mi², would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401020101 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	27.66	0.14	99.5%	0.5%
1-day 100-year	27.65	0.14	99.5%	0.5%
1-day 10-year	27.70	0.09	99.7%	0.3%
1-day 5-year	27.72	0.08	99.7%	0.3%

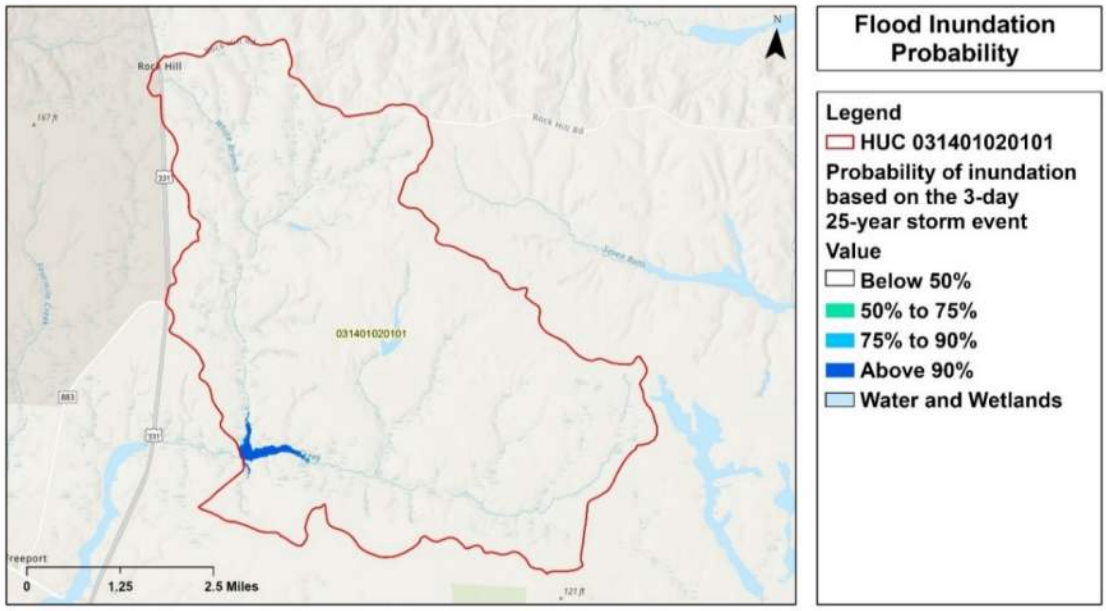

Figure 31. 3-day 25-year storm event for HUC 031401020101 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

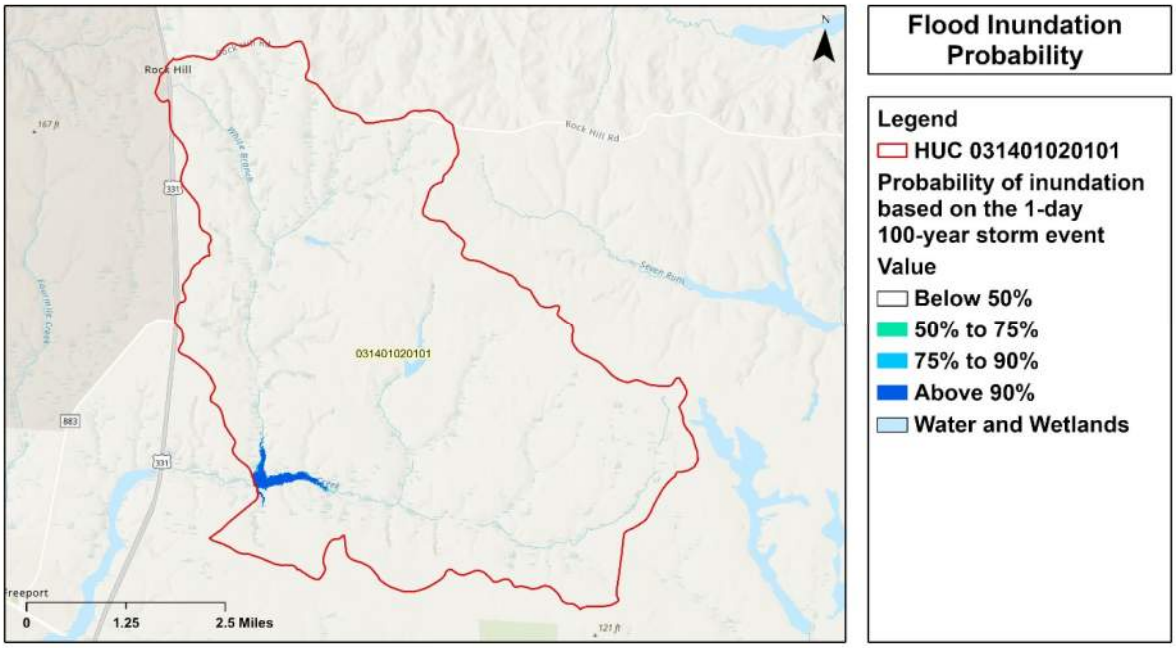

Figure 32. 1-day 100-year storm event for HUC 031401020101 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

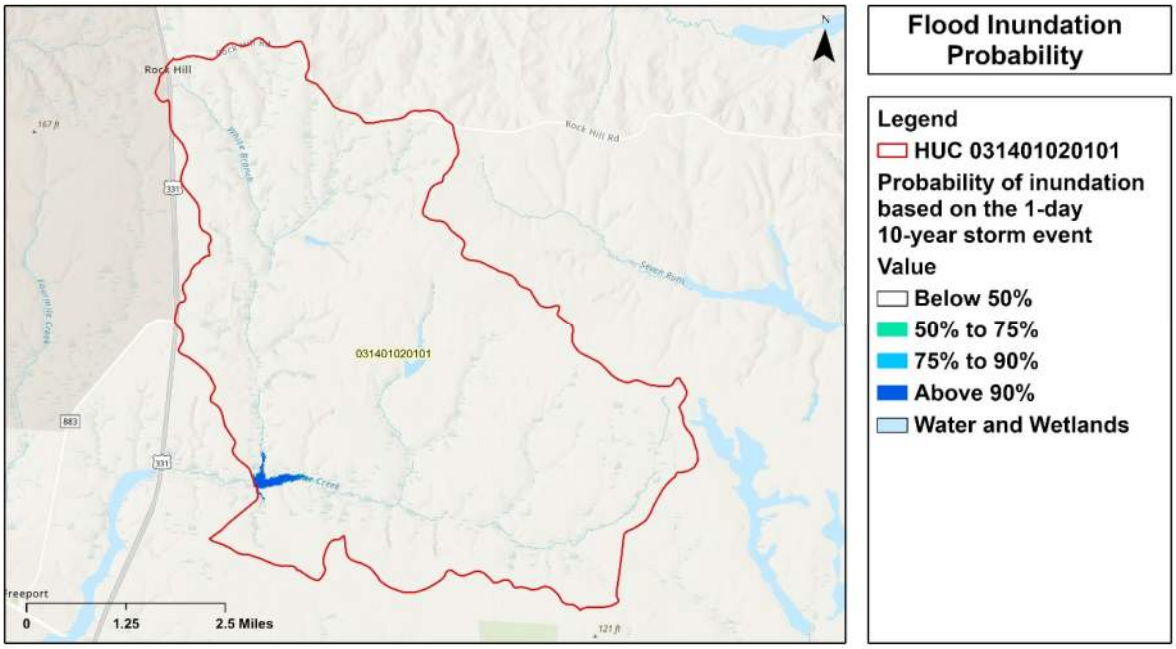

Figure 33. 1-day 10-year storm event for HUC 031401020101 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

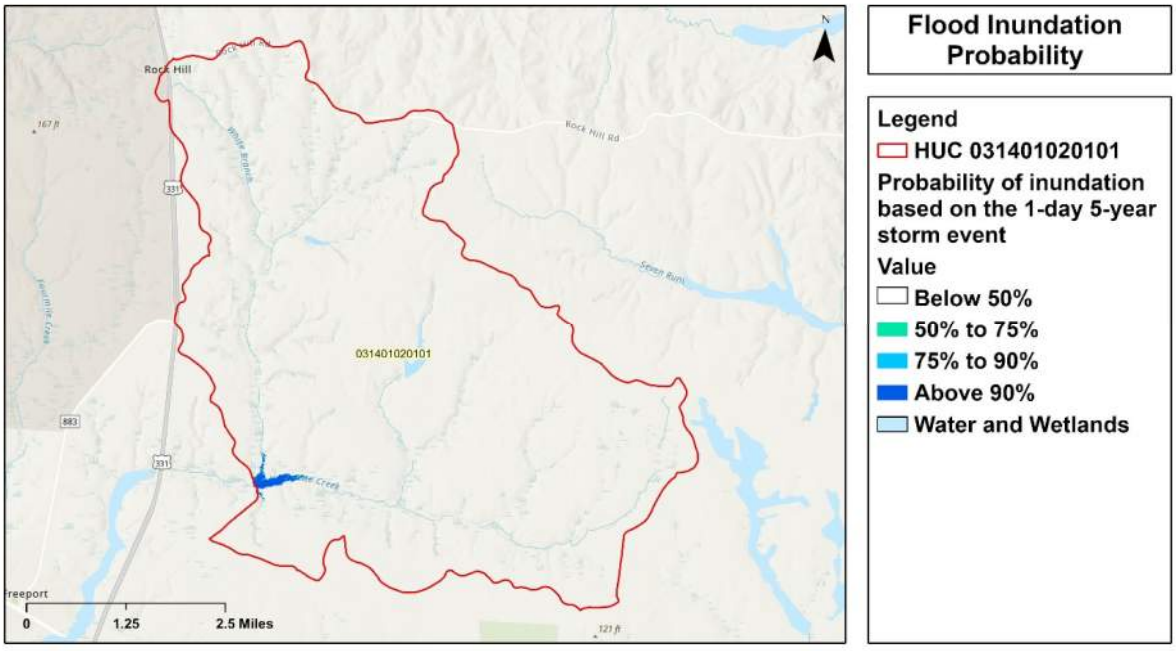

Figure 34. 1-day 5-year storm event for HUC 031401020101sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	Description	TIER (Priority of Land Use)
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6

10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6

37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6

60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1

92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031401020203 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will

be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

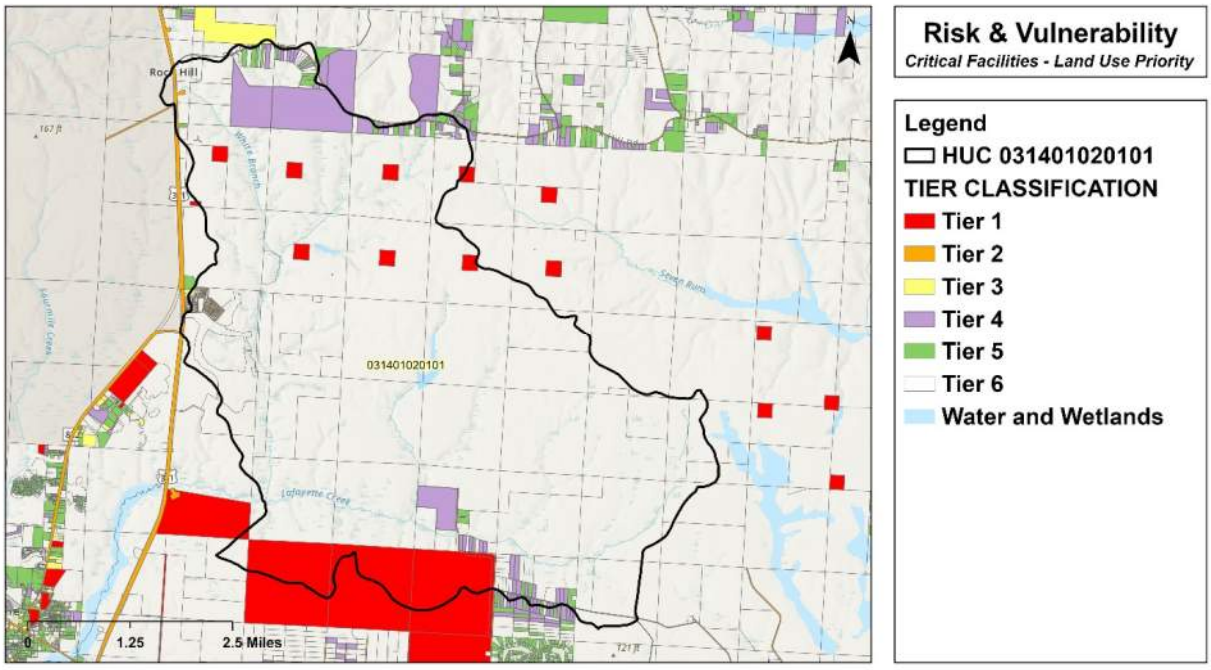

Figure 35. HUC 031401020101 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

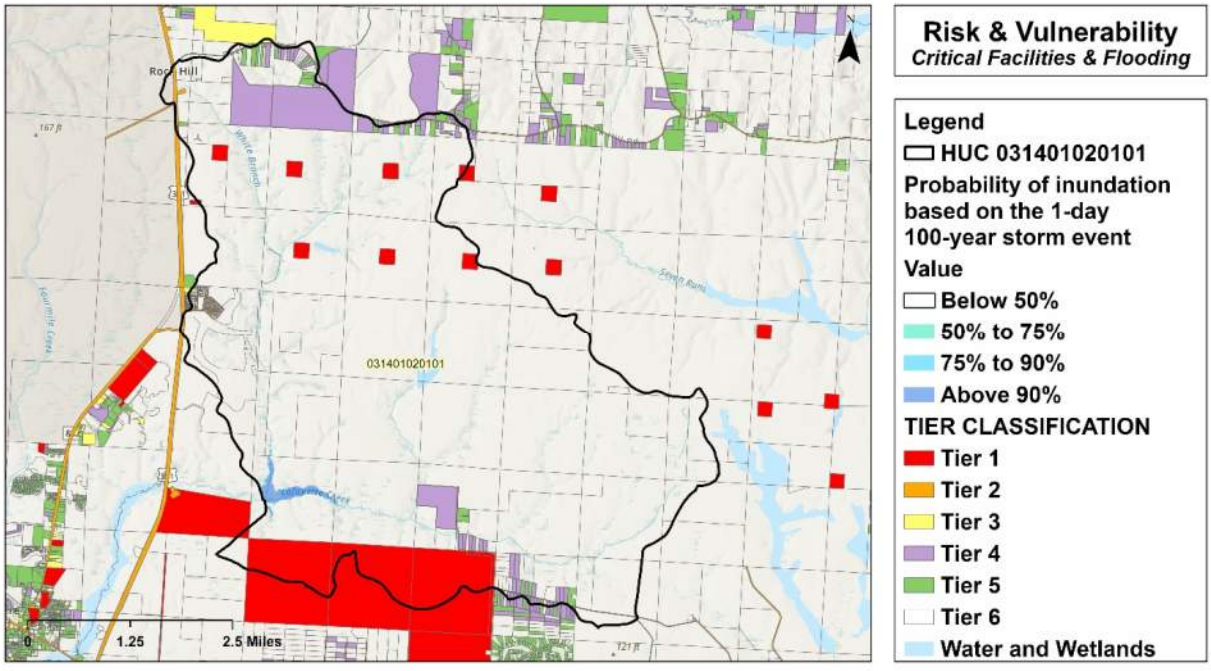

Figure 36. HUC 031401020101 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation map. Processed by FAU.

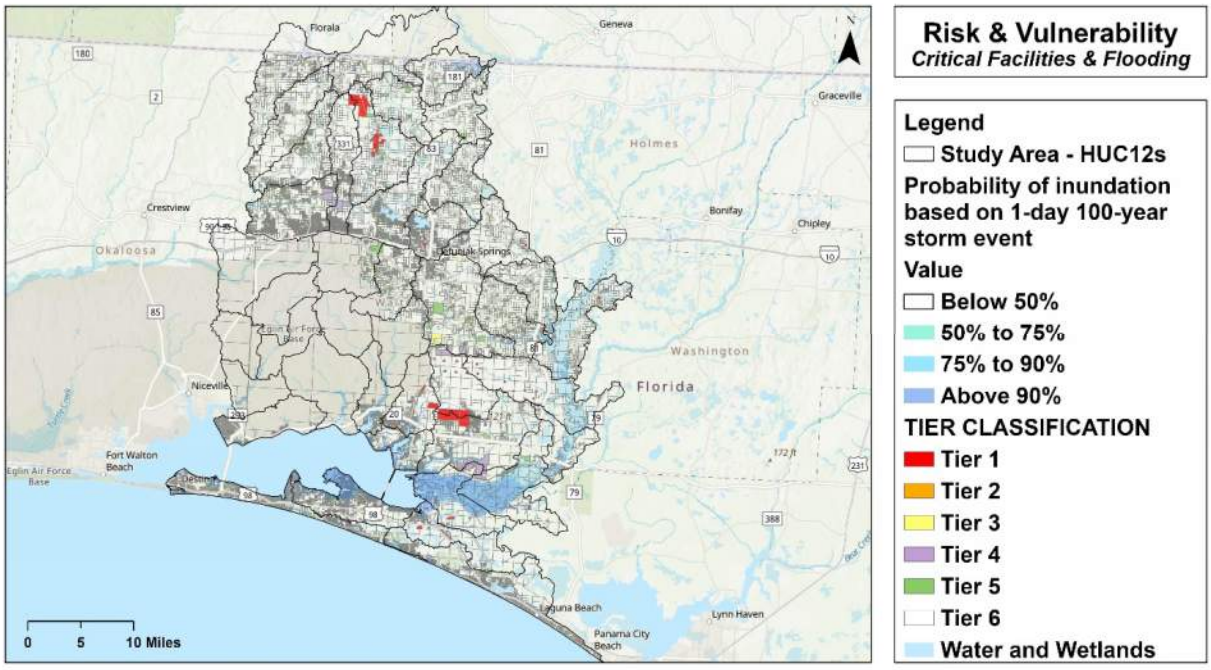

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation map for Walton County. Processed by FAU.

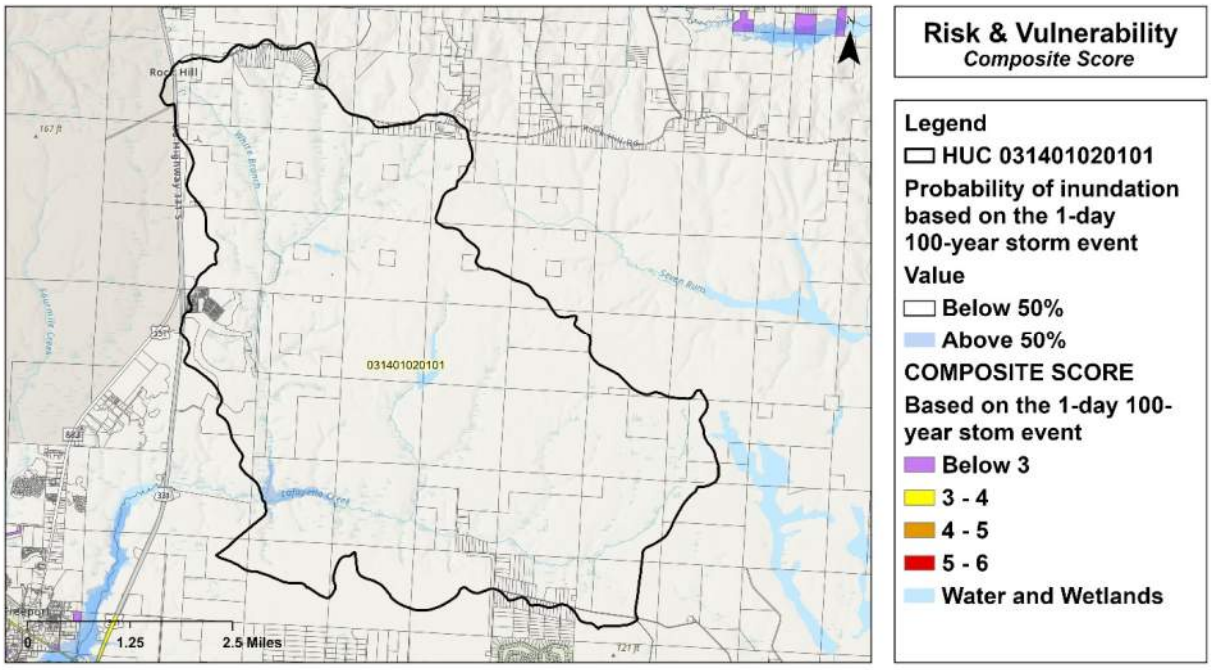

Figure 38. HUC 031401020101 sub-watershed Composite Score Risk map based on the 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation. Processed by FAU.

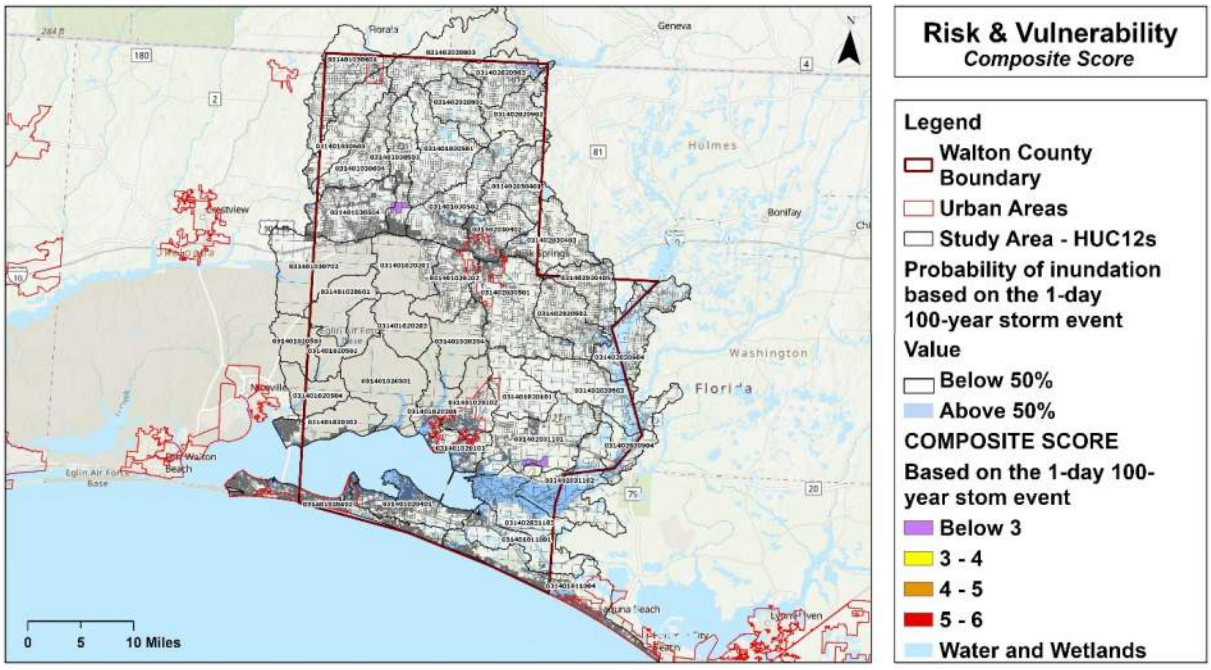

Figure 39. Walton County (mosaic) - Composite Score Risk map based on 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation map. Processed by FAU.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401020203. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401020101. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401020101	17788.68
All of the 1-day 100-year storm event inundation	**91.37**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	91.37
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	91.37
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	0.00

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

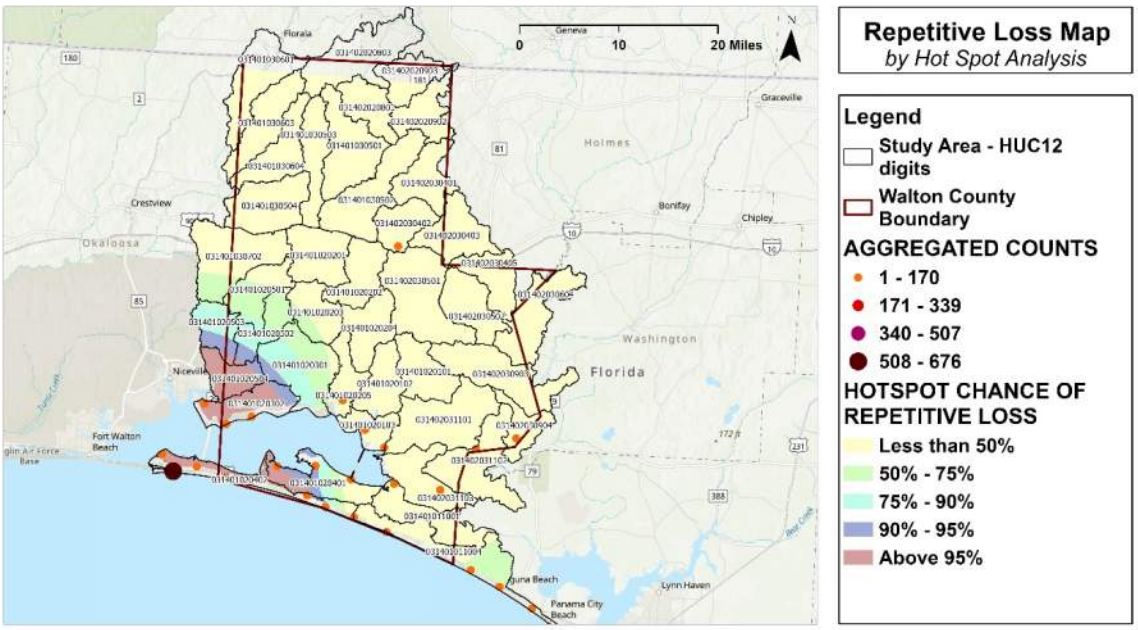

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5 Priority Projects

Considering the priority of land uses within the basin, there are 11 parcels classified as tier 1, all of which are utilities (DOR code 091). Additionally, there is one heavy manufacturing parcel (COR code 042) intersecting the HUC boundary. In this context, there are also several orphanages (COR code 075) and mobile homes (DOR code 002), designated as tier 4, as well as some residential parcels/single-family (DOR code 001) categorized as tier 5, indicating a lower priority for intervention.

On the other hand, when considering the composite score, it notable that there is no critical facilities situated within the flooding zone, once flooding in the area is relatively minor and not alarming, indicating no necessity of priority projects intervention within the basin.

APPENDIX E

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401020102

LAFAYETTE CREEK-FOURMILE CREEK

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Research Assistant: Leticia Sabio

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 sub-watershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub- watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401020102) is highlighted among all the HUCs to help identifying its location. (Figure 3).

The city of Freeport shares a portion of its boundary with the basin. Demographics data and other considerations of Freeport, along with other cities in Walton County, will be covered in subsequent discussions.

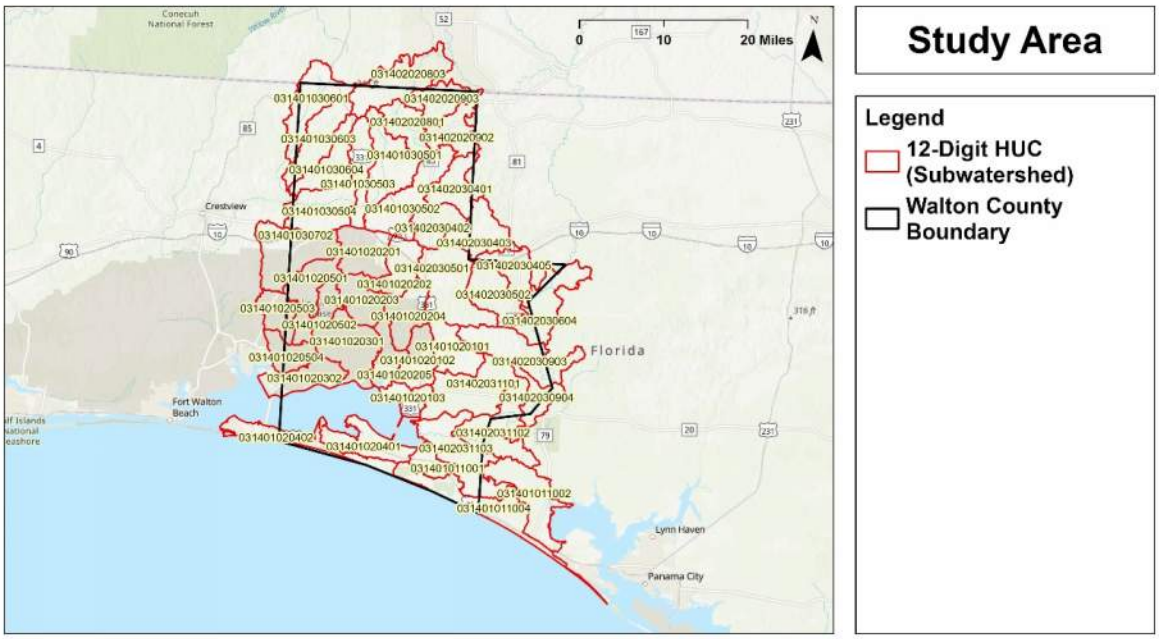

Figure 1. Walton County and all HUCs 12-digit sub-watershed, processed by FAU.

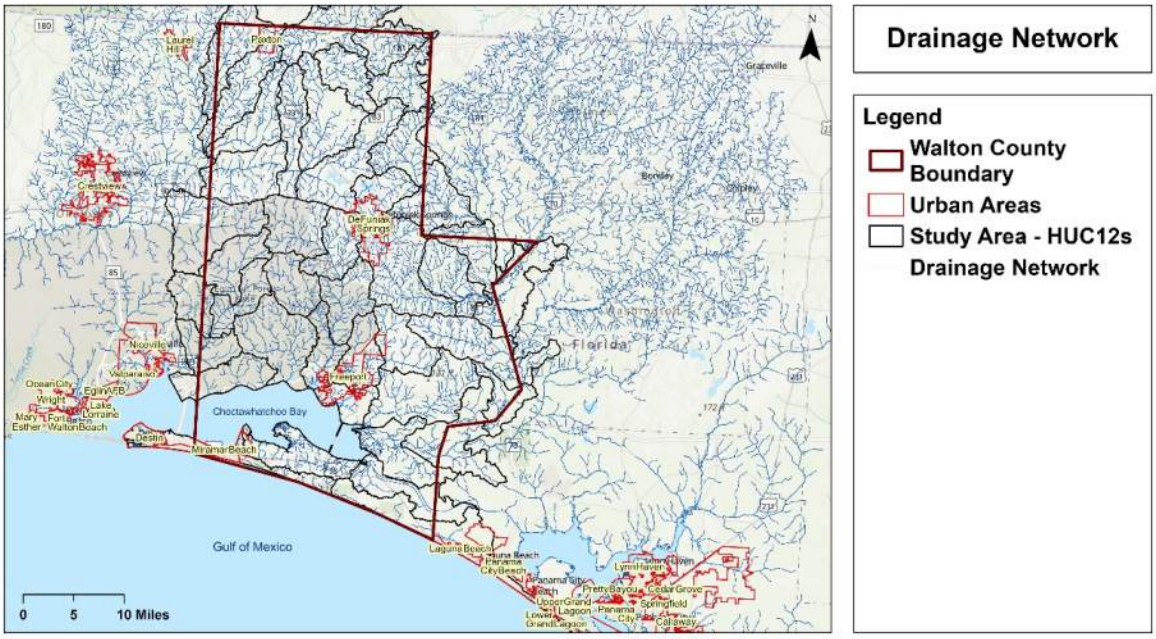

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

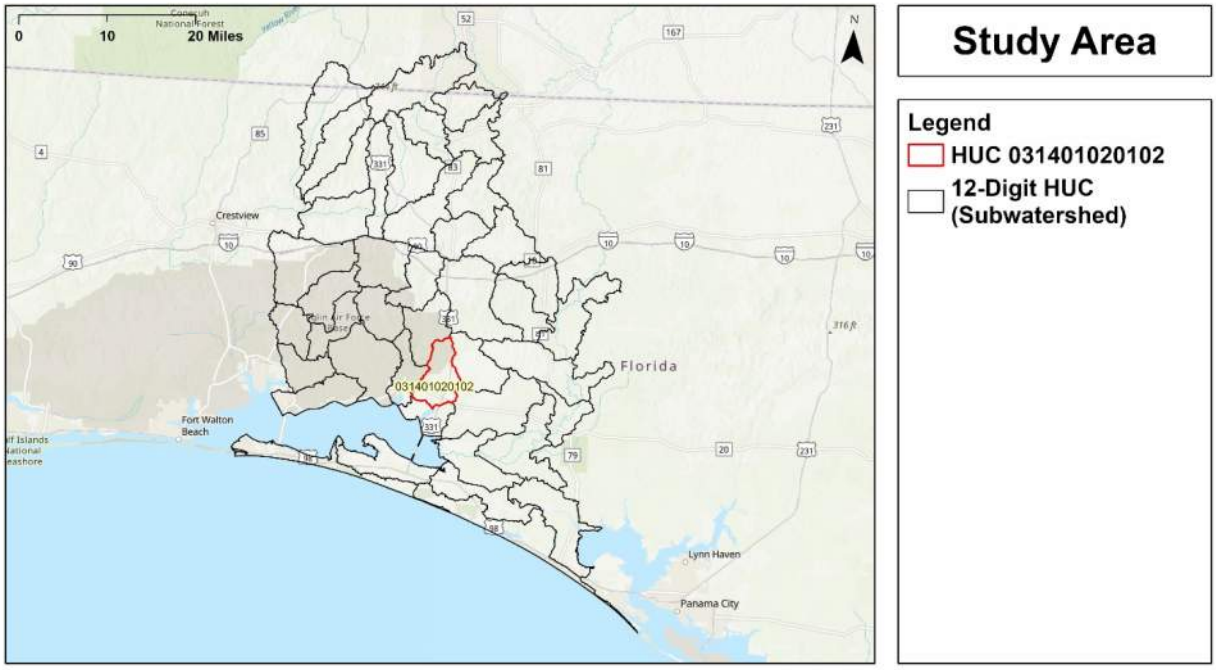

Figure 3. HUC 031401020102 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development, tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Figures 12 and 13 in the county-wide report show the current and projected land use for the County. Based on the 2017 future land use map for Walton County only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in Table 2.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with

high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (Figure 4). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

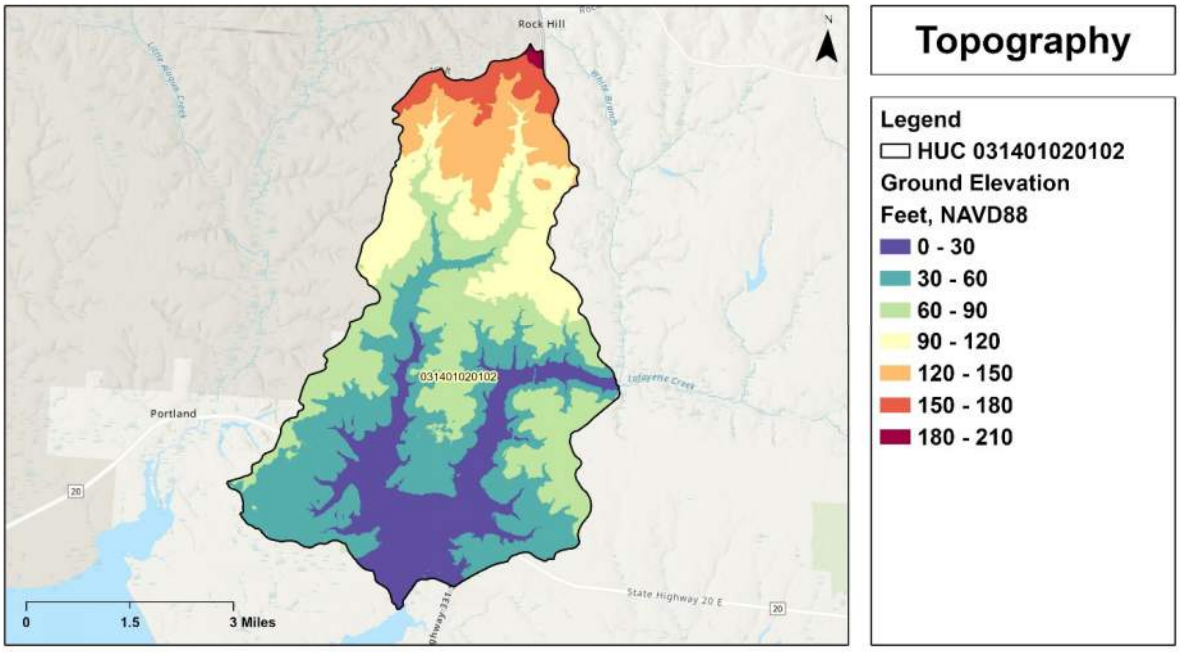

Figure 4. Topographic map of the HUC 031401020102 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology.

Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401020102 sub-watershed is shown in **Error! Reference source not found.**.

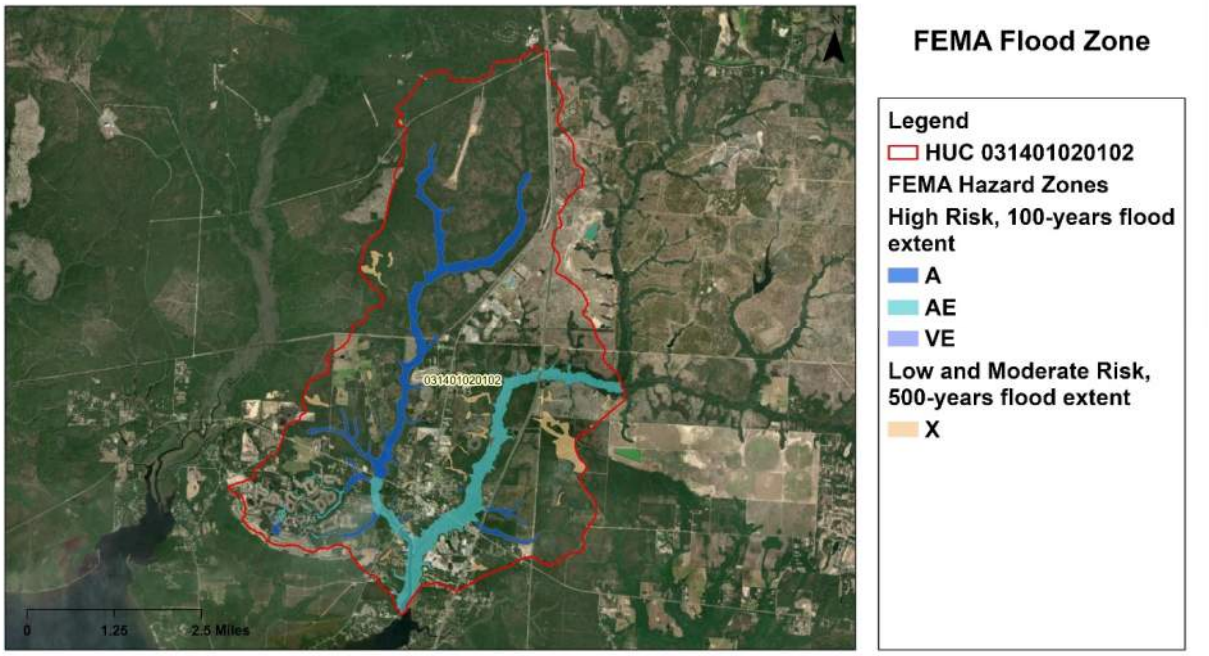

Figure 5. FEMA Flood Zone map (2020) for HUC 031401020102 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal

area, including the sub-watershed 031401020102 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

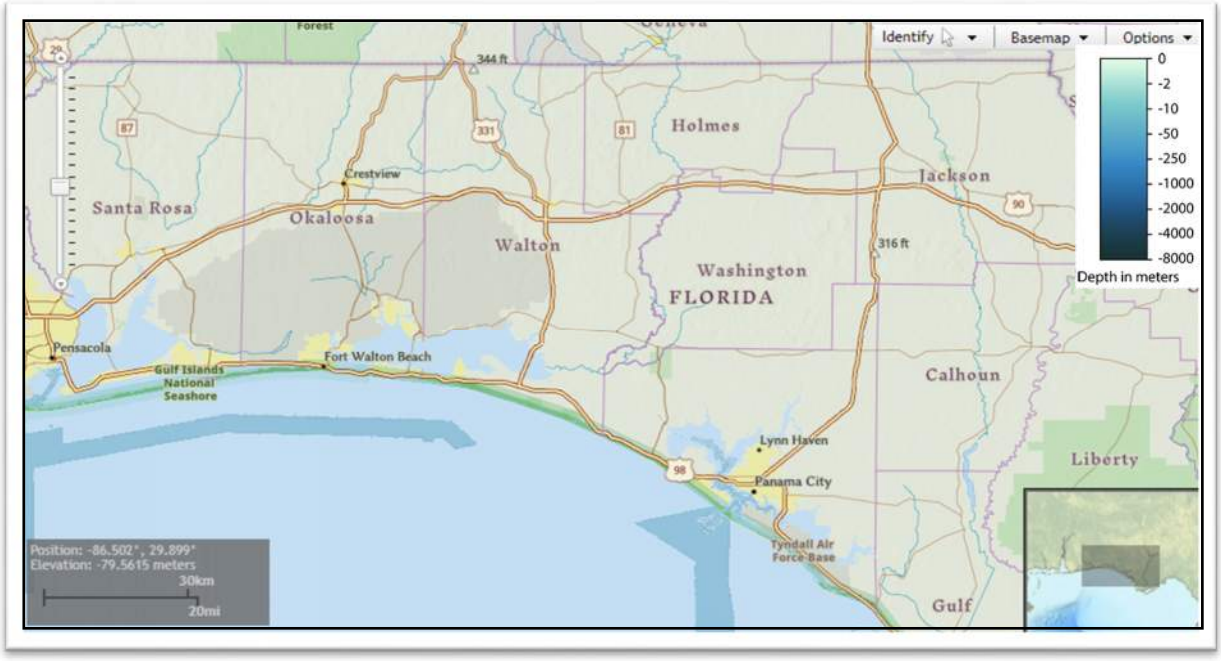

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

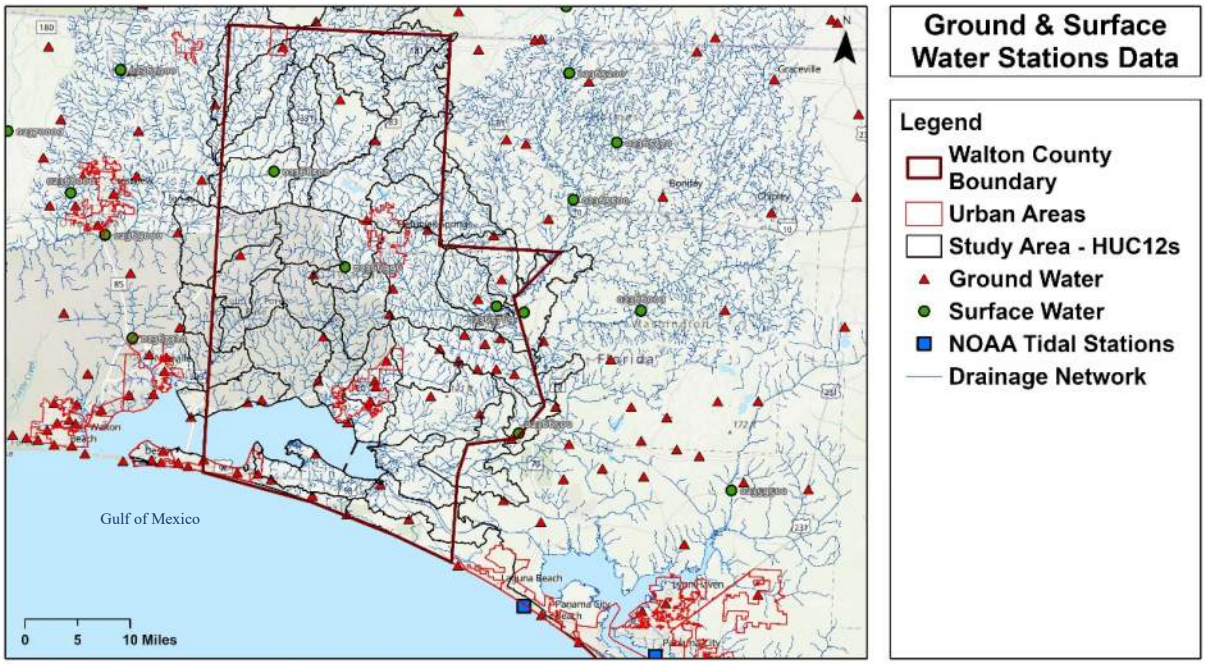

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The major water bodies in the HUC 031401020102 sub-watershed include:

- Fourmile Creek
- Lafayette Creek
- East Branch Fourmile Creek
- Thomas Branch

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366996. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401020102, which is USGS 02366996 Alaqua Creek Near Pleasant Ridge, FL.

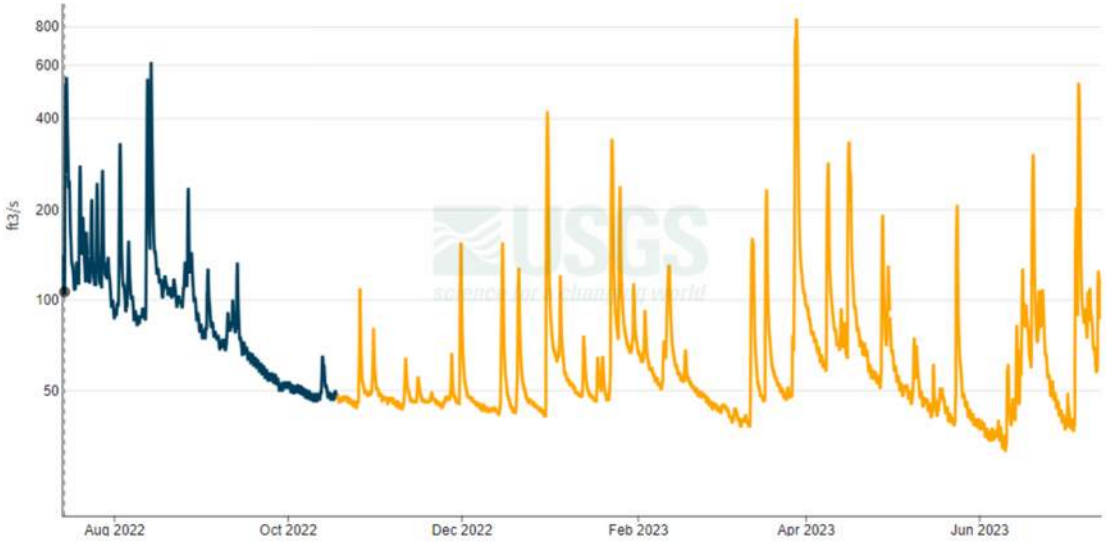

Figure 8. Average streamflow for Alaqua Creek Near Pleasant Ridge, FL (USGS 02366996 Surface-Water, June 2022 to July 2023).
Data retrieved from USGS Water Data Services: https://waterdata.usgs.gov/monitoring-location/02366996/#parameterCode=00065&period=P7D

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the

database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401020102 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031401020102 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

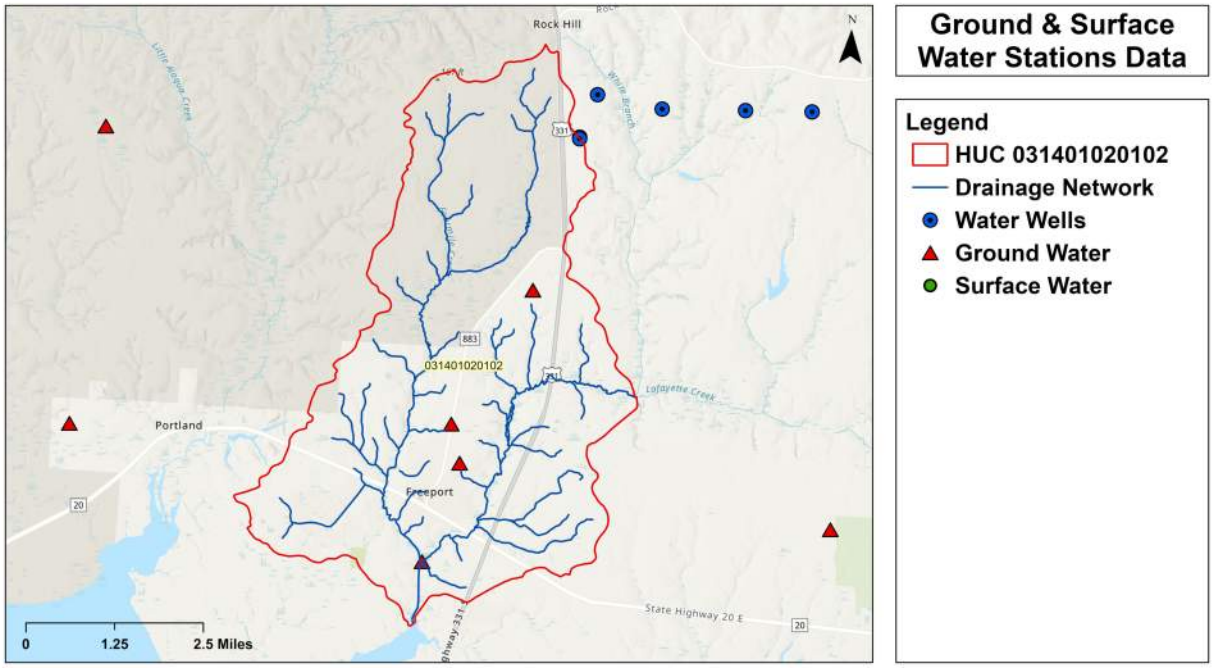

Figure 9. Ground and Surface Water Stations in the HUC 031401020102 sub-watershed, processed by FAU.

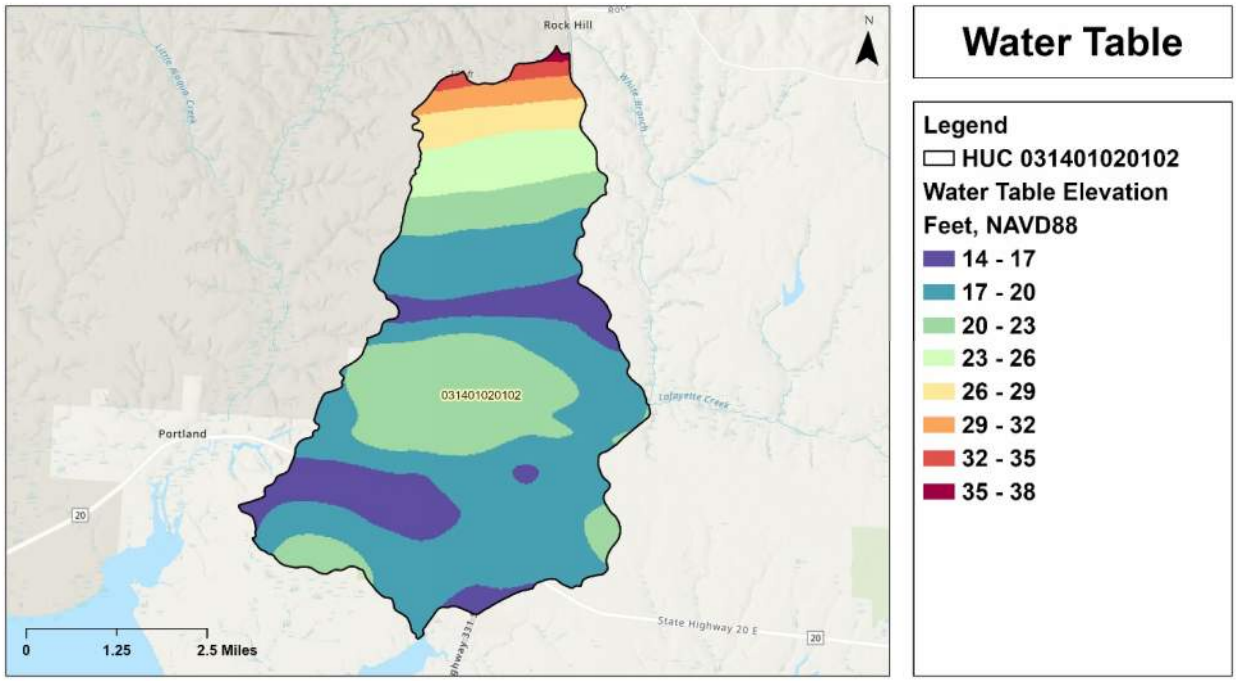

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401020102 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

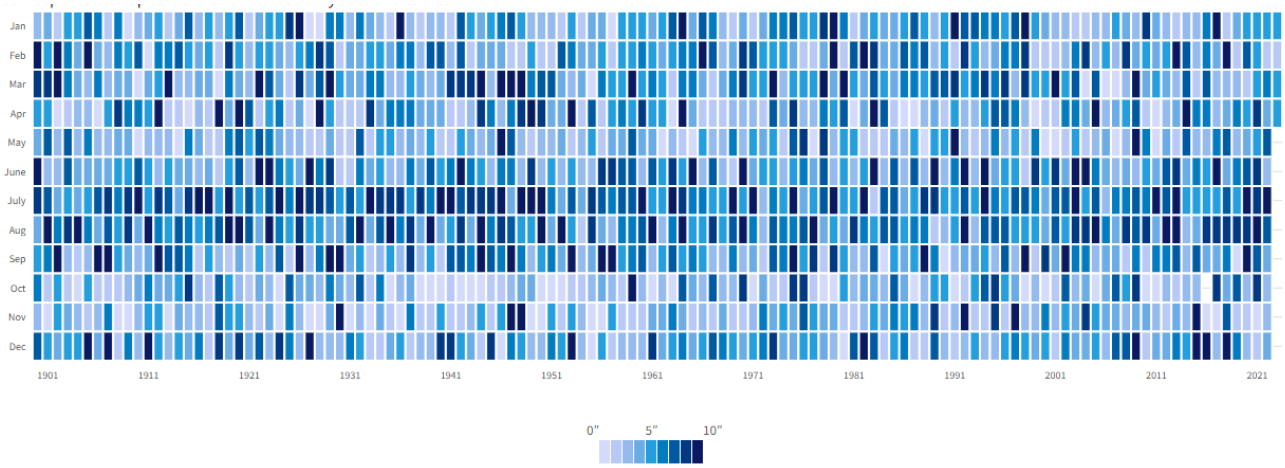

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

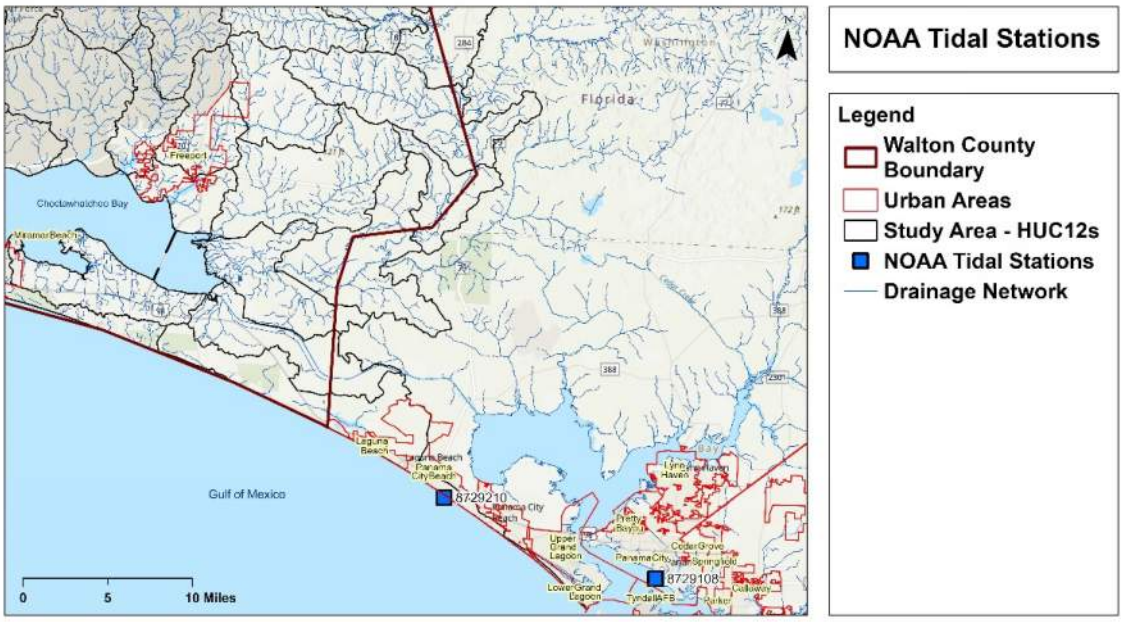

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

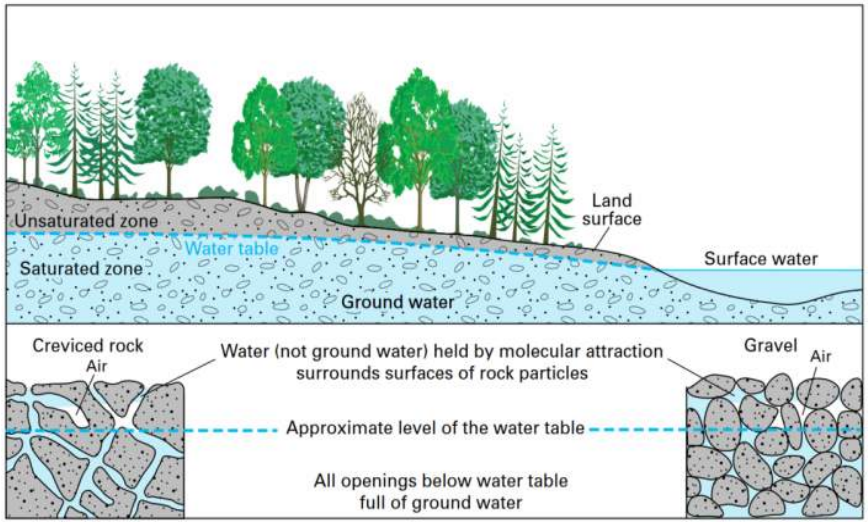

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

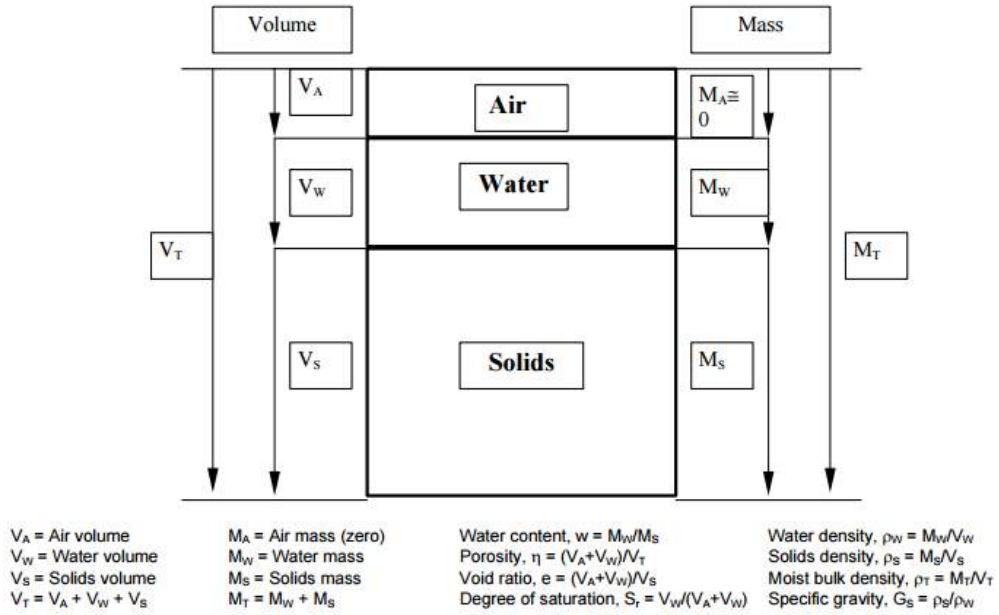

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

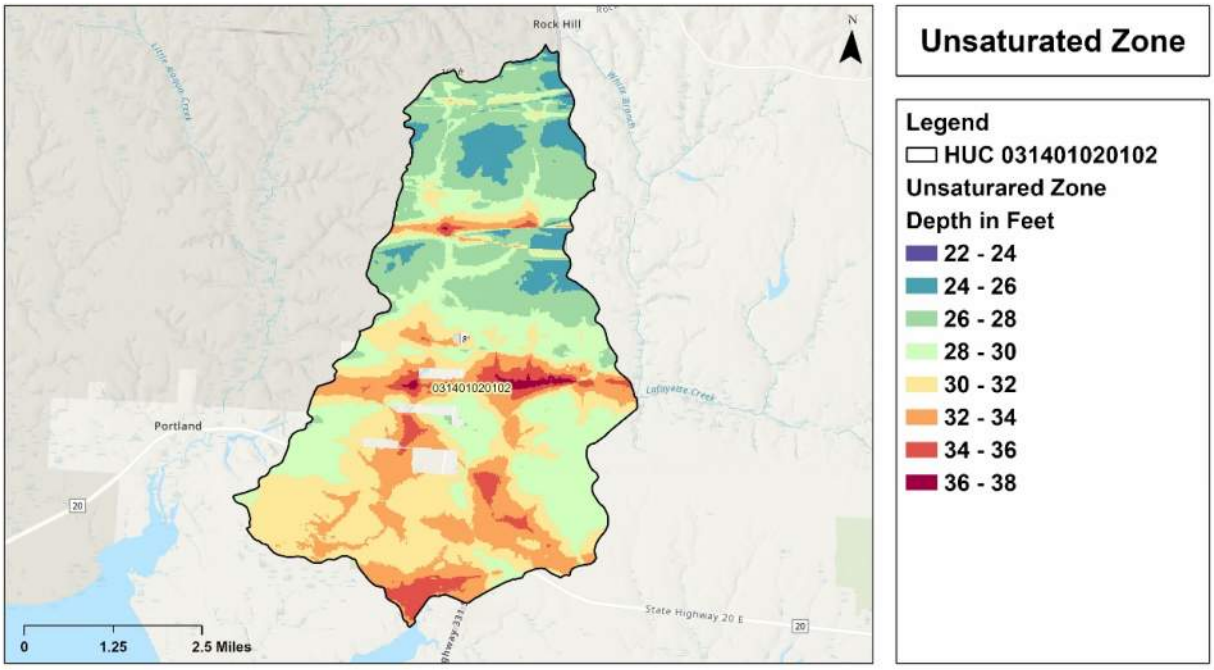

Figure 15. Unsaturated zone map for HUC 031401020102, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately favorable soil storage capacity, falling within the range of 26 to 34 feet of remaining capacity.

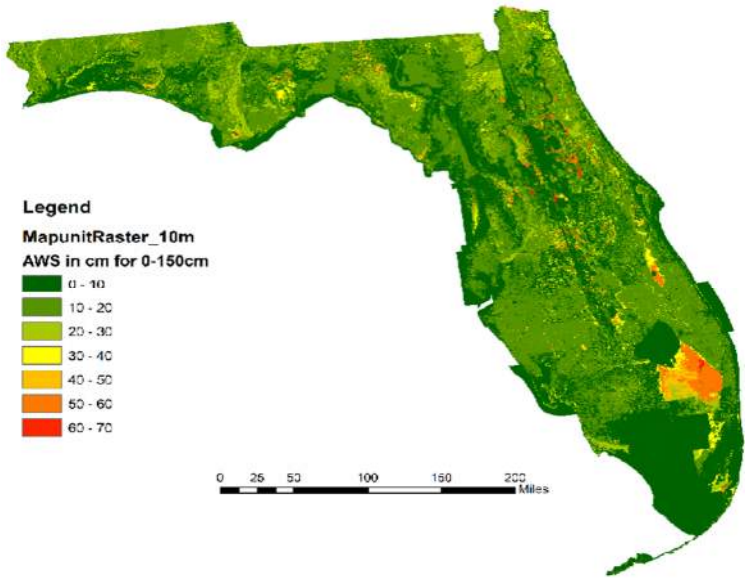

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

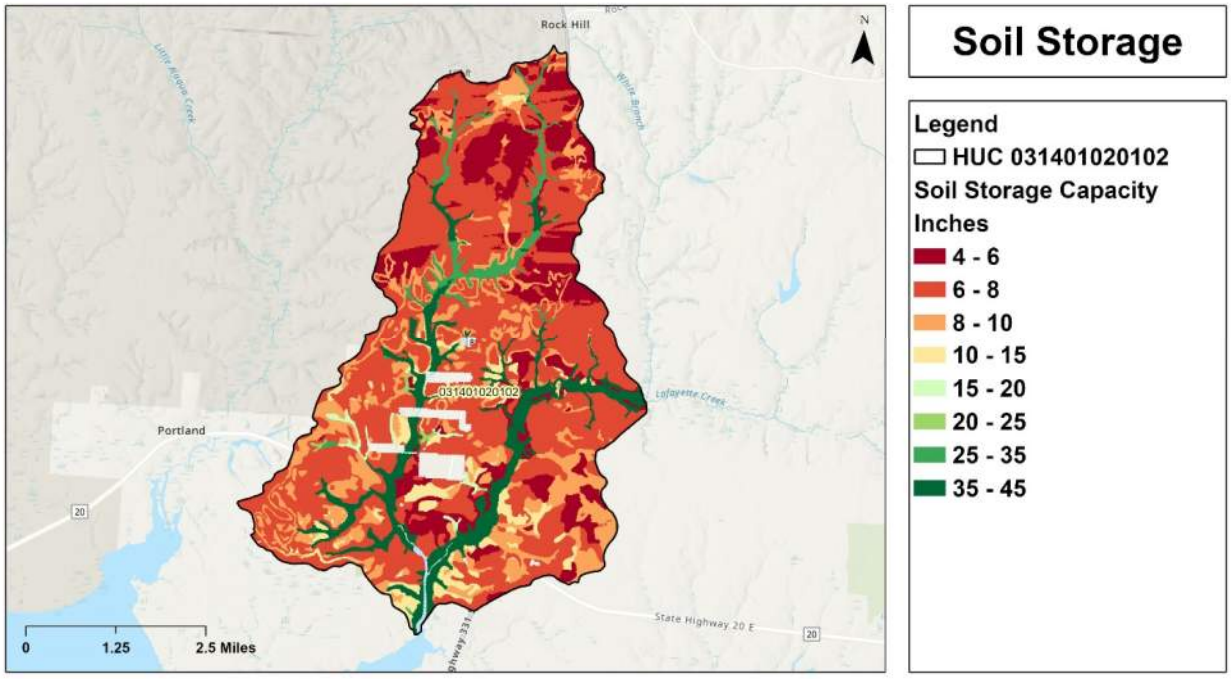

Figure 17. Water storage capacity of soil for the HUC 031401020102 (inches), processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

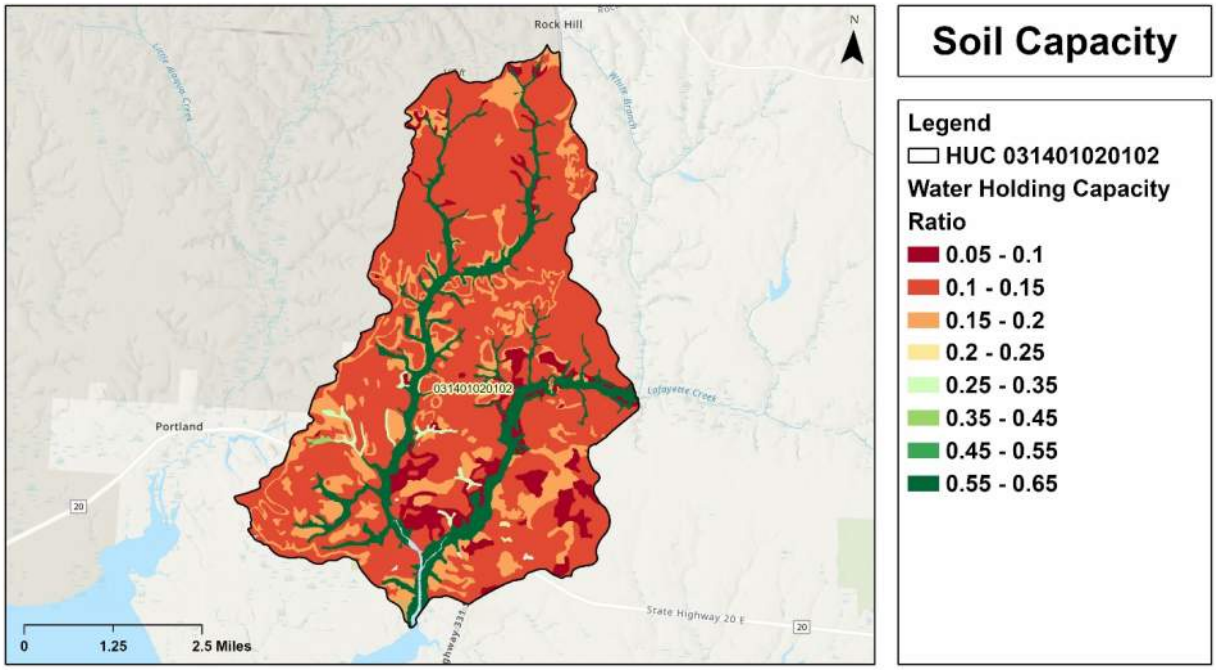

Figure 18. Water Holding Capacity (ratio) for the HUC 031401020102, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

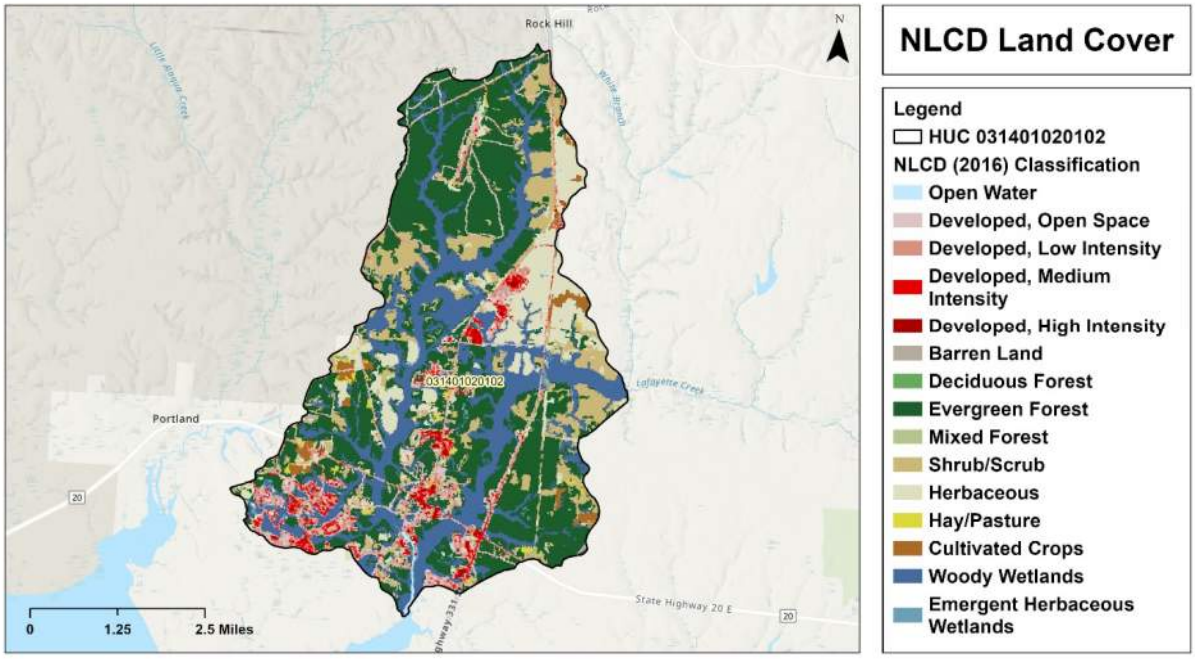

Figure 19. Land use in the HUC 031401020102 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

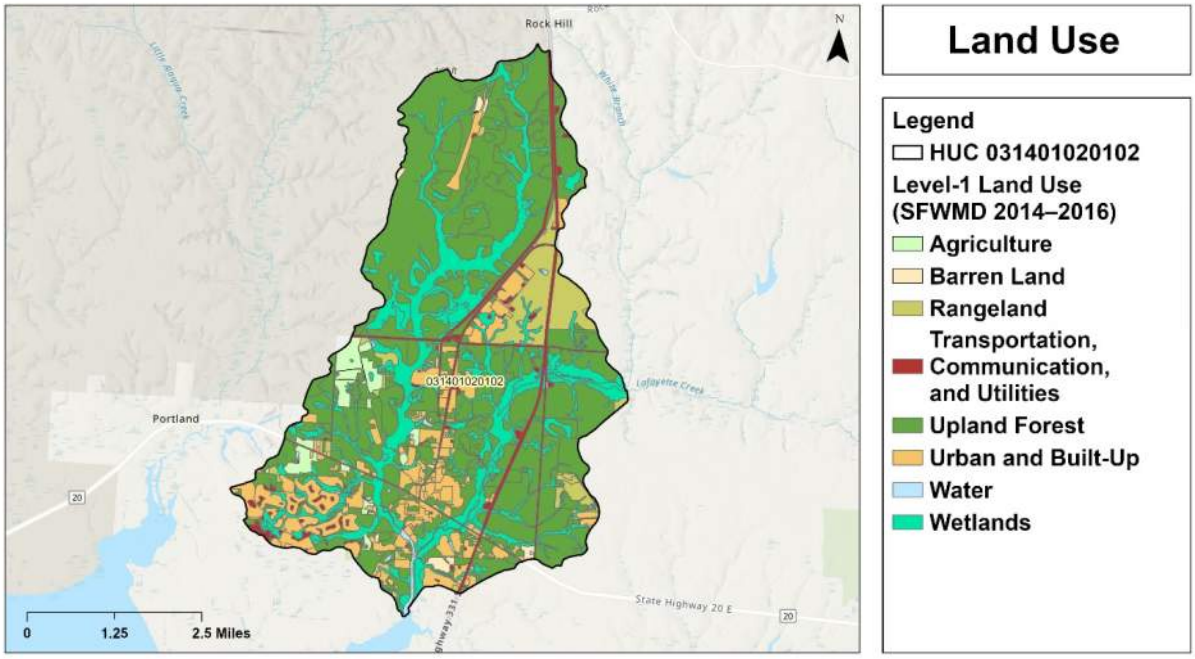

Figure 20. Land use in the HUC 031401020102 (from the 2023 Florida Geographic Data Library (FGDL) database), processed by FAU.

In the HUC 031401020102 sub-watershed, the predominant land cover is upland forest, accounting for 53.48% of the area. Wetlands comes in second at 14.76%, followed by Transportation, Communication, and Utilities at 9.25%, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface. Developed land constitutes also a good portion, with 9.31% categorized as urban and built-up, once the basin encompasses part of the city of Freeport.

Table 3. Land use for HUC 031401020102 sub-watershed (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	402.96	1.61%
Barren Land	276.49	1.10%
Rangeland	1493.53	5.96%
Transportation, Communication, and Utilities	3357.28	13.40%
Upland Forest	13400.53	53.48%
Urban and Built-Up	2333.92	9.31%
Water	96.60	0.39%
Wetlands	3697.60	14.76%
Grand Total:	**25058.91**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

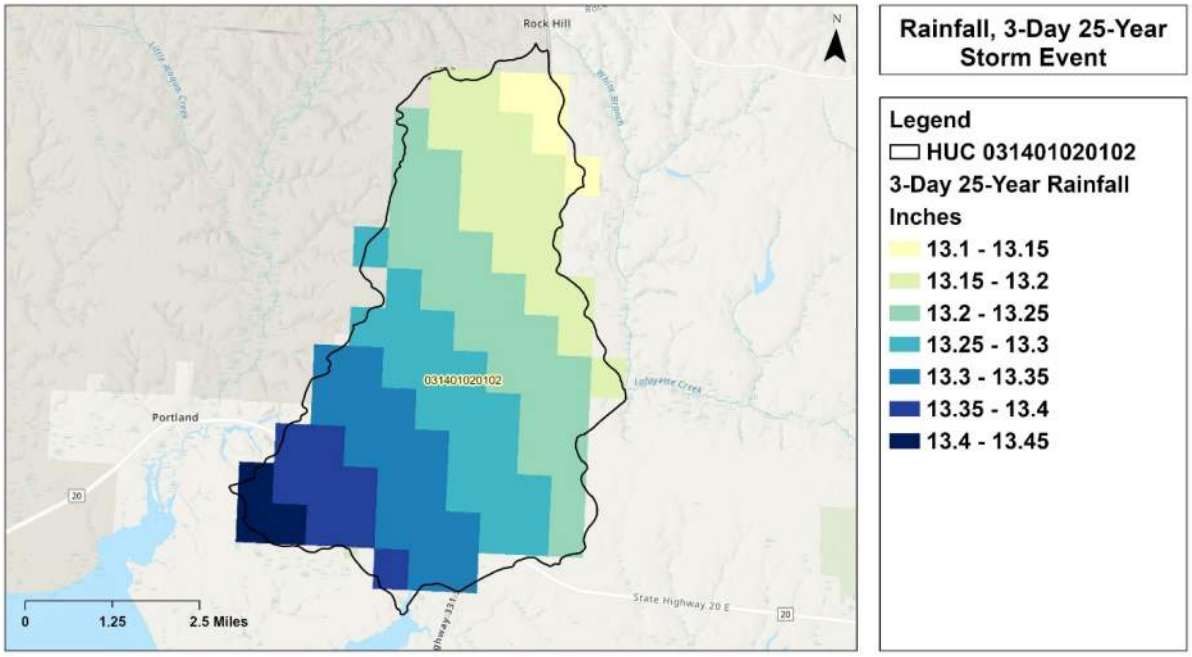

Figure 21. Rainfall distribution map across HUC 031401020102 sub-watershed, for 3-day 25-year storm event, processed by FAU.

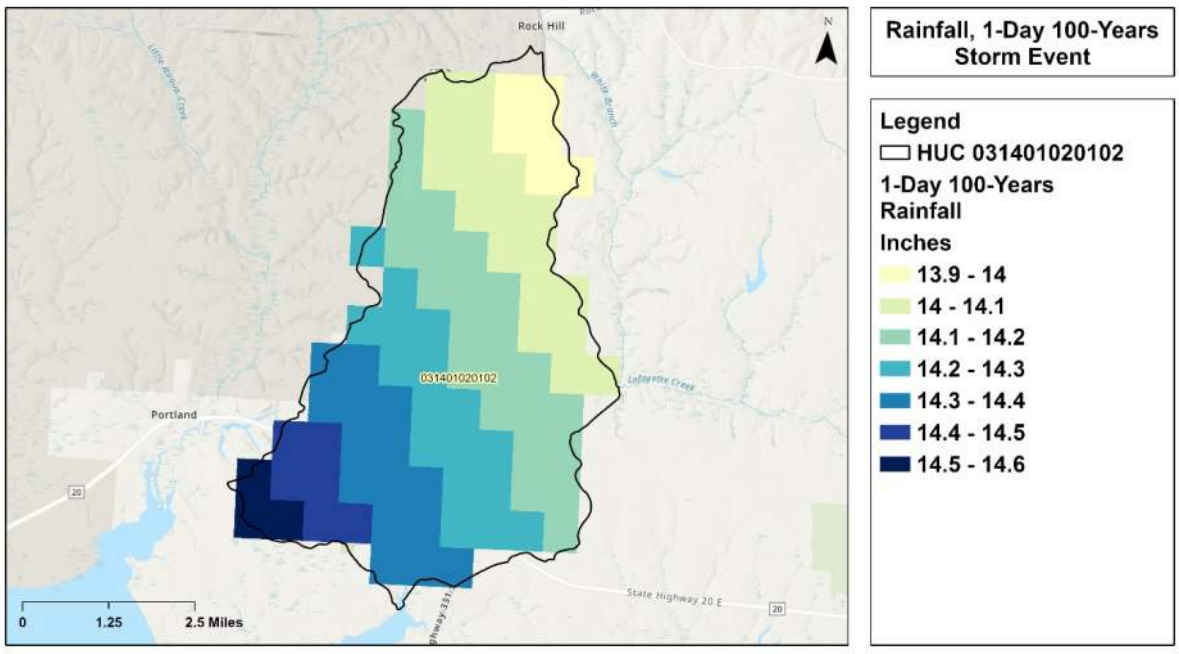

Figure 22. Rainfall distribution map across HUC 031401020102 sub-watershed, for 1-day 100-year storm event, processed by FAU.

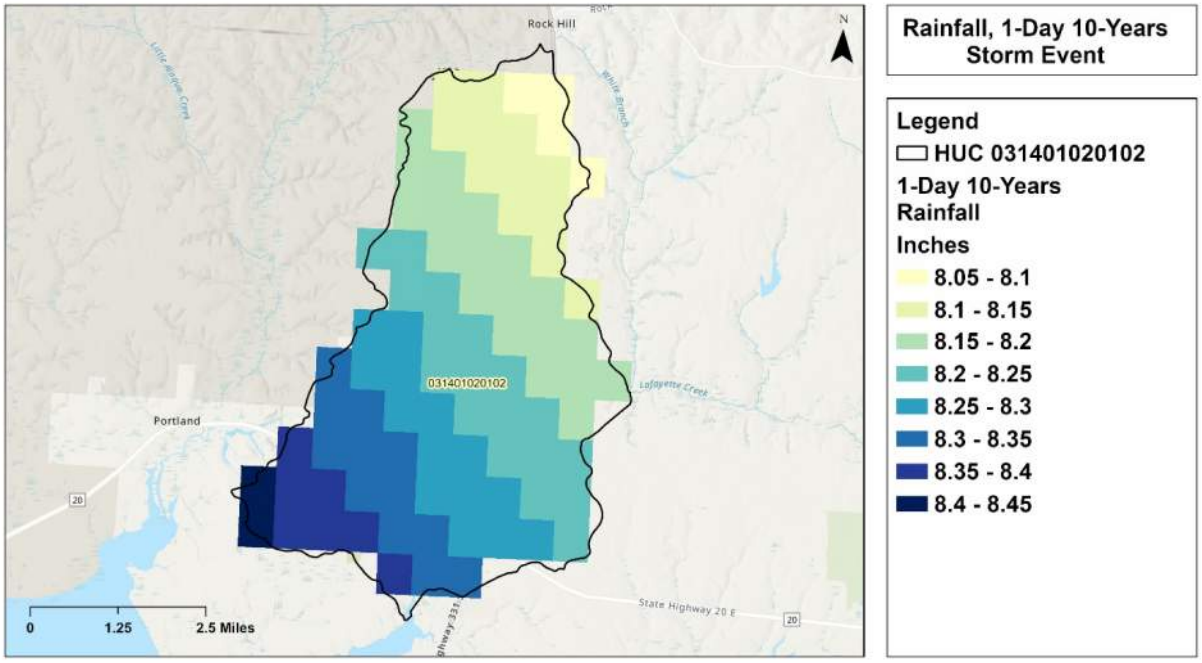

Figure 23. Rainfall distribution map across HUC 031401020102 sub-watershed, for 1-day 10-year storm event, processed by FAU.

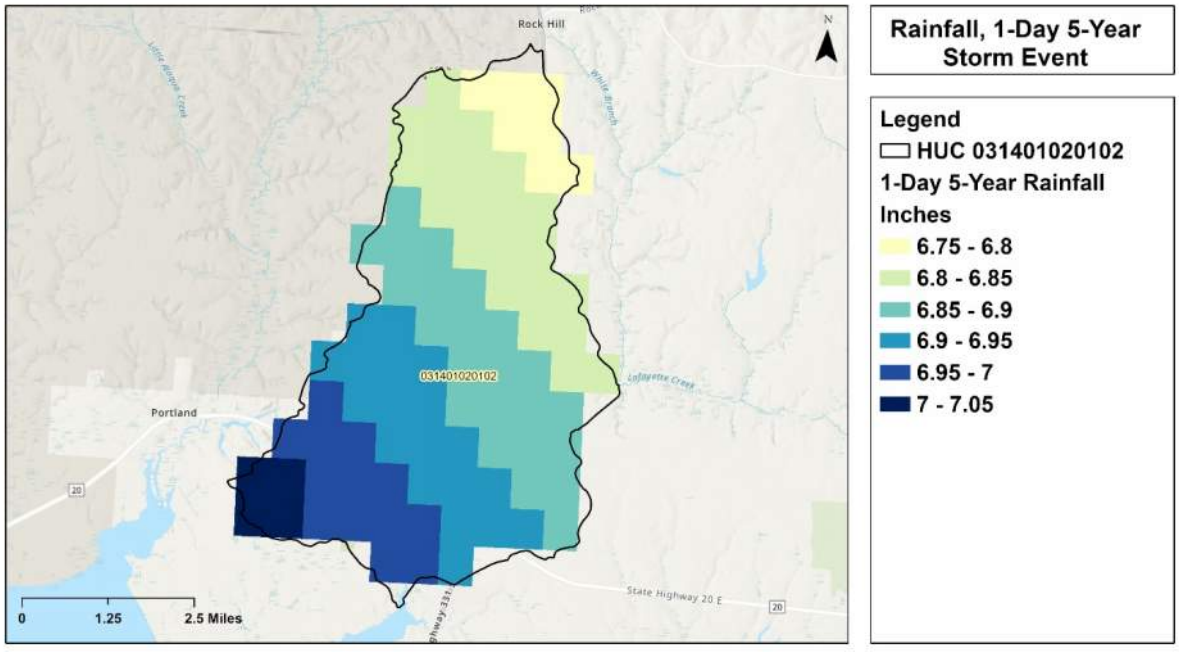

Figure 24. Rainfall distribution map across HUC 031401020102 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically

aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

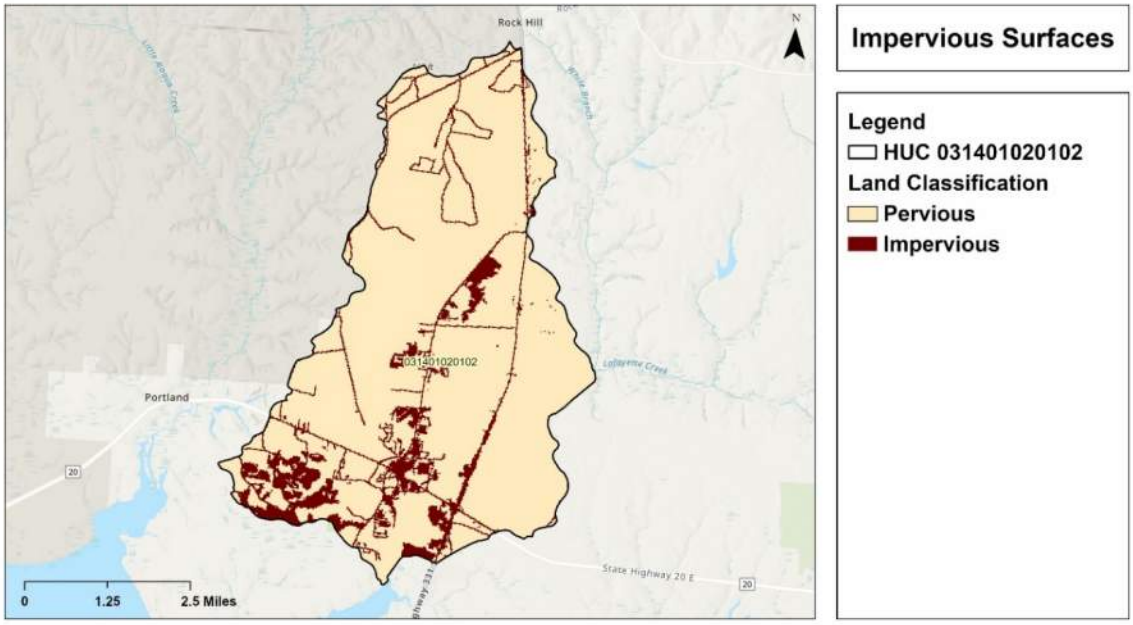

Figure 25. Impervious area map for the HUC 031401020102 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

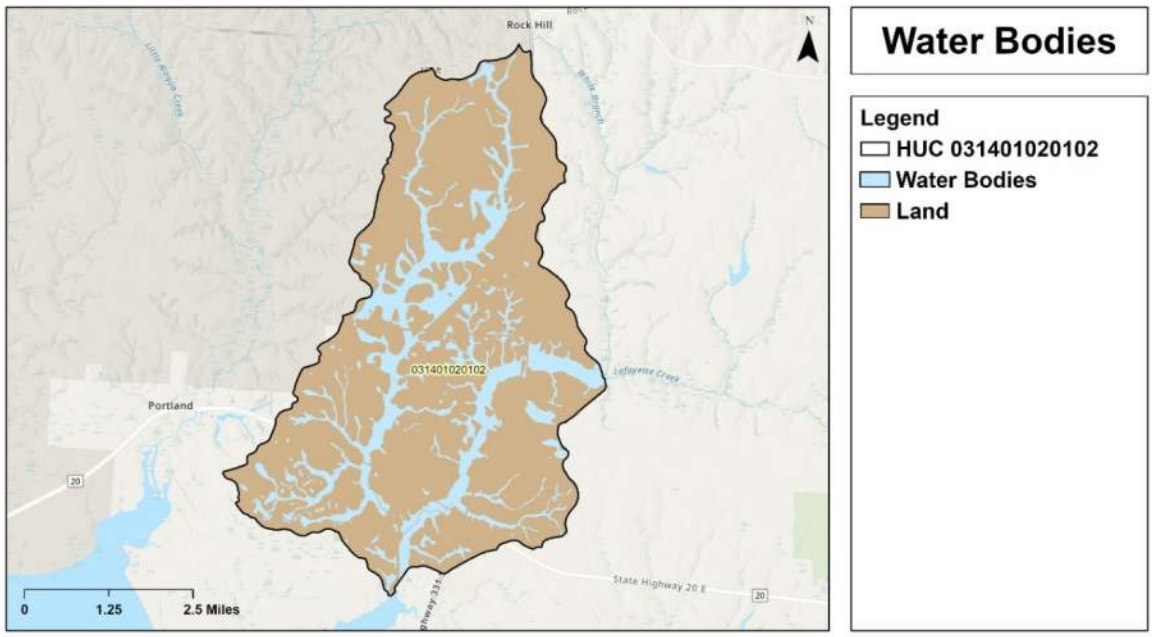

Figure 26. Water bodies map for the HUC 031401020102 sub-watershed, processed by FAU.

2.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other

waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant

control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

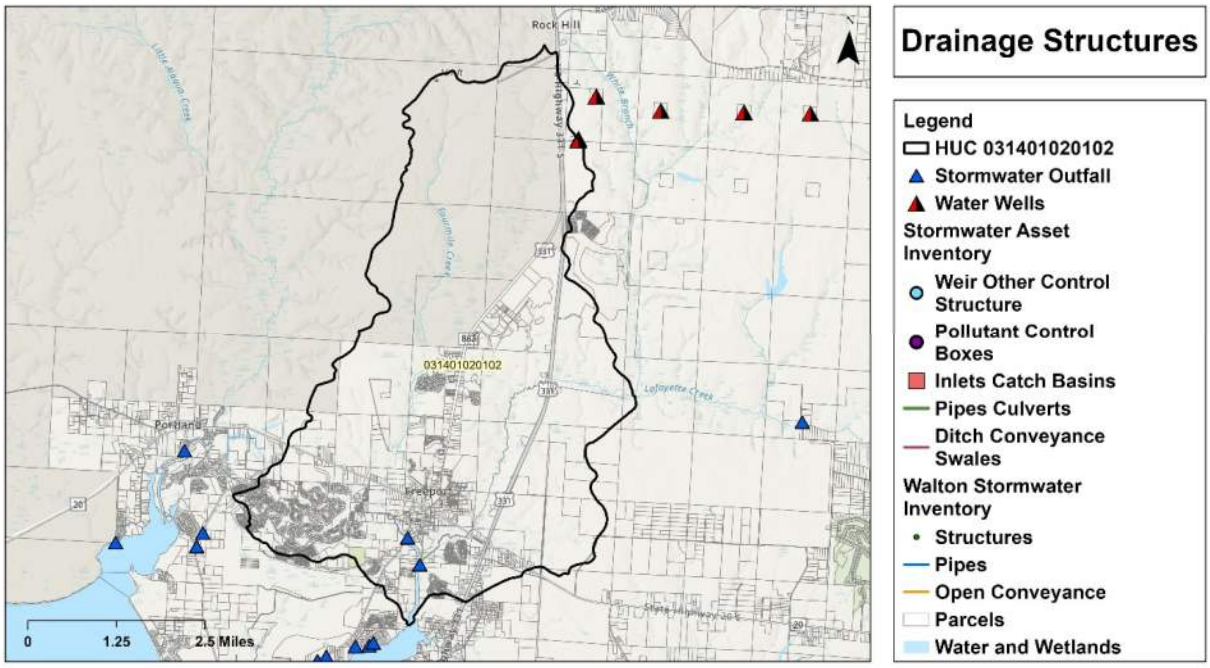

Figure 27. Stormwater Infrastructure for the HUC 031401020102. Processed by FAU.

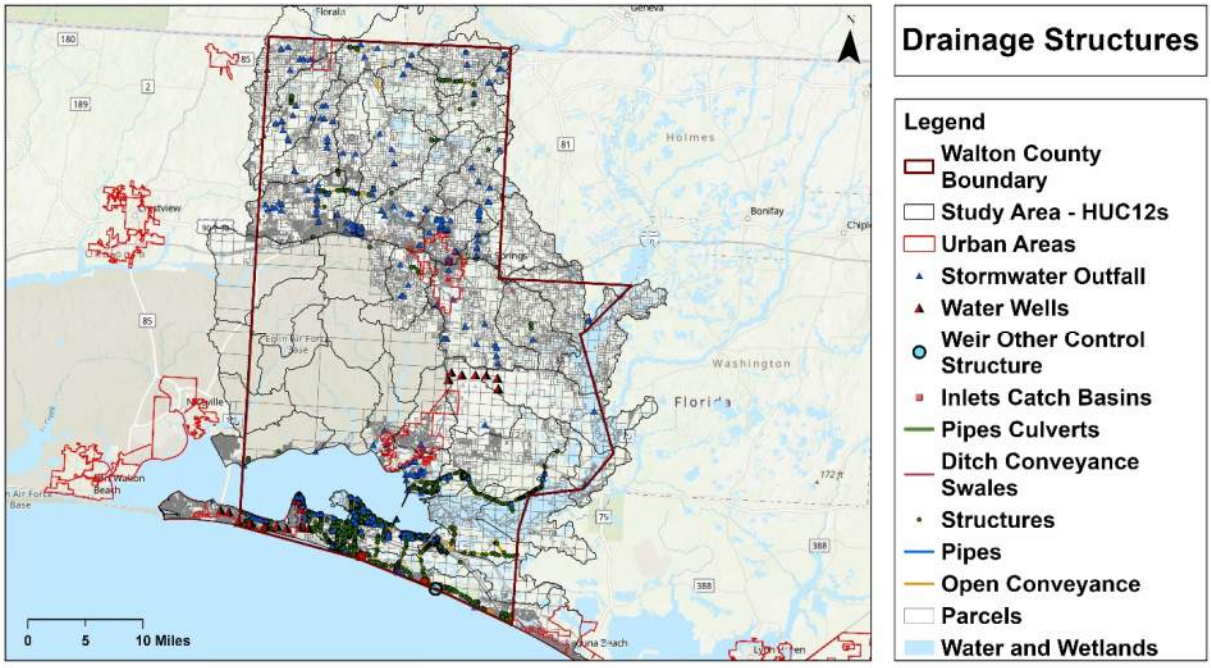

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in Table 5. The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401020102 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

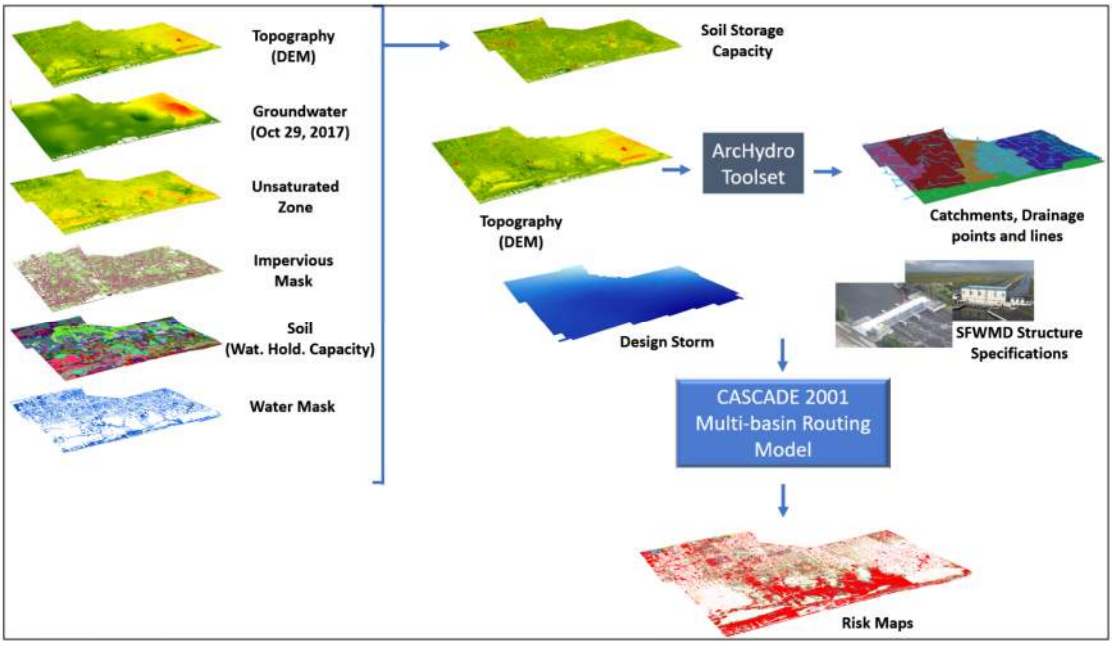

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

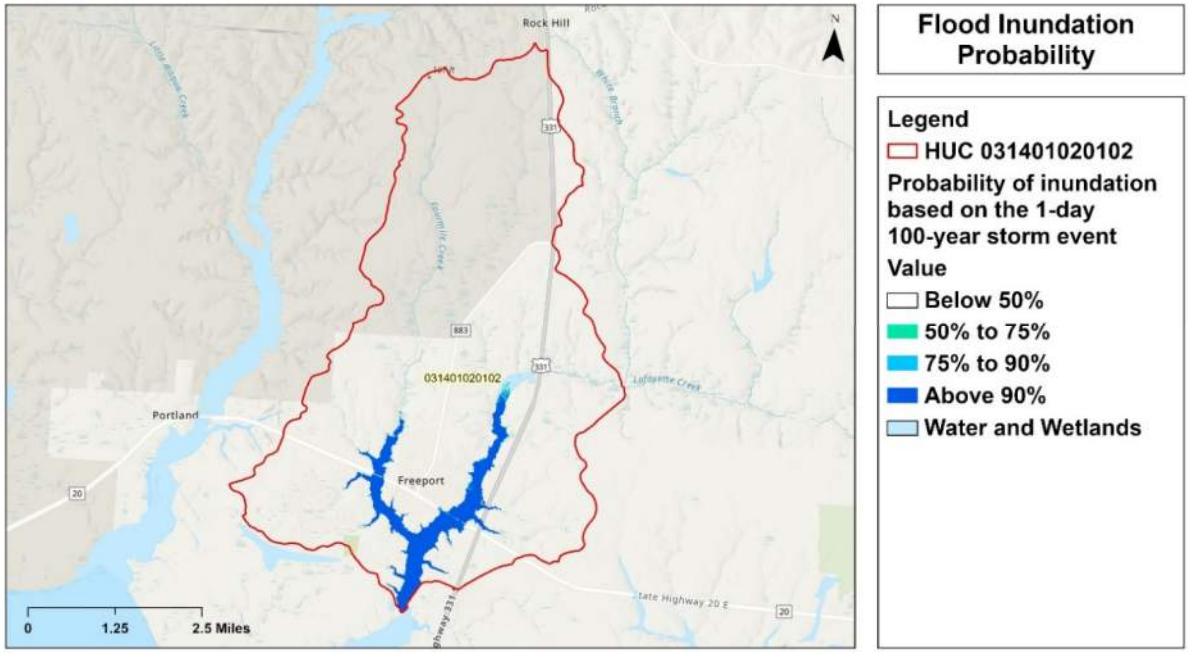

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401020102, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA

will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Future Challenges of Sea Level Rise and Climate Change

Global observations from satellites and long-term data collection have made it possible to document and analyze patterns in the Earth's climate. Scientific analysis of the impact of these changes has helped to improve the understanding of future flood hazard driving forces and long-term impacts on human activities and watershed master planning (http://www.research.noaa.gov/climate/t_observing.html). Examples of impacts are rising global average air and ocean temperatures, increased and earlier snow and ice melt, shorter subtropical rainy seasons, shifted seasons, sea level rise and greater variations in temperature and precipitation (IPCC, 2013; Freas et al., 2008; Marshall et al., 2004; Bloetscher et al., 2010). Marshall et al. (2004) specifically focused on the Florida peninsula to predict changes in rainfall and warmer temperatures but interspersed lower low temperatures due to the potential loss of wetlands.

Future changes in climate will add to the existing impacts, at a time when the population of the state is expected to nearly double by 2030. Additional research and high-resolution climate modeling for the Florida peninsula and local jurisdictions is needed to help guide long-term plans like WMPs. Rainfall appears to be decreasing and temperatures rising (see **Error! Reference source not found.**).

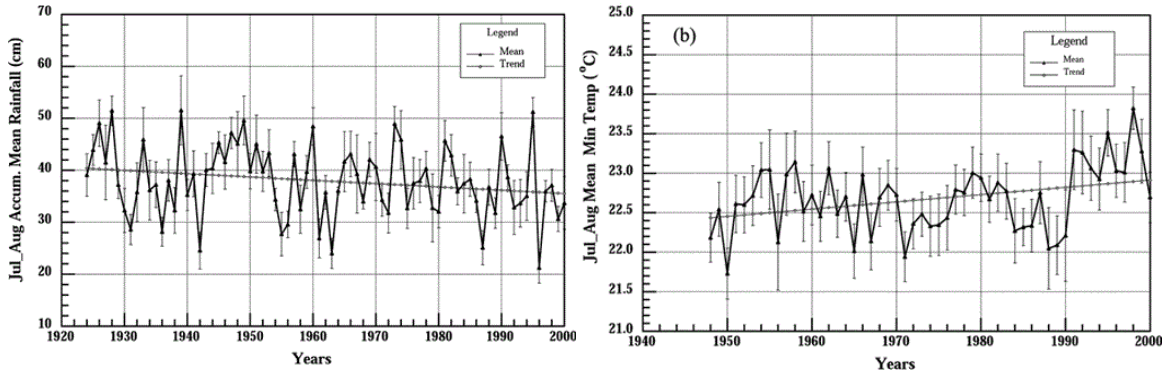

Figure 31. Change in average rainfall and change in average temp 1924 to 2000. Note the reversed trend, which means groundwater input variability is lessened. Source: Marshall et al., 2004.

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3 feet. Accompanying these drivers are potential changes in storm frequency and intensity, desertification, population migration, ocean acidification and coastal flooding (IPCC, 2007), exacerbated by the land cover and land use changes, which are substantially impacted by the fluxes, timing and quality of precipitation (Adrians et al., 2003; Scanlon et al., 2005; Marshall et al., 2004; Salmun and Molod, 2006), and leading to changes in the timing of peak flows and volumes (Richey and Costa-Cabral, 2006).

The results of these climatic changes are likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to

the ocean, c) increasingly An outcome of these climatic patterns is that during the past 140 years, an increase in sea levels has been observed (Bloetscher, 2012), a worrying pattern since sea level rise is a permanent phenomenon, that can be catastrophic to low lying areas in the long-term. The question is how much and how soon? Various studies (Bindoff et al., 2007; Domingues et al., 2008; Edwards, 2007; Gregory, 2008; Vermeer and Rahmstorf, 2009; Jevrejeva, Moore and Grinsted, 2010; Bloetscher, 2010, 2011; IPCC, 2007; Heimlich et al., 2009) indicate large uncertainty in projections of sea level rise by 2100. Gregory et al. (2012) note that during the last two decades, the global rate of sea level rise has been larger than the 20th-century time-mean, and Church et al. (2011) suggested that the cause was increased rates of thermal expansion, glacier mass loss, and ice discharge from icesheets. Gregory et al. (2012) suggested that there may also be increasing contributions to global sea level rise from the effects of groundwater depletion, reservoir impoundment, and loss of storage capacity in surface waters due to siltation. Measurements of Florida's east coast (Maul, 2008) show an average rate of sea level rise of 2.27 ± 0.04 mm per year from 1915 to 1992 based on tide gauge readings. Analyzing the tidal gauge readings for Florida shows that:

1. Florida average sea level rise is 2.10 ± 0.49 mm/yr
2. All but one location is within the 95% confidence limit range (the exception is Panama City where there is evidence of submergence and other land-based issues)
3. None of the Florida sea level rise rates differ statistically
4. Average global sea level rise for 1920-2000 was 2.0 mm/yr – within 95% confidence limit for Florida locations

From 1929 to 1992, over eight inches of sea, with another 6 inches added since 1992, which is already having significant impacts on coastal communities where population growth has increased the need for improved flood management strategies (Bloetscher, 2008; Parkinson, 2010; Zhang et al., 2011, 2011a; NFIP, 2011; Schmidt et al., 2011; Warner et al., 2012).

As a result, the SFRCCC (2015) adopted USACE's methodology to derive scenarios of sea level change intermediate to high rates of sea level rise for years 2030 (3" to 7") and 2060 (9" to 24") as the consensus projection to guide future planning. The path keeps increasing – now 14 inches since 1929 (**Error! Reference source not found.**) caused by thermal expansion of the ocean and melting ice caps (Jevrejeva et al., 2010; Vermeer and Rahmstorf, 2009). Sea level rise is a major concern in Florida, including Walton County, since the majority of the state's population live on the coast, involving most major commercial, residential, and economic enterprises. **Error! Reference source not found.** demonstrate the estimated sea level change for Panama City, considering the predictions of NOAA 2017. For NOAA high scenario SLR change scenario, the estimated level change is higher than 8 ft., while for the intermediate and low scenarios are about 3.9 feet and 1.7 feet respectively.

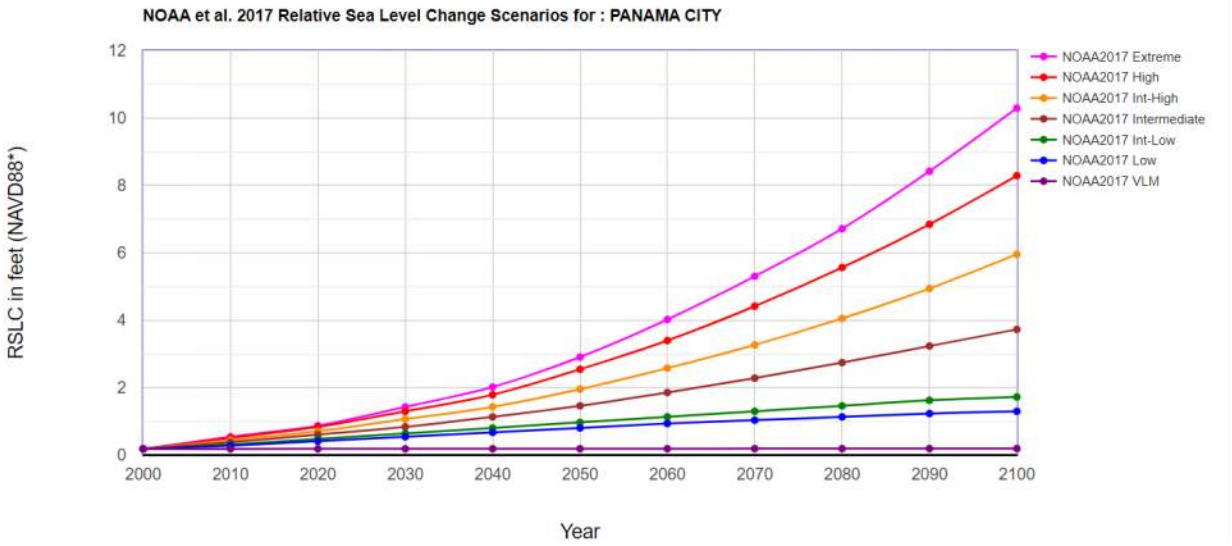

Figure 32. Relative Sea Level Change Scenarios for gauge 8729108, Panama City, FL. . Data from NOAA 2017. All values are expressed in feet relative to NAVD88. Source: https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html

NOAA (2017) outlines five scenarios for sea level rise. The NFIP proposes the use of the intermediate high projection, which is 1.2 meters or 4 ft globally from current sea level elevations (**Error! Reference source not found.**).

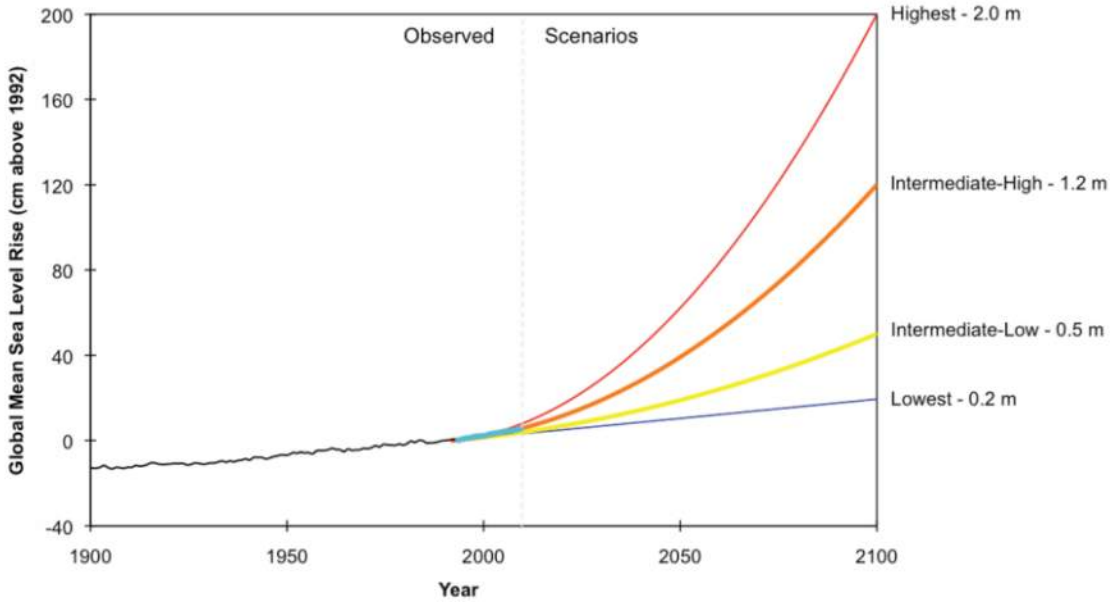

Figure 33. Graphic of global sea level rise projections from NOAA (2017). Source:https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

As sea level rises, access to roads, bridges, rail, and transit could be at risk of flooding, causing the effects of sea level rise to spread indirectly throughout the entire transportation network, affecting the overall system performance. For example, the flooding of a critical road or facility access can cause a shifting of traffic flow causing congested conditions in other roadways that are not actually flooded. Since the roadway network would be unable to carry the traffic demand, the system would experience operational failure; as a result, causing travel times and delays. Moreover, the inundation of a critical access could cause transportation connectivity problems to essential infrastructure like ports or airports. Transportation infrastructure relies on the effectiveness of flood control and stormwater drainage systems for the transportation corridors. Road integrity relies on adequate drainage. The increased risk of severe flooding in Florida's low-lying terrain can adversely affect transportation infrastructure along the coastline; roads can be inundated, and roadway beds can be damaged. Sea level rise will cause increased water table levels (FDOT, 2012), as regional water tables cannot exist naturally below mean high tide (2 feet in Florida). Adding 3 feet of sea level rise on top of groundwater would compound the risk of flooding in low-lying areas. Road bases below 5 feet NVGD would become saturated under this scenario, likely causing premature base failure. As soil storage capacity is diminished due to rising groundwater elevations associated with sea level rise, the potential for more frequently flooded roadways would likely damage pavements (FDOT, 2012). Hence sea level rise must be accounted for in WMPs in coastal areas. To allow flexibility in the analysis due to the range of increases within the different time periods, an approach that uses incremental increases of 1, 2, and 3 feet of sea level rise is suggested for modeling. The increments can work as threshold values in planning considerations in terms of allowing planners the ability to know ahead of time where the next set of vulnerable areas will be, to allow for a proactive response approach that can be matched to the observed future rates. Sea level rise is a major concern since nearly half the US population lives within 50 miles of the coast, involving most major commercial, residential, and economic enterprises. The effects of 5 ft sea level rise, King tide, and 1-day 100-year storm event are shown in **Error! Reference source not found.**.

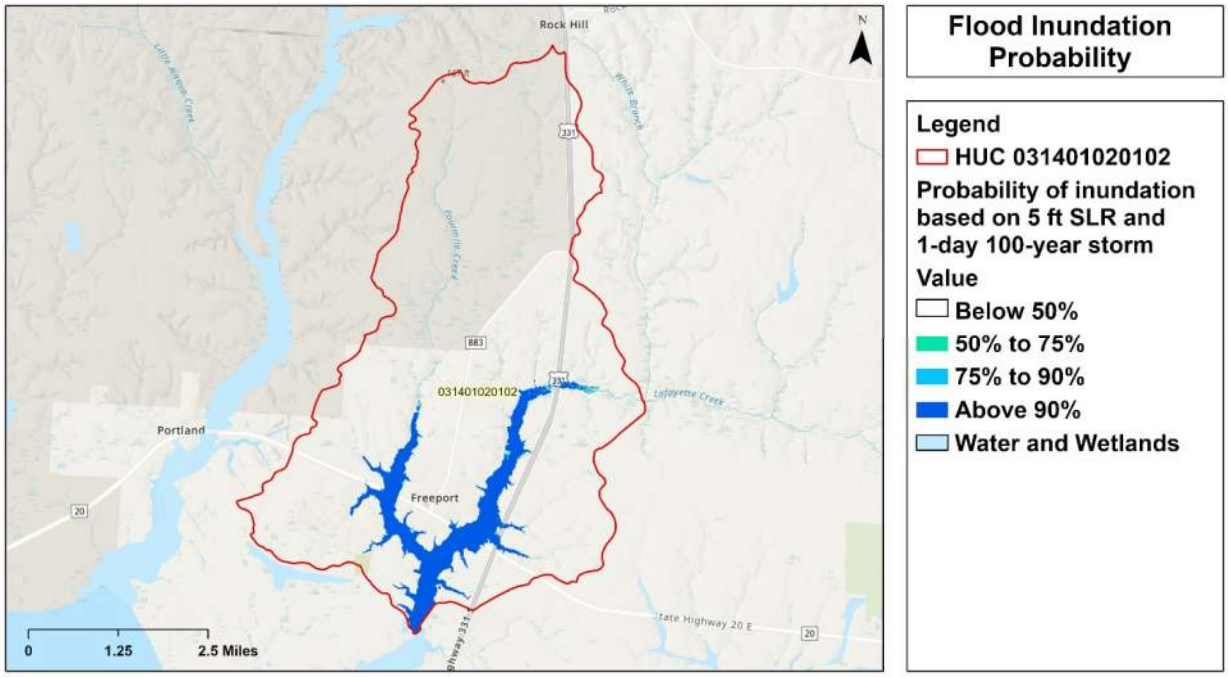

Figure 34. Flood Inundation Probability for a Sea level rise of 5 ft + 1-day 100-year storm event for HUC 031401020102 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Dark blue is area under 5 ft NAVD88 and potentially inundated at the 99th percentile tidal conditions. Processed by FAU.

2.4 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. **3-day 25-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 35)
2. **1-day 100-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 36)
3. **1-day 10-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 37)
4. **1-day 5-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 38)
5. **Sea level rise of 1 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 39)

6. **Sea level rise of 1 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations storm (Figure 40)
7. **Sea level rise of 1 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 41)
8. **Sea level rise of 1 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 42)
9. **Sea level rise of 2 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 43)
10. **Sea level rise of 2 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 44)
11. **Sea level rise of 2 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 45)
12. **Sea level rise of 2 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 46)
13. **Sea level rise of 3 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 47)
14. **Sea level rise of 3 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 48)
15. **Sea level rise of 3 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 49)
16. **Sea level rise of 3 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 50)
17. **Sea level rise of 4 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 51)
18. **Sea level rise of 4 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 52)

19. **Sea level rise of 4 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 53)
20. **Sea level rise of 4 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 54)
21. **Sea level rise of 5 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 55)
22. **Sea level rise of 5 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 56)
23. **Sea level rise of 5 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 57)
24. **Sea level rise of 5 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 58)

In all cases, a significant amount of flooding is noted near Choctawhatchee Bay and along the Intracoastal Waterway. As this basin connects to the ocean though Choctawhatchee Bay, SLR scenarios plays an important hole, implying a considered growth as the projected scenario of rising tides rises.

The design storm simulation determined that approximately 4.6% of the HUC total area or 1.15 mi² has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 4.8% of the HUC's total area, or 1.20 mi² would be expected to be inundated during a 1-day 100-year design storm. Approximately 4.7% of the HUC's total area, or 1.17 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 3.7% of the HUC's total area, or 0.91 mi², would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401020102 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	23.72	1.15	95.4%	4.6%
1-day 100-year	23.69	1.20	95.2%	4.8%
1-day 10-year	23.70	1.17	95.3%	4.7%
1-day 5-year	23.96	0.91	96.3%	3.7%

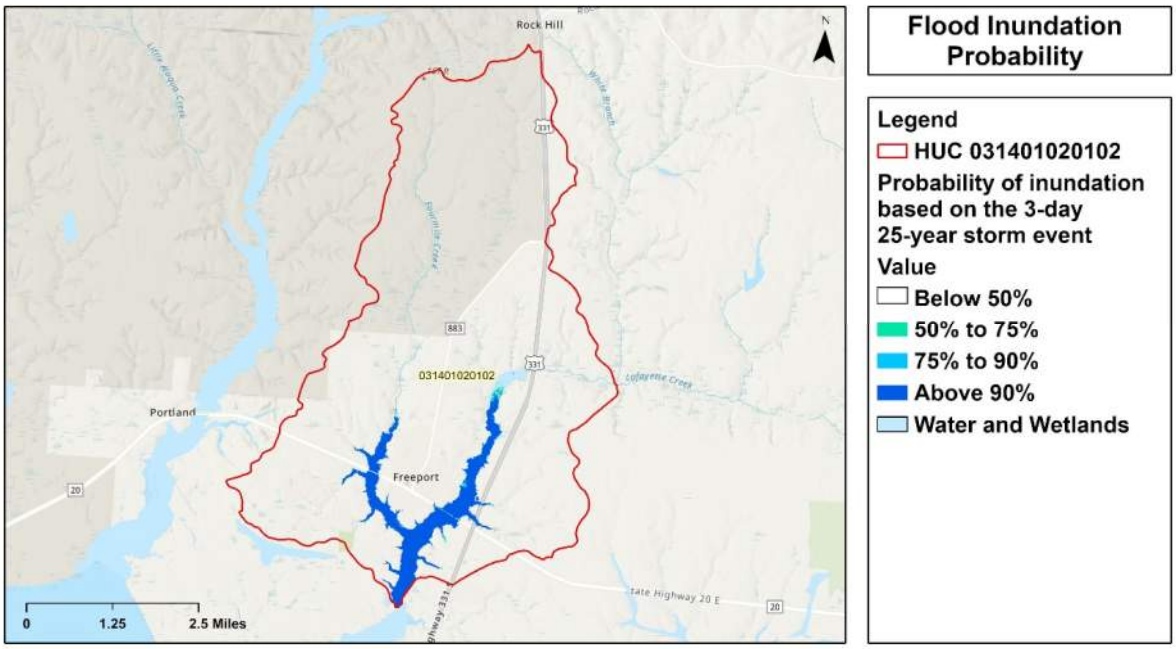

Figure 35. 3-day 25-year storm event for HUC 031401020102 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

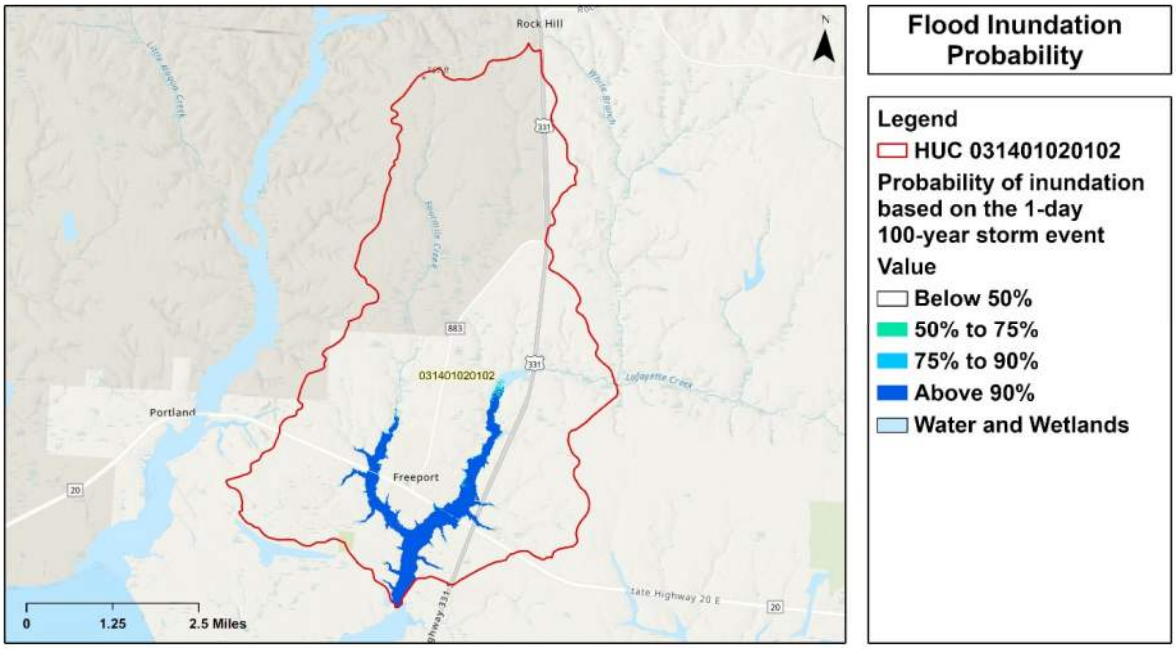

Figure 36. 1-day 100-year storm event for HUC 031401020102 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

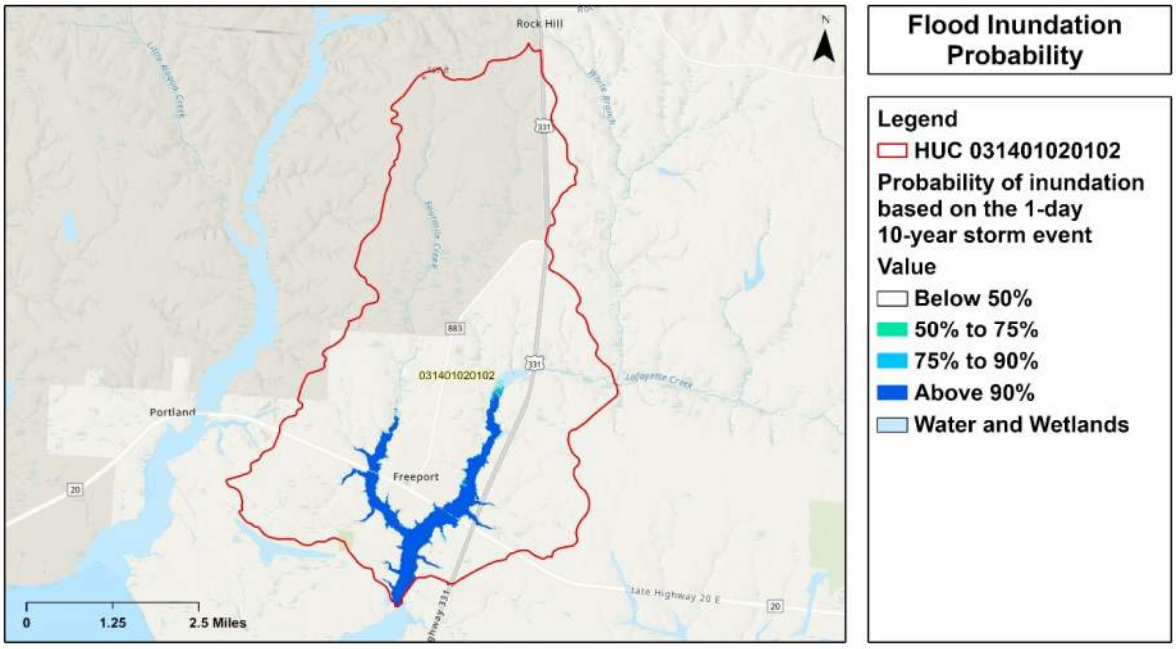

Figure 37. 1-day 10-year storm event for HUC 031401020102 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

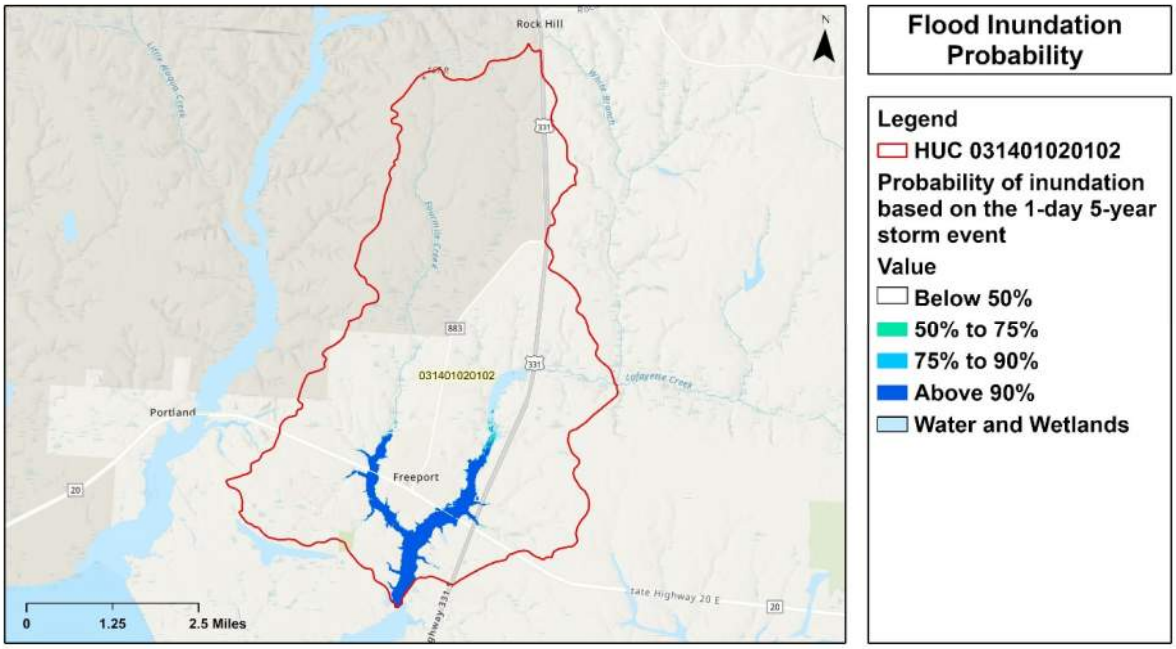

Figure 38. 1-day 5-year storm event for HUC 031401020102 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

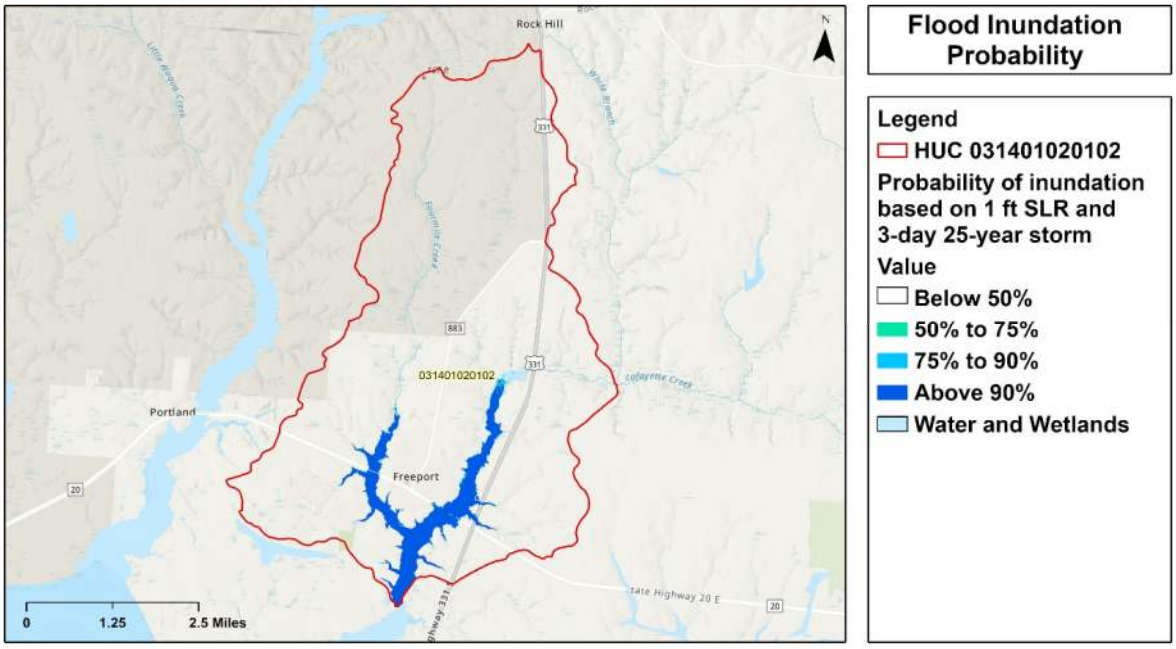

Figure 39. Sea level rise of 1 ft + 3-day 25-year storm for HUC 031401020102 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

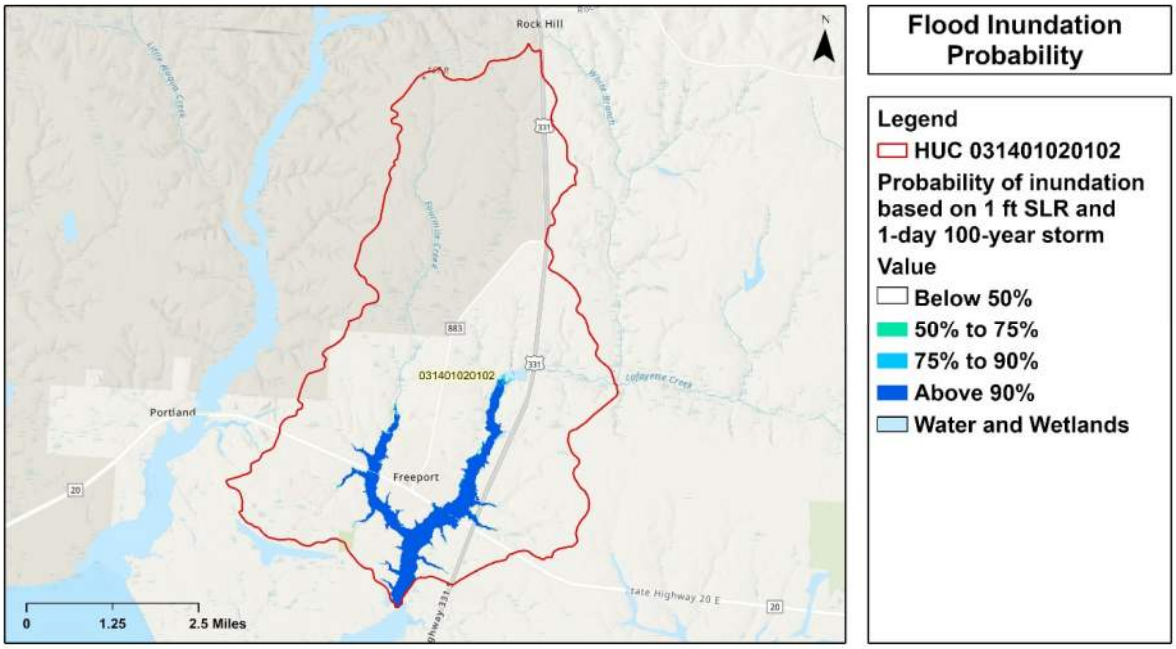

Figure 40. Sea level rise of 1 ft + 1-day 100-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

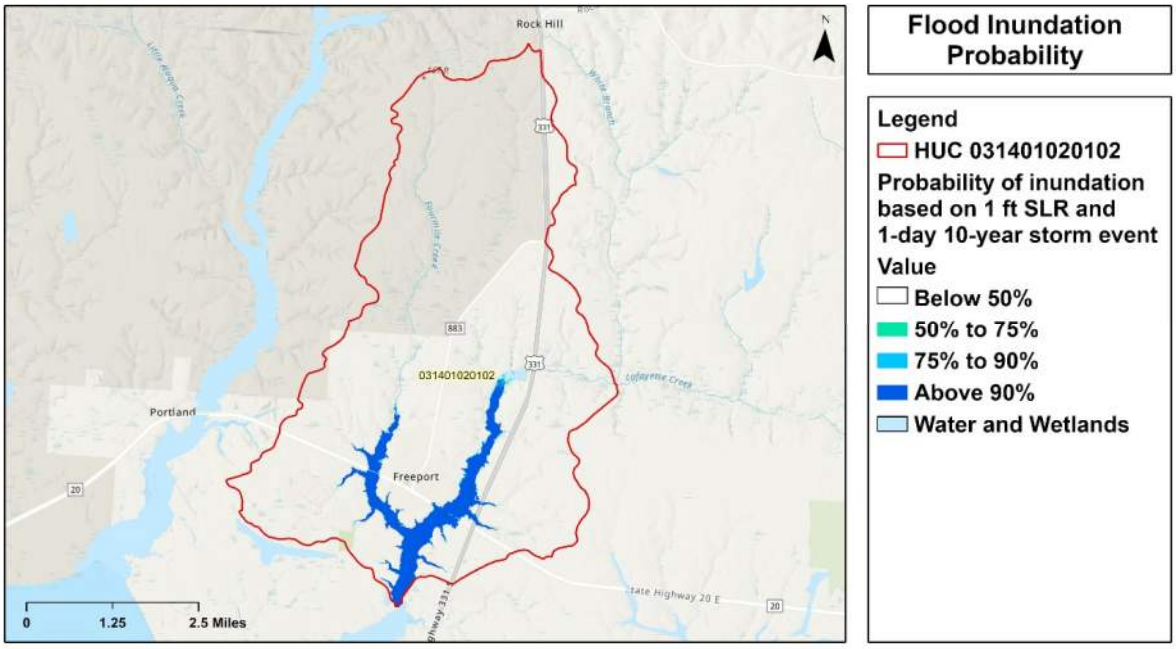

Figure 41. Sea level rise of 1 ft + 1-day 10-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

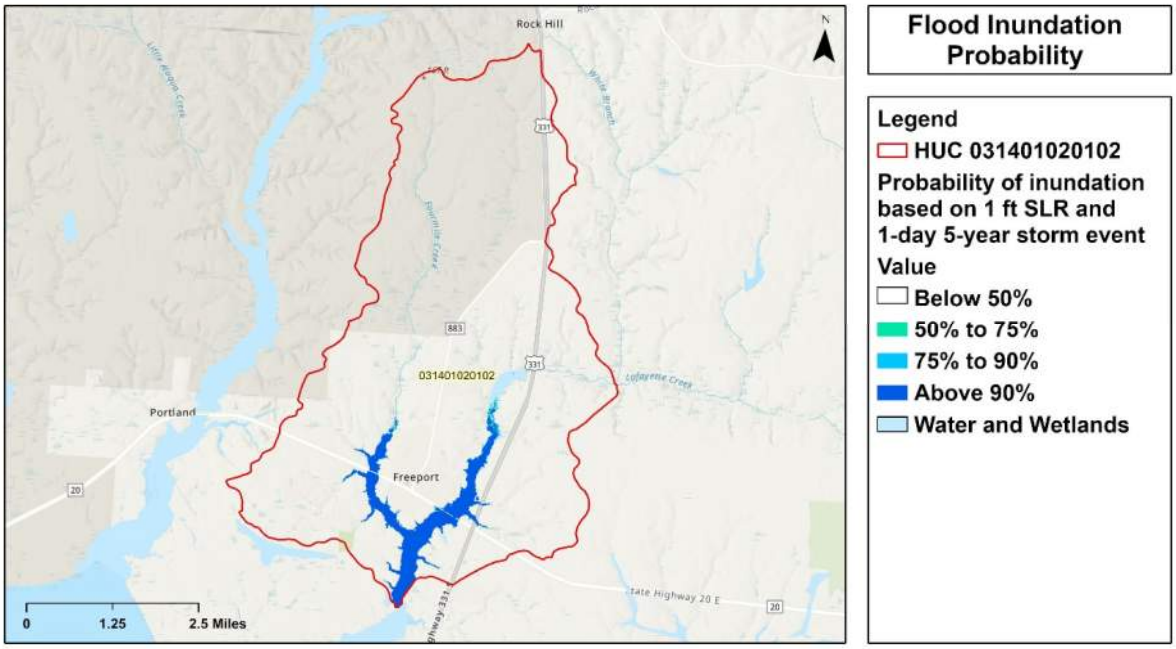

Figure 42. Sea level rise of 1 ft + 1-day 5-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

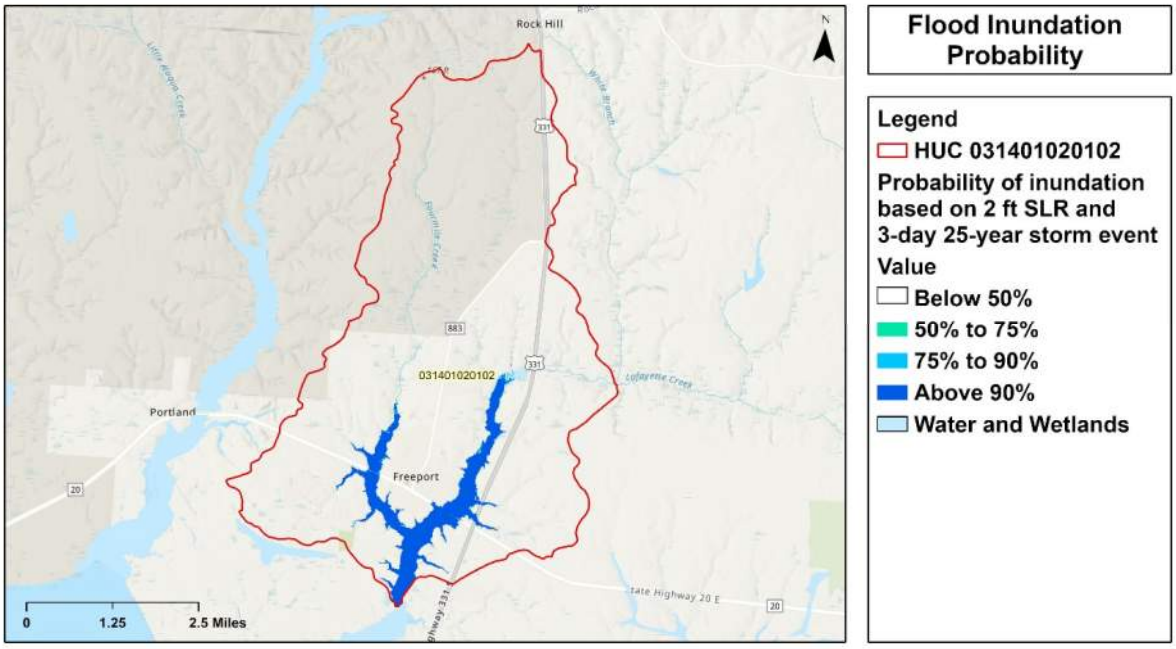

Figure 43. Sea level rise of 2 ft + 3-day 25-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

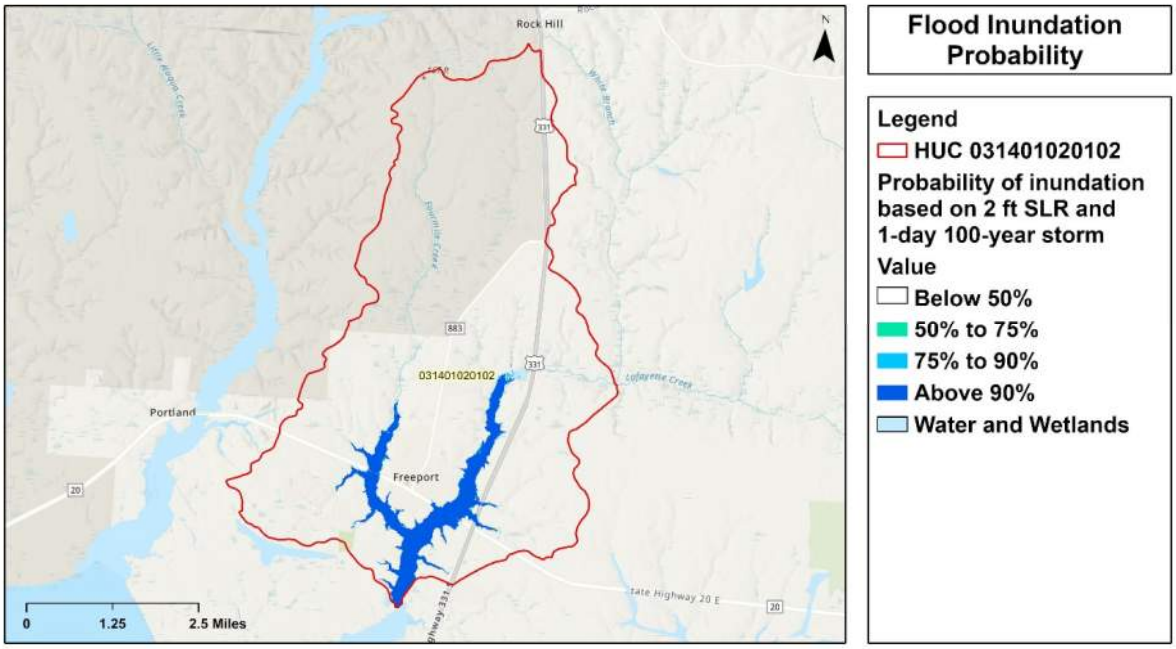

Figure 44. Sea level rise of 2 ft + 1-day 100-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

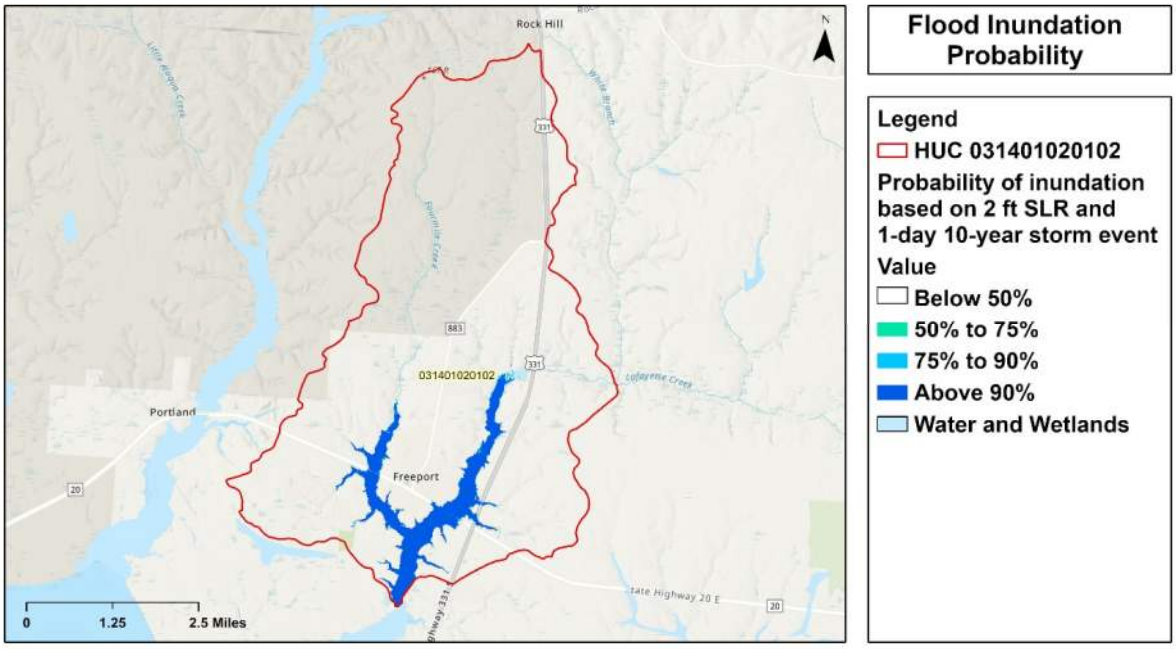

Figure 45. Sea level rise of 2 ft + 1-day 10-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

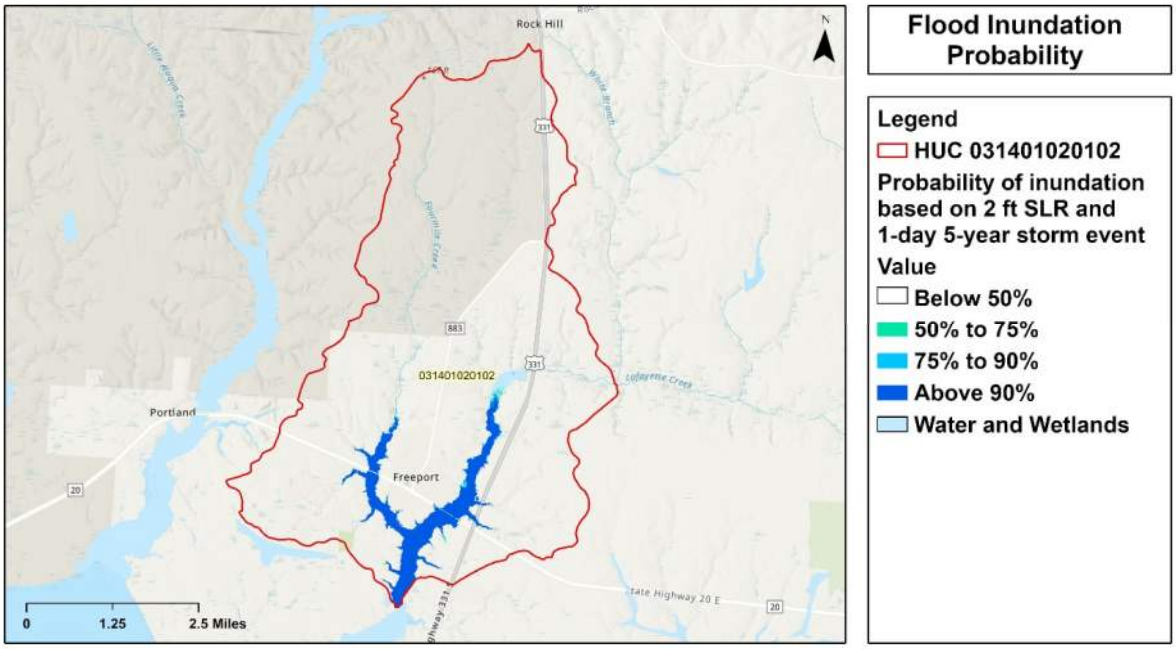

Figure 46. Sea level rise of 2 ft + 1-day 5-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

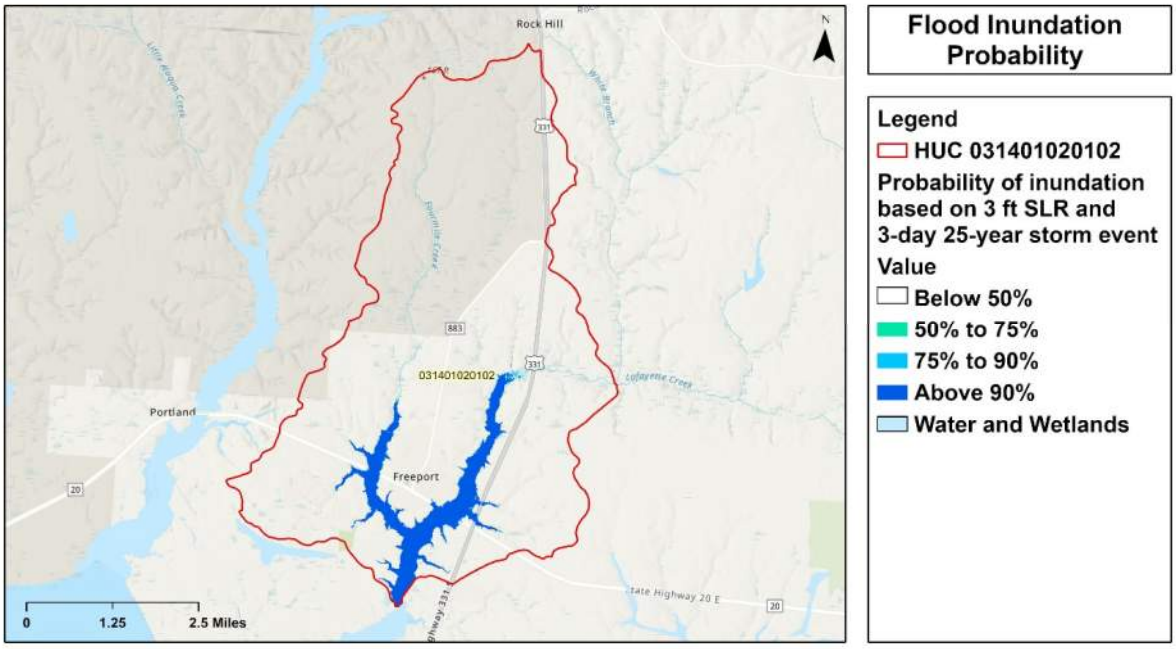

Figure 47. Sea level rise of 3 ft + 3-day 25-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

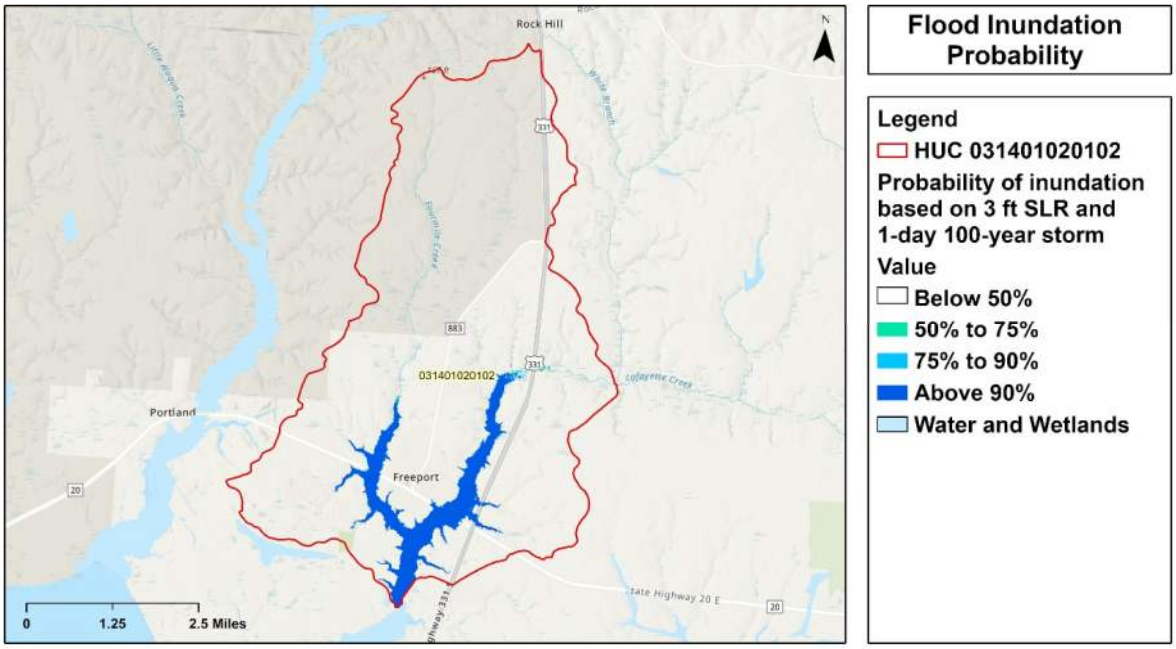

Figure 48. Sea level rise of 3 ft + 1-day 100-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

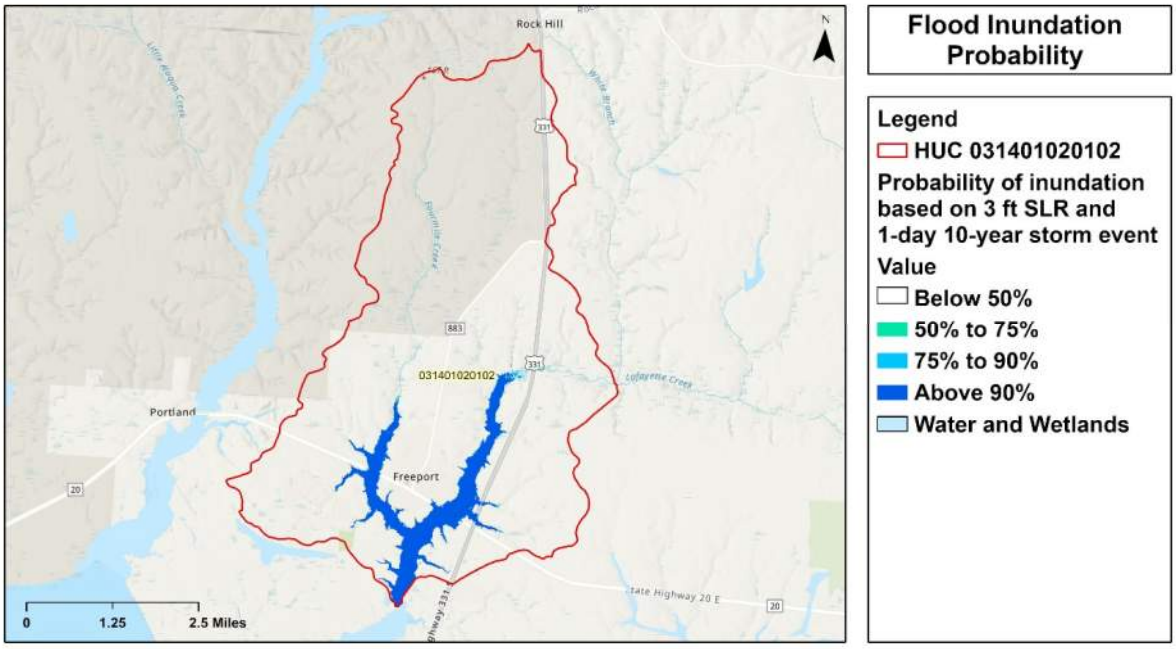

Figure 49. Sea level rise of 3 ft + 1-day 10-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

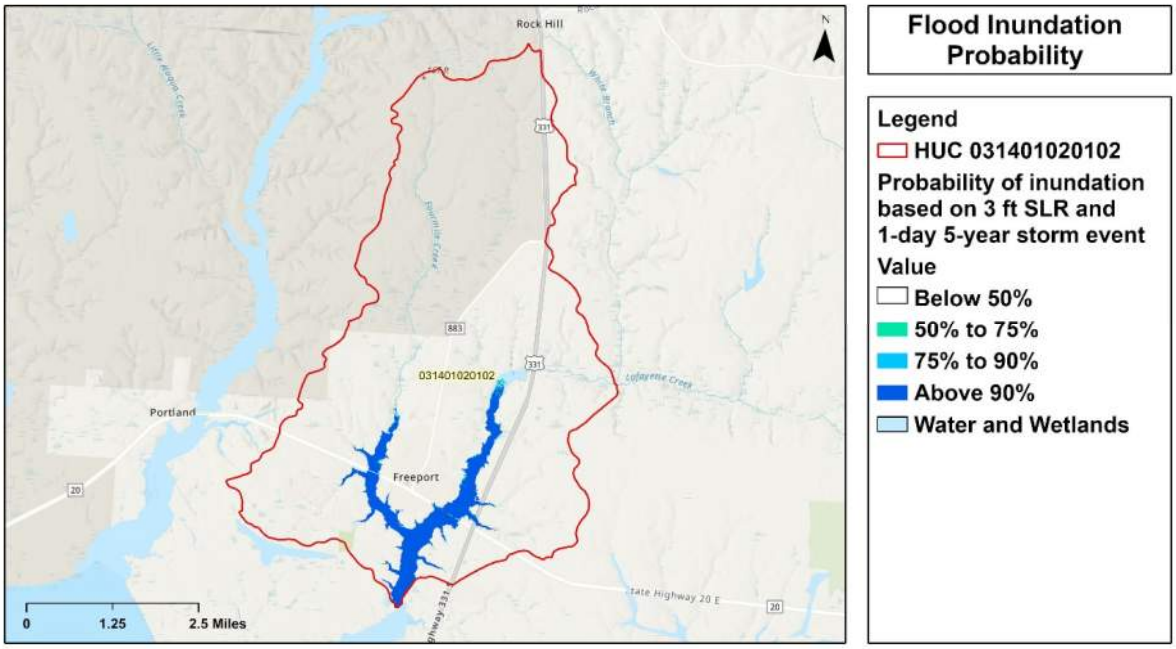

Figure 50. Sea level rise of 3 ft + 1-day 5-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

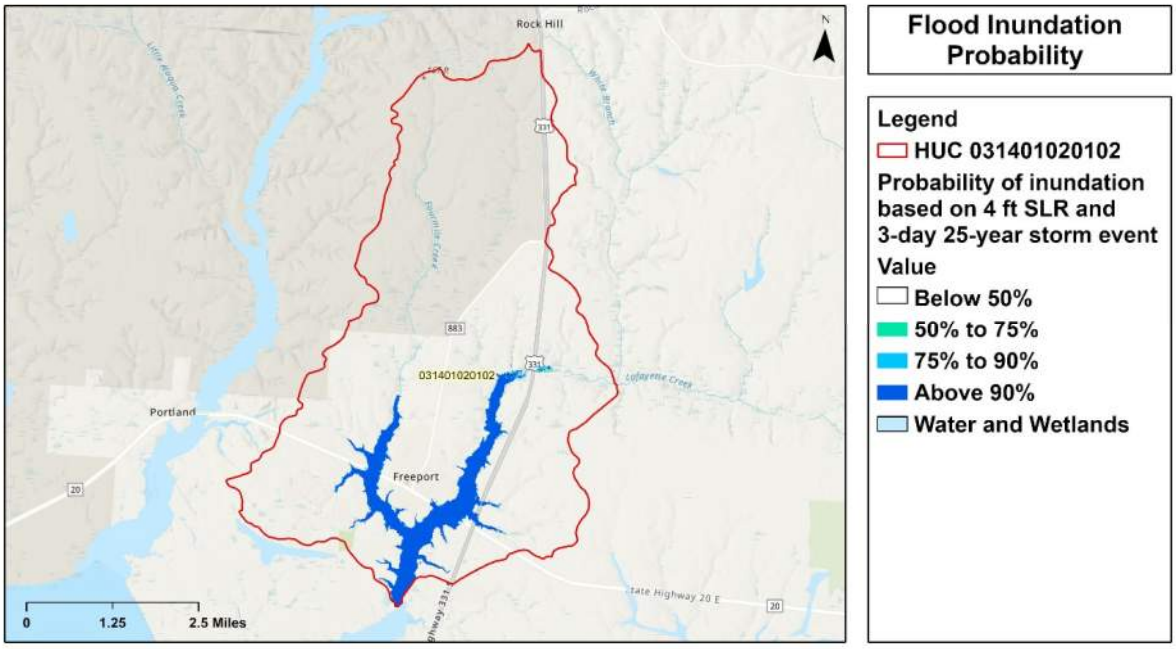

Figure 51. Sea level rise of 4 ft + 3-day 25-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

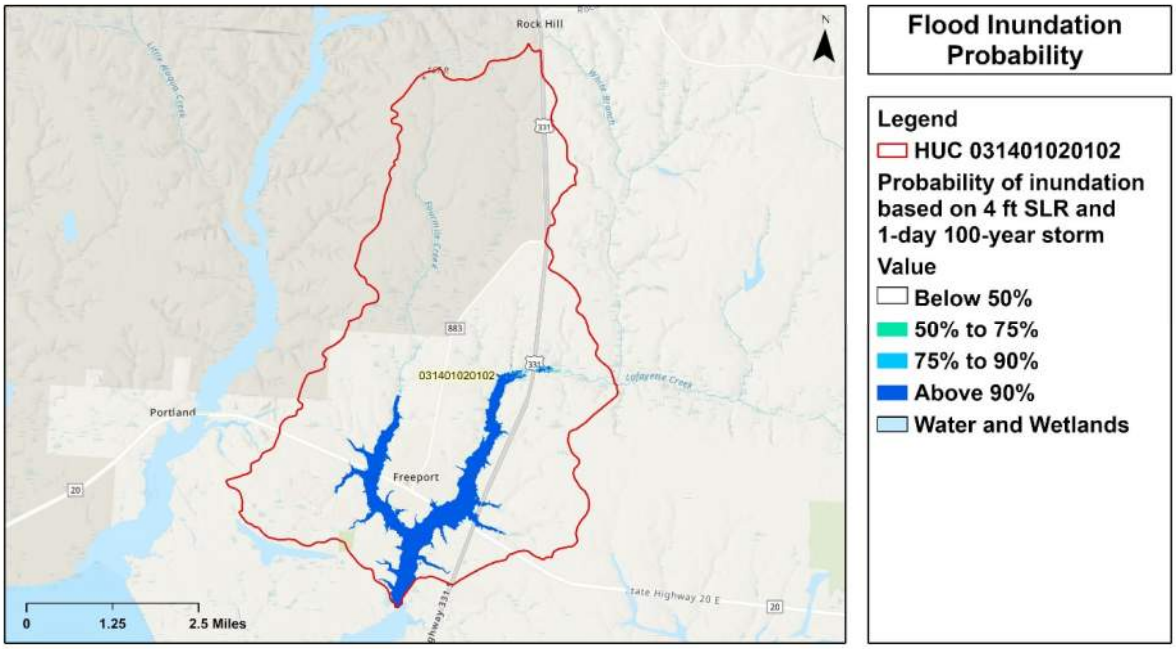

Figure 52. Sea level rise of 4 ft + 1-day 100-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

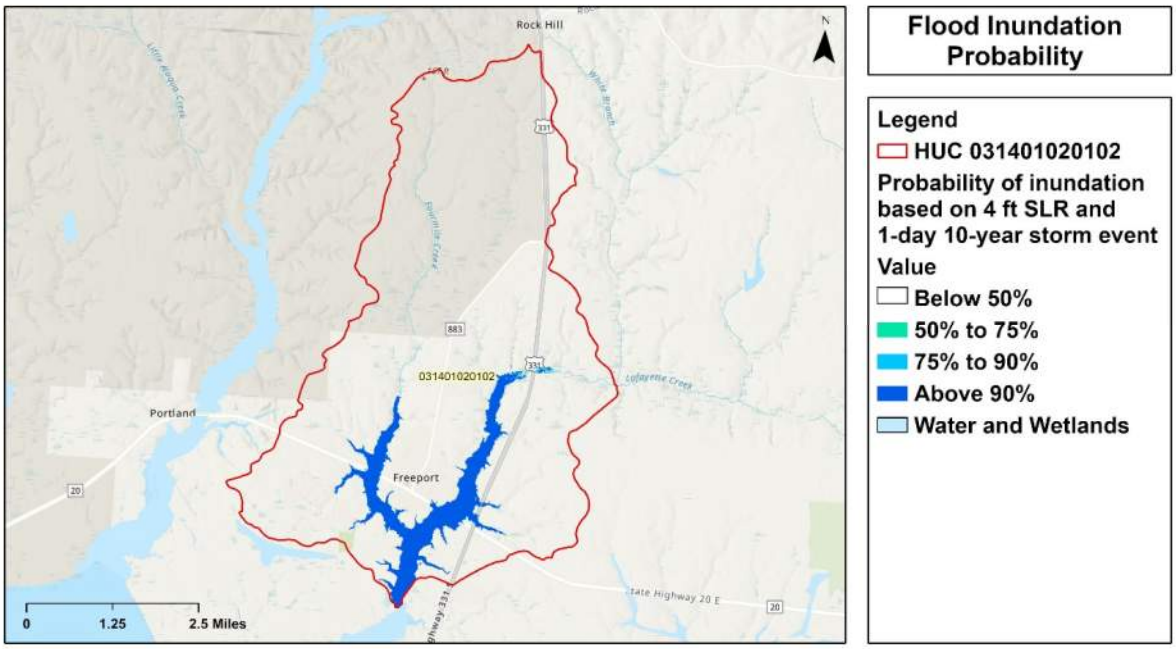

Figure 53. Sea level rise of 4 ft + 1-day 10-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

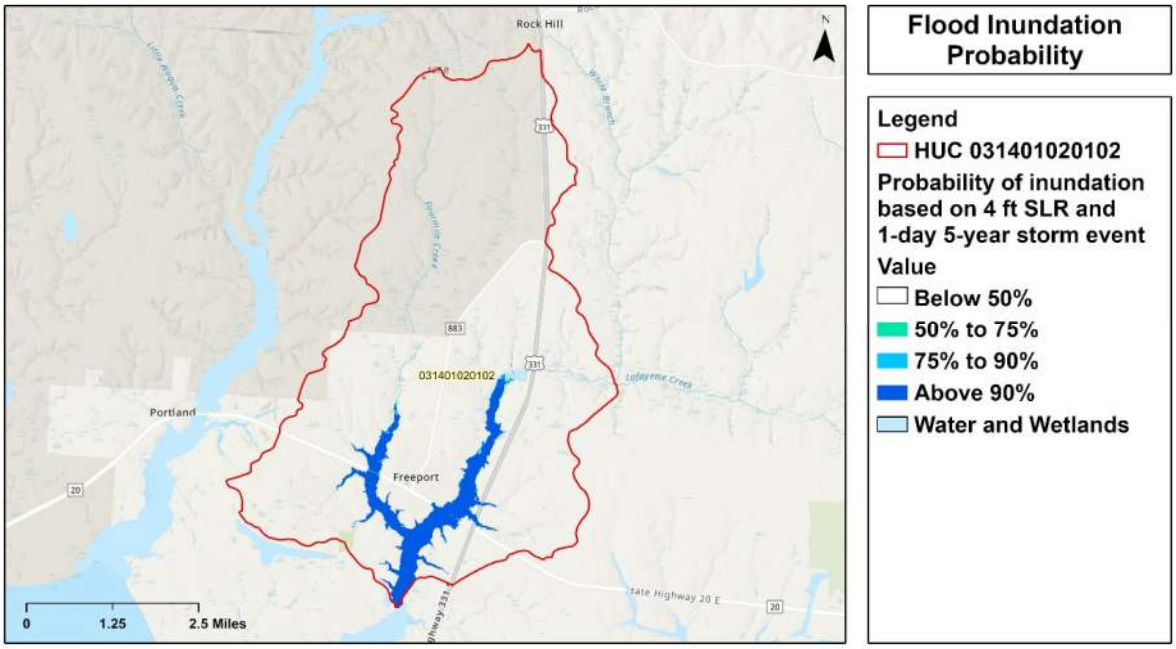

Figure 54. Sea level rise of 4 ft + 1-day 5-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

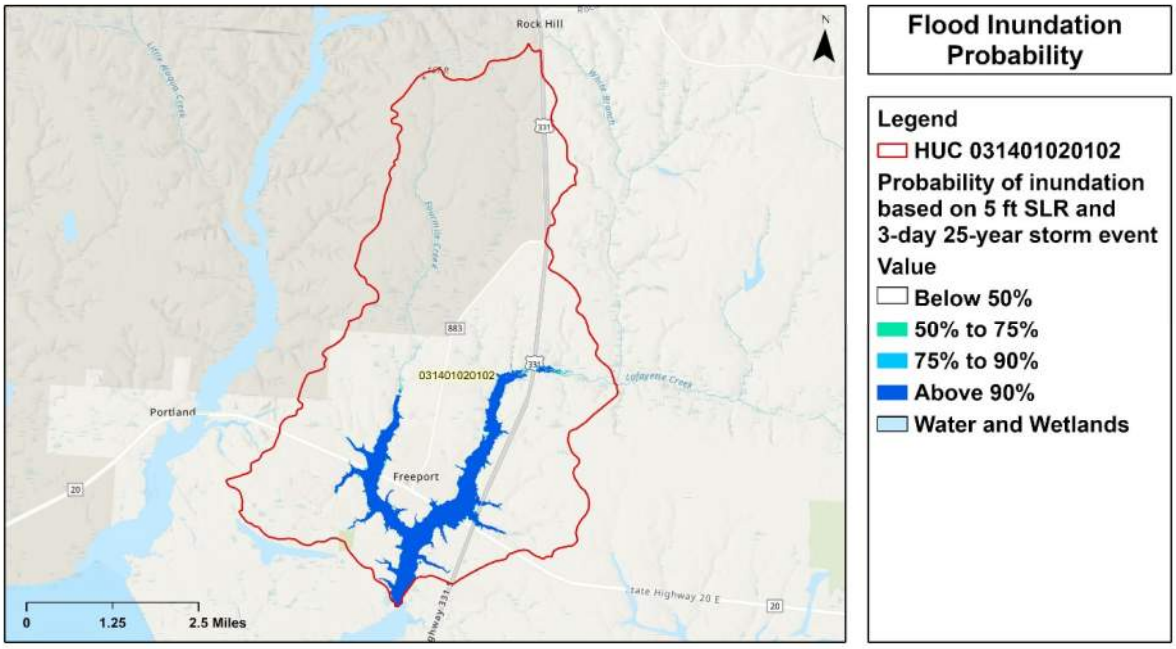

Figure 55. Sea level rise of 5 ft + 3-day 25-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

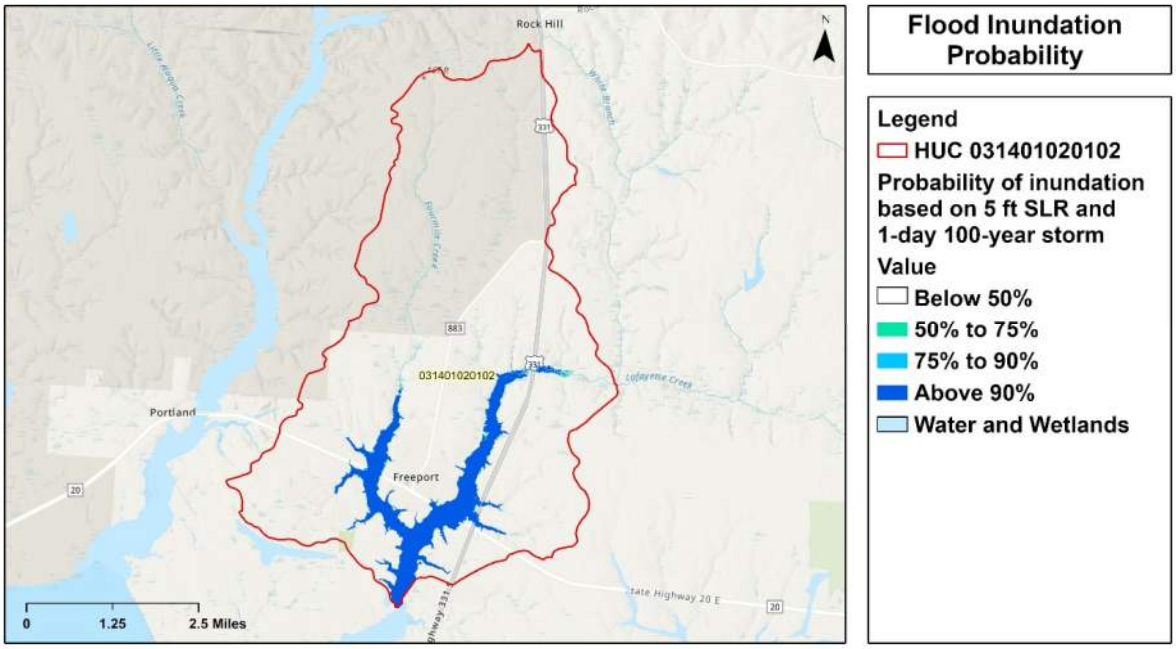

Figure 56. Sea level rise of 5 ft + 1-day 100-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

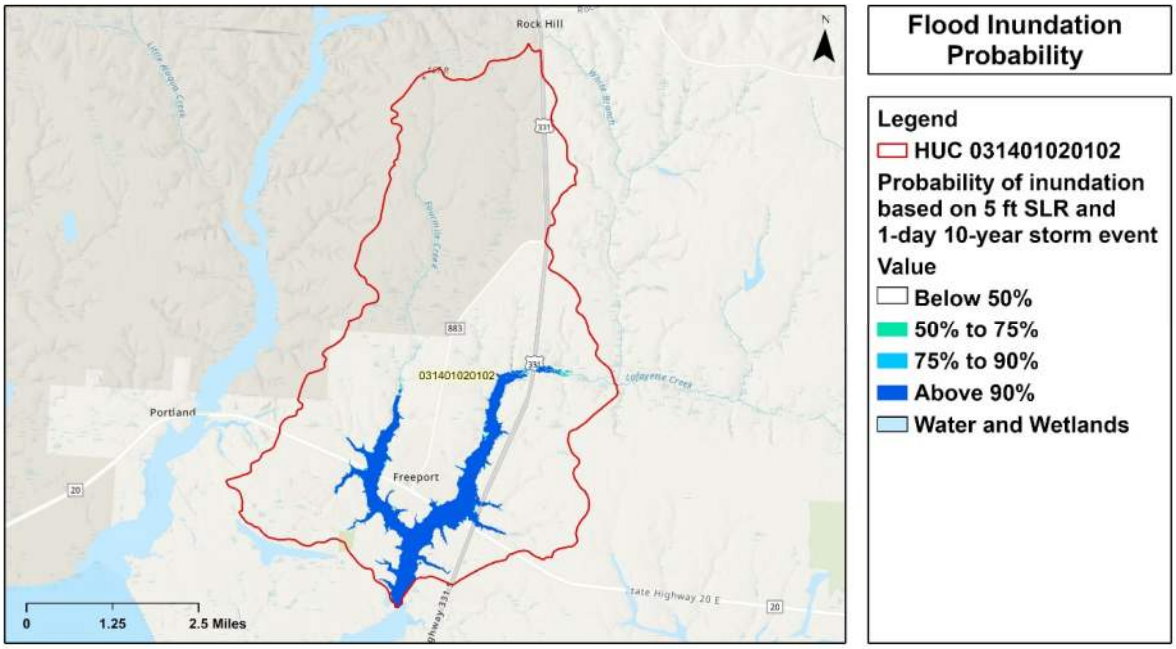

Figure 57. Sea level rise of 5 ft + 1-day 10-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

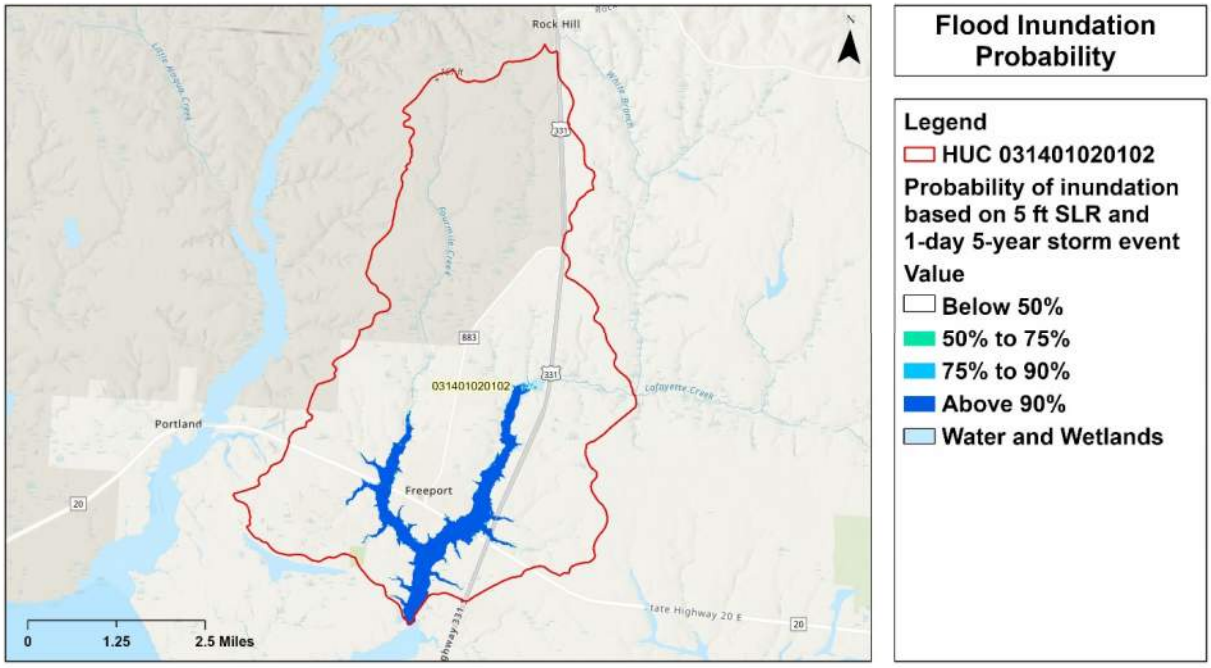

Figure 58. Sea level rise of 5 ft + 1-day 5-year storm for HUC 031401020102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.5 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6

11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3

43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2

74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, as shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.5.1 Results

Error! Reference source not found. to **Error! Reference source not found.** depict the HUC 031401020102 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 60) overlays critical facilities onto the 1-day 100-year storm event scenario, while the third map (**Error! Reference source not found.**) represents the same overlay within the context of 5 feet of sea level rise (SLR)

combined with the 1-day 100-year storm event. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 5 feet SLR + 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** and **Error! Reference source not found.** illustrate the composite score for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. **Error! Reference source not found.** represents the calculation for composite score based on 1-day 100-year storm event, while **Error! Reference source not found.** shows the calculation for composite score for the same storm event, but including a 5 feet of Sea Level Rise scenario. **Error! Reference source not found.** shows the same area zoomed out.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

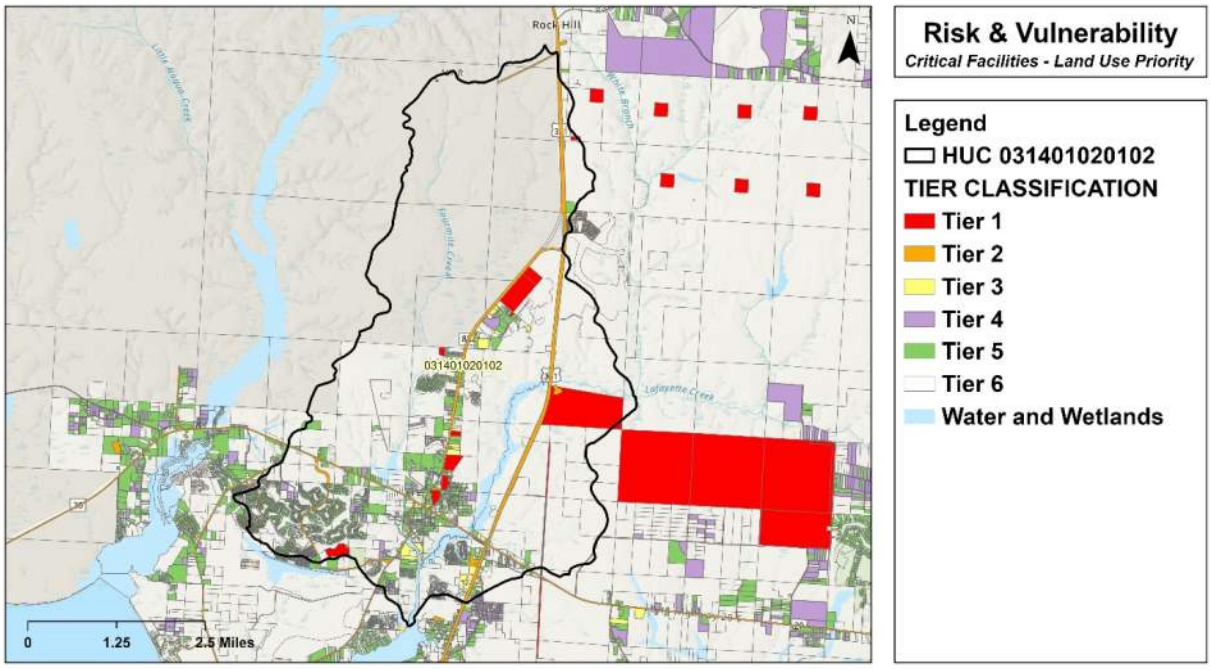

Figure 59. HUC 31401020102 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

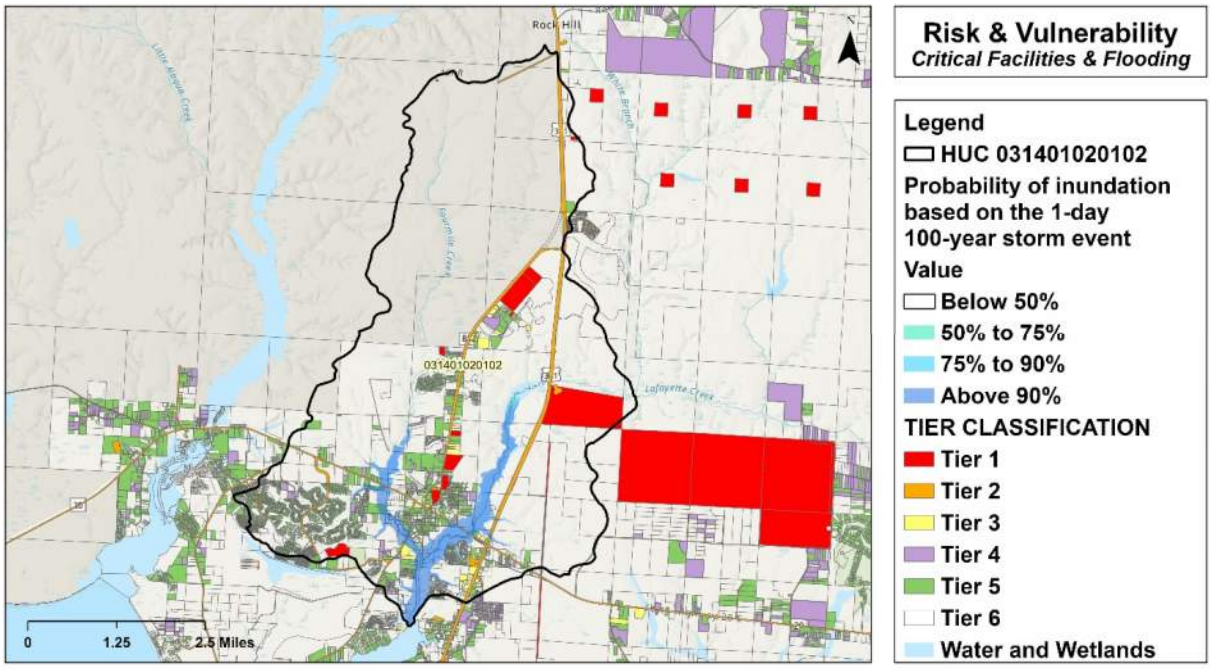

Figure 60. HUC 031401020102 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation map. Processed by FAU.

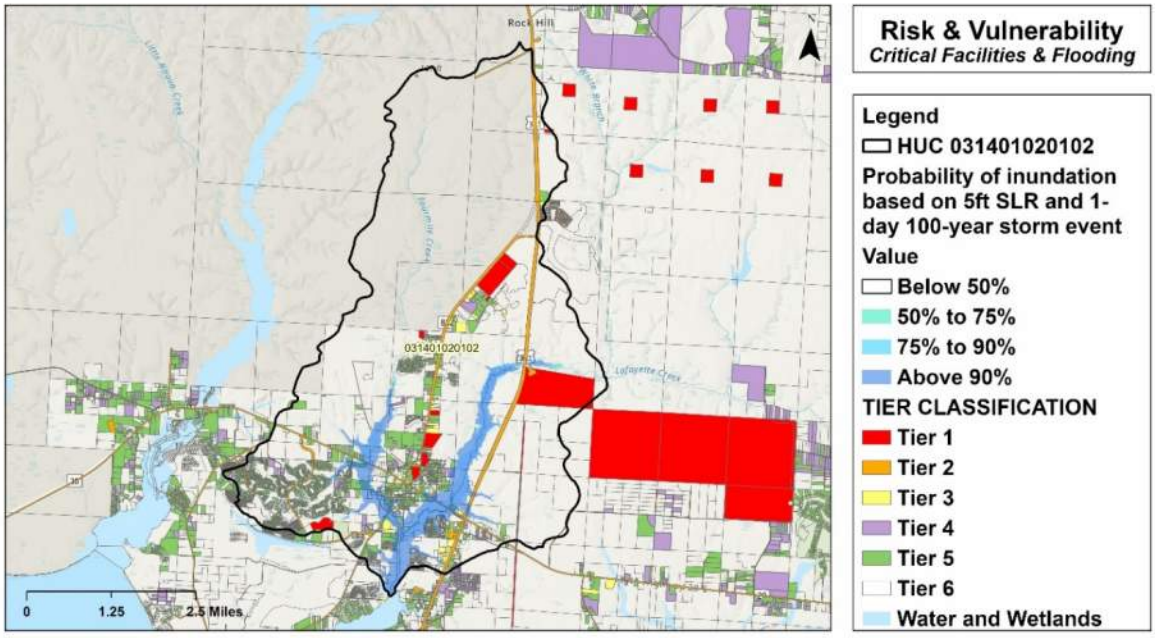

Figure 61. HUC 031401020102 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event + 5 ft SLR probability of inundation map. Processed by FAU.

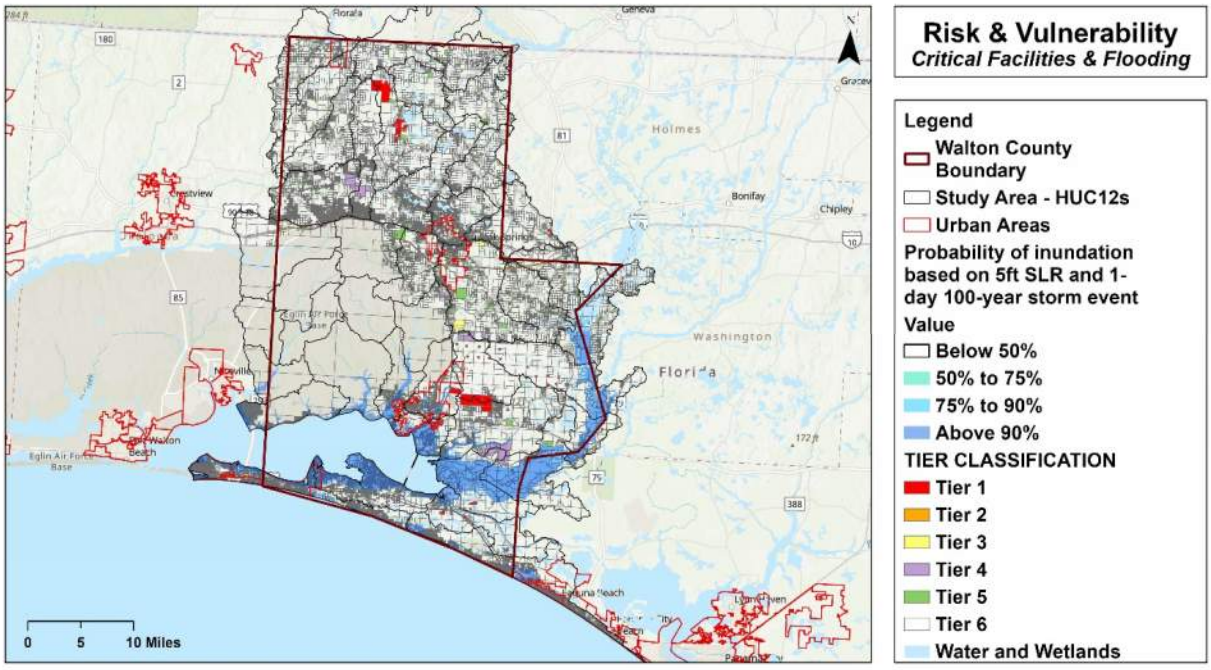

Figure 62. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event + 5 ft SLR probability of inundation map for Walton County. Processed by FAU.

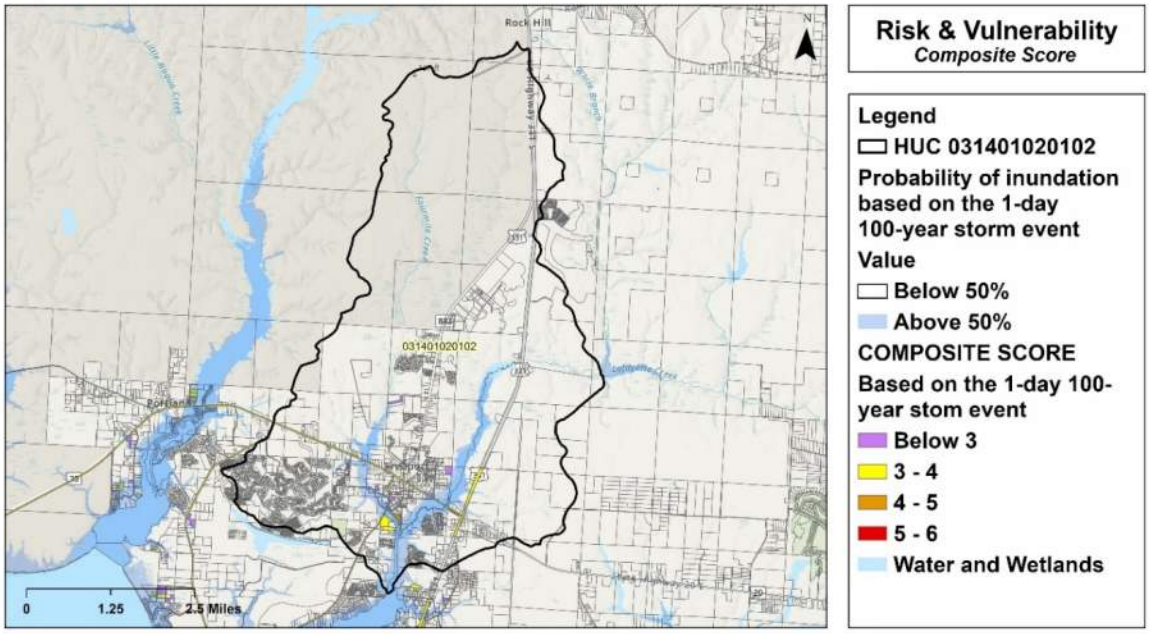

Figure 63. HUC 031401020102 sub-watershed Composite Score Risk map based on the 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation. Processed by FAU.

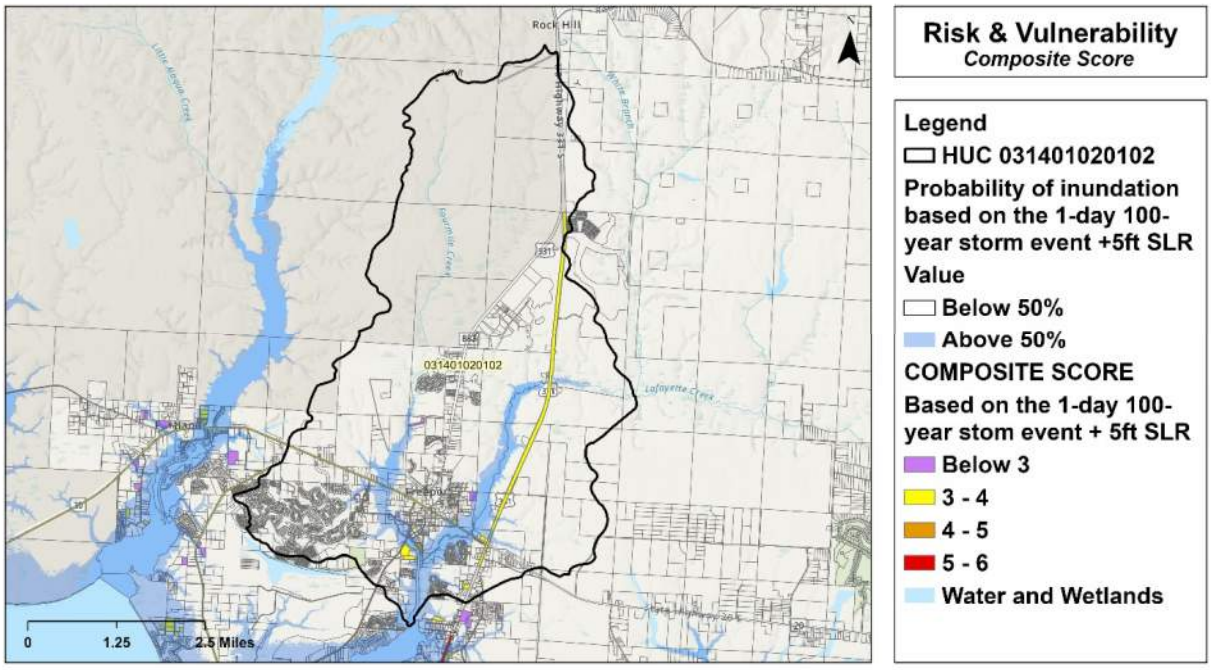

Figure 64. HUC 031401020102 sub-watershed Composite Score Risk map based on 1-day 100-year storm event + 5 ft. SRL, overlaid on the 1-day 100-year + 5 ft. SLR probability of inundation. Processed by FAU.

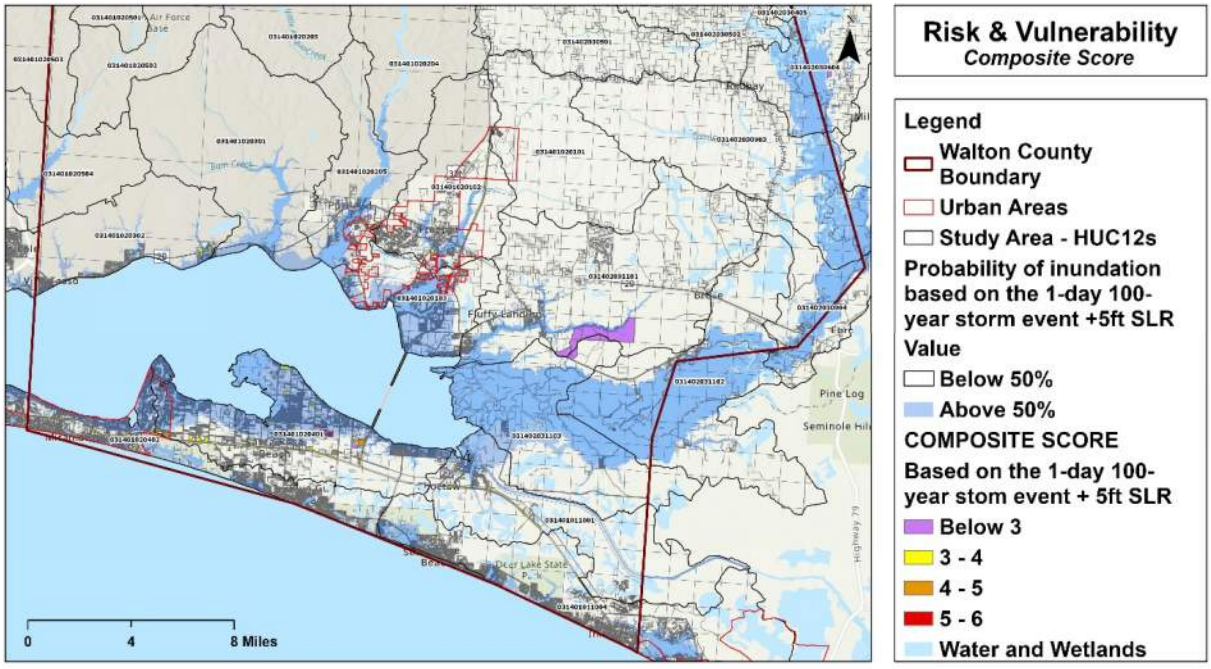

Figure 65. Coastal Area of Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event + 5 ft SLR probability of inundation. Processed by FAU.

2.5.2 Drill-down – Freeport

For enhanced visualization of the urban areas within this HUC 031401020102, Figure 66 to Figure 75 illustrate the same results for critical facilities (land use priorities) and composite scores, but on a reduced scale, which better facilitates the examination of finer details within the urban area (Freeport). These maps cover both the 1-day 100-year scenario and the 1-day 100-year + 5 feet SLR scenario.

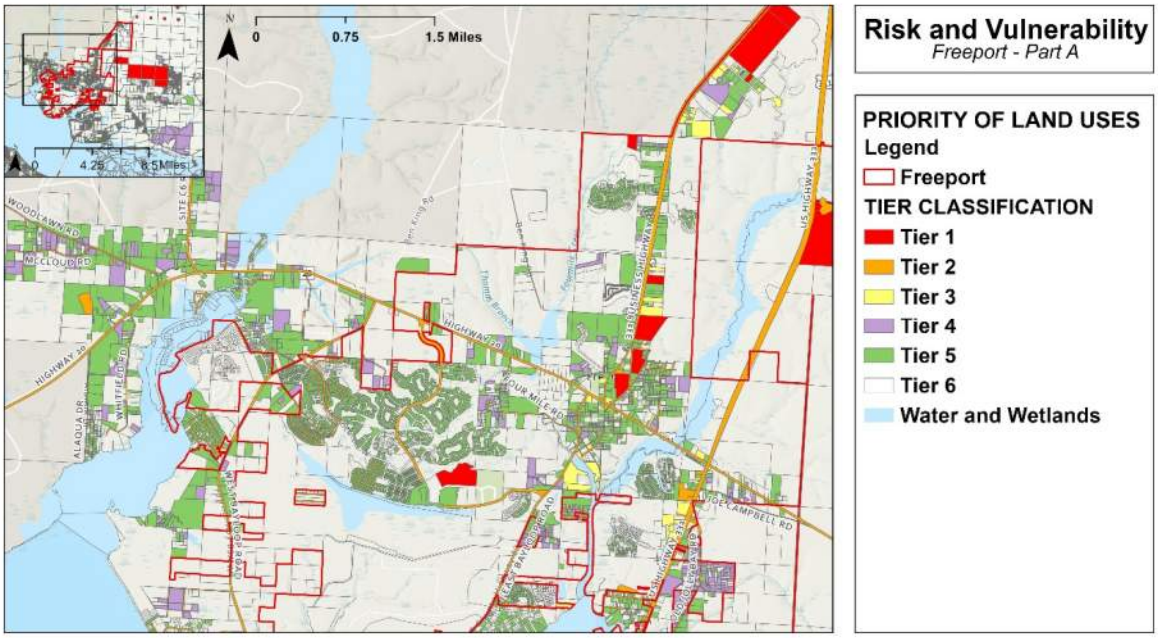

Figure 66. Critical Facilities (priority of land uses) map for Freeport (part A). Processed by FAU.

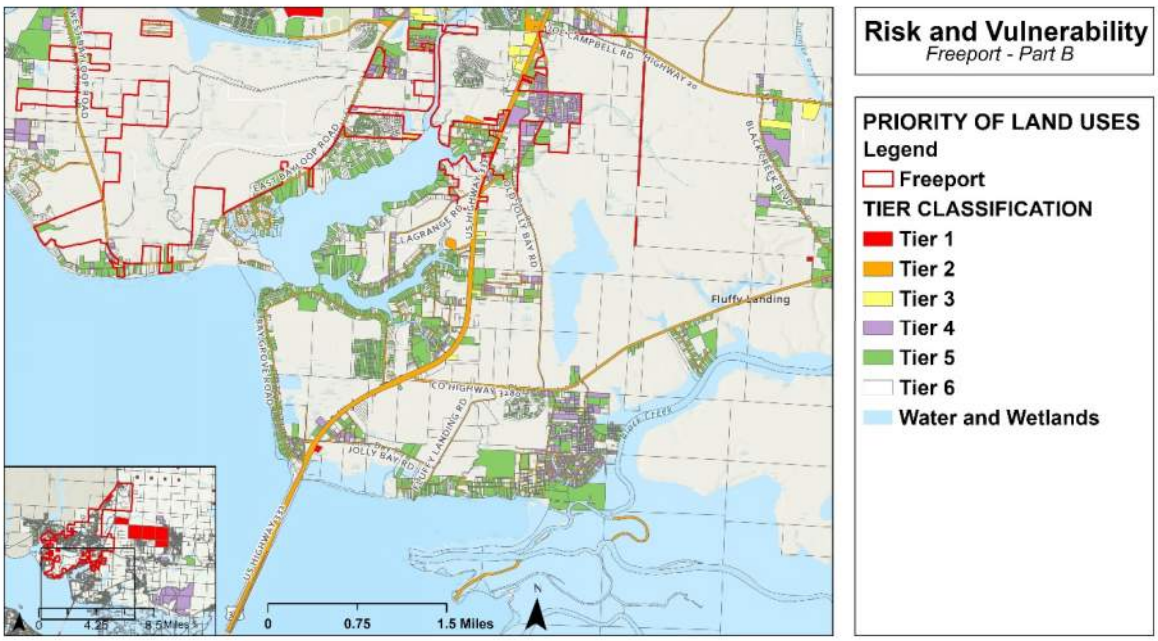

Figure 67. Critical Facilities (priority of land uses) map for Freeport (part B). Processed by FAU.

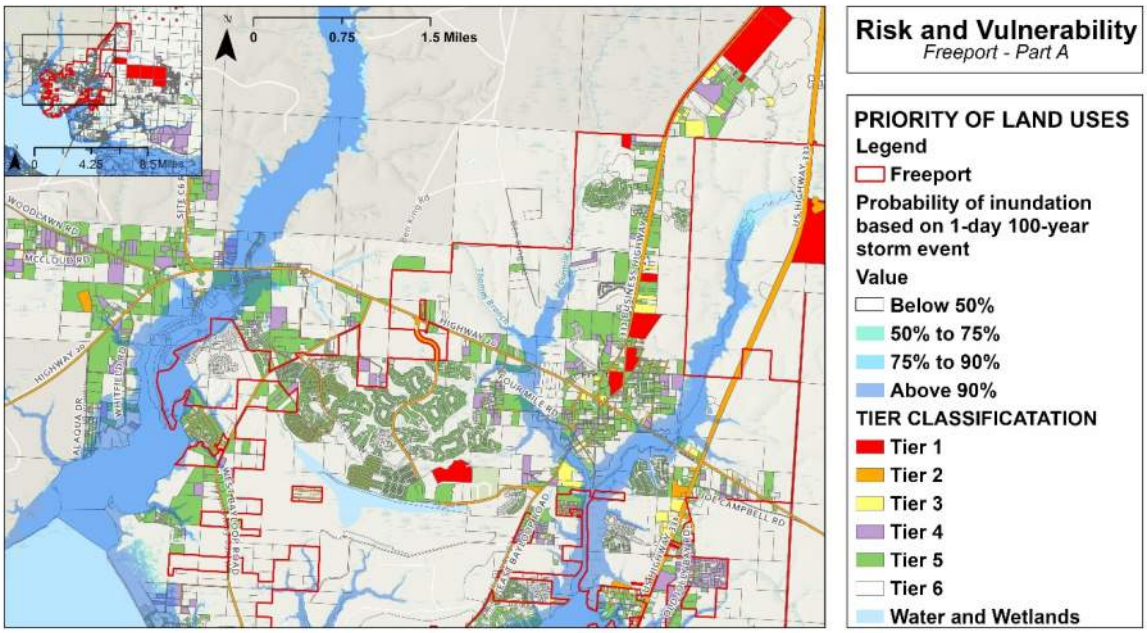

Figure 68. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event for Freeport (part A). Processed by FAU.

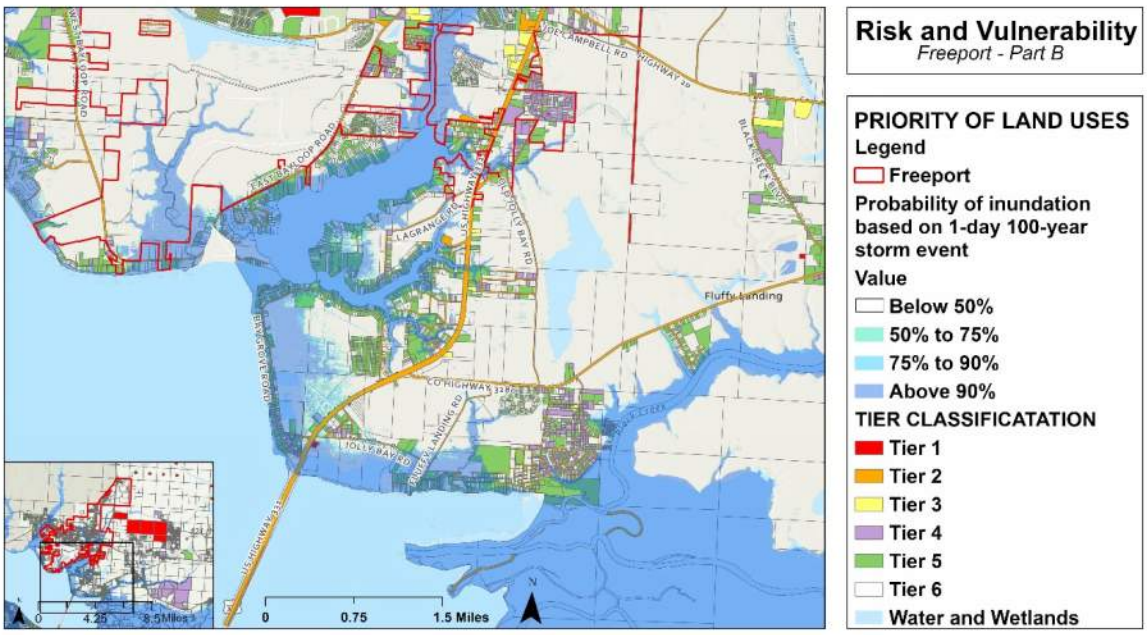

Figure 69. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event for Freeport (part B). Processed by FAU.

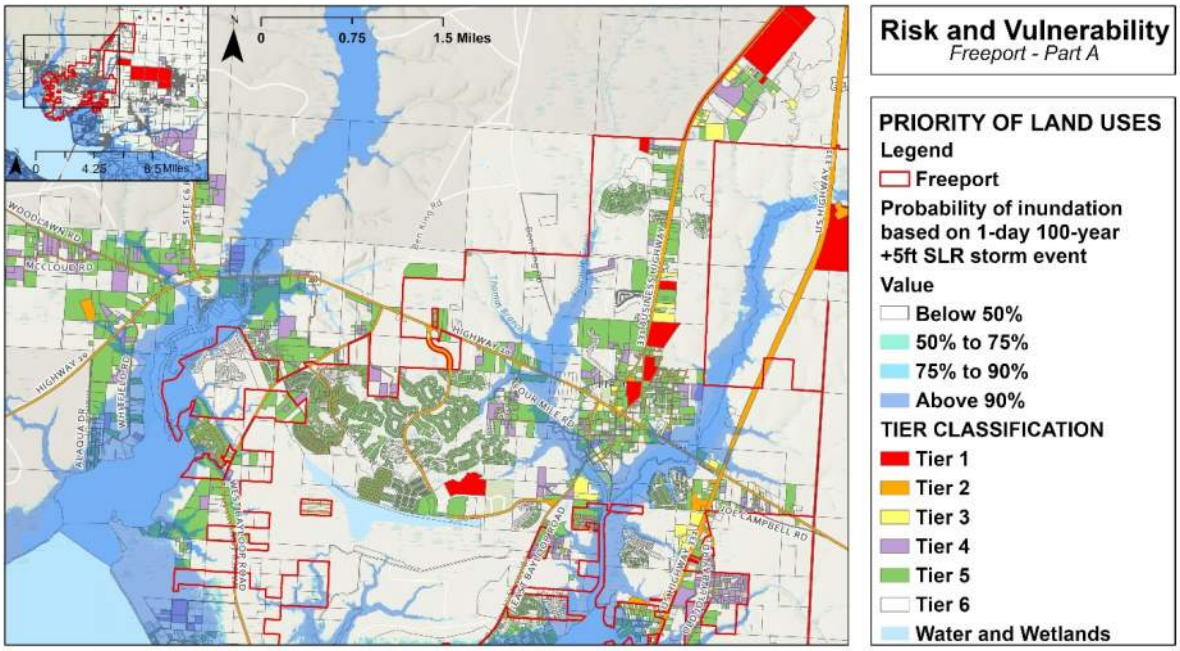

Figure 70. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event + 5 feet SLR for Freeport (part A). Processed by FAU.

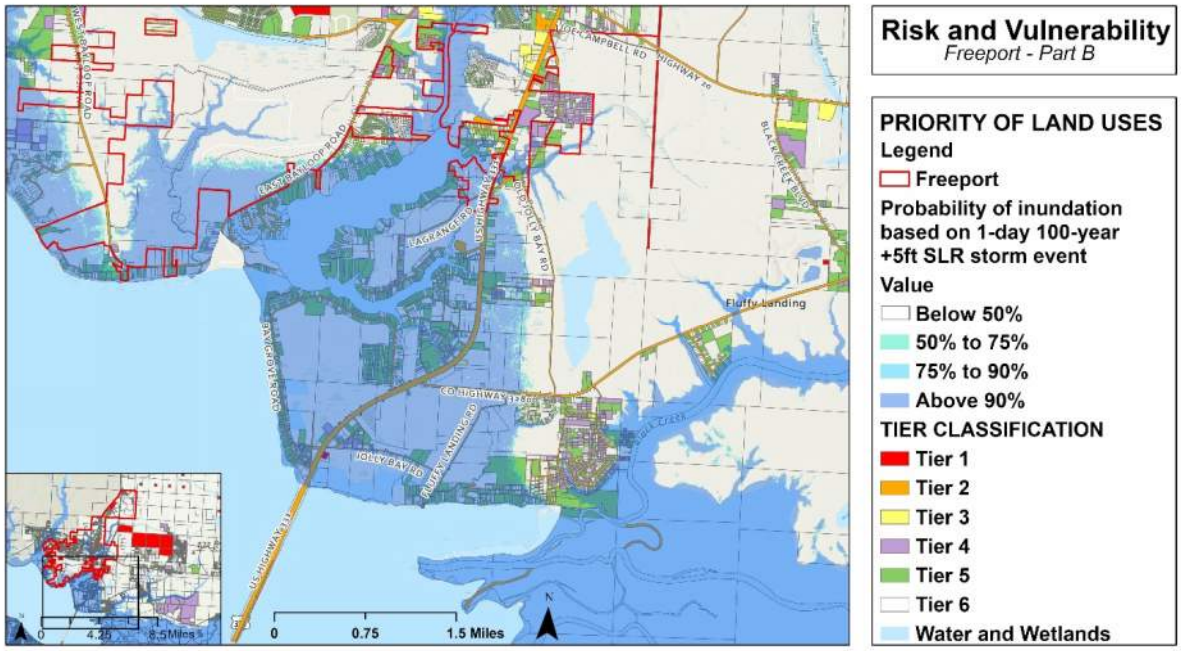

Figure 71. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event + 5 feet SLR for Freeport (part B). Processed by FAU.

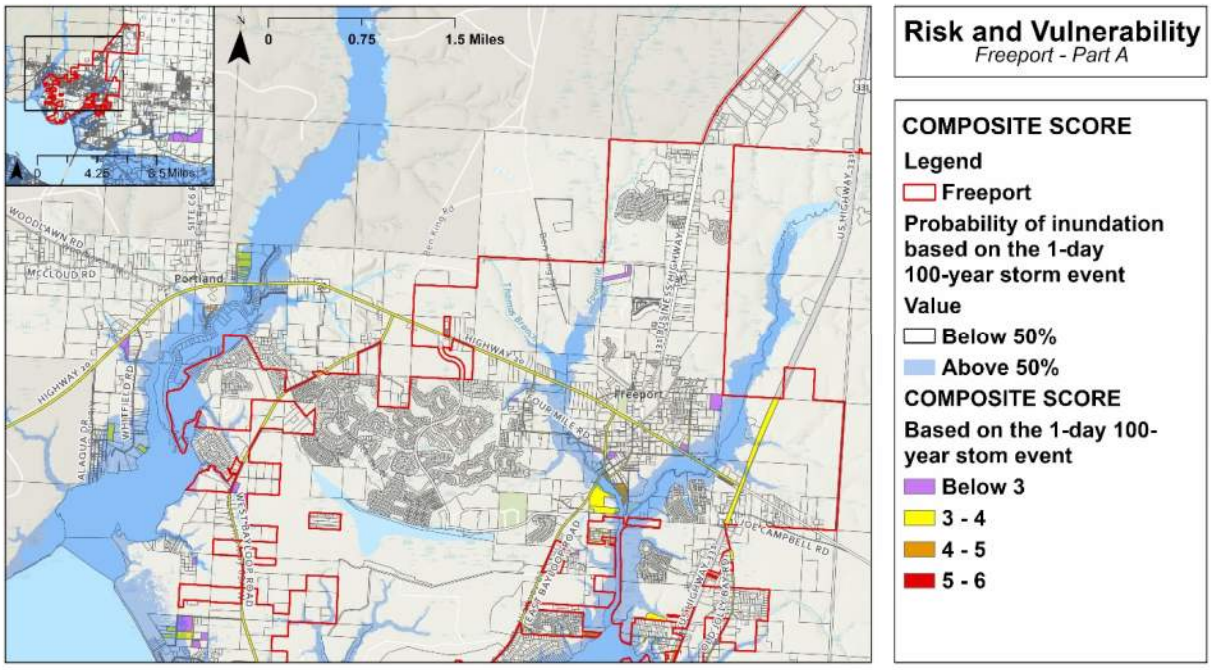

Figure 72. Composite Score map based on 1-day 100-year storm event, overlaid in flooding layer for Freeport (part A). Processed by FAU.

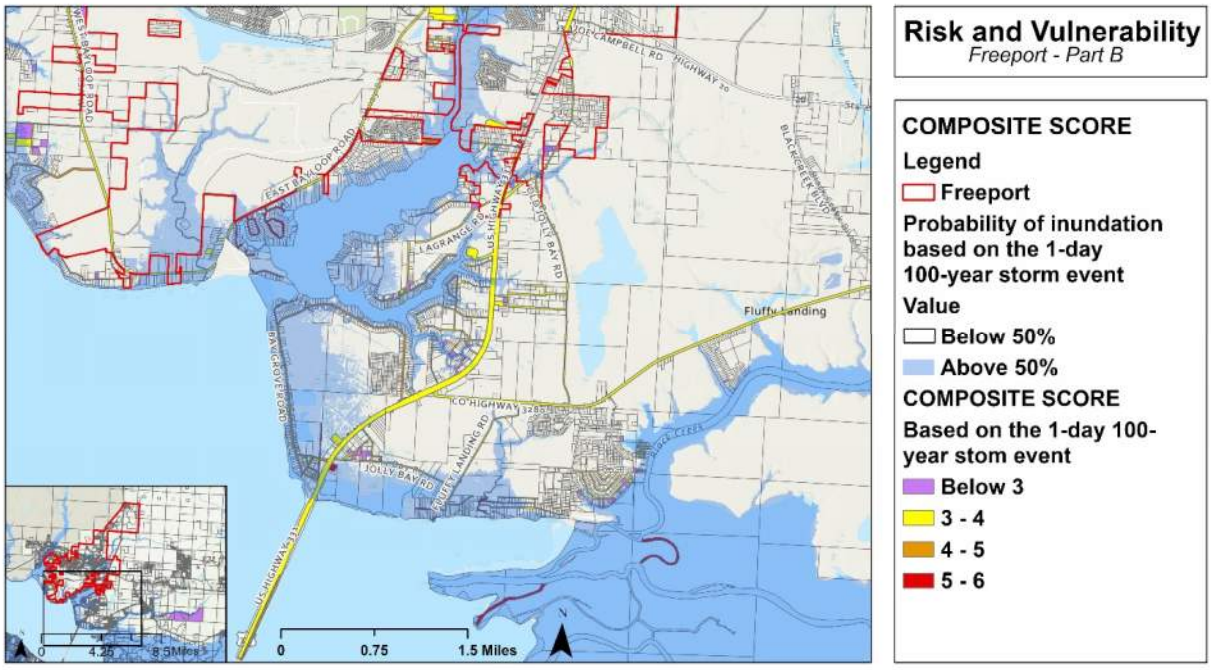

Figure 73. Composite Score map based on 1-day 100-year storm event, overlaid in flooding layer for Freeport (part B). Processed by FAU.

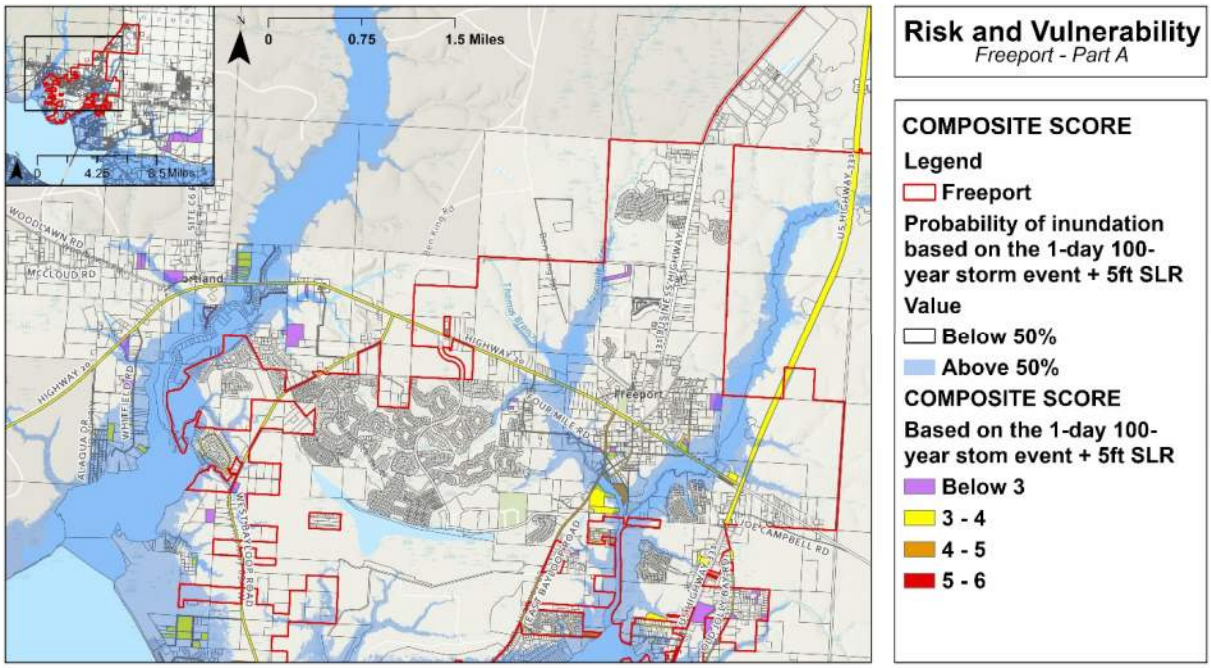

Figure 74. Composite Score map based on 1-day 100-year storm event + 5 feet SLR, overlaid in flooding layer for Freeport (part A). Processed by FAU.

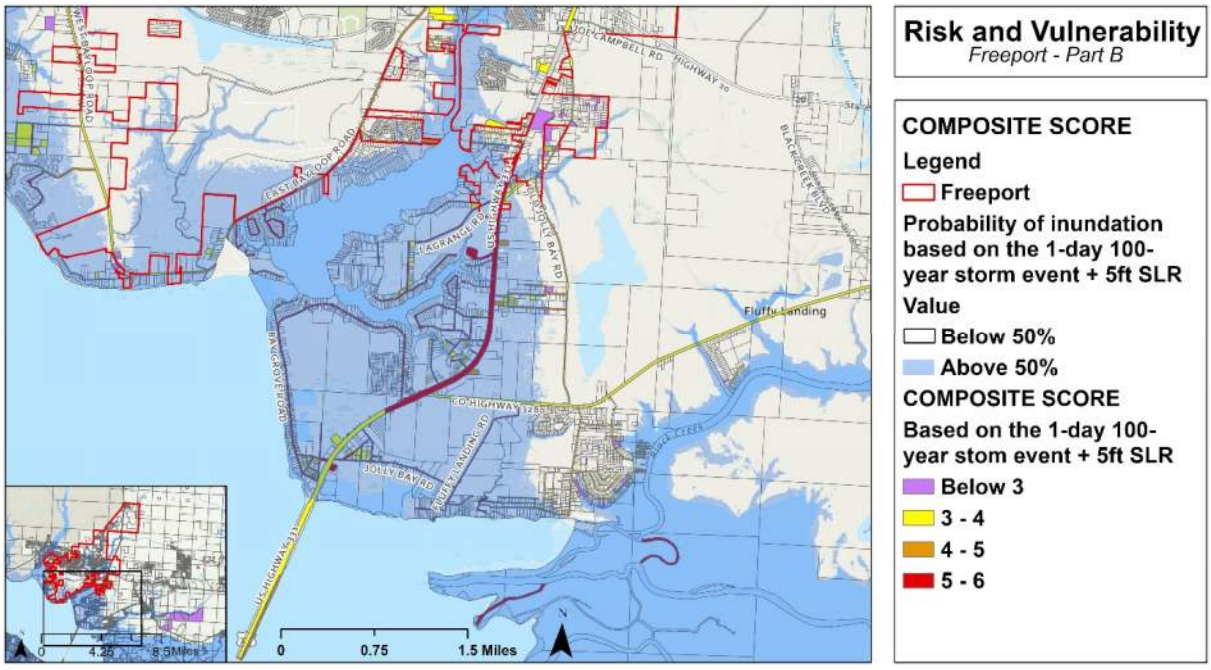

Figure 75. Composite Score map based on 1-day 100-year storm event + 5 feet SLR, overlaid in flooding layer for Freeport (part B). Processed by FAU.

2.5.3 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401020102. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.5.4 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401020102. Processed by FAU.

AREAS	ACRES
HUC-12 Sub-watershed: 031401020102	15918.61
All of the 1-day 100-year storm event inundation	**760.15**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	288.57
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.01
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	471.57
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	471.56

2.5.5 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. Figure 76 indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

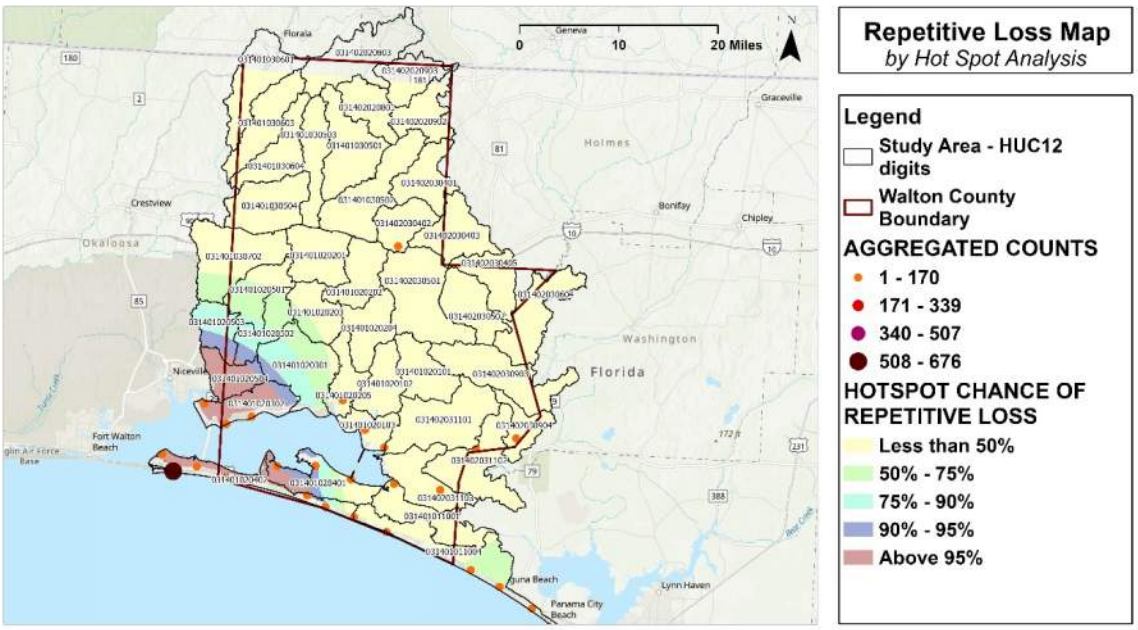

Figure 76. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.5.6. Priority Projects

The area displays a moderate level of development, with numerous parcels falling into tiers 1 to 3, and a subset of these parcels located within the flood zone. Notably, there are nine critical facilities in total, including six public schools and three utilities, although none of them are within the flood zone.

Several roads fall into tier 2, with some needing attention as a portion of them intersects the flood zone. These roads include East Bayloop Road, Four Mile Rd, Highway 20, Shipyard Rd, Buchanan Street, Us Highway 331, and N Jackson Street.

In terms of the composite score, the highest priority parcels within the basin consist of three local streets near Fourmile Creek, one of which is named Grant Street, while the other two has no name in the Property Appraisal Dataset. Within the score range of 4 to 5, there are four roads (Four Mile Rd, Shipyard Rd, East Bayloop Road, and Shipyard Rd) and two parcels, one designated as light manufacturing and the other as an office building.

The score range of 3 to 4 encompasses 26 parcels, including a community shopping center, two light manufacturing facilities, two mobile homes, three office buildings, one orphanage, and 17 roads. Among these, significant roads include US Highway 331, Highway 20, Madison St, N Jackson Street, S Jackson St, North St, Pierce Street, Buchanan Street, Taylor Street, and West Bayloop Road.

APPENDIX F

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401020103

LAYFAYETTE CREEK FRONTAL

Principal Investigator: Frederick Bloetscher, Ph.D., P.E.

Co-Principal Investigators: Weibo Liu, Ph.D., Daniel Meeroff, Ph.D., Diana Mitsova, Ph.D., S. Nagarajan, Ph.D., Hongbo Su, Ph.D., Ramesh Teegavarapu, Ph.D., Zhixiao Xie, Ph.D., Yan Yong, Ph.D., and Caiyun Zhang, Ph.D., Ahmet Urusan, Ph.D., Shannon Egger, Eva Suarez, Ph.D.

Research Assistant: Leticia Sabio

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 sub-watershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 (031401020103) is highlighted among all the HUCs to help identifying its location. (Figure 3).

The city of Freeport shares a great portion of its boundary with the basin. Demographics data and other considerations of Freeport, along with other cities in Walton County, will be covered in subsequent discussions.

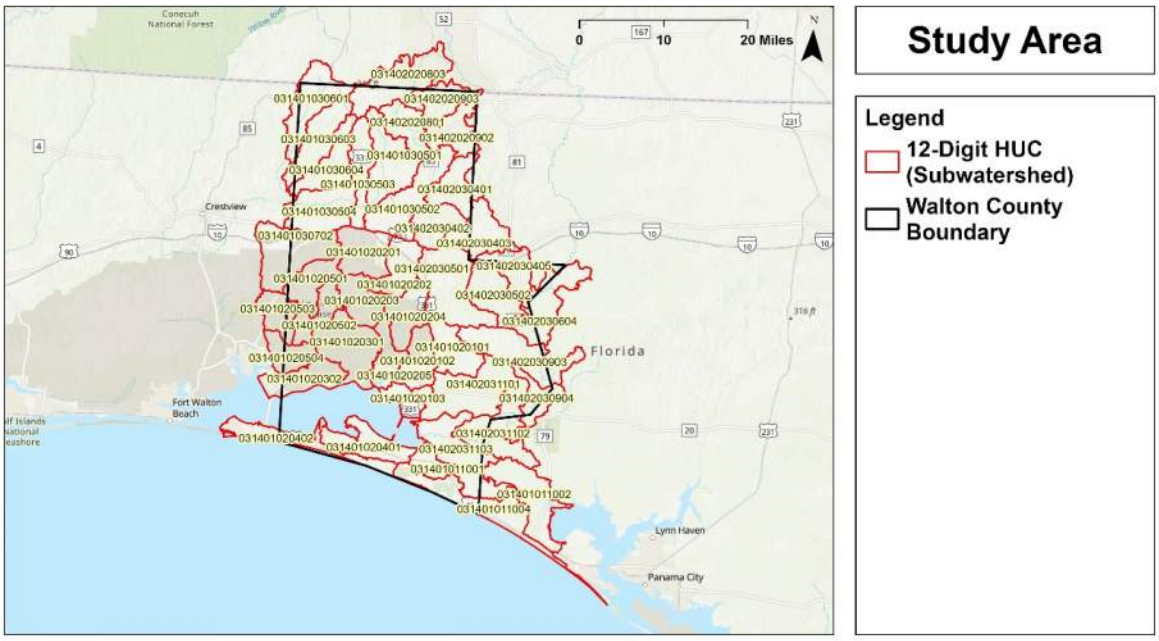

Figure 1. Walton County and all HUCs 12-digit sub-watershed, processed by FAU.

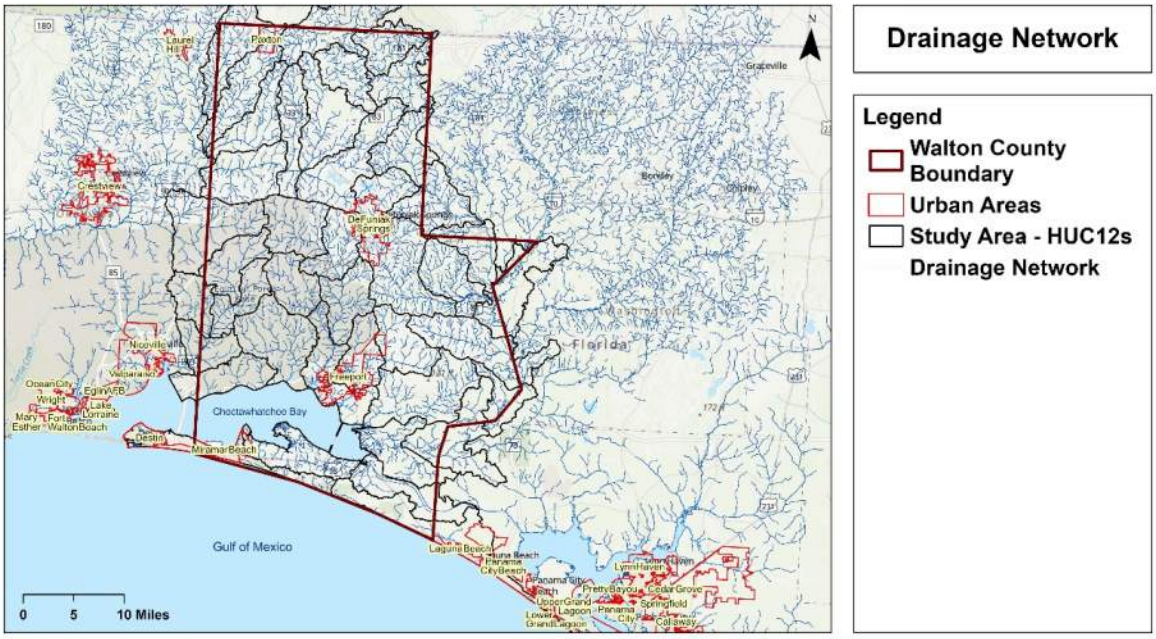

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

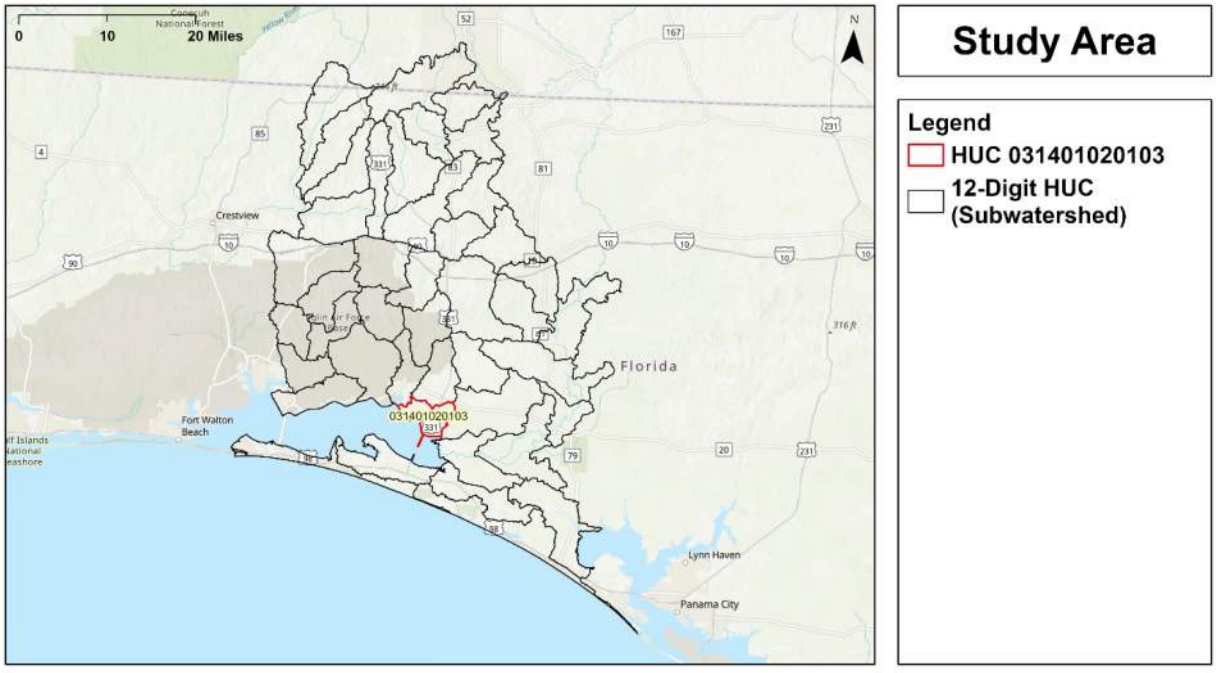

Figure 3. HUC 031401020103 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development, tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Based on the land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water

in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

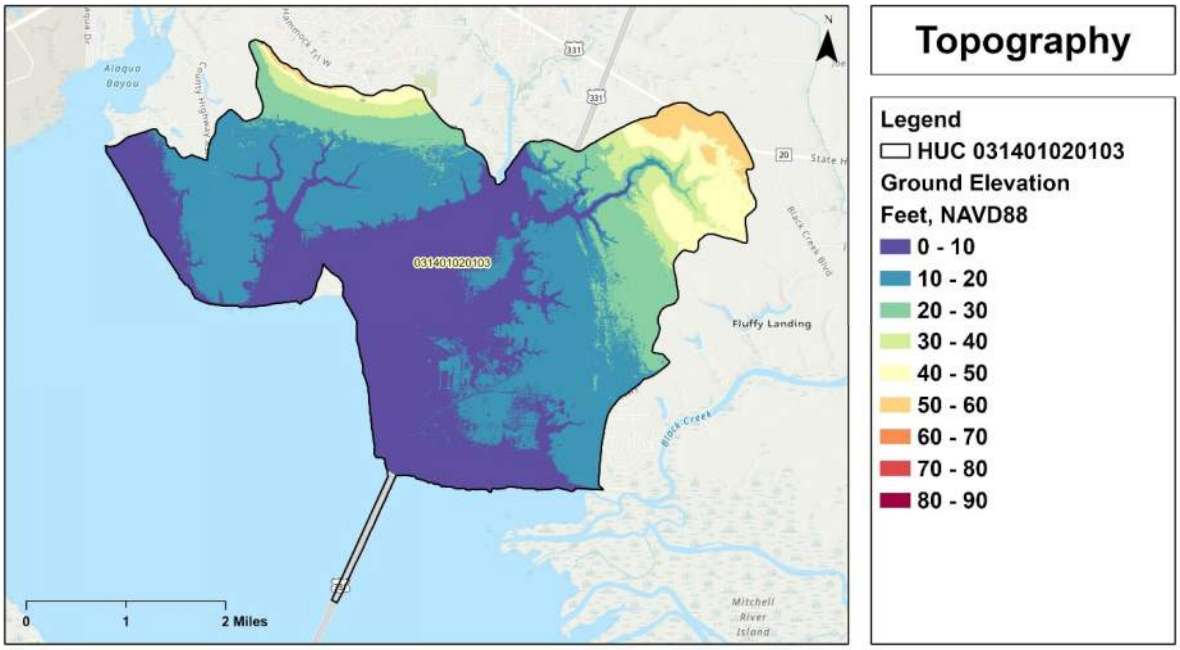

Figure 4. Topographic map of the HUC 031401020103 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401020103 sub-watershed is shown in **Error! Reference source not found.**.

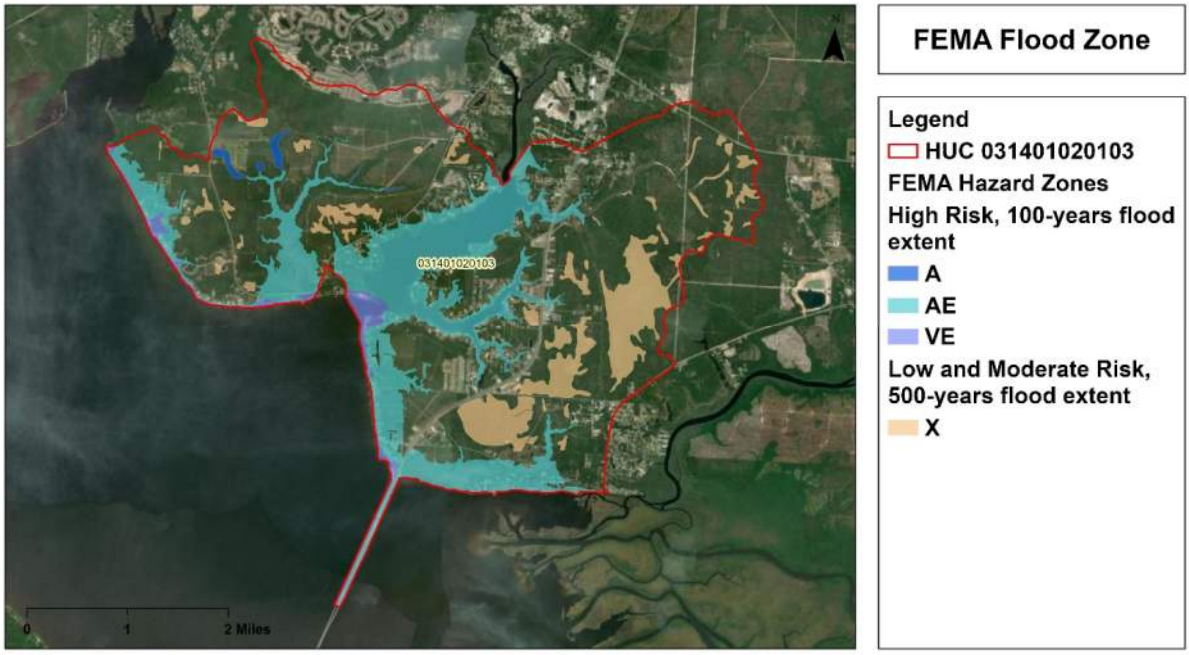

Figure 5. FEMA Flood Zone map (2020) for HUC 031401020103 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself

characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401020103 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

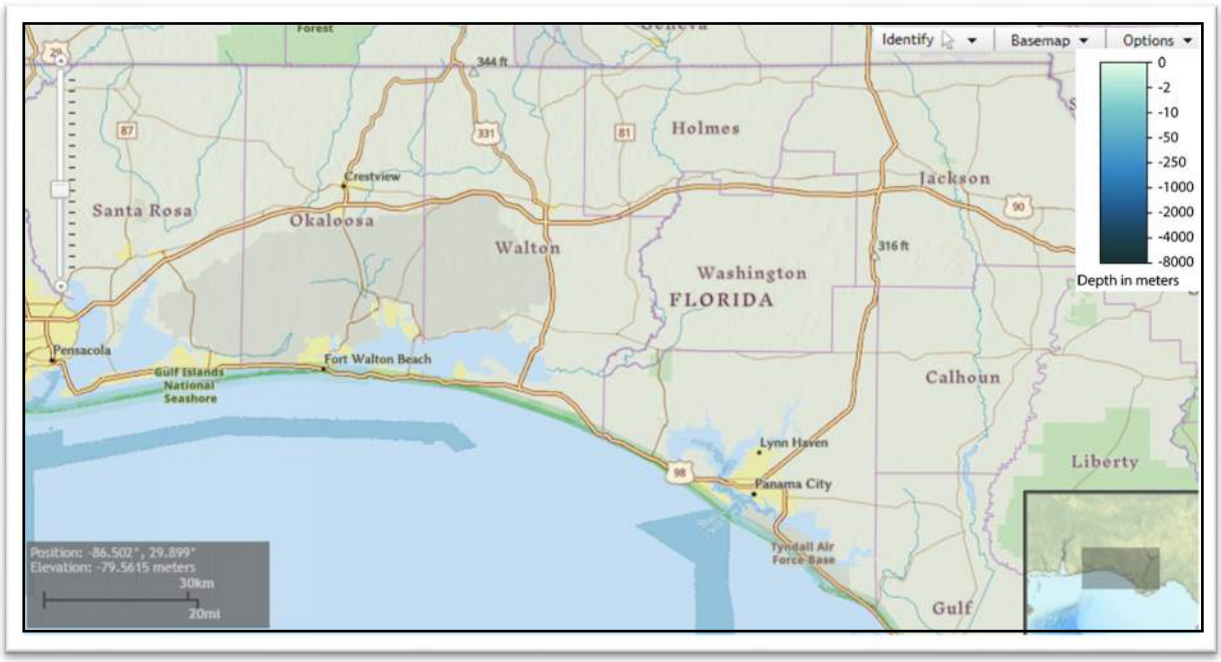

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

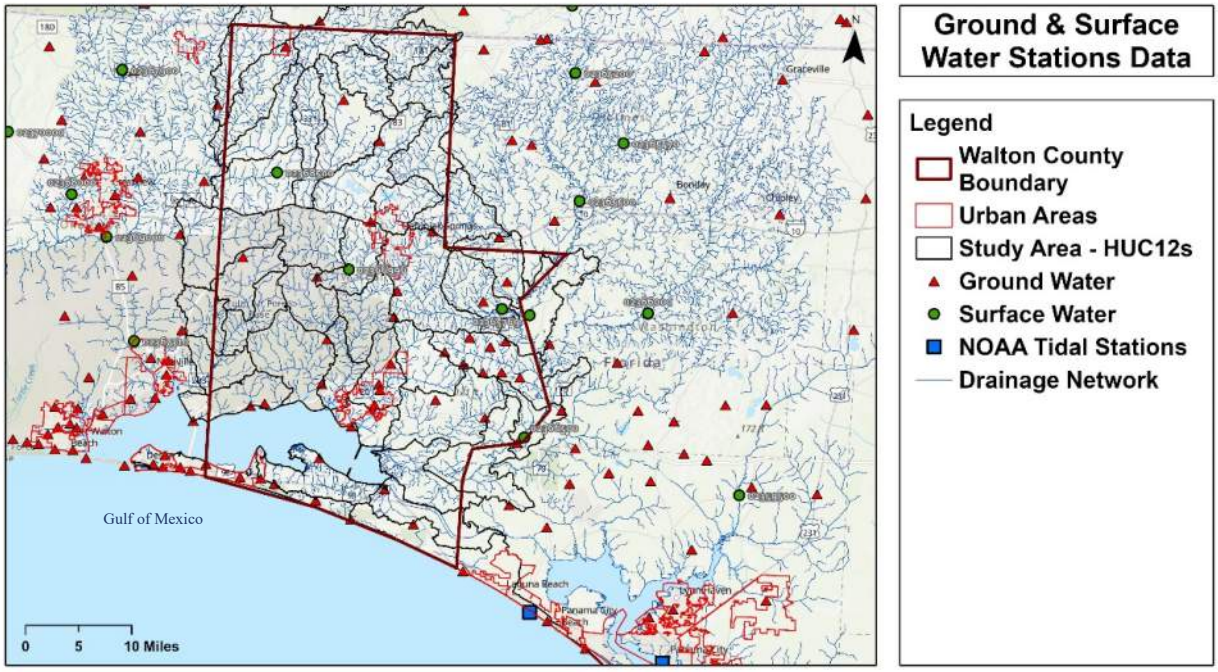

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The major water bodies in the sub-watershed are the Choctawhatchee Bay at the south side of the HUC-12 with the associated rivers and canals:

- Ramsey Branch

- Bear Creek

Given that stream flow data are critical for estimating flooding, Figure 8 shows the historical streamflow during June 2022 to July 2023 for USGS 02366500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401020103, which is USGS 02366500 Choctawhatchee River NR Bruce FLA.

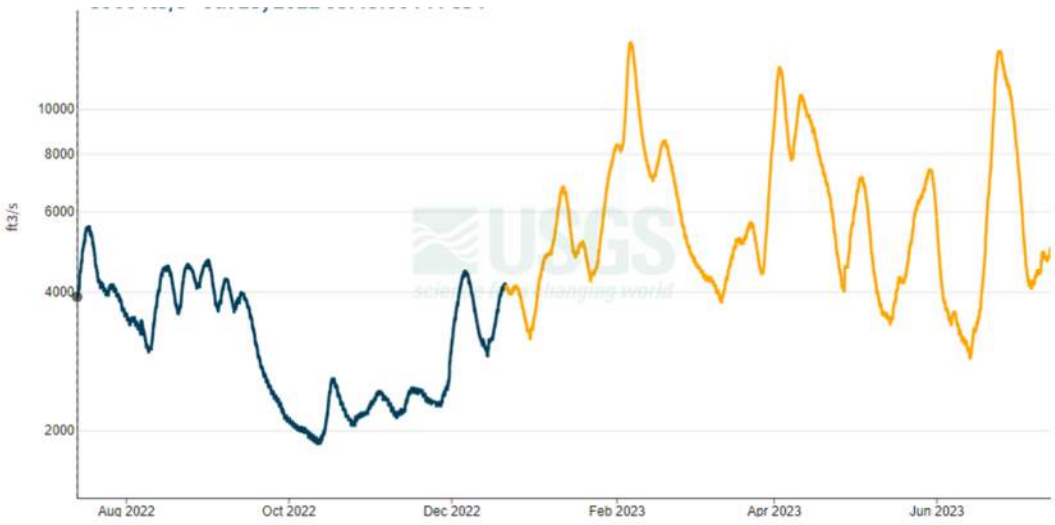

Figure 8. Average streamflow for Choctawhatchee River NR Bruce FLA (USGS 02366500 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366500/#parameterCode=00065&period=P365D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401020103 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031401020103 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

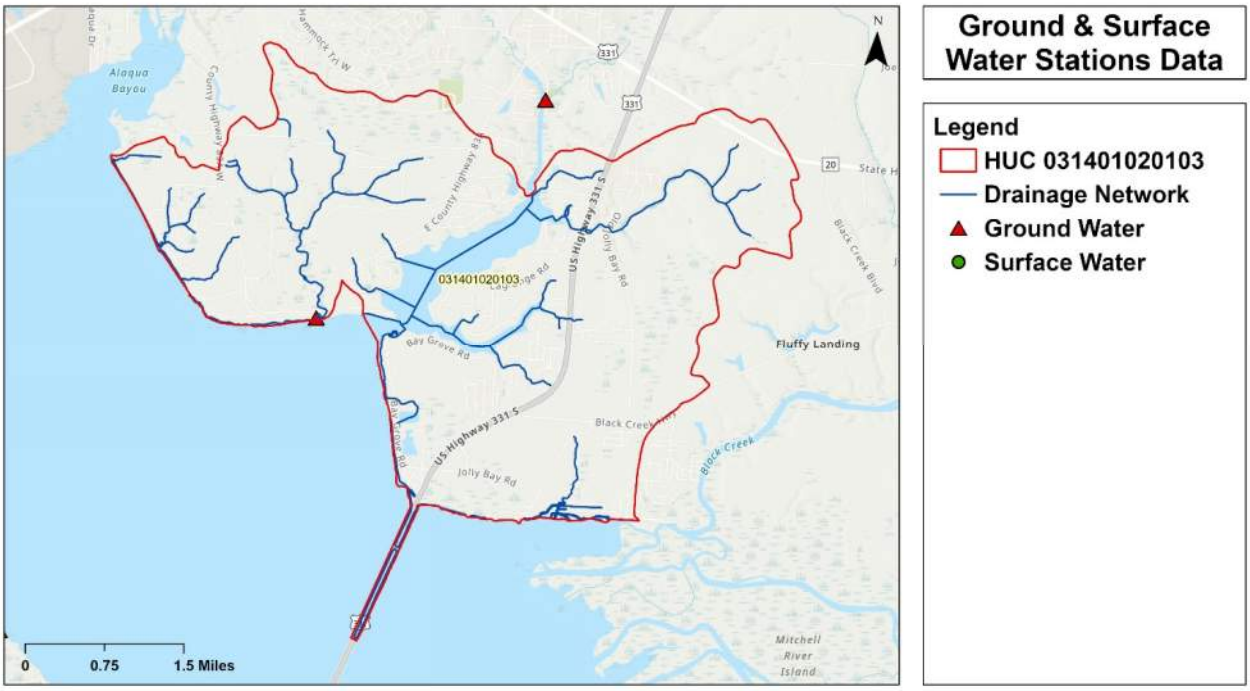

Figure 9. Ground and Surface Water Stations in the HUC 031401020103 sub-watershed, processed by FAU.

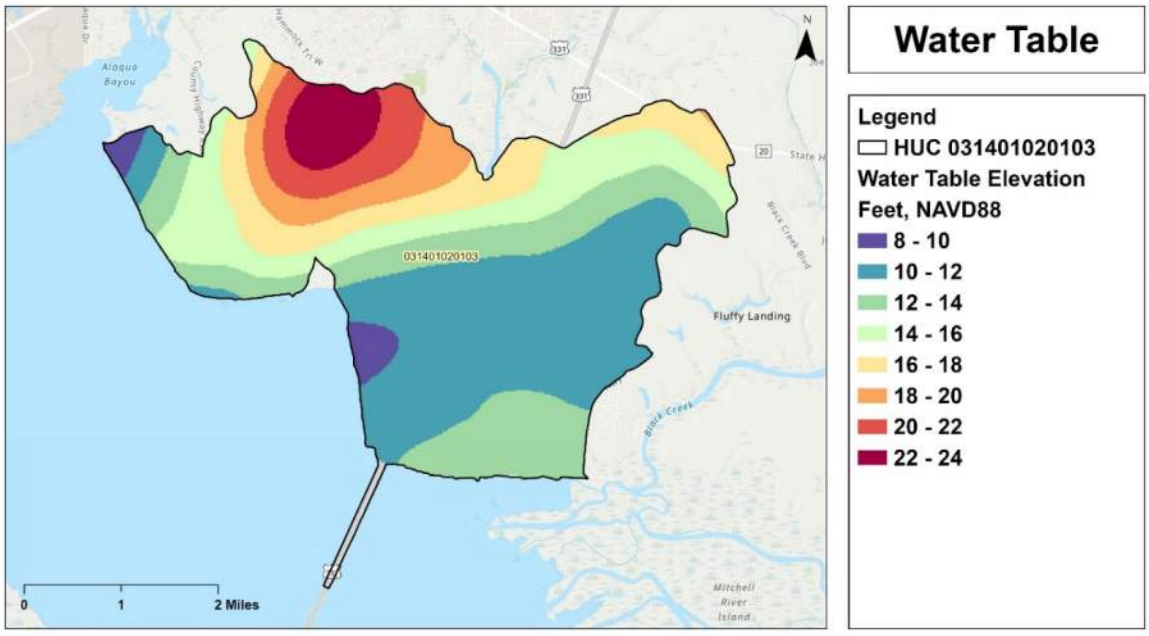

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401020103 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

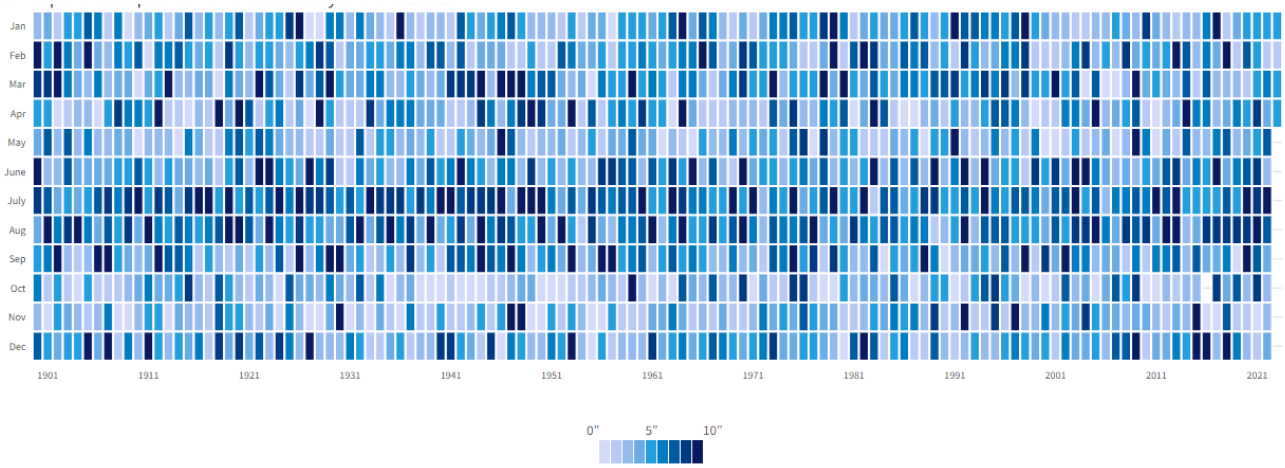

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/)

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there are no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

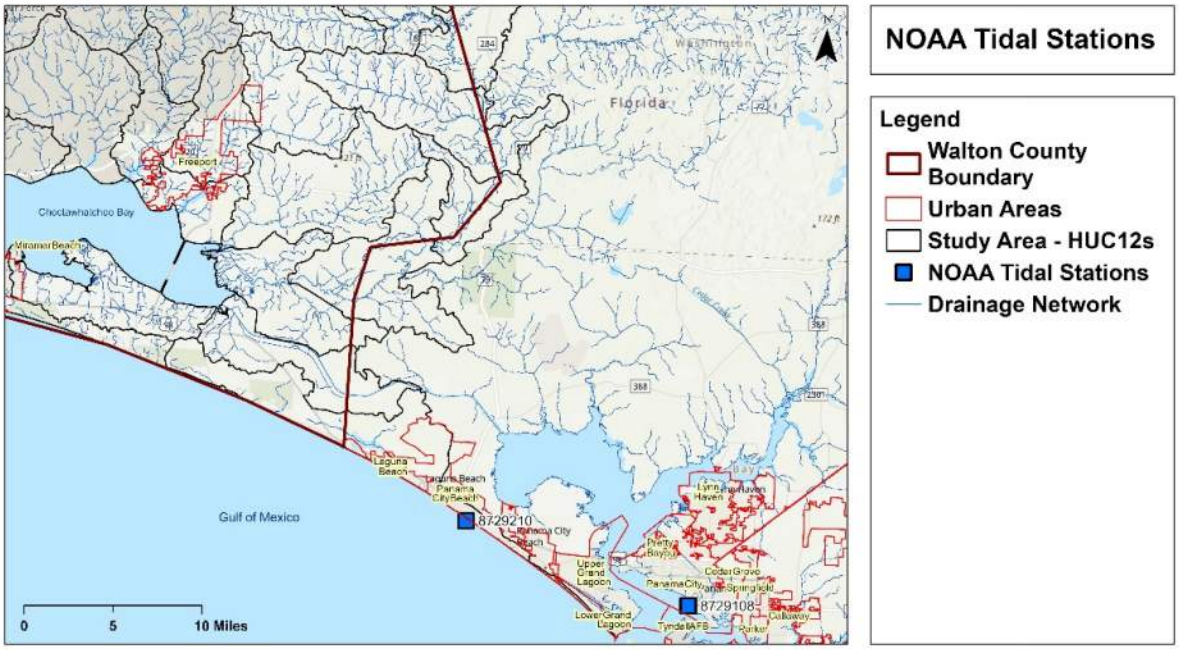

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

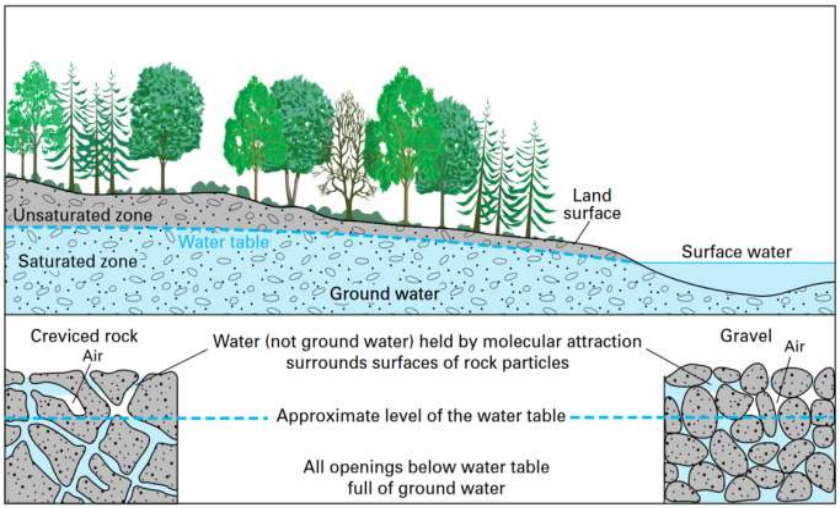

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

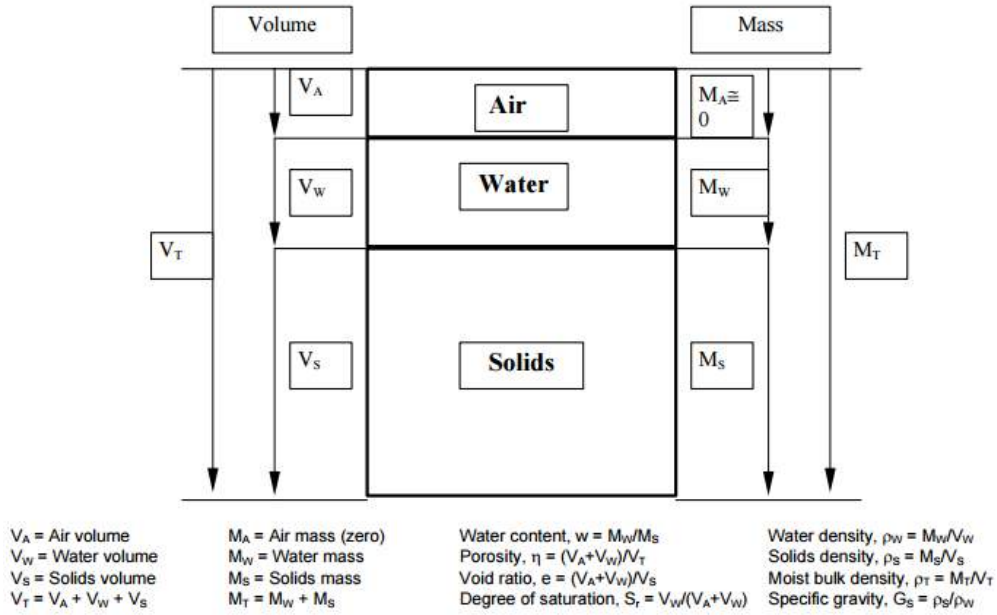

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

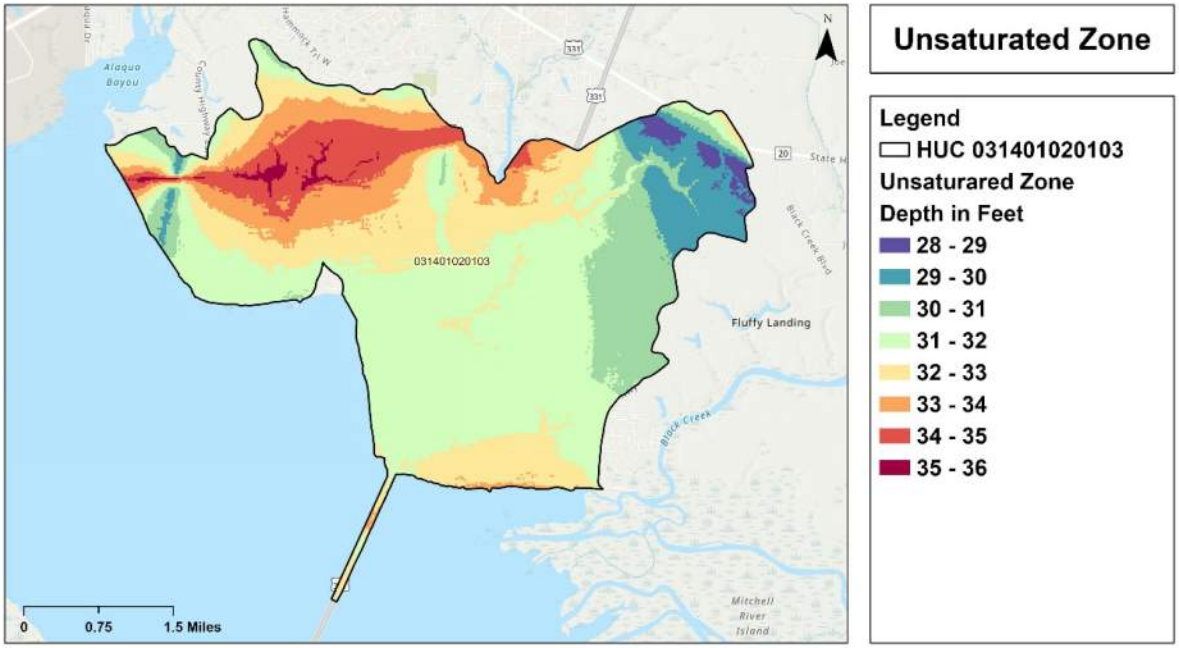

Figure 15. Unsaturated zone map for HUC 031401020103, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately favorable soil storage capacity, falling within the range of 29 to 35 feet of remaining capacity.

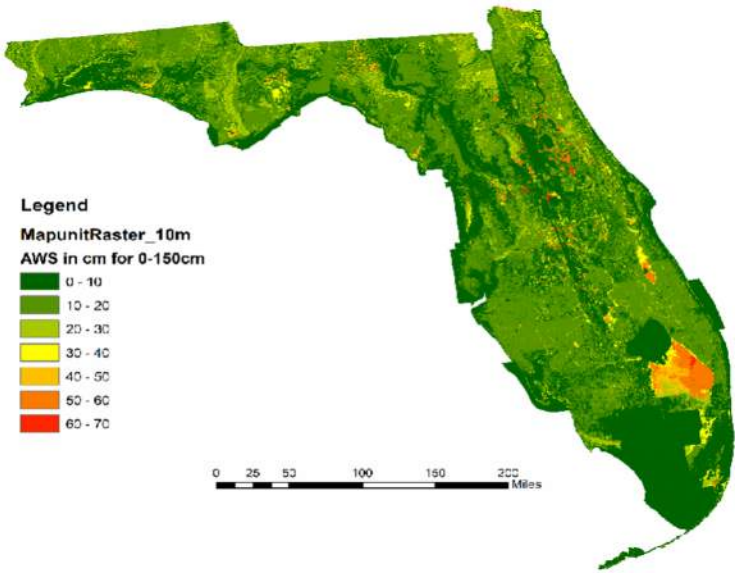

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

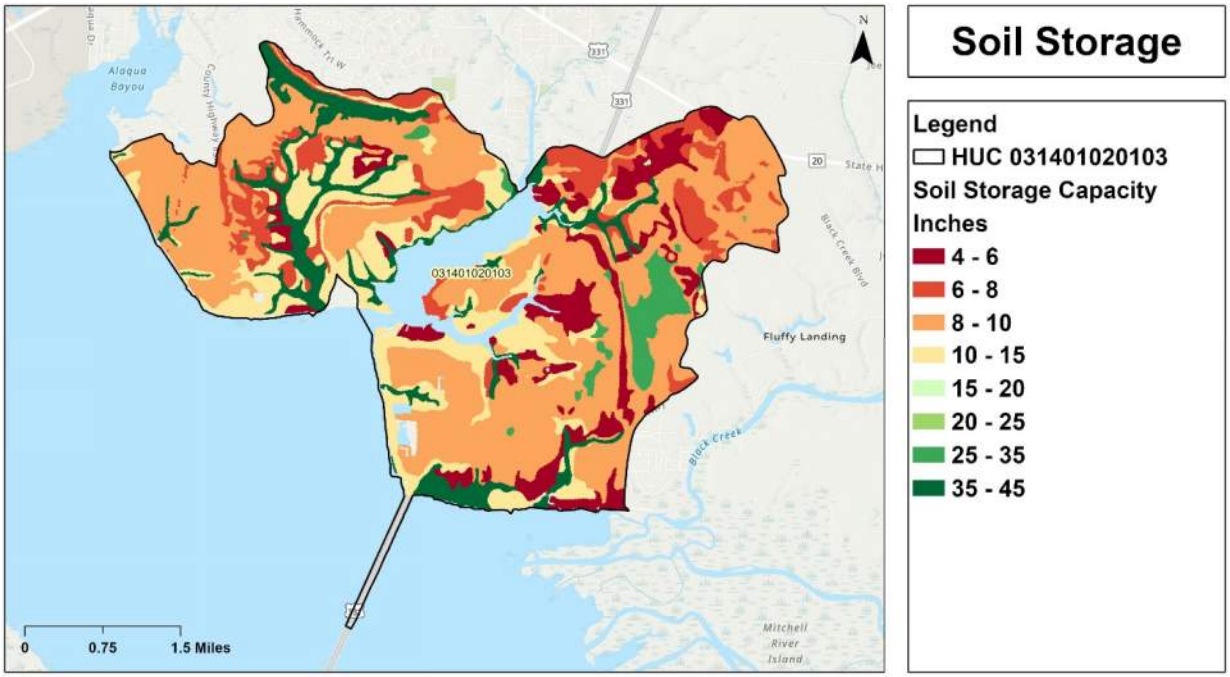

Figure 17. Water storage capacity of soil for the HUC 031401020103 (inches), processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

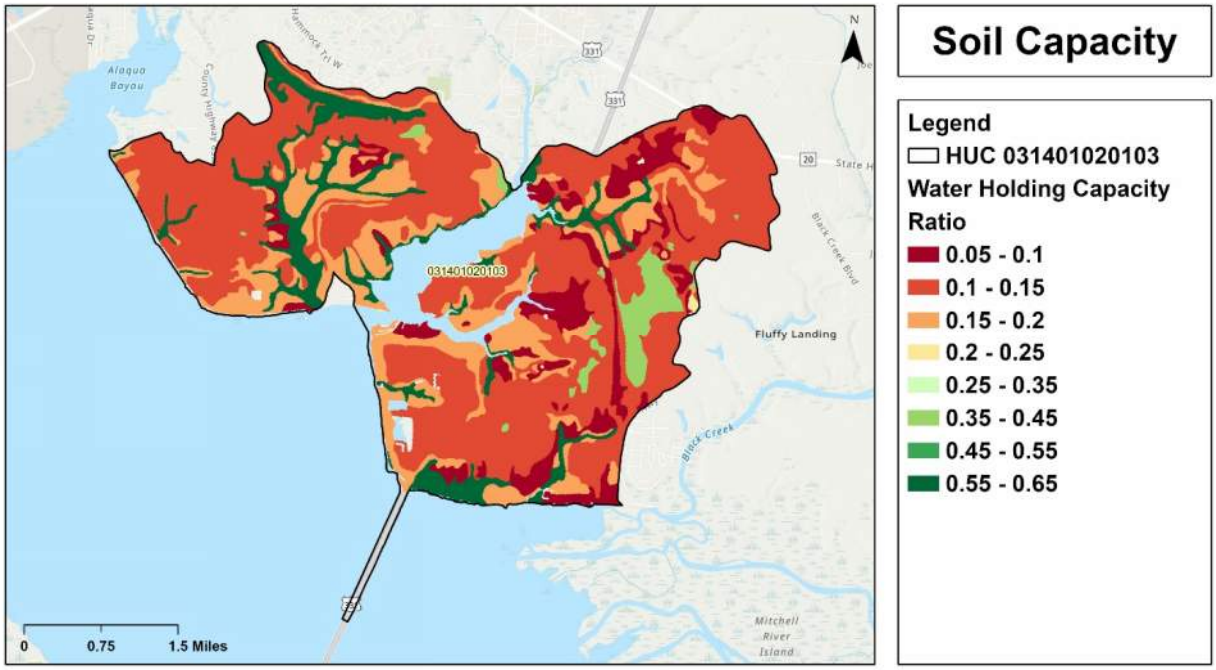

Figure 18. Water Holding Capacity (ratio) for the HUC 031401020103, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

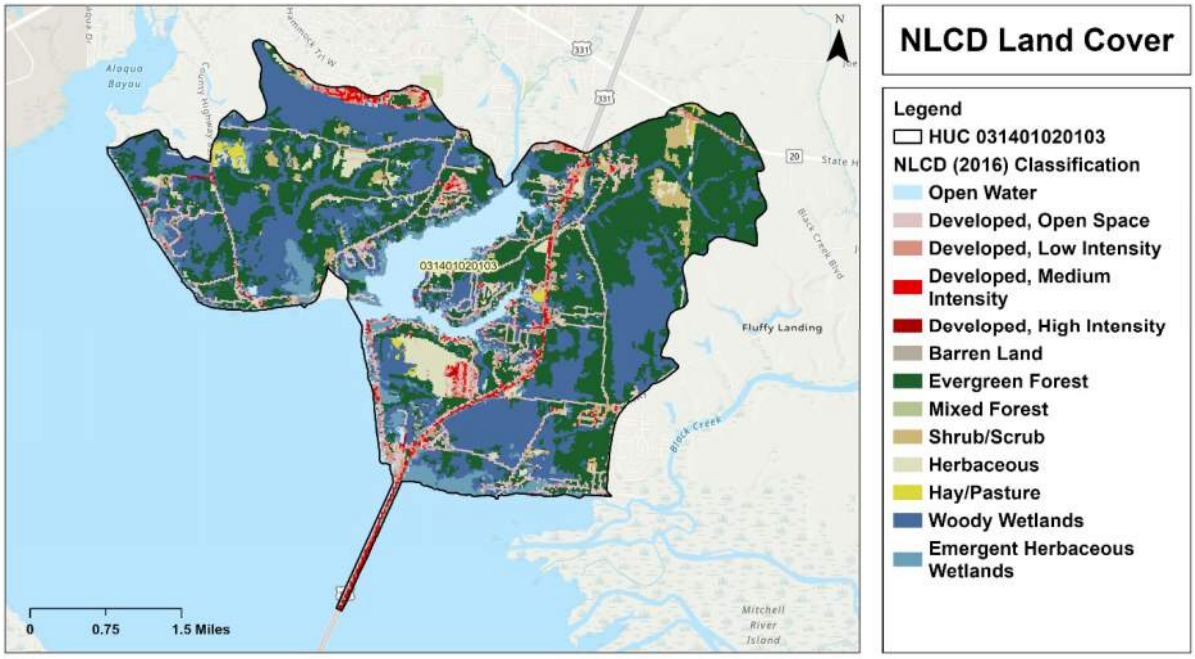

Figure 19. Land use in the HUC 031401020103 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

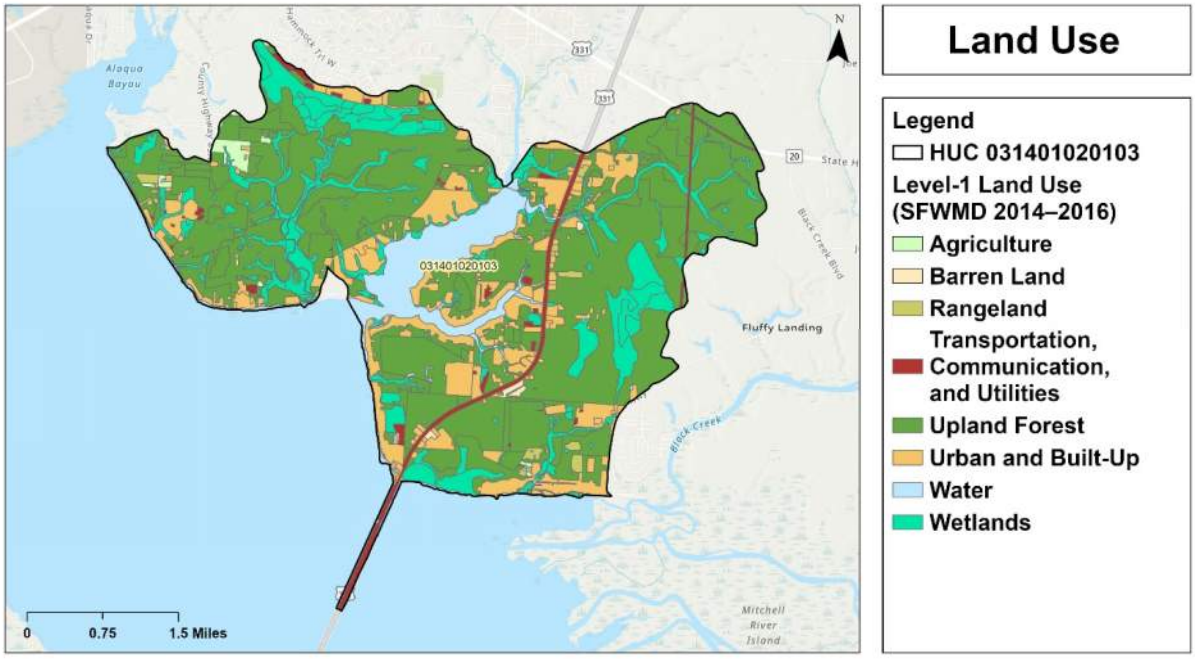

Figure 20. Land use in the HUC 031401020103 (2023 Florida Geographic Data Library (FGDL), processed by FAU.

In the HUC 031401020103 sub-watershed, the predominant land cover is upland forest, accounting for 37.49% of the area. Water comes in second at 26.08%, followed by Transportation, Communication, and Utilities at 15.74%, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface. Developed land constitutes also a good portion, with 9.71% categorized as urban and built-up, once the basin encompasses a great part of the city of Freeport.

Table 3. Land use for HUC 031401020103 sub-watershed

Level 1 Land Use Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	87.76	0.45%
Barren Land	47.17	0.24%
Rangeland	108.48	0.56%
Transportation, Communication, and Utilities	3039.26	15.74%
Upland Forest	7237.84	37.49%
Urban and Built-Up	1875.56	9.71%
Water	5035.20	26.08%
Wetlands	1875.61	9.71%
Grand Total:	**19306.88**	**100.00%**

(Source Data: 2023 Florida Geographic Data Library (FGDL) database))

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

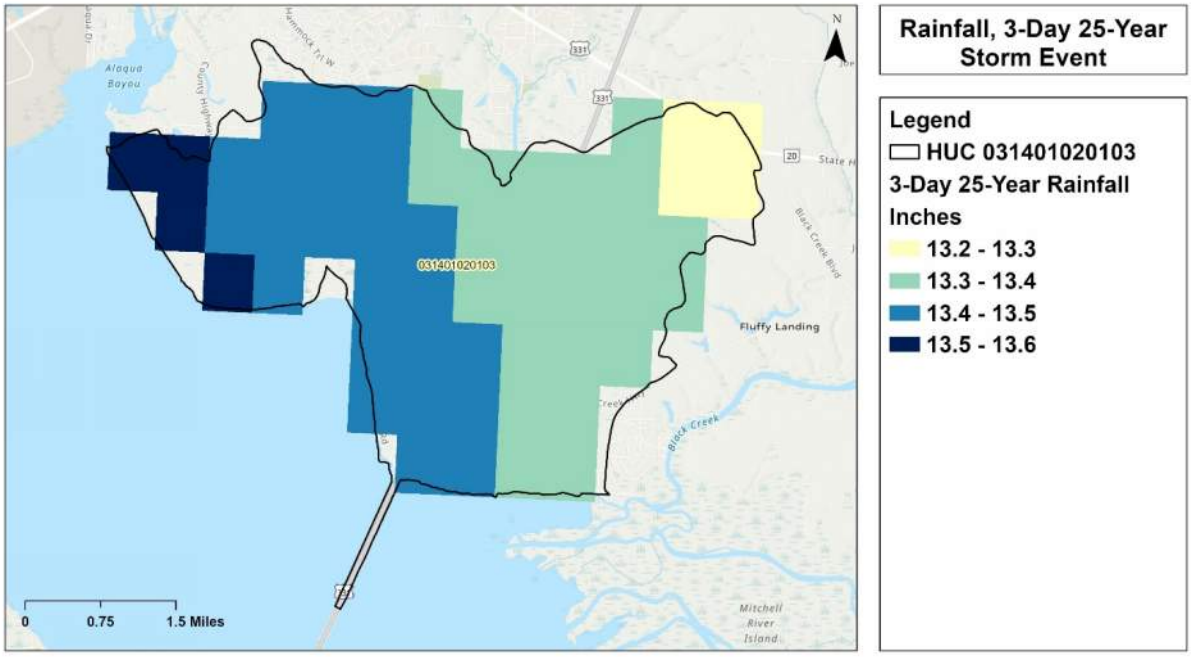

Figure 21. Rainfall distribution map across HUC 031401020103 sub-watershed, for 3-day 25-year storm event, processed by FAU.

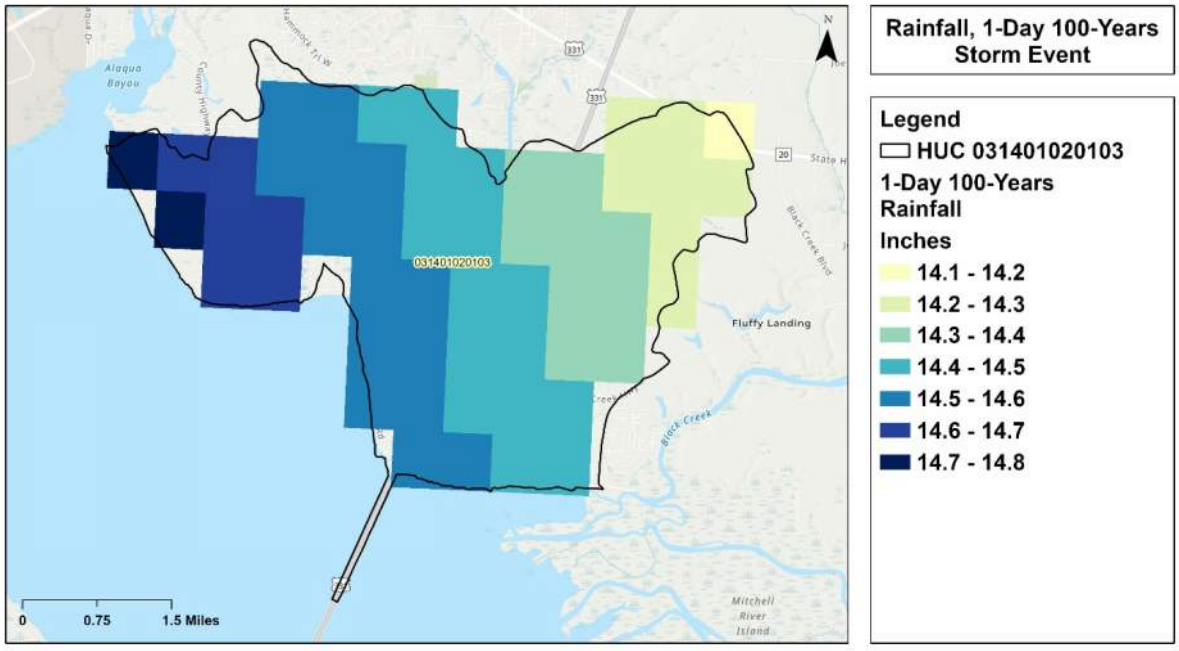

Figure 22. Rainfall distribution map across HUC 031401020103 sub-watershed, for 1-day 100-year storm event, processed by FAU.

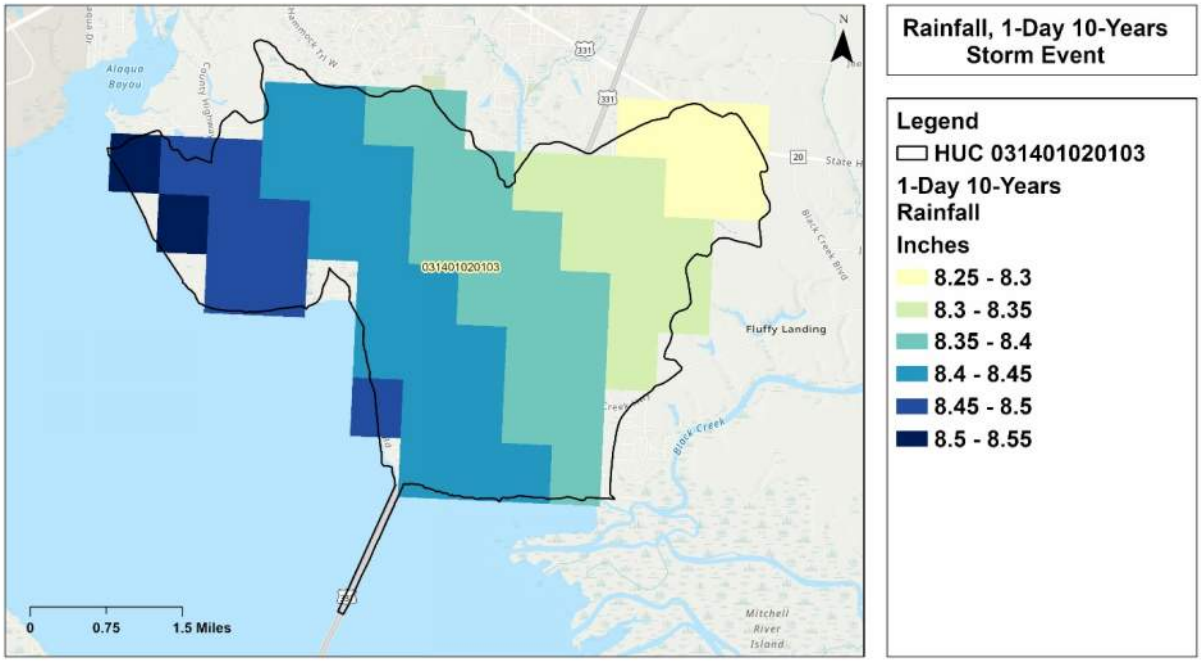

Figure 23. Rainfall distribution map across HUC 031401020103 sub-watershed, for 1-day 10-year storm event, processed by FAU

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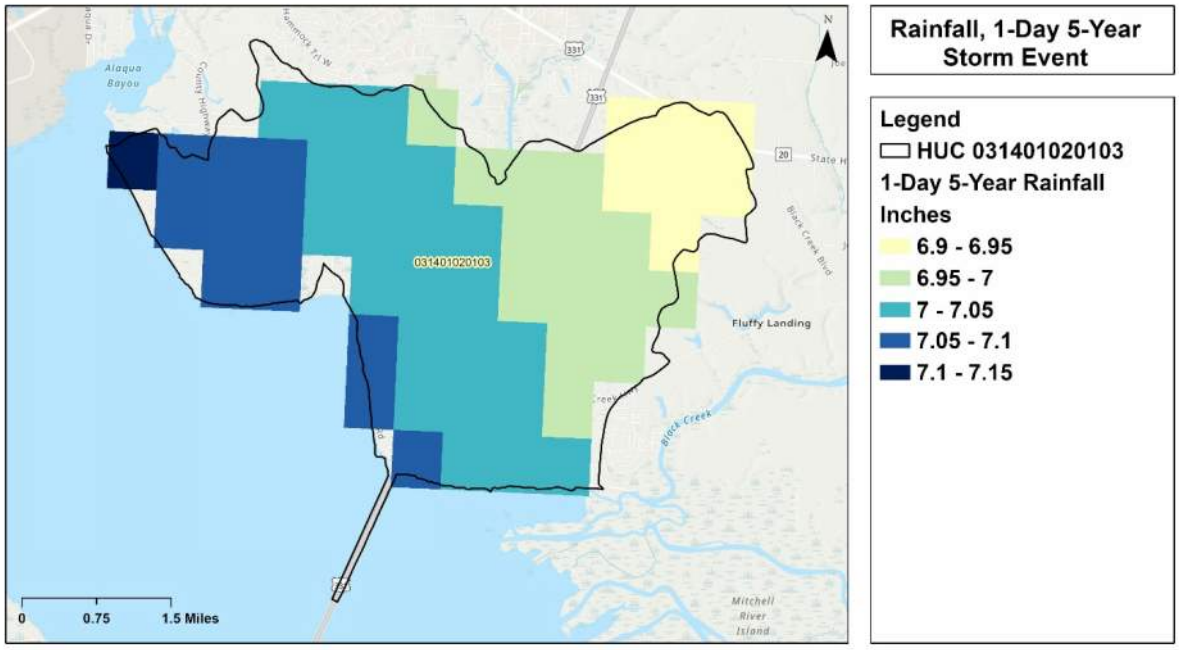

Figure 24. Rainfall distribution map across HUC 031401020103 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land

cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

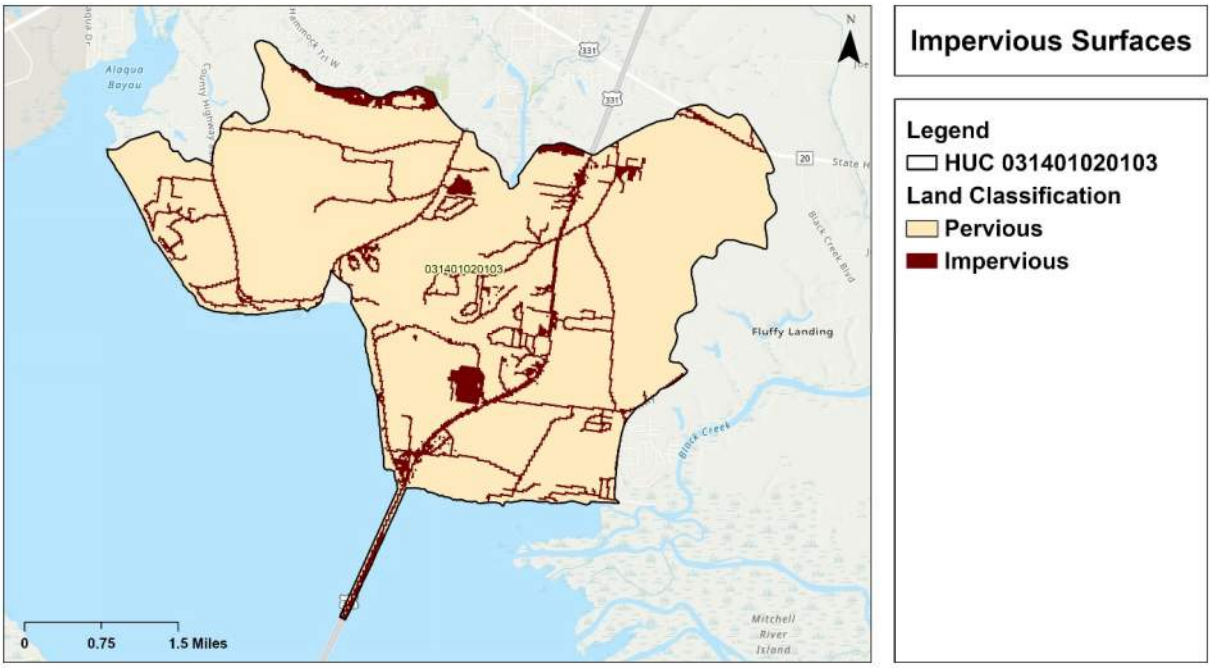

Figure 25. Impervious area map for the HUC 031401020103 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

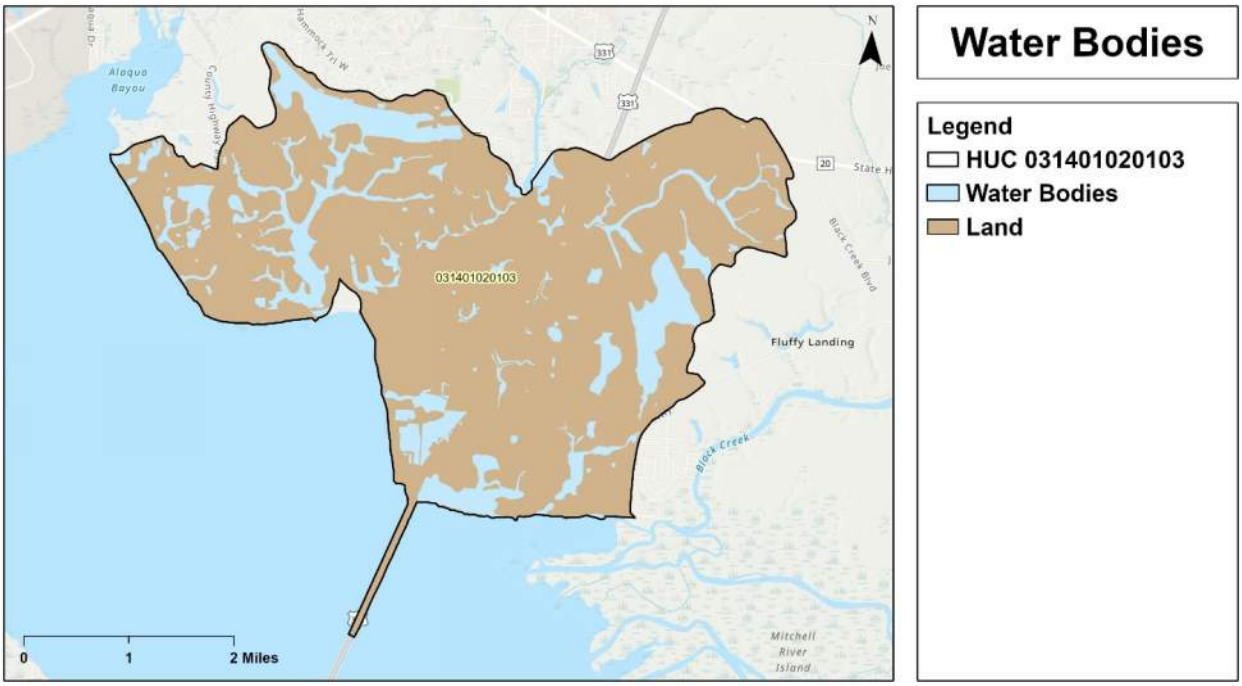

Figure 26. Water bodies map for the HUC 031401020103 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

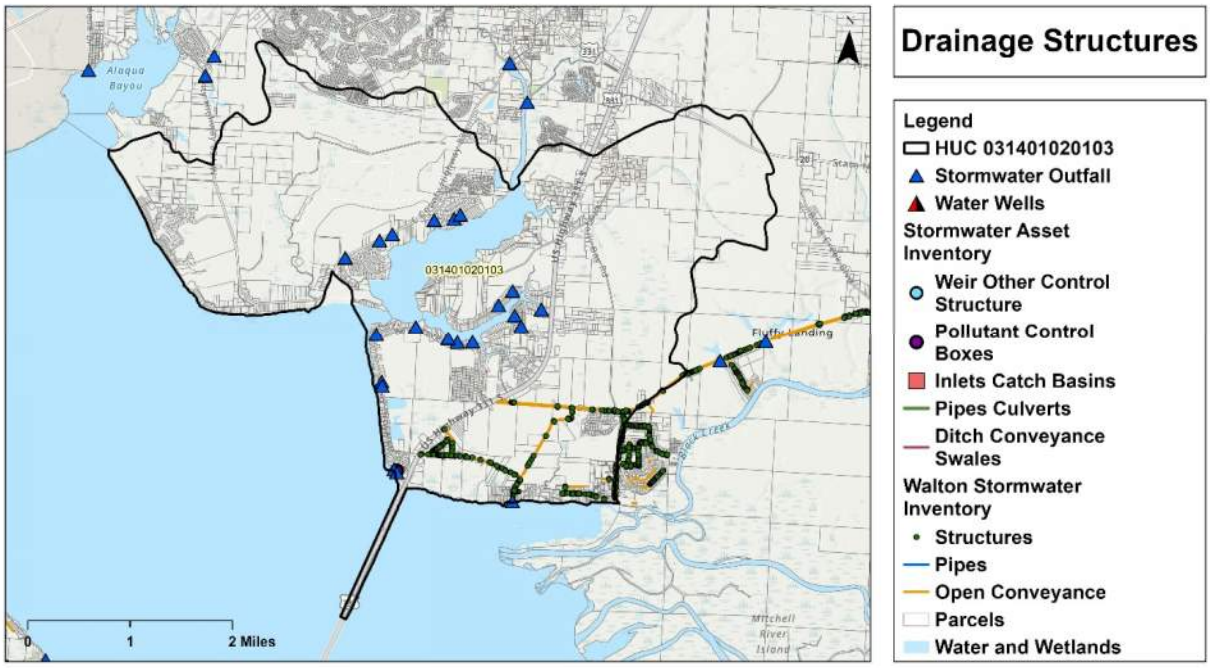

Figure 27. Stormwater Infrastructure for the HUC 031401020103. Processed by FAU.

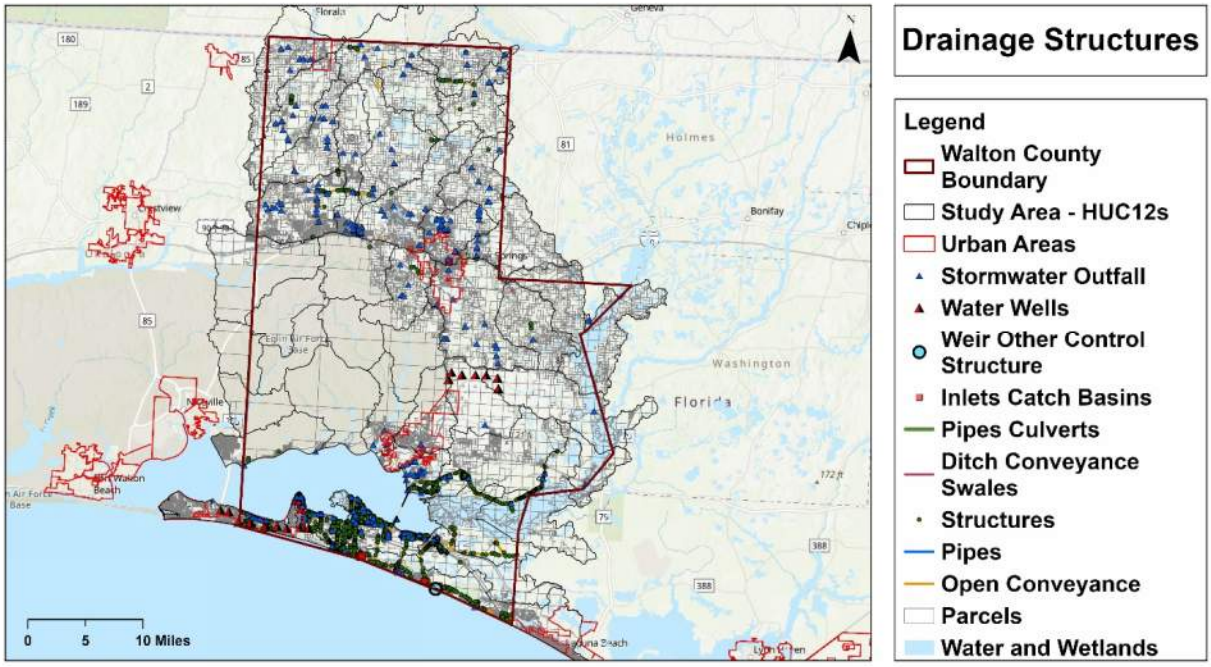

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401020103 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species

while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

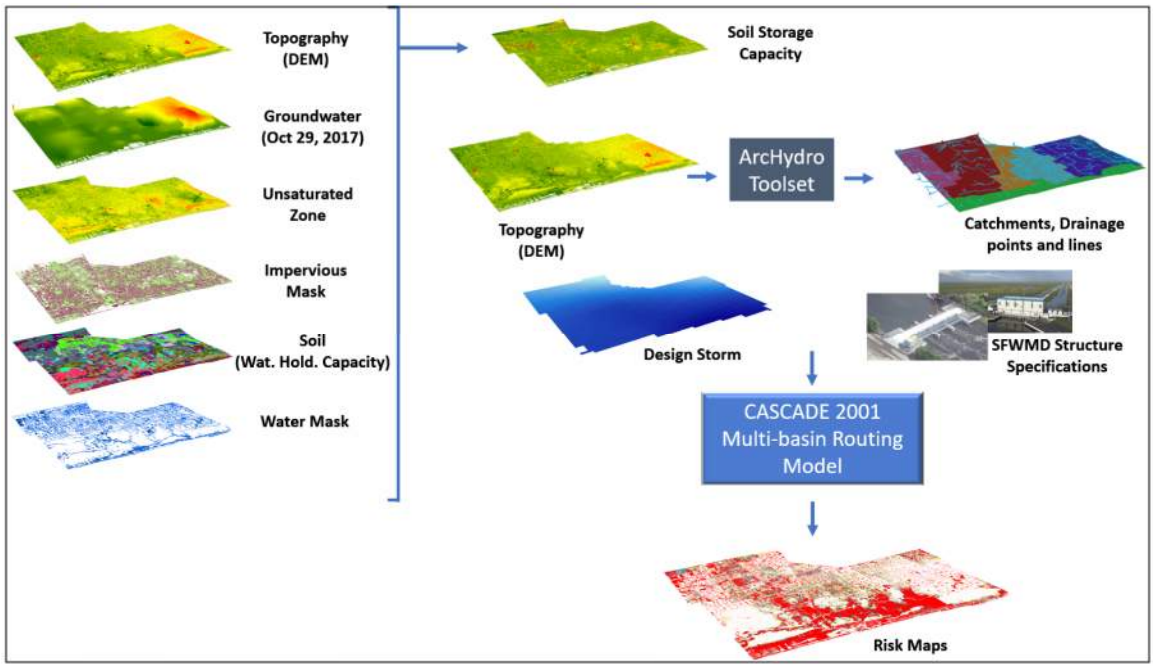

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are

critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

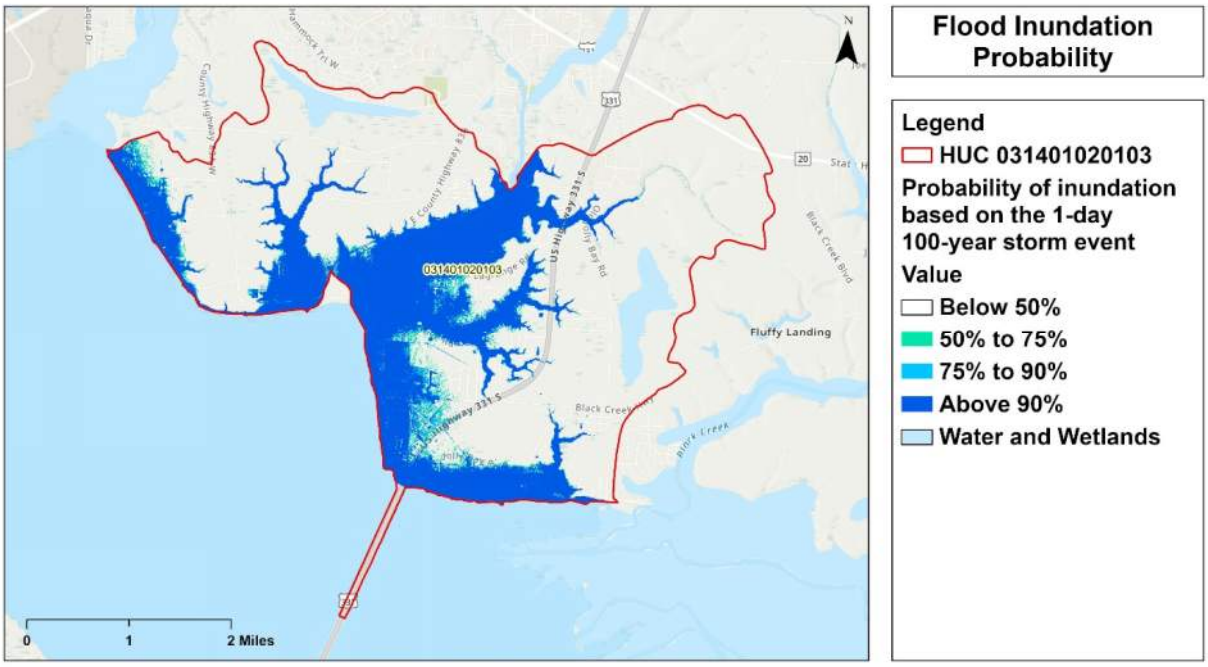

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401020103, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate

the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not

eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Future Challenges of Sea Level Rise and Climate Change

Global observations from satellites and long-term data collection have made it possible to document and analyze patterns in the Earth's climate. Scientific analysis of the impact of these changes has helped to improve the understanding of future flood hazard driving forces and long-term impacts on human activities and watershed master planning (http://www.research.noaa.gov/climate/t_observing.html). Examples of impacts are rising global average air and ocean temperatures, increased and earlier snow and ice melt, shorter subtropical rainy seasons, shifted seasons, sea level rise and greater variations in temperature and precipitation (IPCC, 2013; Freas et al., 2008; Marshall et al., 2004; Bloetscher et al., 2010). Marshall et al. (2004) specifically focused on the Florida peninsula to predict changes in rainfall and warmer temperatures but interspersed lower low temperatures due to the potential loss of wetlands.

Future changes in climate will add to the existing impacts, at a time when the population of the state is expected to nearly double by 2030. Additional research and high-resolution climate modeling for the Florida peninsula and local jurisdictions is needed to help guide long-term plans like WMPs. Rainfall appears to be decreasing and temperatures rising (see **Error! Reference source not found.**).

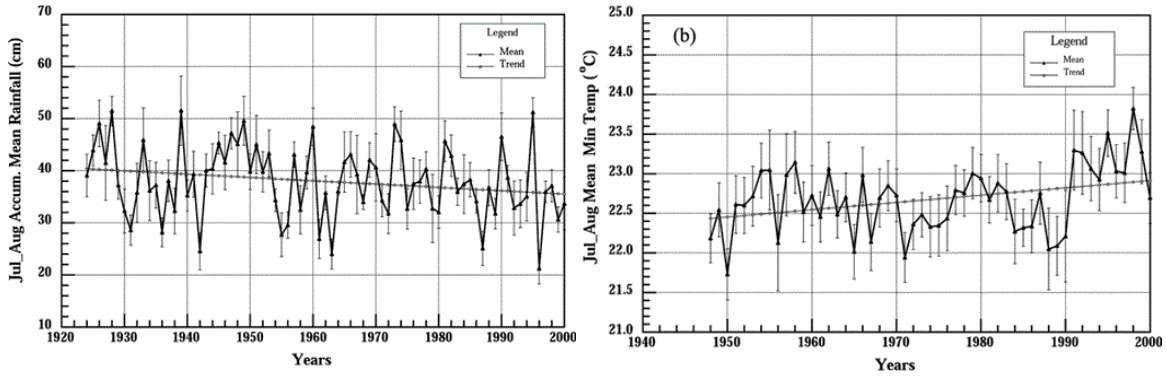

Figure 31. Change in average rainfall and change in average temp 1924 to 2000. Note the reversed trend, which means groundwater input variability is lessened. Source: Marshall et al., 2004.

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as

sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3 feet. Accompanying these drivers are potential changes in storm frequency and intensity, desertification, population migration, ocean acidification and coastal flooding (IPCC, 2007), exacerbated by the land cover and land use changes, which are substantially impacted by the fluxes, timing and quality of precipitation (Adrians et al., 2003; Scanlon et al., 2005; Marshall et al., 2004; Salmun and Molod, 2006), and leading to changes in the timing of peak flows and volumes (Richey and Costa-Cabral, 2006).

The results of these climatic changes are likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly An outcome of these climatic patterns is that during the past 140 years, an increase in sea levels has been observed (Bloetscher, 2012), a worrying pattern since sea level rise is a permanent phenomenon, that can be catastrophic to low lying areas in the long-term. The question is how much and how soon? Various studies (Bindoff et al., 2007; Domingues et al., 2008; Edwards, 2007; Gregory, 2008; Vermeer and Rahmstorf, 2009; Jevrejeva, Moore and Grinsted, 2010; Bloetscher, 2010, 2011; IPCC, 2007; Heimlich et al., 2009) indicate large uncertainty in projections of sea level rise by 2100. Gregory et al. (2012) note that during the last two decades, the global rate of sea level rise has been larger than the 20th-century time-mean, and Church et al. (2011) suggested that the cause was increased rates of thermal expansion, glacier mass loss, and ice discharge from icesheets. Gregory et al. (2012) suggested that there may also be increasing contributions to global sea level rise from the effects of groundwater depletion, reservoir impoundment, and loss of storage capacity in surface waters due to siltation. Measurements of Florida's east coast (Maul, 2008) show an average rate of sea level rise of 2.27 ± 0.04 mm per year from 1915 to 1992 based on tide gauge readings. Analyzing the tidal gauge readings for Florida shows that:

1. Florida average sea level rise is 2.10 ± 0.49 mm/yr
2. All but one location is within the 95% confidence limit range (the exception is Panama City where there is evidence of submergence and other land-based issues)

3. None of the Florida sea level rise rates differ statistically
4. Average global sea level rise for 1920-2000 was 2.0 mm/yr – within 95% confidence limit for Florida locations

From 1929 to 1992, over eight inches of sea, with another 6 inches added since 1992, which is already having significant impacts on coastal communities where population growth has increased the need for improved flood management strategies (Bloetscher, 2008; Parkinson, 2010; Zhang et al., 2011, 2011a; NFIP, 2011; Schmidt et al., 2011; Warner et al., 2012).

As a result, the SFRCCC (2015) adopted USACE's methodology to derive scenarios of sea level change intermediate to high rates of sea level rise for years 2030 (3" to 7") and 2060 (9" to 24") as the consensus projection to guide future planning. The path keeps increasing – now 14 inches since 1929 (**Error! Reference source not found.**) caused by thermal expansion of the ocean and melting ice caps (Jevrejeva et al., 2010; Vermeer and Rahmstorf, 2009). Sea level rise is a major concern in Florida, including Walton County, since the majority of the state's population live on the coast, involving most major commercial, residential, and economic enterprises. **Error! Reference source not found.** demonstrate the estimated sea level change for Panama City, considering the predictions of NOAA 2017. For NOAA high scenario SLR change scenario, the estimated level change is higher than 8 ft., while for the intermediate and low scenarios are about 3.9 feet and 1.7 feet respectively.

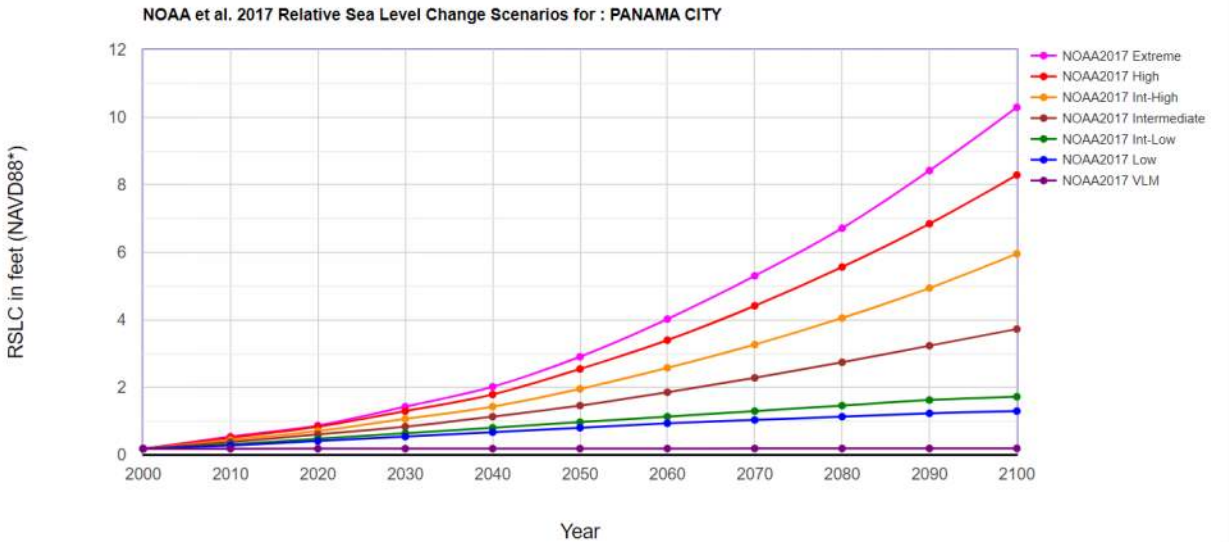

Figure 32. Relative Sea Level Change Scenarios for gauge 8729108, Panama City, FL. Source: NOAA, 2017 (https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html).

NOAA (2017) outlines five scenarios for sea level rise. The NFIP proposes the use of the intermediate high projection, which is 1.2 meters or 4 ft globally from current sea level elevations (**Error! Reference source not found.**).

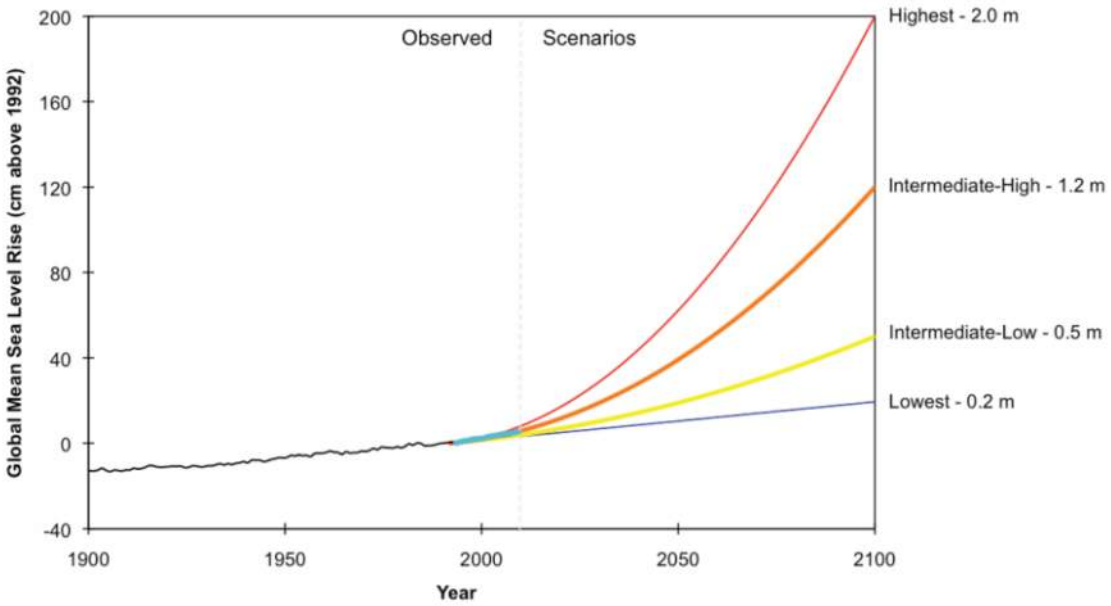

Figure 33. Graphic of global sea level rise projections from NOAA (2017). Source:https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

As sea level rises, access to roads, bridges, rail, and transit could be at risk of flooding, causing the effects of sea level rise to spread indirectly throughout the entire transportation network, affecting the overall system performance. For example, the flooding of a critical road or facility access can cause a shifting of traffic flow causing congested conditions in other roadways that are not actually flooded. Since the roadway network would be unable to carry the traffic demand, the system would experience operational failure; as a result, causing travel times and delays. Moreover, the inundation of a critical access could cause transportation connectivity problems to essential infrastructure like ports or airports. Transportation infrastructure relies on the effectiveness of flood control and stormwater drainage systems for the transportation corridors. Road integrity relies on adequate drainage. The increased risk of severe flooding in Florida's low-lying terrain can adversely affect transportation infrastructure along the coastline; roads can be inundated, and roadway beds can be damaged. Sea level rise will cause increased water table levels (FDOT, 2012), as regional water tables cannot exist naturally below mean high tide (2 feet in Florida). Adding 3 feet of sea level rise on top of groundwater would compound the risk of flooding in low-lying areas. Road bases below 5 feet NVGD would become saturated under this scenario, likely causing premature base failure. As soil storage capacity is diminished due to rising groundwater elevations associated with sea level rise, the potential for more frequently flooded roadways would likely damage pavements (FDOT, 2012). Hence sea level rise must be accounted for in WMPs in coastal areas. To allow flexibility in the analysis due to the range of increases within the different time periods, an approach that uses incremental increases of 1, 2, and 3 feet of sea level rise is suggested for modeling. The increments can work as threshold values in planning

considerations in terms of allowing planners the ability to know ahead of time where the next set of vulnerable areas will be, to allow for a proactive response approach that can be matched to the observed future rates. Sea level rise is a major concern since nearly half the US population lives within 50 miles of the coast, involving most major commercial, residential, and economic enterprises. The effects of 5 ft sea level rise, King tide, and 1-day 100-year storm event are shown in **Error! Reference source not found.**.

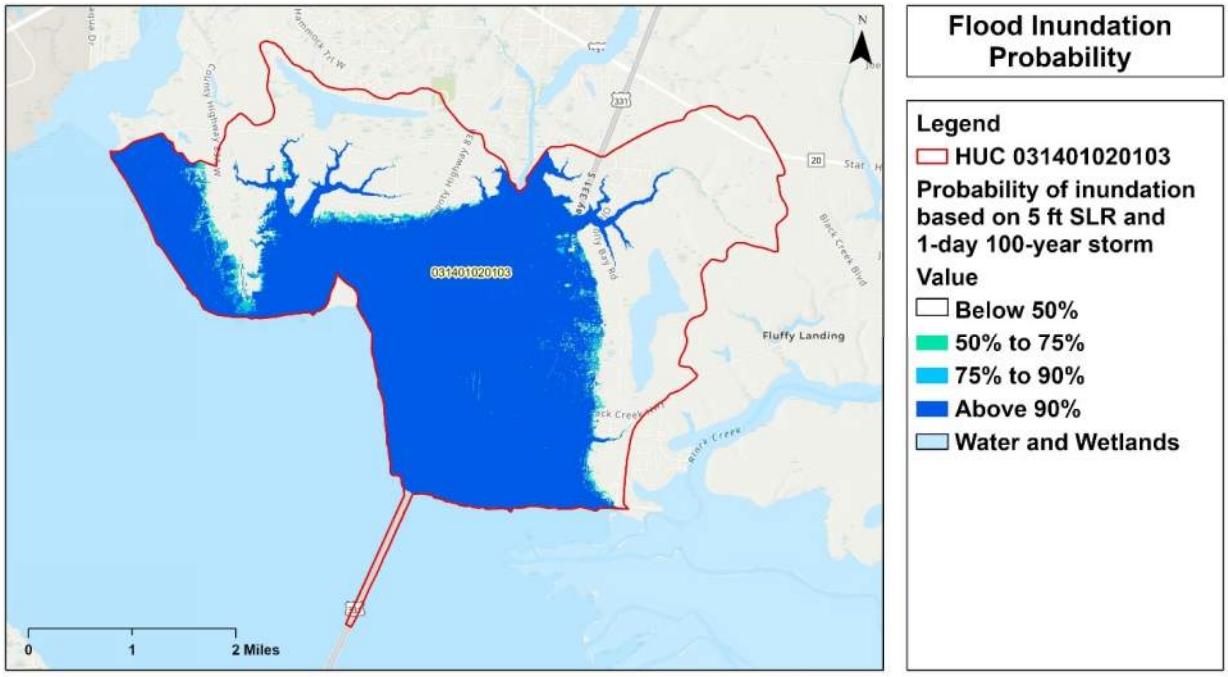

Figure 34. Flood Inundation Probability for a Sea level rise of 5 ft + 1-day 100-year storm event for HUC 031401020103 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Dark blue is area under 5 ft NAVD88 and potentially inundated at the 99th percentile tidal conditions. Processed by FAU.

2.4 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. **3-day 25-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 35)
2. **1-day 100-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 36)

3. **1-day 10-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 37)
4. **1-day 5-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 38)
5. **Sea level rise of 1 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 39)
6. **Sea level rise of 1 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations storm (Figure 40)
7. **Sea level rise of 1 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 41)
8. **Sea level rise of 1 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 42)
9. **Sea level rise of 2 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 43)
10. **Sea level rise of 2 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 44)
11. **Sea level rise of 2 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 45)
12. **Sea level rise of 2 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 46)
13. **Sea level rise of 3 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 47)
14. **Sea level rise of 3 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 48)
15. **Sea level rise of 3 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 49)
16. **Sea level rise of 3 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 50)

17. **Sea level rise of 4 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 51)
18. **Sea level rise of 4 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 52)
19. **Sea level rise of 4 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 53)
20. **Sea level rise of 4 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 54)
21. **Sea level rise of 5 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 55)
22. **Sea level rise of 5 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 56)
23. **Sea level rise of 5 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 57)
24. **Sea level rise of 5 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 58)

In all cases, a significant amount of flooding is noted near Choctawhatchee Bay and along the Intracoastal Waterway. As this basin connects to the ocean though Choctawhatchee Bay, SLR scenarios plays an important hole, implying a considered growth as the projected scenario of rising tides rises.

The design storm simulation determined that approximately 27.4% of the HUC total area or 4.23 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 28.4% of the HUC's total area, or 4.39 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 22.9% of the HUC's total area, or 3.54 mi^2, would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 21.8% of the HUC's total area, or 3.36 mi^2, would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401020103 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	11.23	4.23	72.6%	27.4%
1-day 100-year	11.07	4.39	71.6%	28.4%
1-day 10-year	11.92	3.54	77.1%	22.9%
1-day 5-year	12.10	3.36	78.3%	21.8%

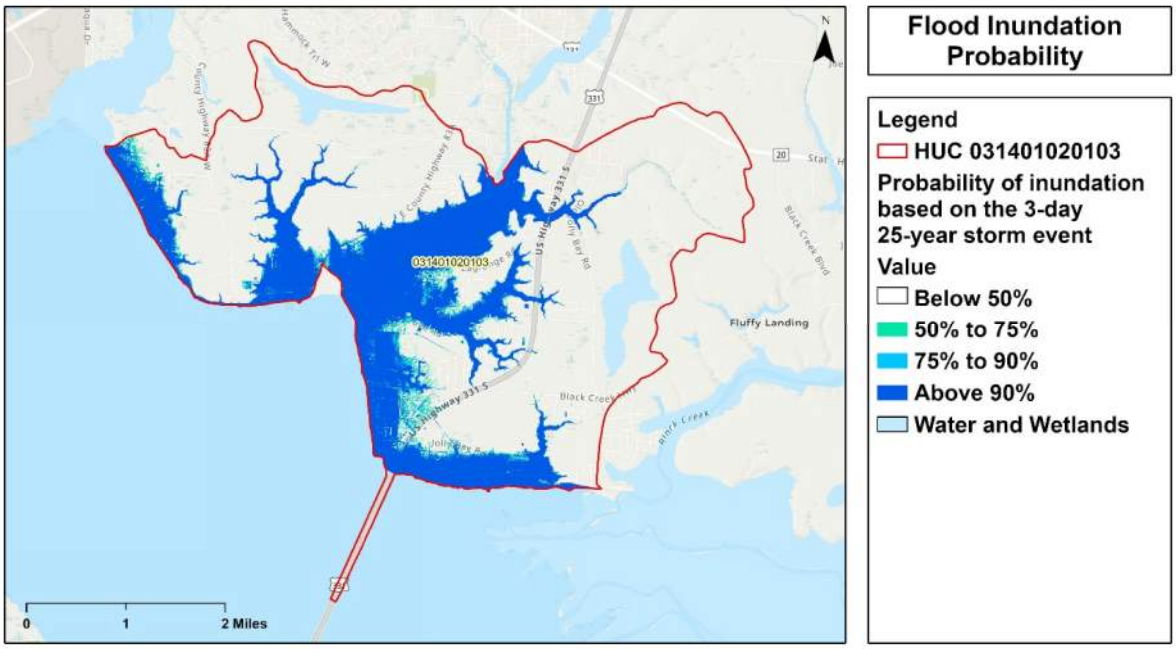

Figure 35. 3-day 25-year storm event for HUC 031401020103 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

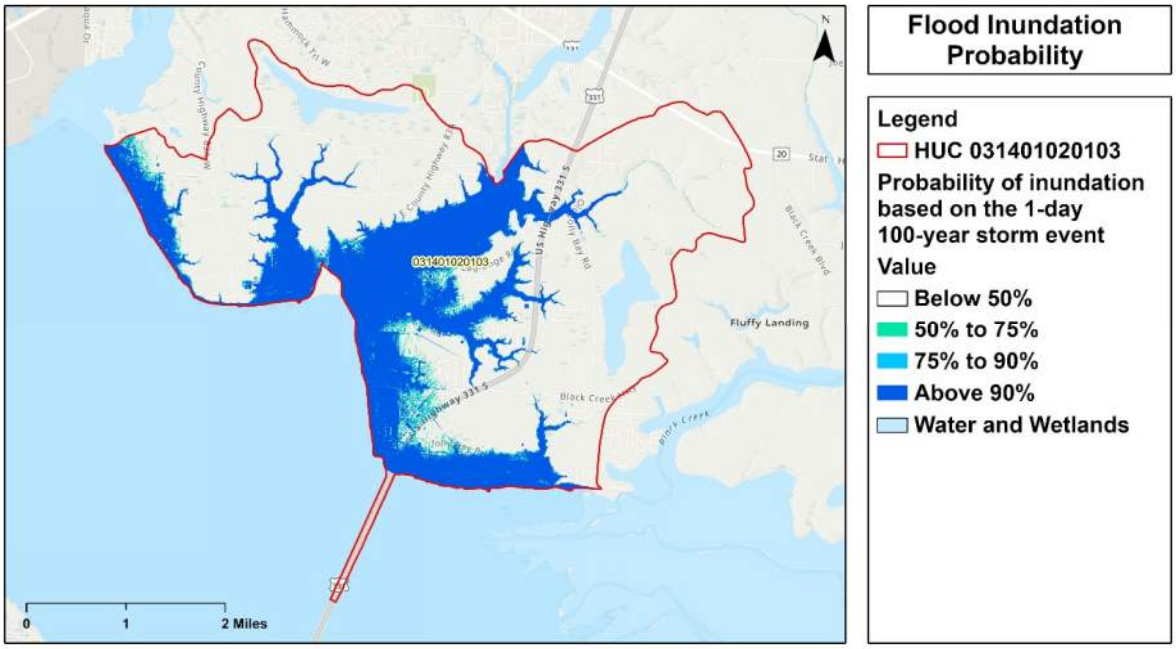

Figure 36. 1-day 100-year storm event for HUC 031401020103 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

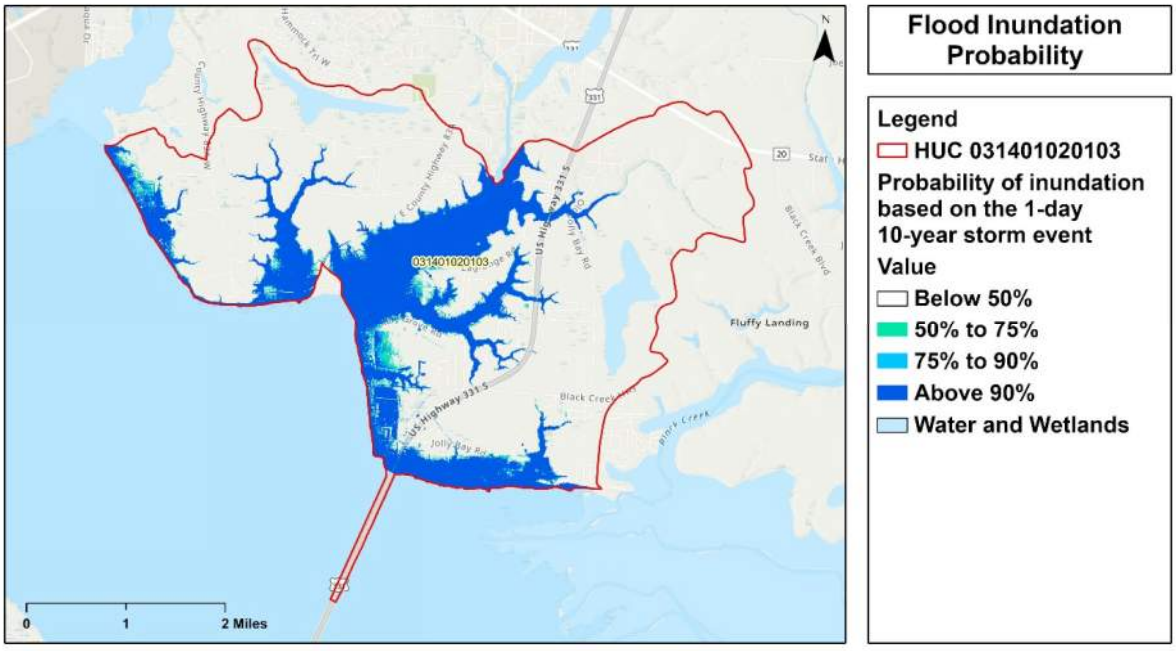

Figure 37. 1-day 10-year storm event for HUC 031401020103 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

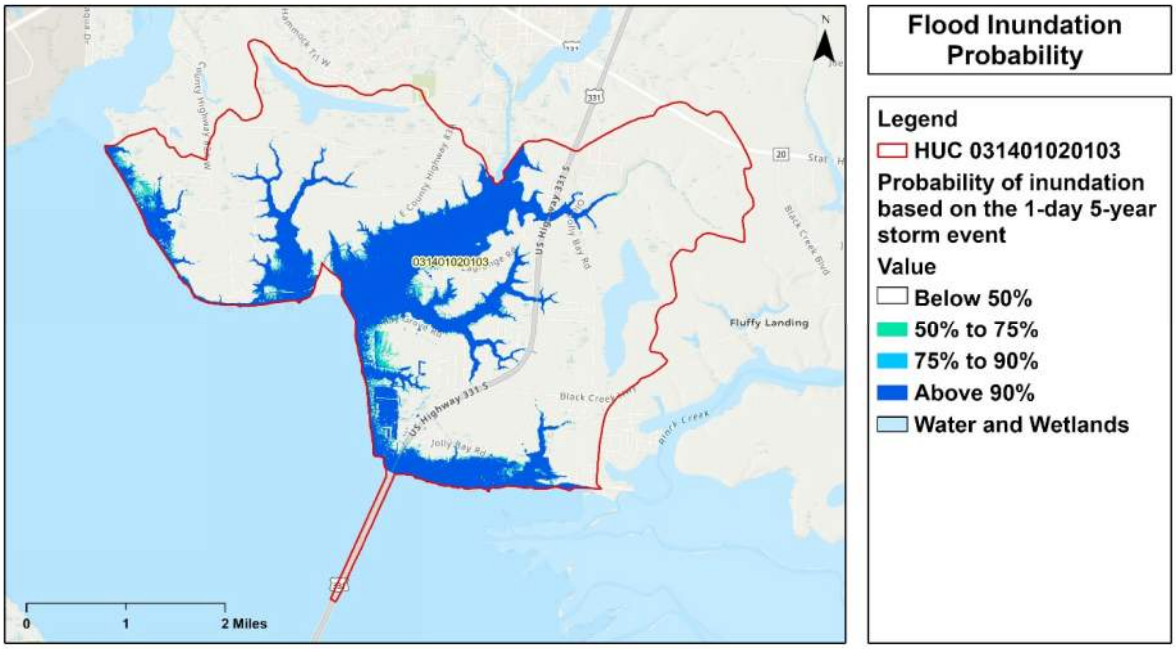

Figure 38. 1-day 5-year storm event for HUC 031401020103 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

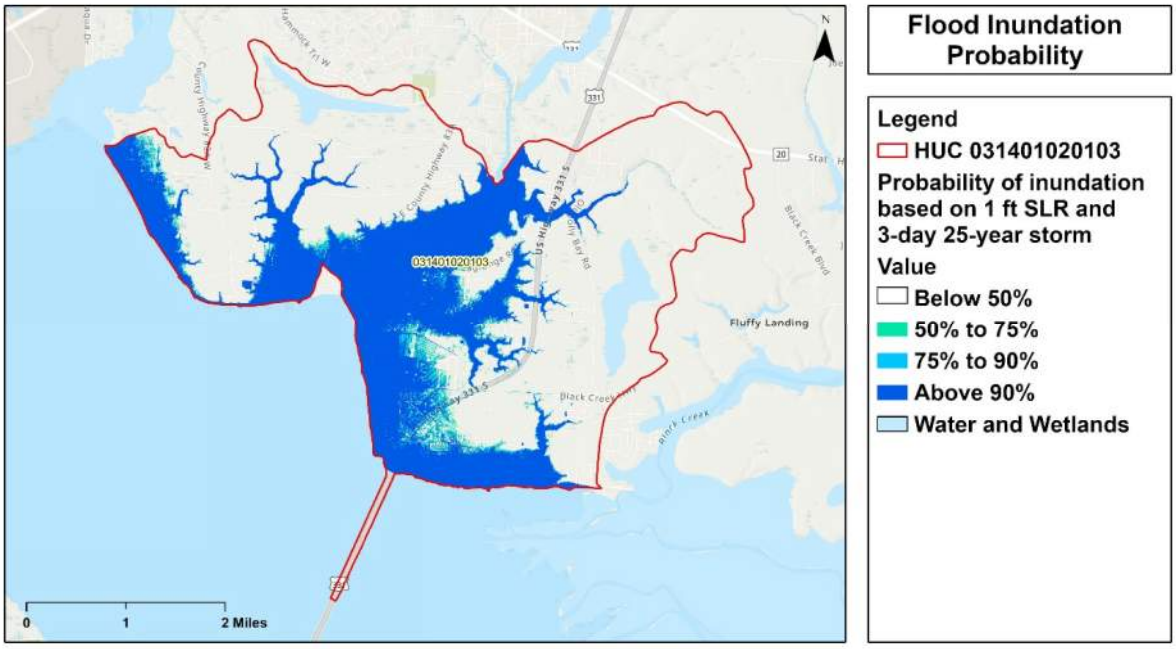

Figure 39. Sea level rise of 1 ft + 3-day 25-year storm for HUC 031401020103 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

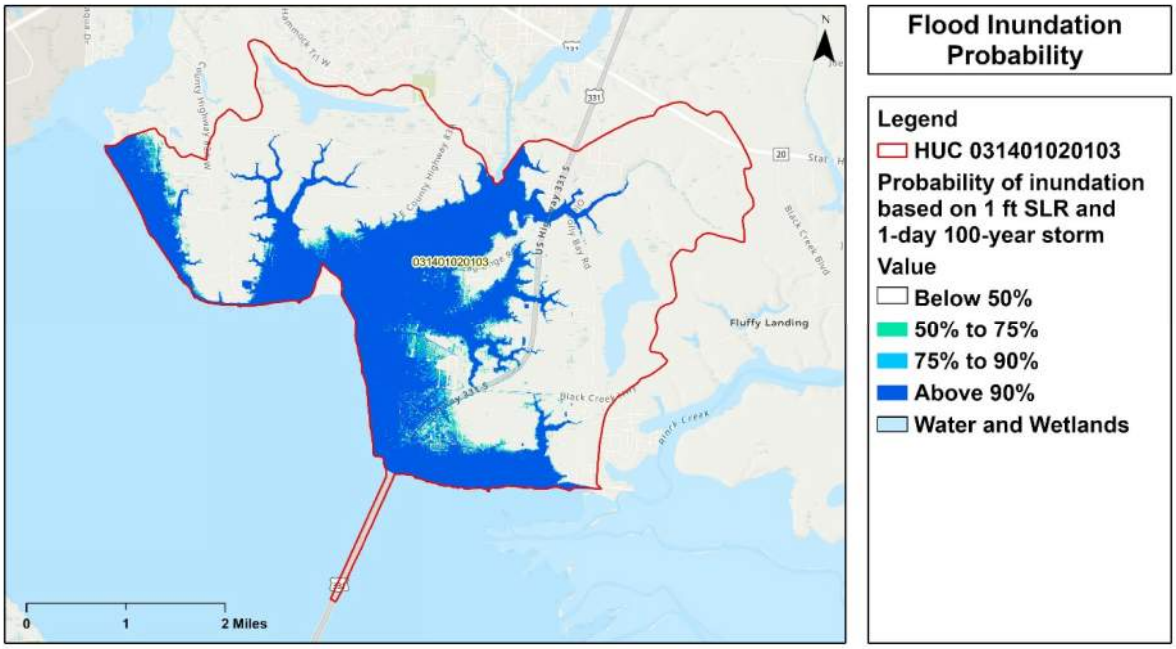

Figure 40. Sea level rise of 1 ft + 1-day 100-year storm for HUC 031401020103 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

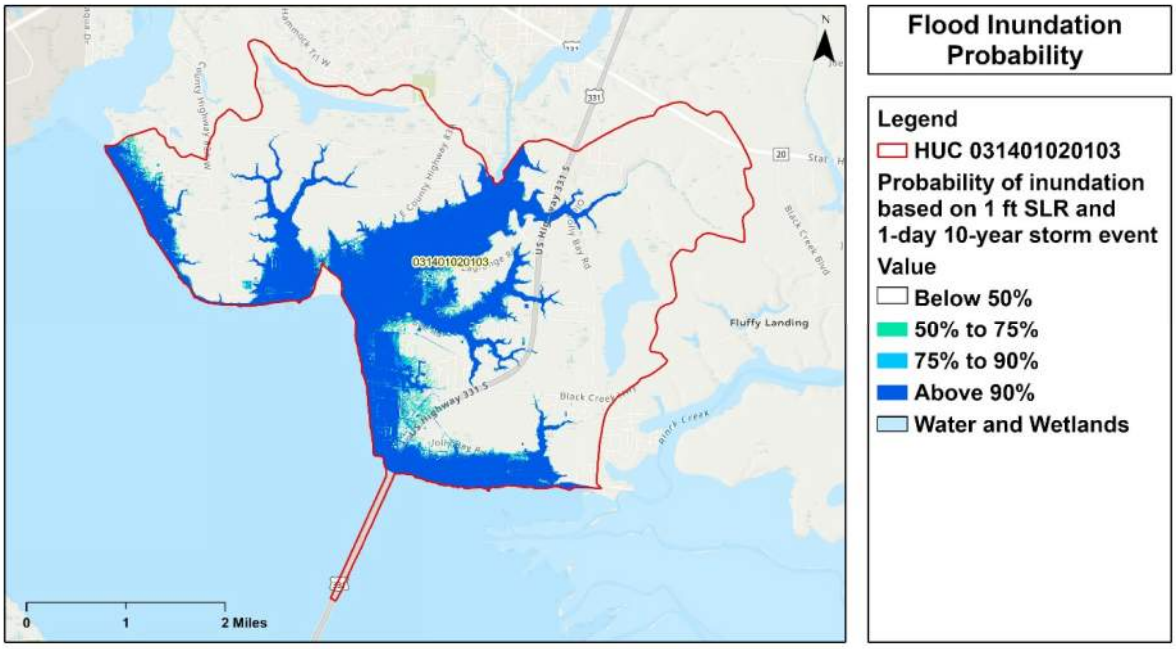

Figure 41. Sea level rise of 1 ft + 1-day 10-year storm for HUC 031401020103 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

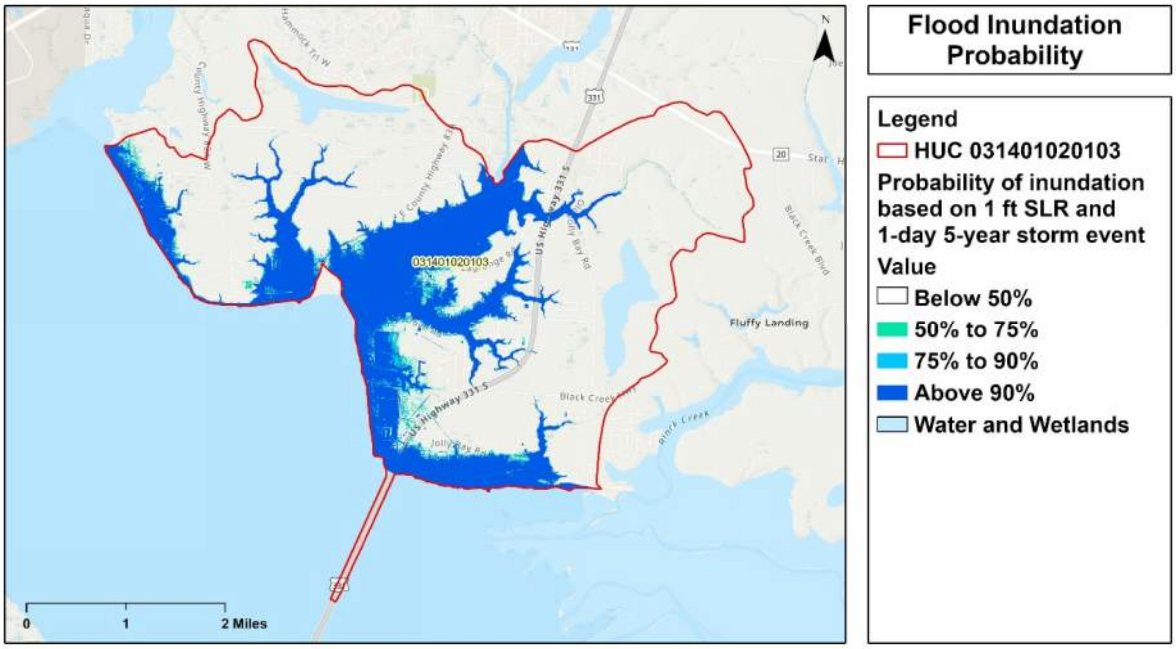

Figure 42. Sea level rise of 1 ft + 1-day 5-year storm for HUC 031401020103 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

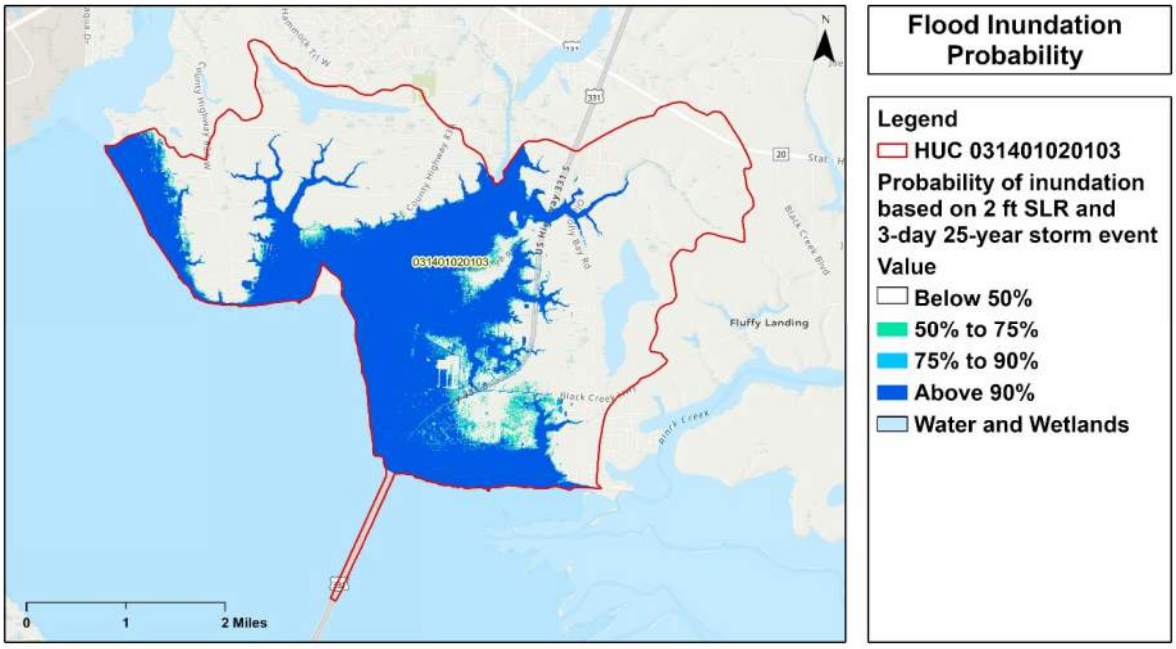

Figure 43. Sea level rise of 2 ft + 3-day 25-year storm for HUC 031401020103 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

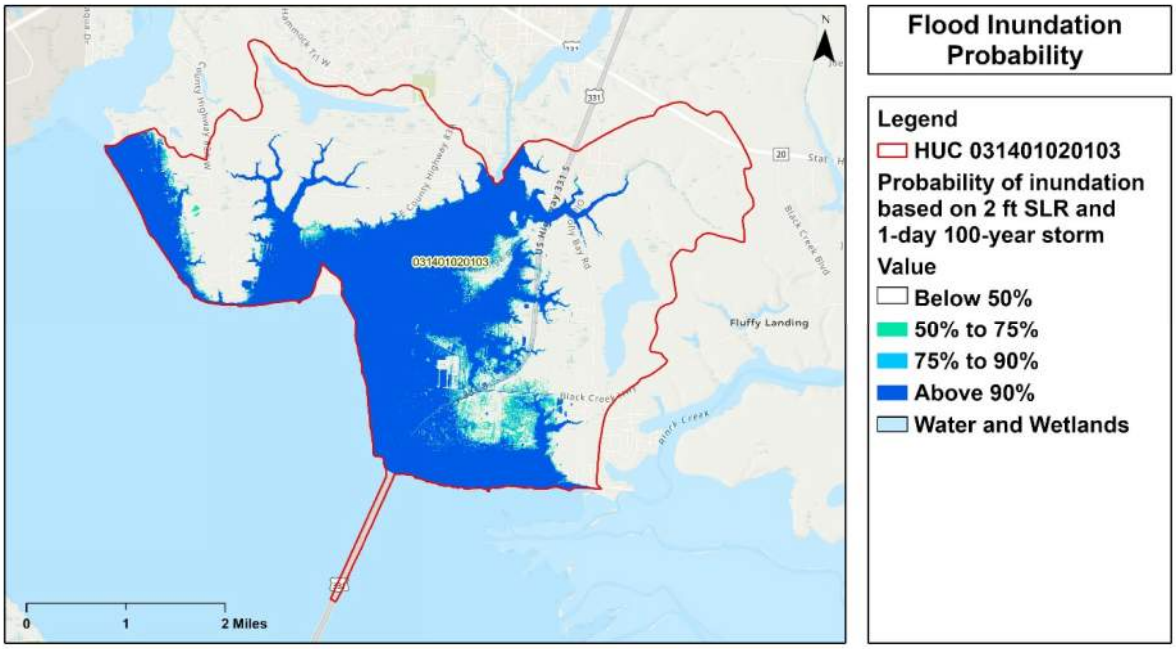

Figure 44. Sea level rise of 2 ft + 1-day 100-year storm for HUC 031401020103 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

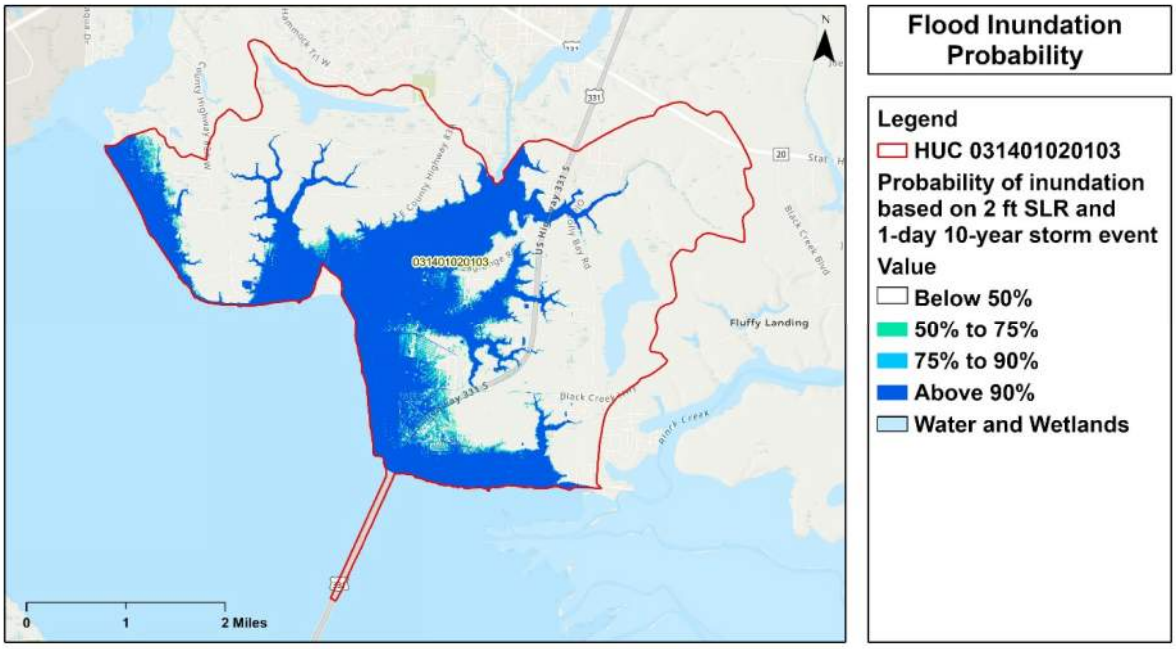

Figure 45. Sea level rise of 2 ft + 1-day 10-year storm for HUC 031401020103 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

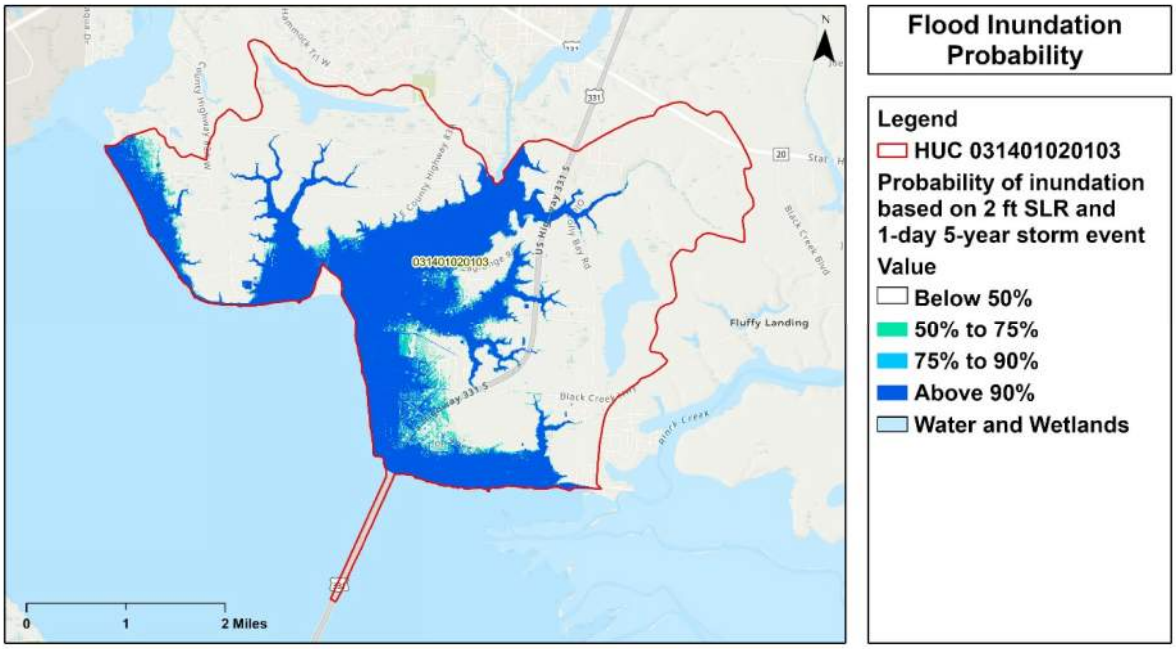

Figure 46. Sea level rise of 2 ft + 1-day 5-year storm for HUC 031401020103 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

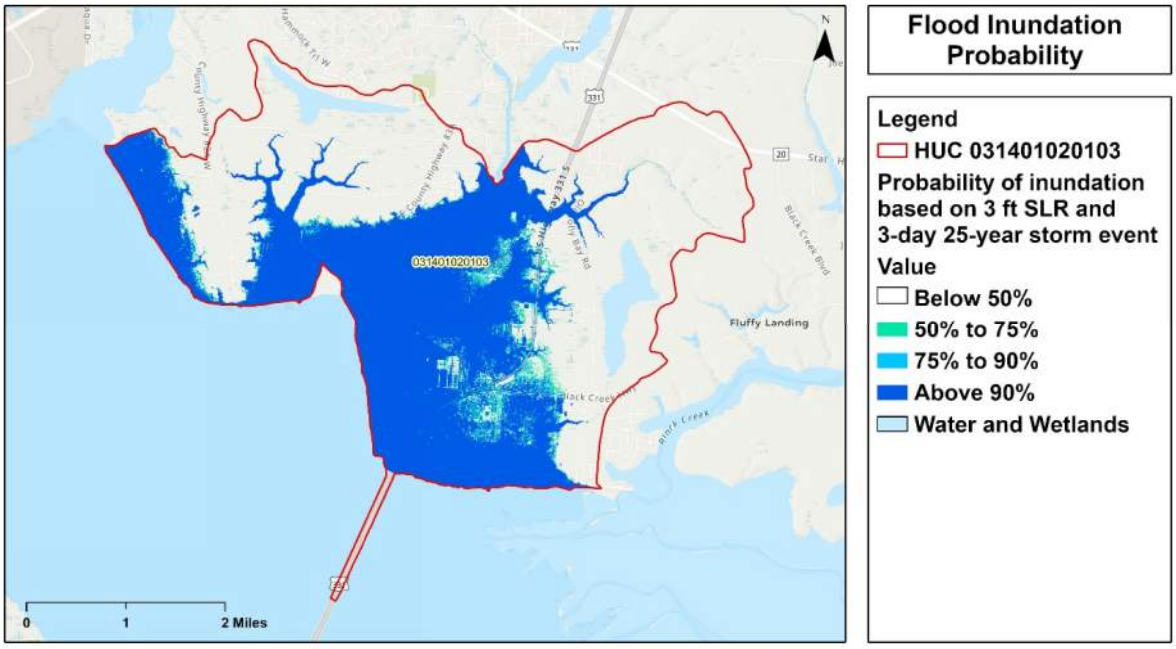

Figure 47. Sea level rise of 3 ft + 3-day 25-year storm for HUC 031401020103 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

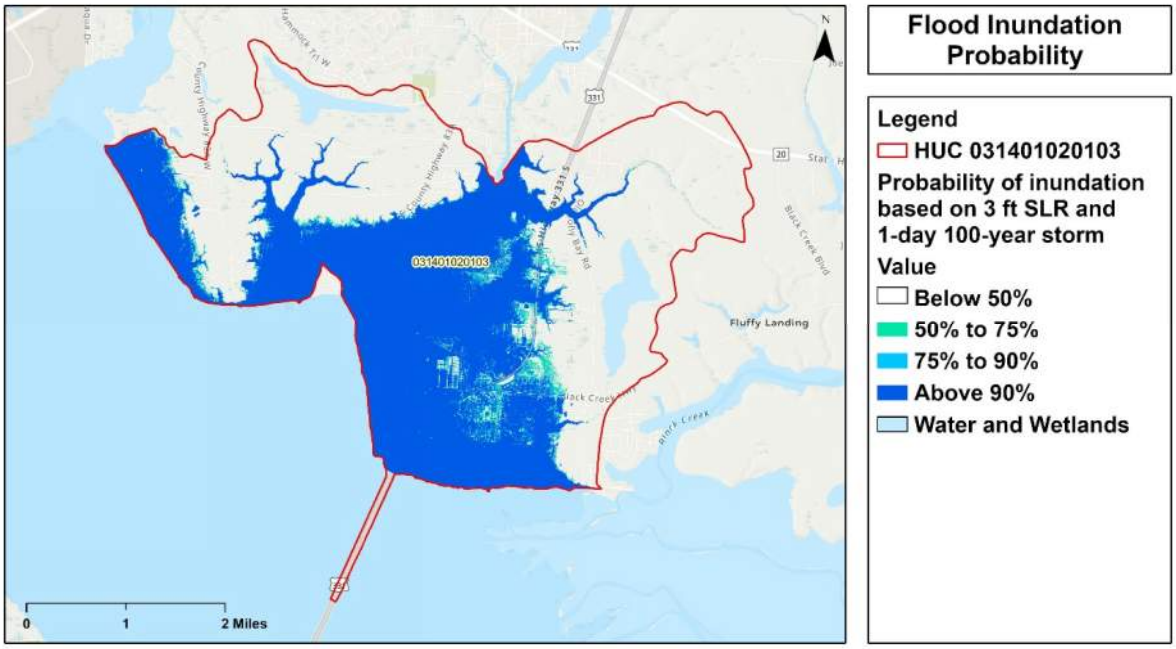

Figure 48. Sea level rise of 3 ft + 1-day 100-year storm for HUC 031401020103 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

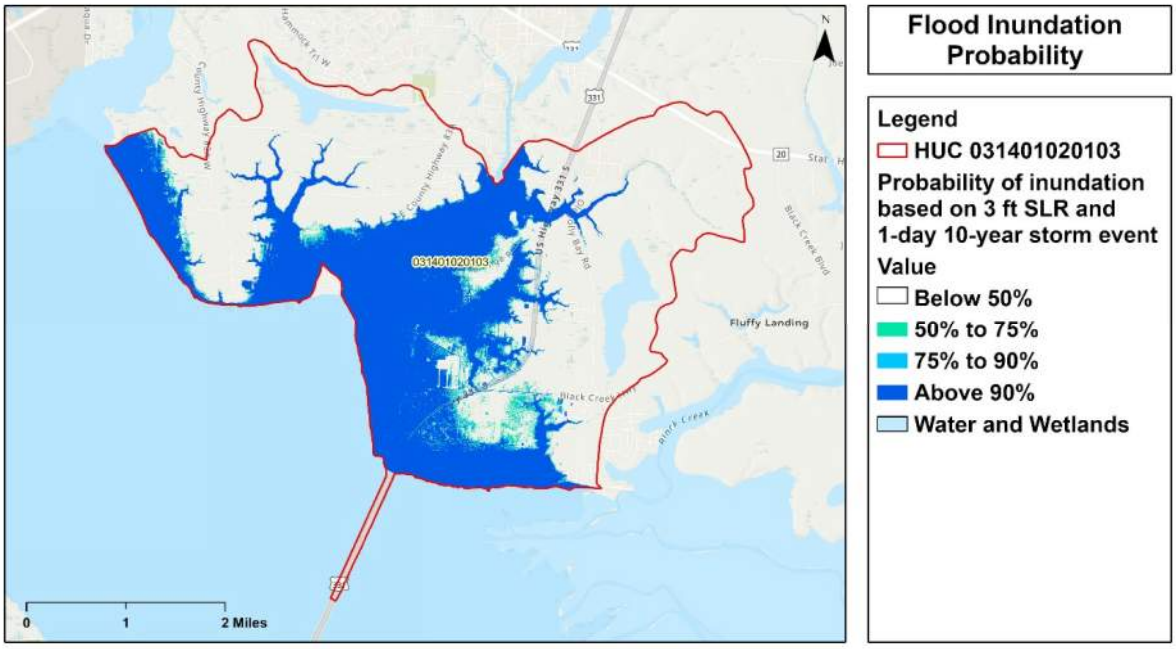

Figure 49. Sea level rise of 3 ft + 1-day 10-year storm for HUC 031401020103 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

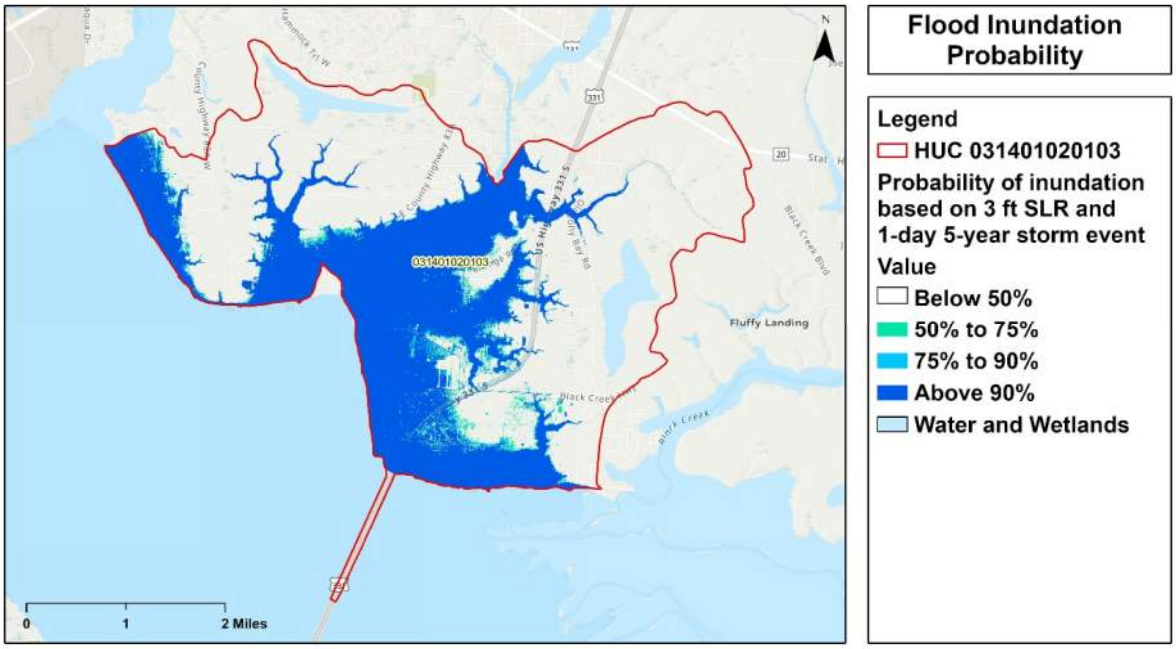

Figure 50. Sea level rise of 3 ft + 1-day 5-year storm for HUC 031401020103 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

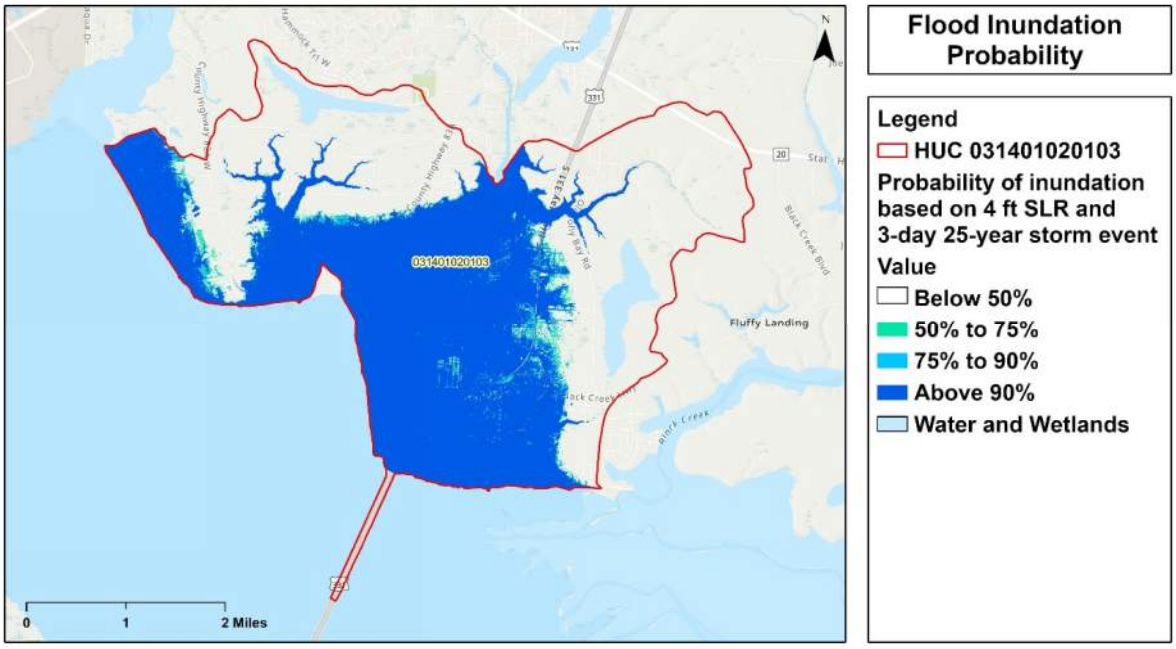

Figure 51. Sea level rise of 4 ft + 3-day 25-year storm for HUC 031401020103 sub-watershed . *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

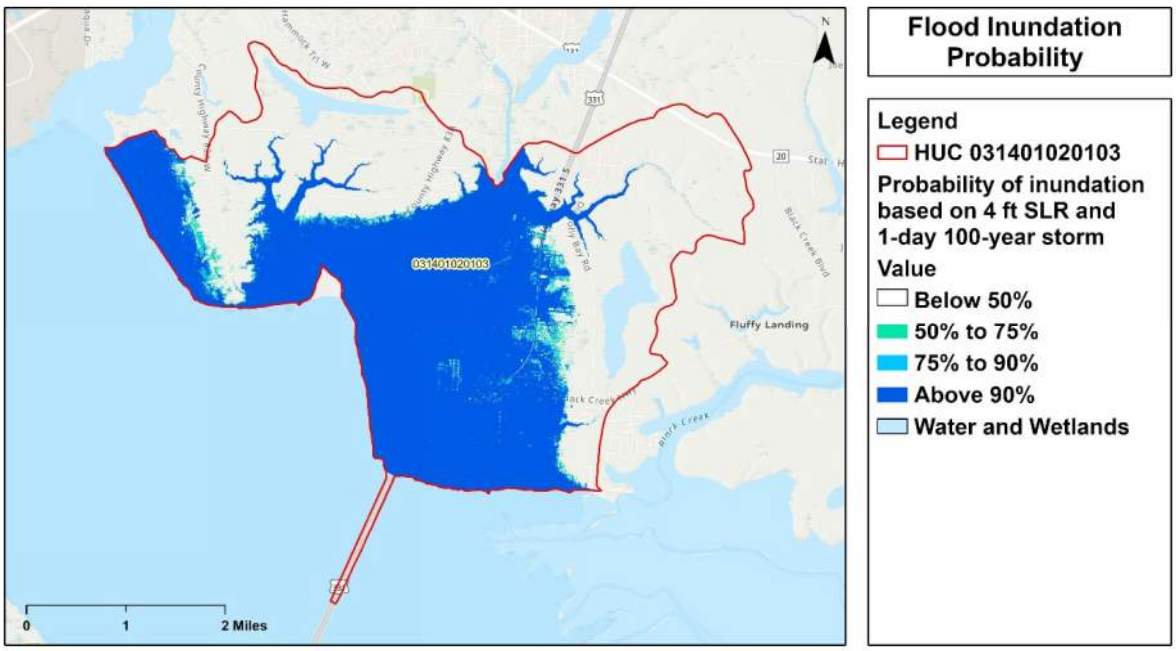

Figure 52. Sea level rise of 4 ft + 1-day 100-year storm for HUC 031401020103 sub-watershed . *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

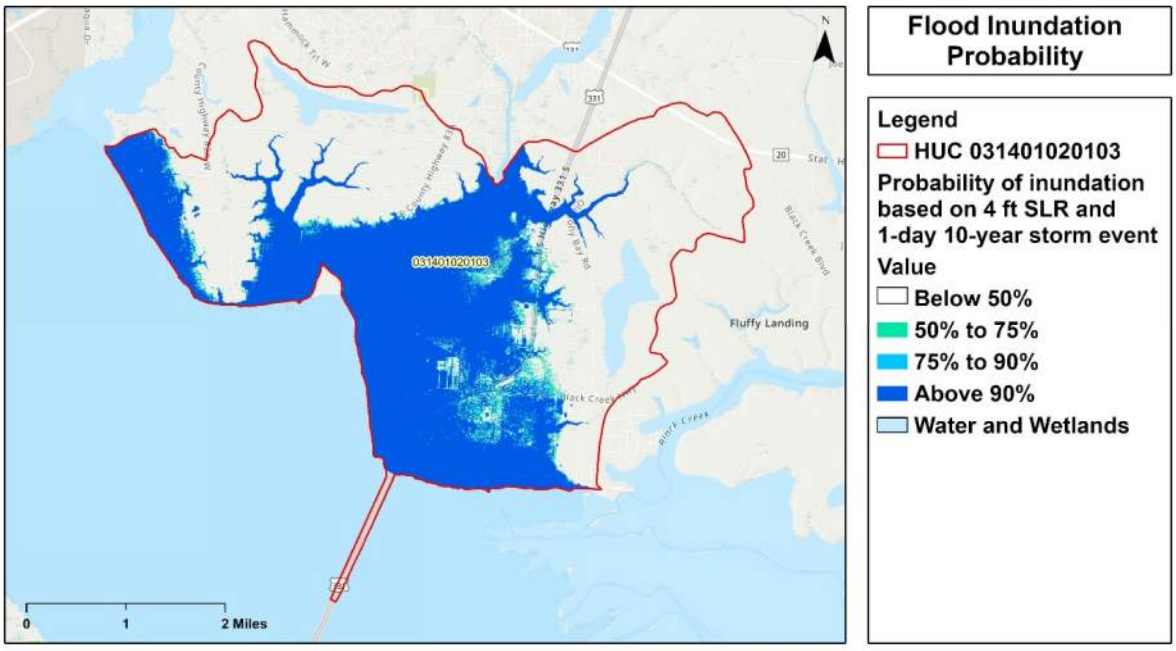

Figure 53. Sea level rise of 4 ft + 1-day 10-year storm for HUC 031401020103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

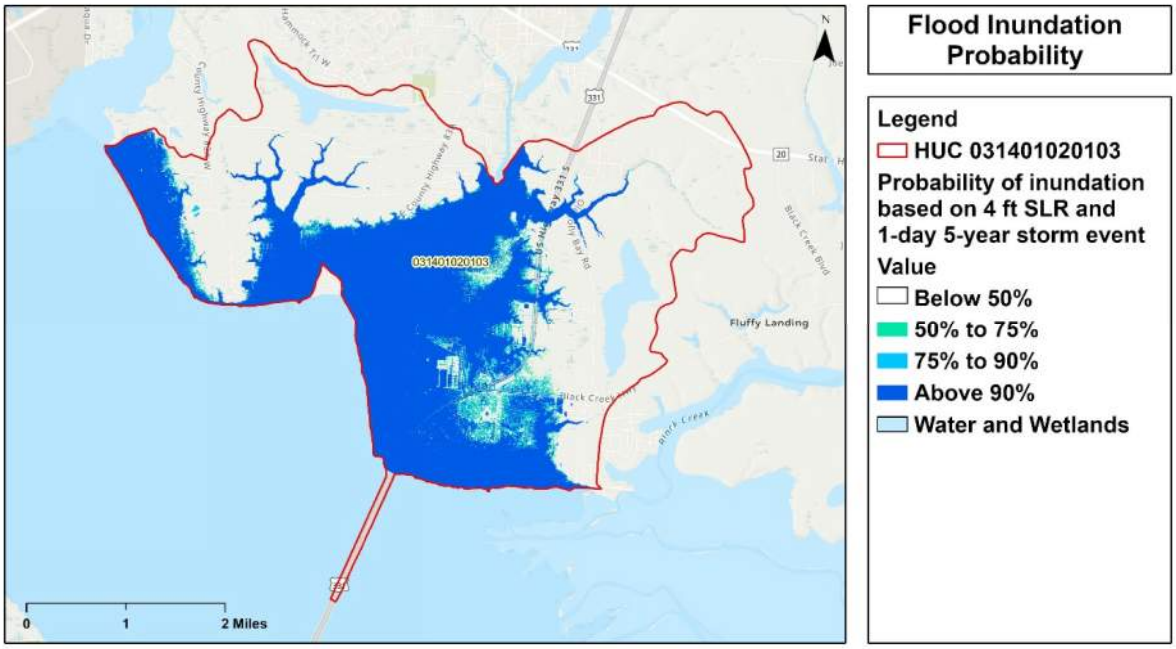

Figure 54. Sea level rise of 4 ft + 1-day 5-year storm for HUC 031401020103 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

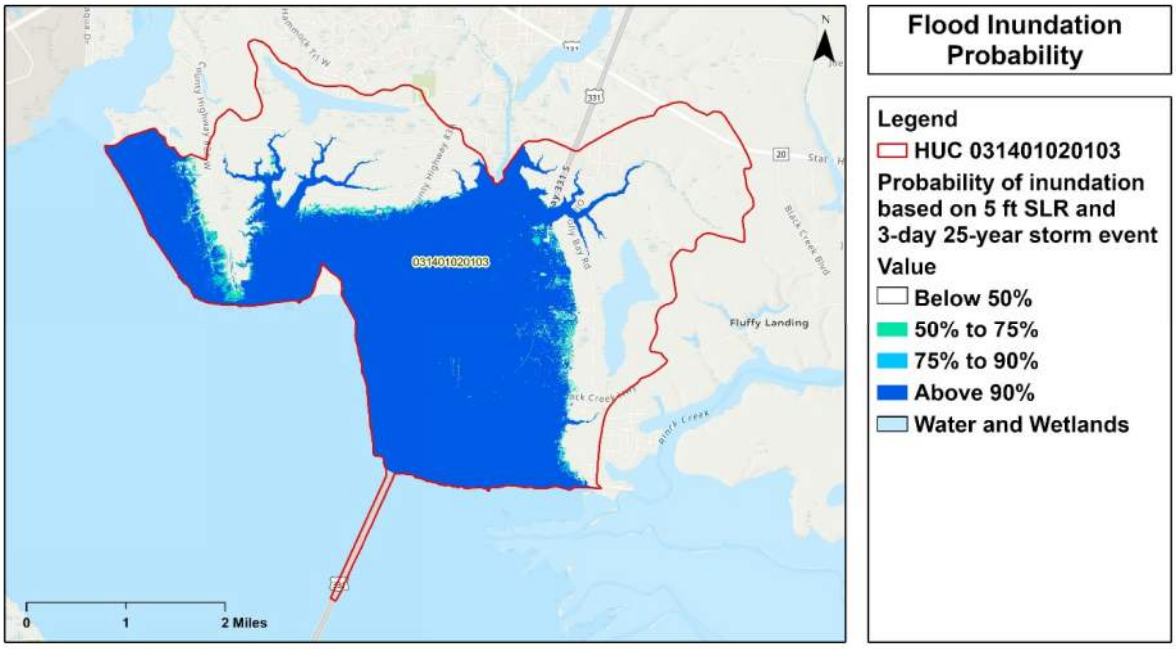

Figure 55. Sea level rise of 5 ft + 3-day 25-year storm for HUC 031401020103 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

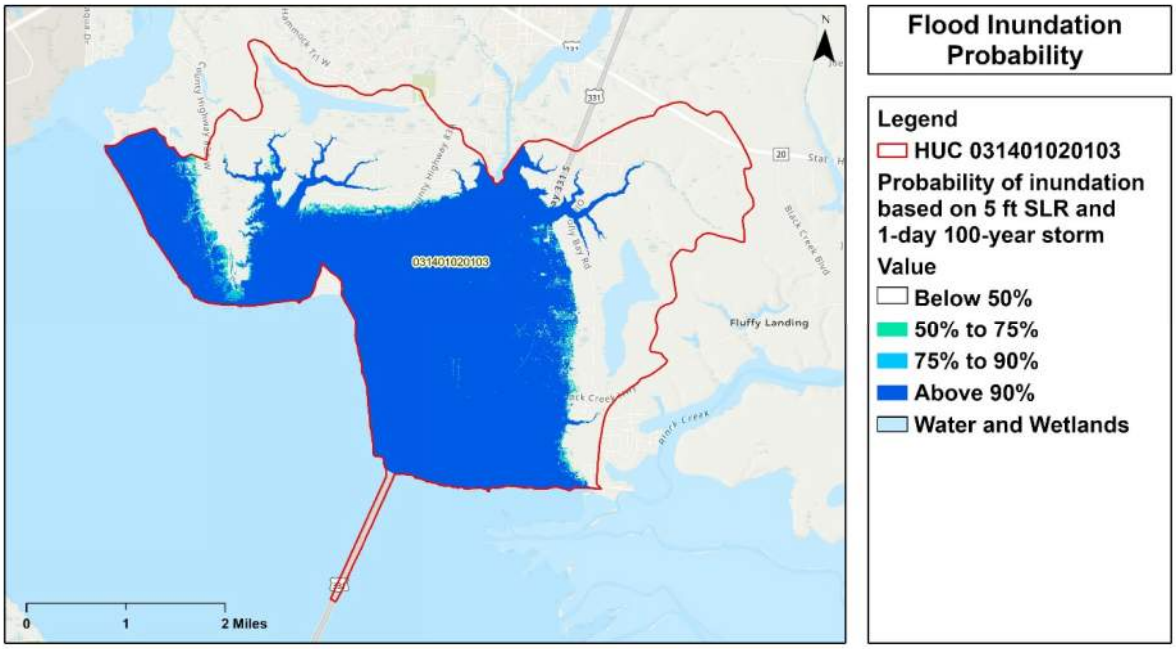

Figure 56. Sea level rise of 5 ft + 1-day 100-year storm for HUC 031401020103 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

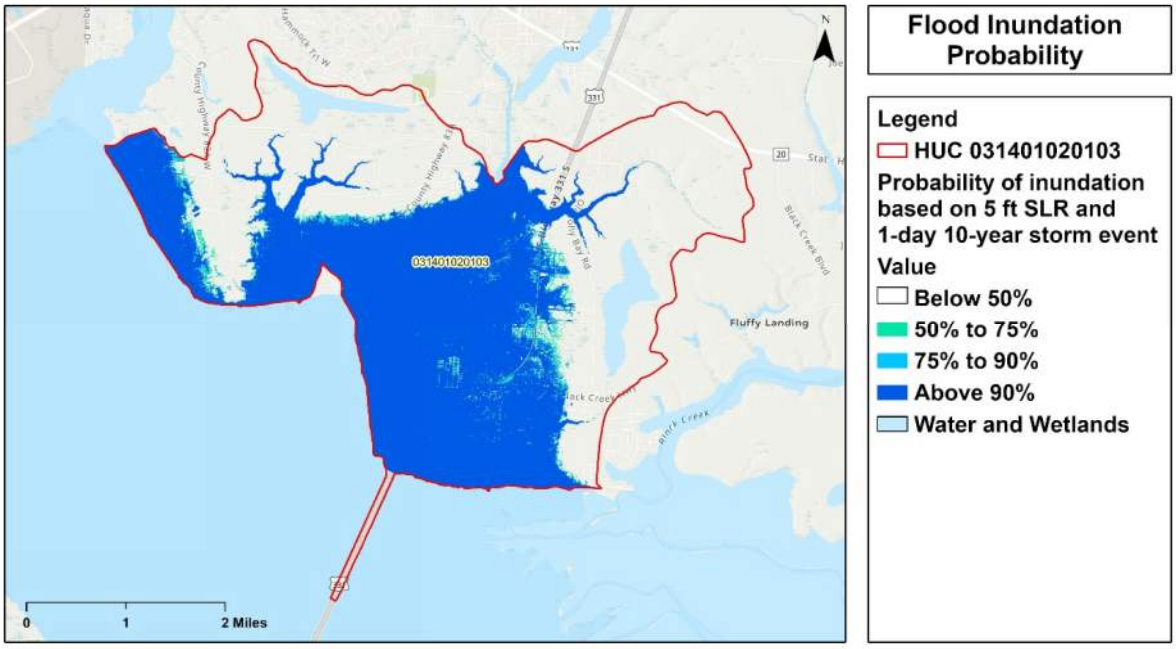

Figure 57. Sea level rise of 5 ft + 1-day 10-year storm for HUC 031401020103 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

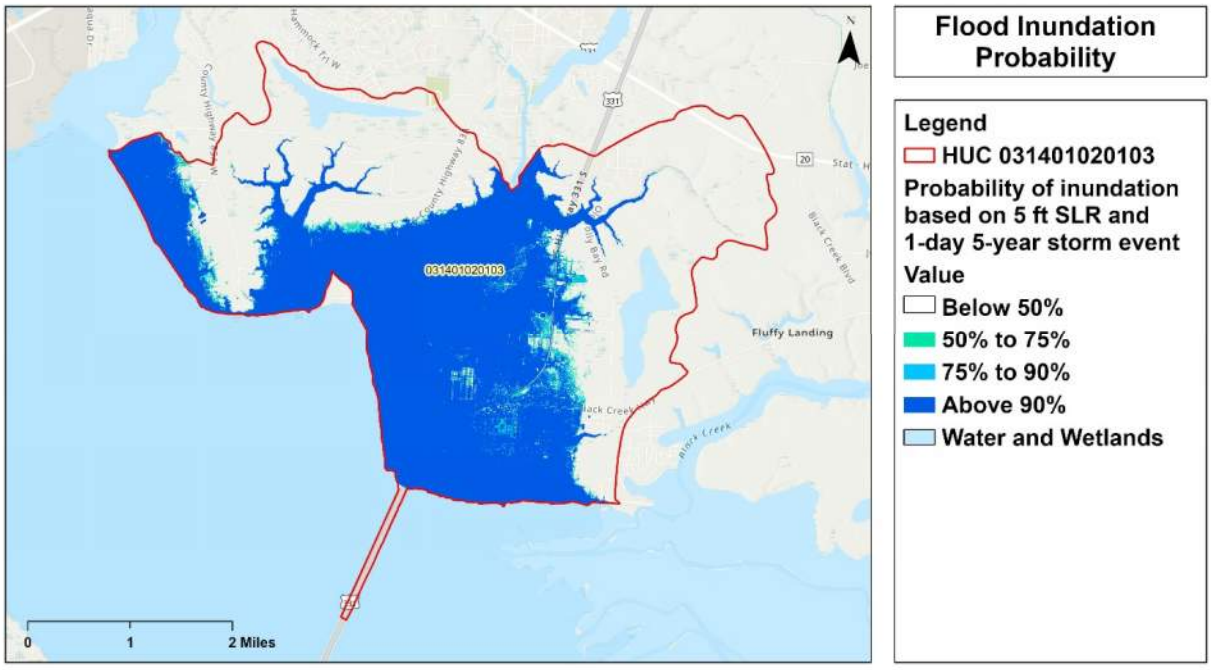

Figure 58. Sea level rise of 5 ft + 1-day 5-year storm for HUC 031401020103 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

2.5 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older,

poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5

27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6

58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6

94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.5.1 Results

Error! Reference source not found. to **Error! Reference source not found.** depict the HUC 031401020103 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 60) overlays critical facilities onto the 1-day 100-year storm event scenario, while the third map (**Error! Reference source not found.**) represents the same overlay within the context of 5 feet of sea level rise (SLR) combined with the 1-day 100-year storm event. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 5 feet SLR + 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** and **Error! Reference source not found.** illustrate the composite score for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. **Error! Reference source not found.** represents the calculation for composite score based on 1-day 100-year storm event, while **Error! Reference source not found.** shows the calculation for composite score for the same storm event, but including a 5 feet of Sea Level Rise scenario. **Error! Reference source not found.** shows the same area zoomed out.

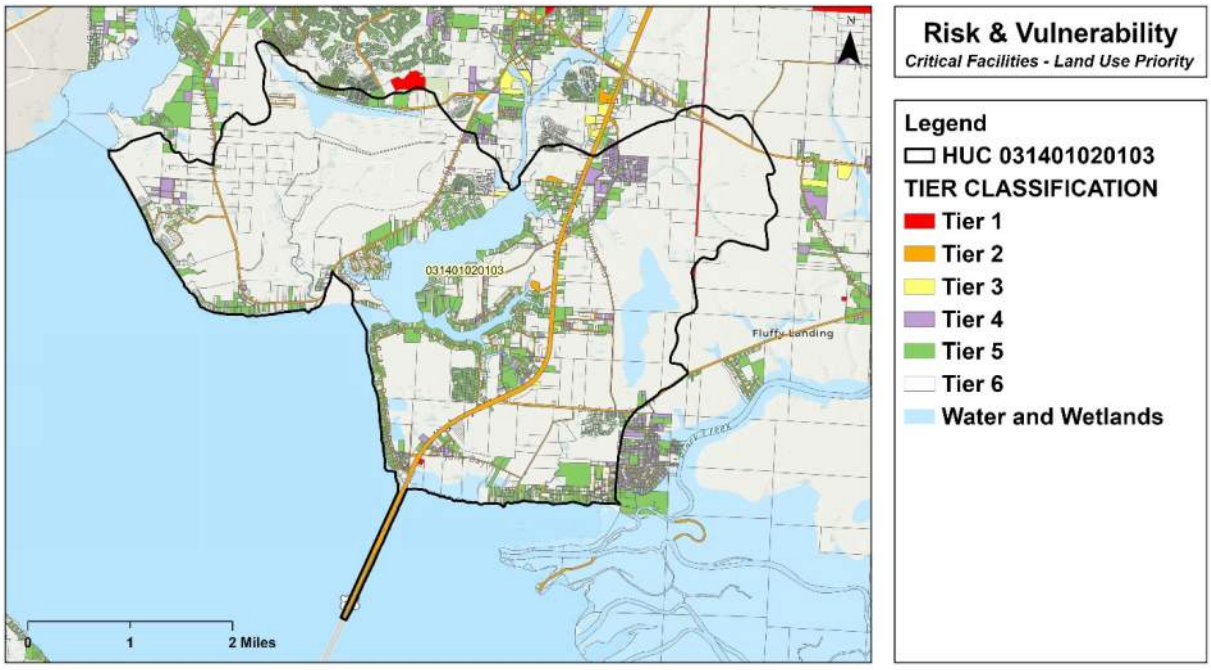

Figure 59. HUC 31401020103 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

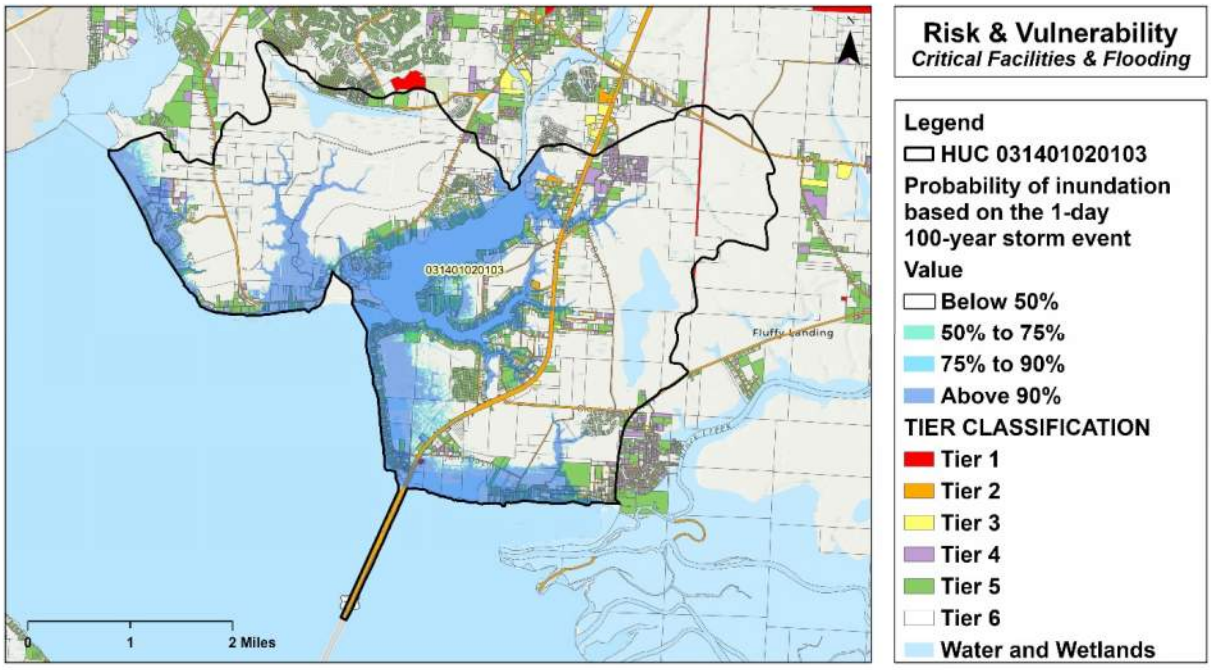

Figure 60. HUC 031401020103 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation map. Processed by FAU.

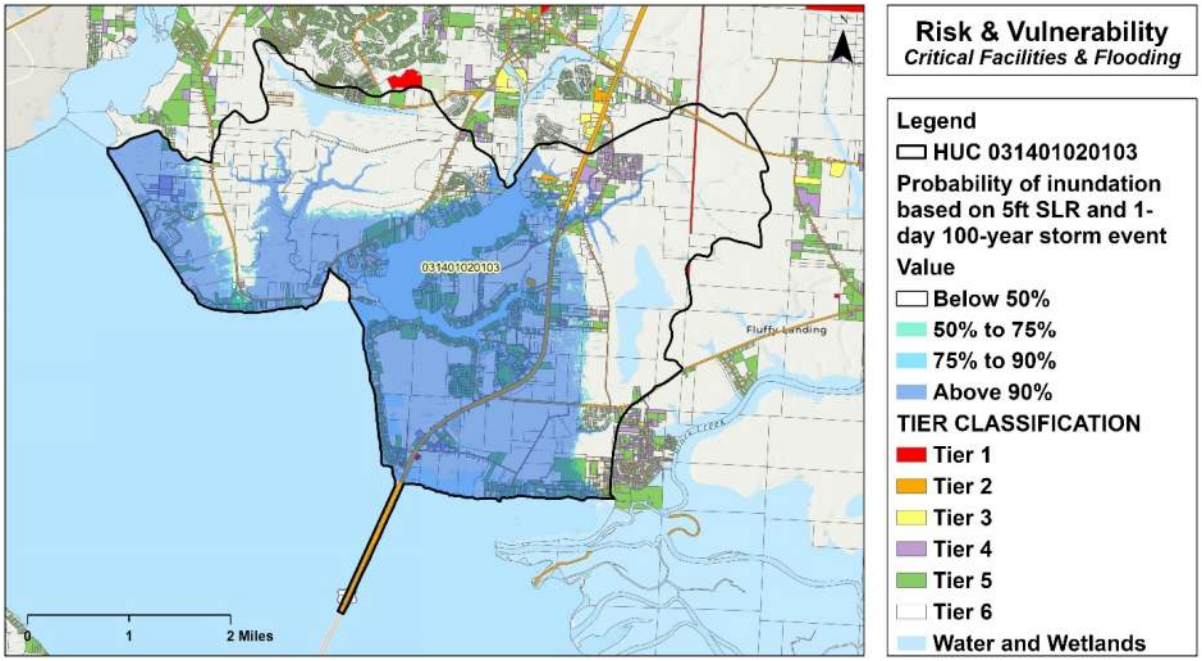

Figure 61. HUC 031401020103 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event + 5 ft SLR probability of inundation map. Processed by FAU.

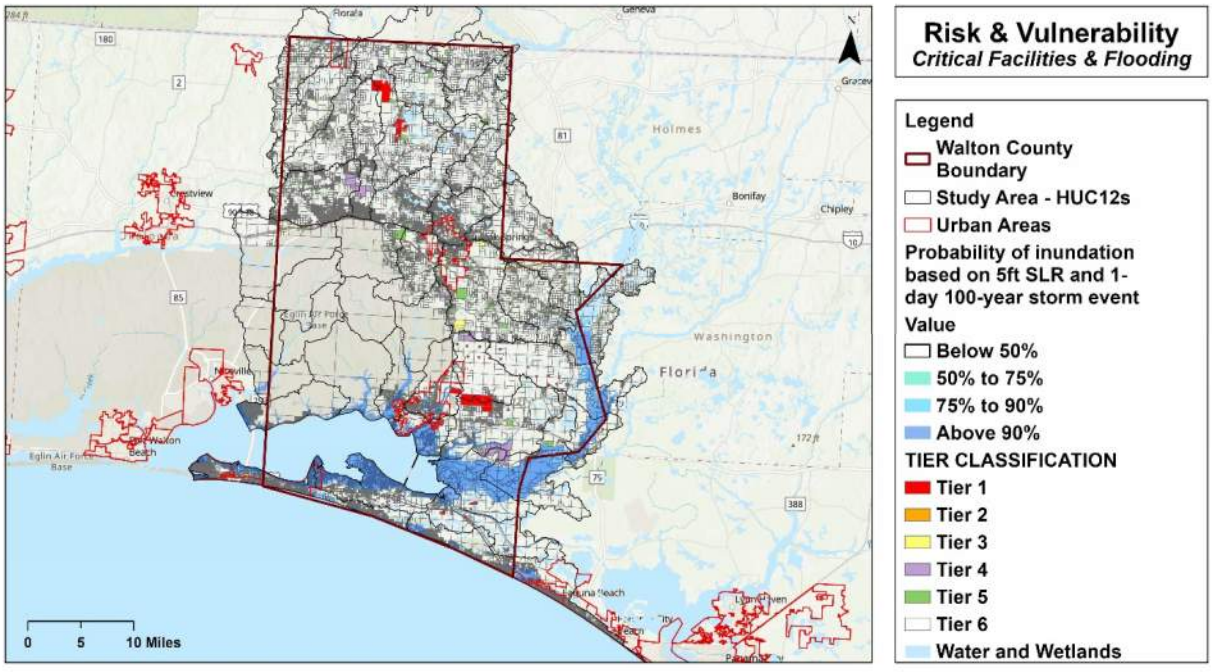

Figure 62. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event + 5 ft SLR probability of inundation map for Walton County. Processed by FAU.

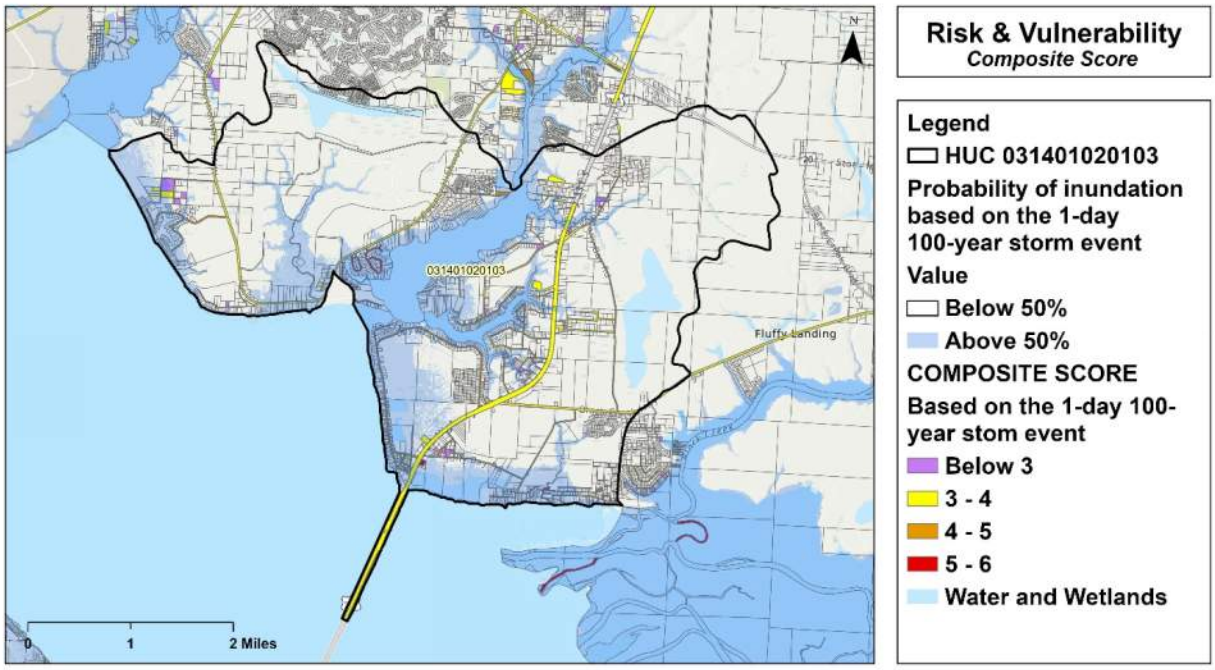

Figure 63. HUC 031401020103 sub-watershed Composite Score Risk map based on the 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation. Processed by FAU.

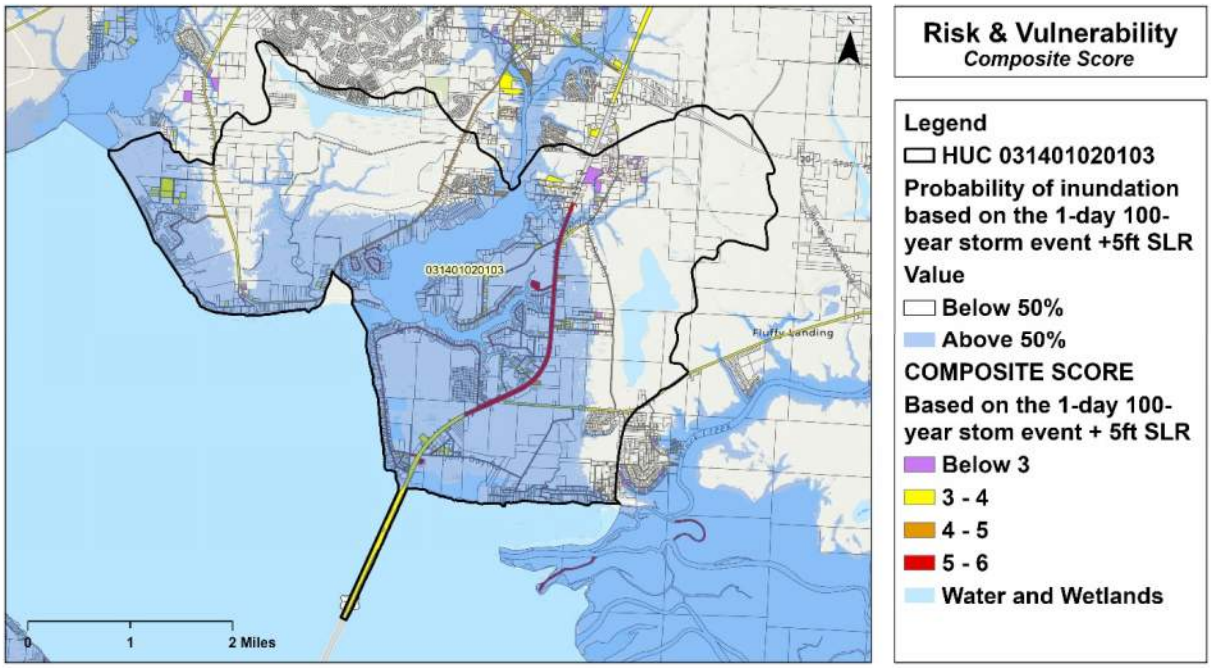

Figure 64. HUC 031401020103 sub-watershed Composite Score Risk map based on 1-day 100-year storm event + 5 ft SRL, overlaid on the 1-day 100-year + 5 ft SLR probability of inundation. Processed by FAU.

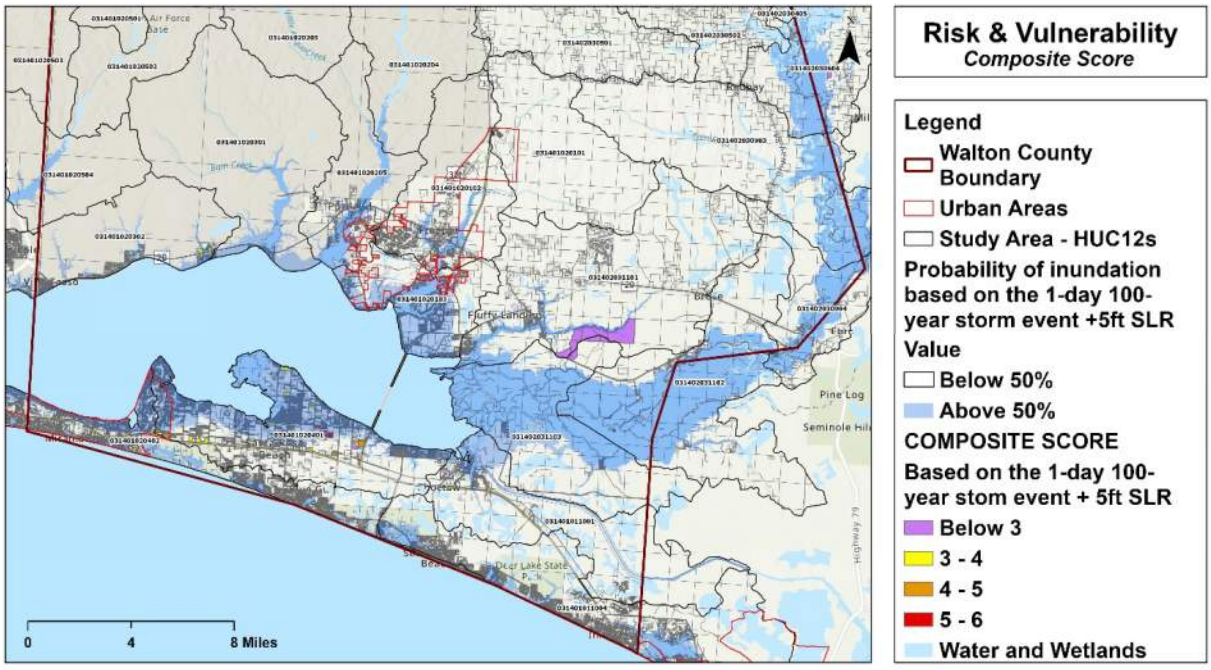

Figure 65. Coastal Area of Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event + 5 ft SLR probability of inundation. Processed by FAU.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

2.5.2 Drill-down – Freeport

For enhanced visualization of the urban areas within this HUC 031401020103, Figure 66 to Figure 75 illustrate the same results for critical facilities (land use priorities) and composite scores, but on a reduced scale, which better facilitates the examination of finer details within the urban area (Freeport). These maps cover both the 1-day 100-year scenario and the 1-day 100-year + 5 feet SLR scenario.

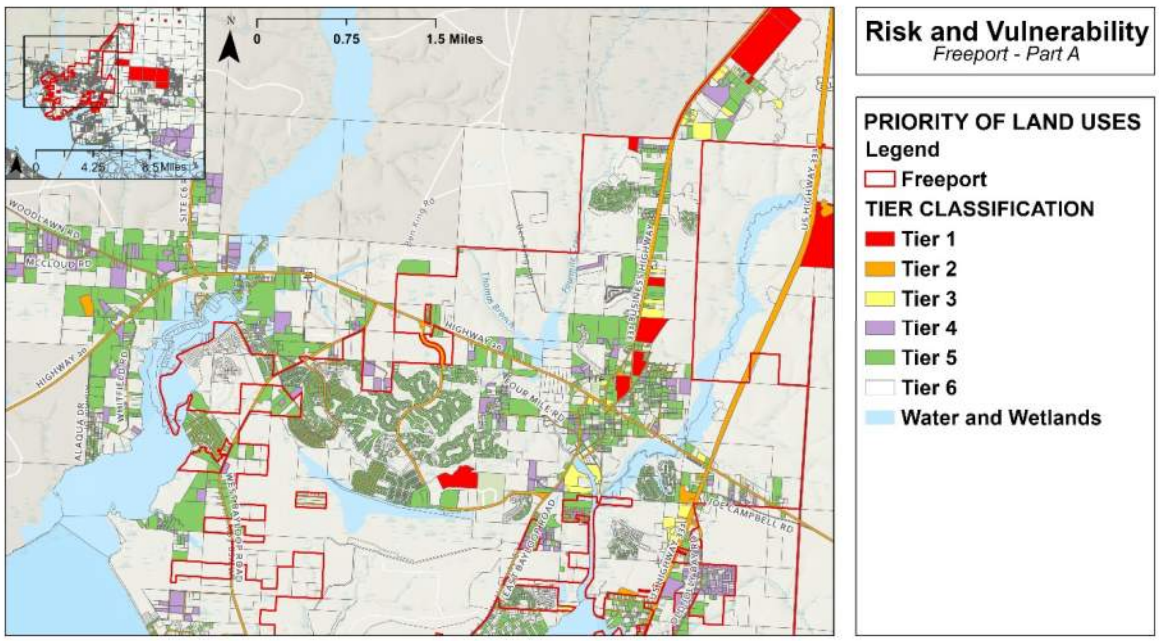

Figure 66. Critical Facilities (priority of land uses) map for Freeport (part A). Processed by FAU
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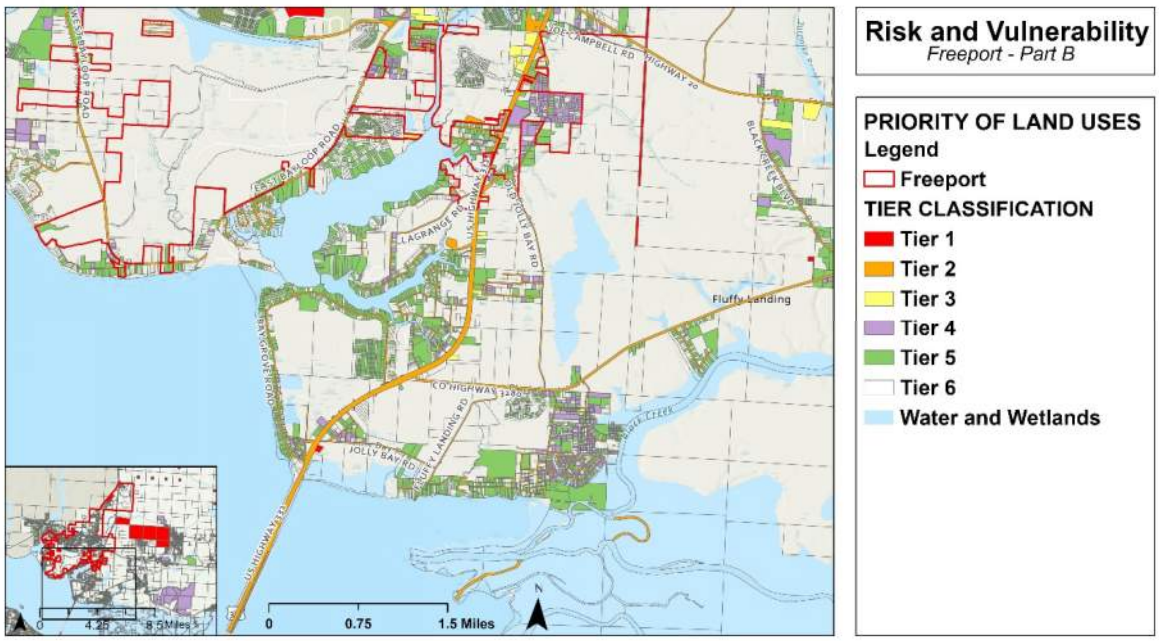

Figure 67. Critical Facilities (priority of land uses) map for Freeport (part B). Processed by FAU.

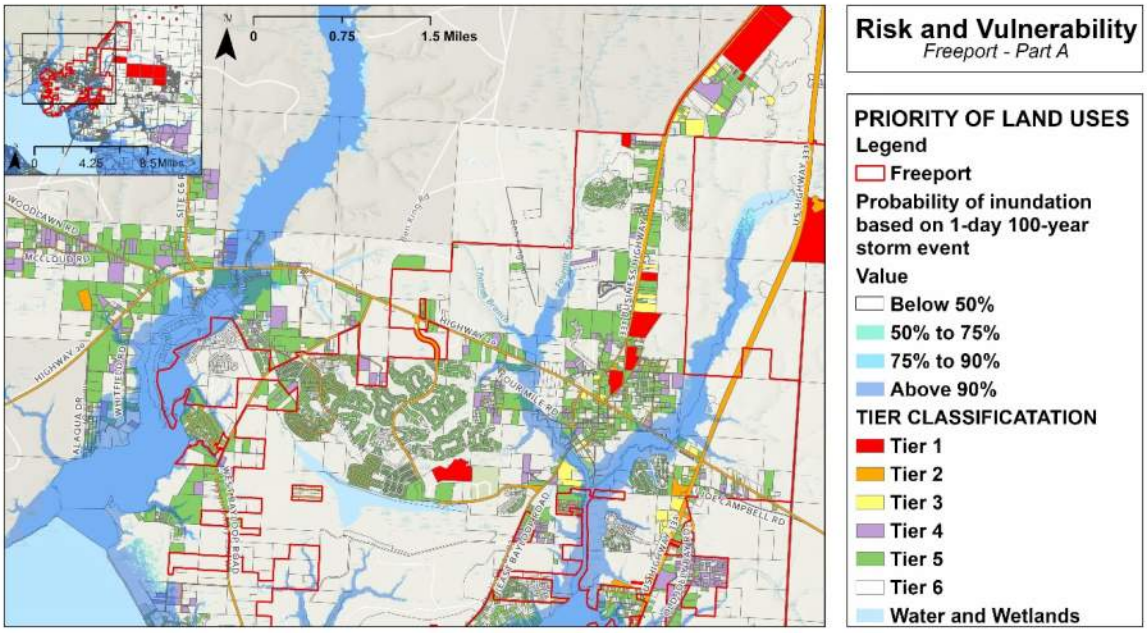

Figure 68. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event for Freeport (part A). Processed by FAU.

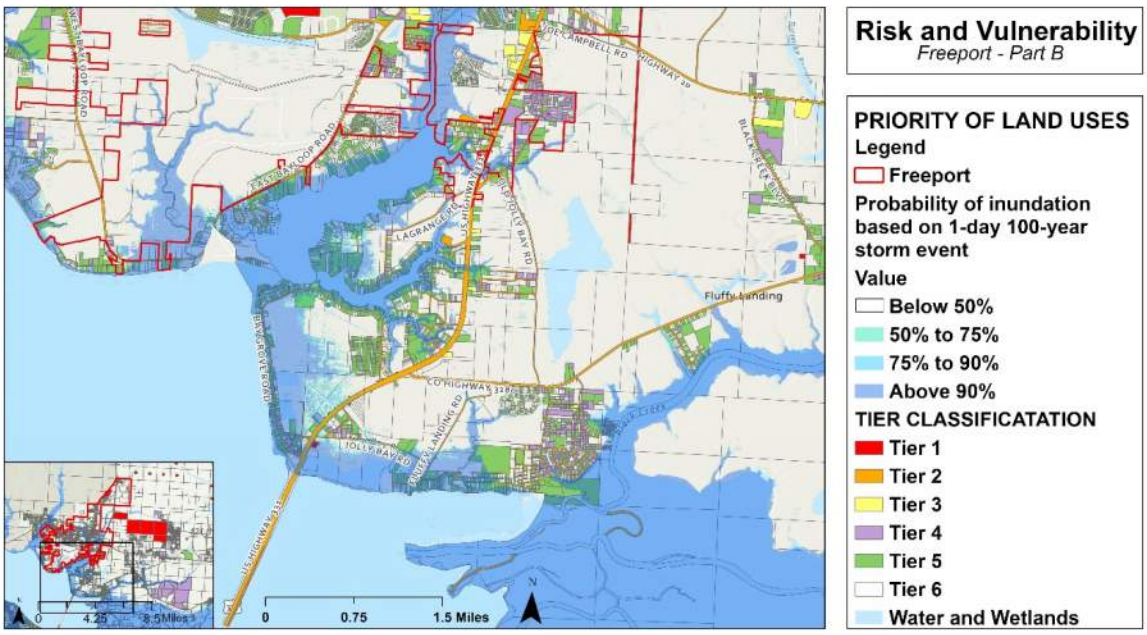

Figure 69. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event for Freeport (part B). Processed by FAU.

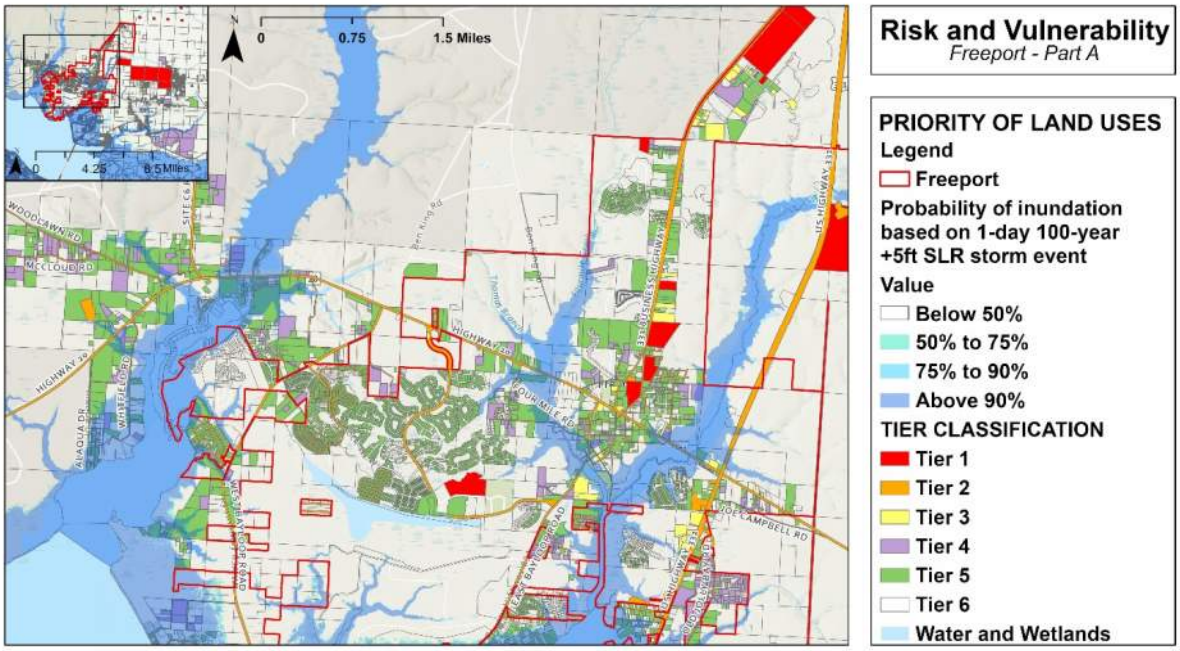

Figure 70. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event + 5 feet SLR for Freeport (part A). Processed by FAU.

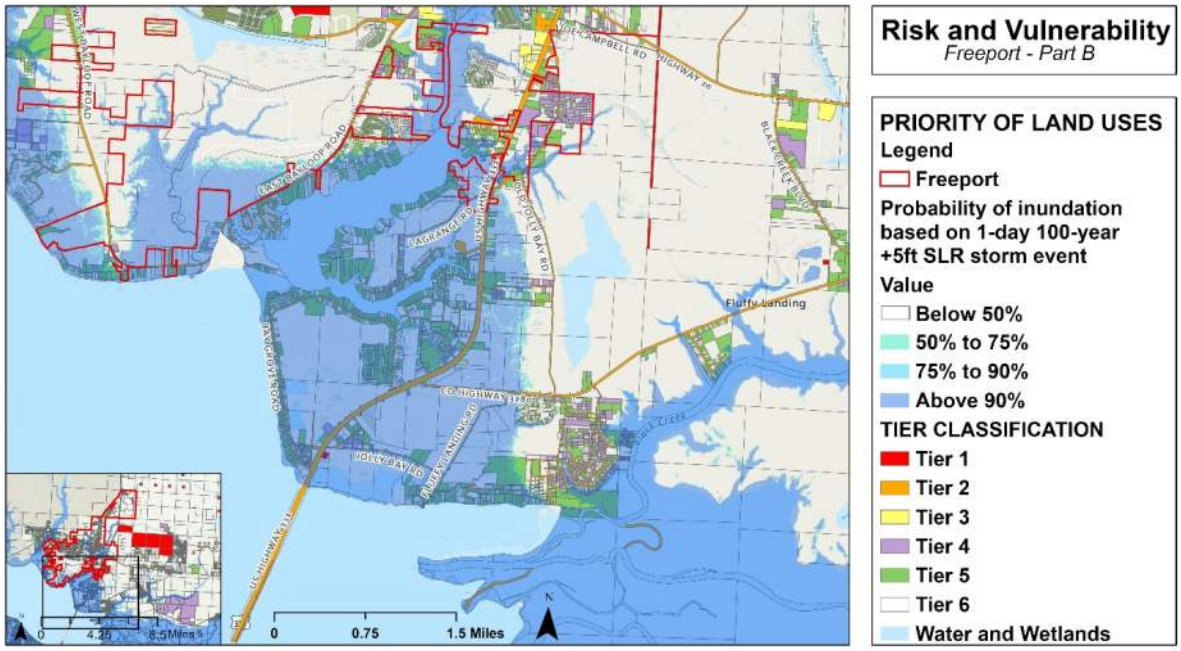

Figure 71. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event + 5 feet SLR for Freeport (part B). Processed by FAU.

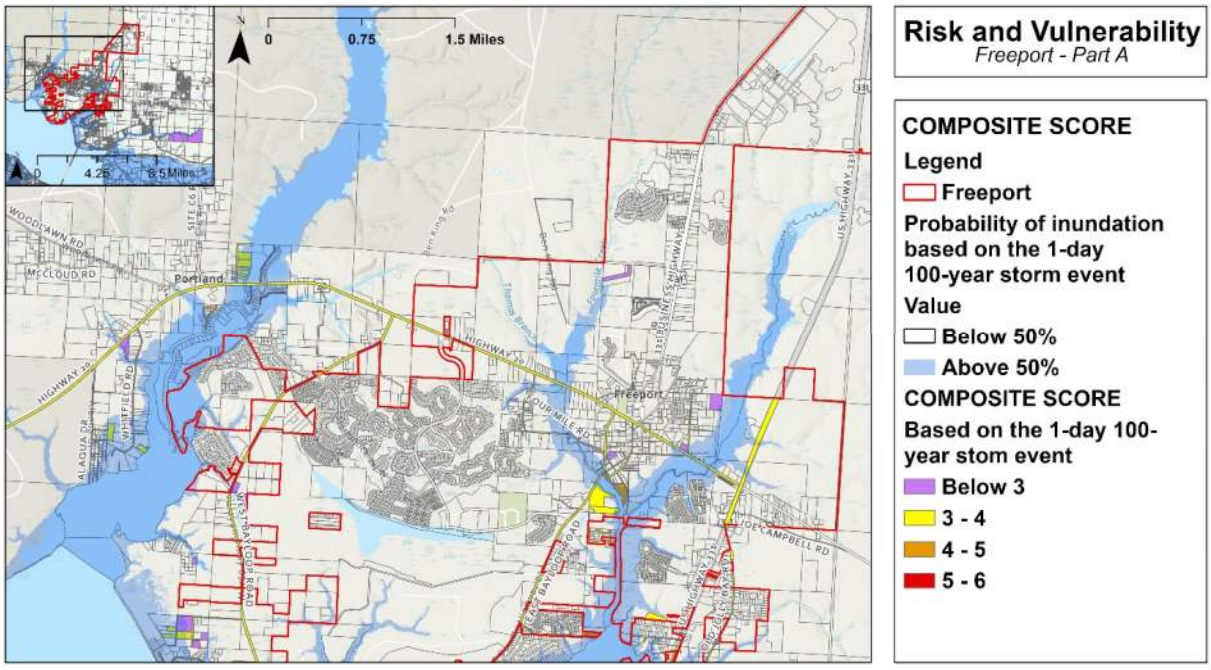

Figure 72. Composite Score map based on 1-day 100-year storm event, overlaid in flooding layer for Freeport (part A). Processed by FAU.

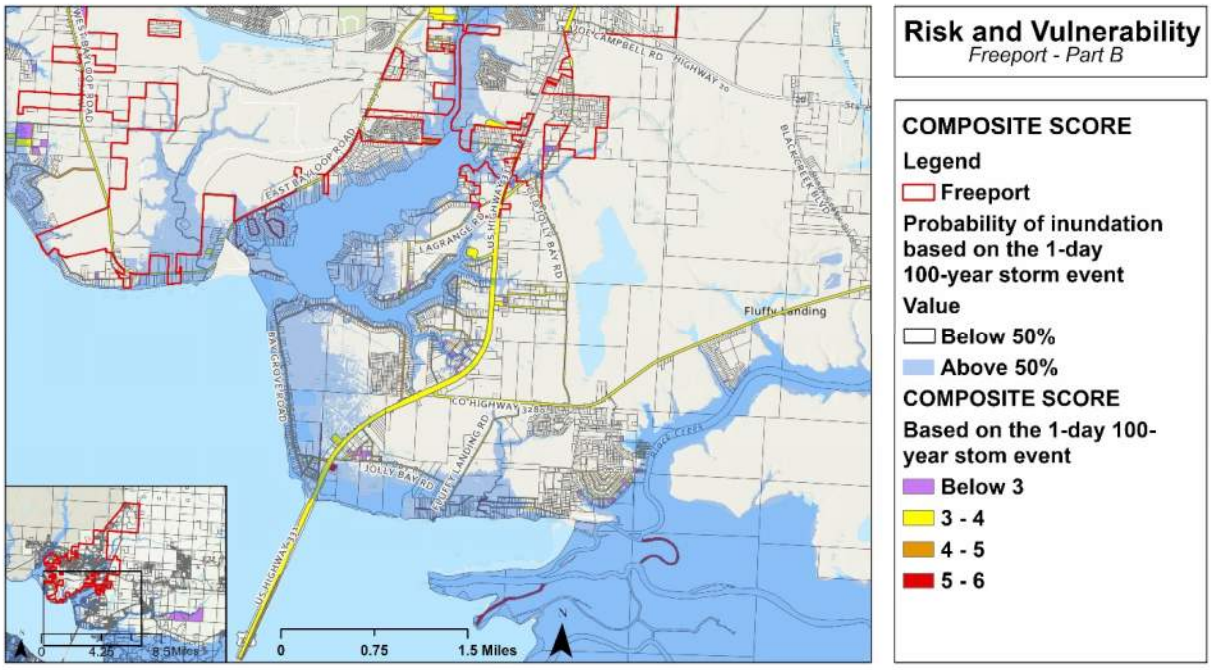

Figure 73. Composite Score map based on 1-day 100-year storm event, overlaid in flooding layer for Freeport (part B). Processed by FAU.

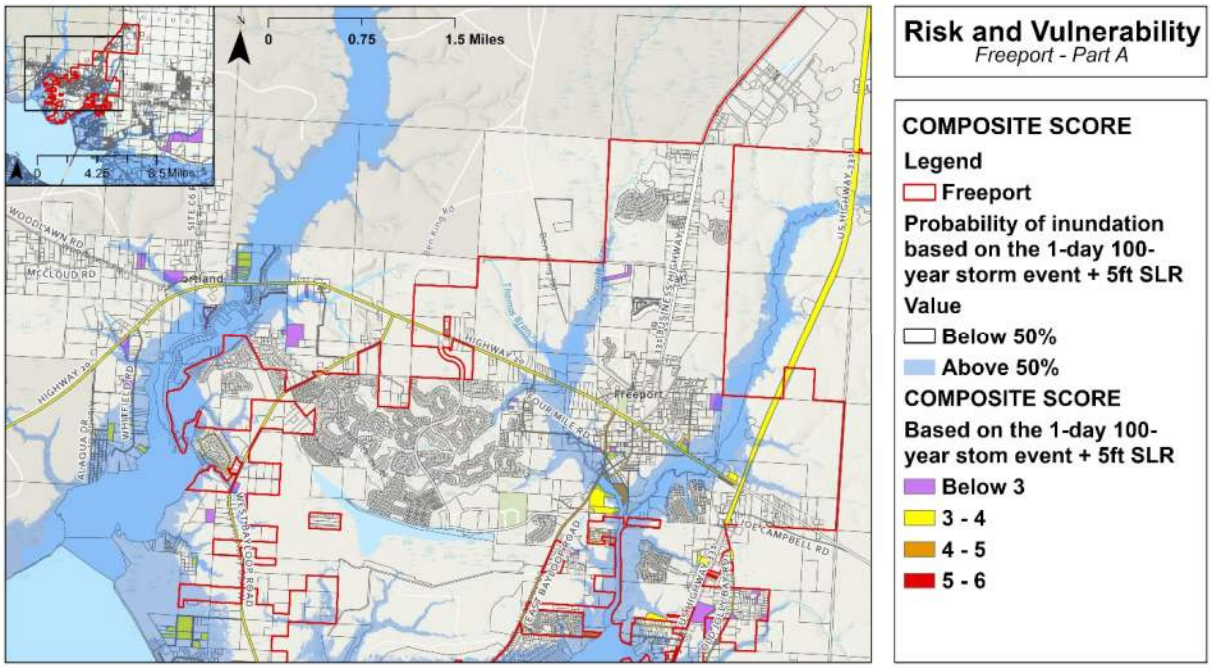

Figure 74. Composite Score map based on 1-day 100-year storm event + 5 feet SLR, overlaid in flooding layer for Freeport (part A). Processed by FAU.

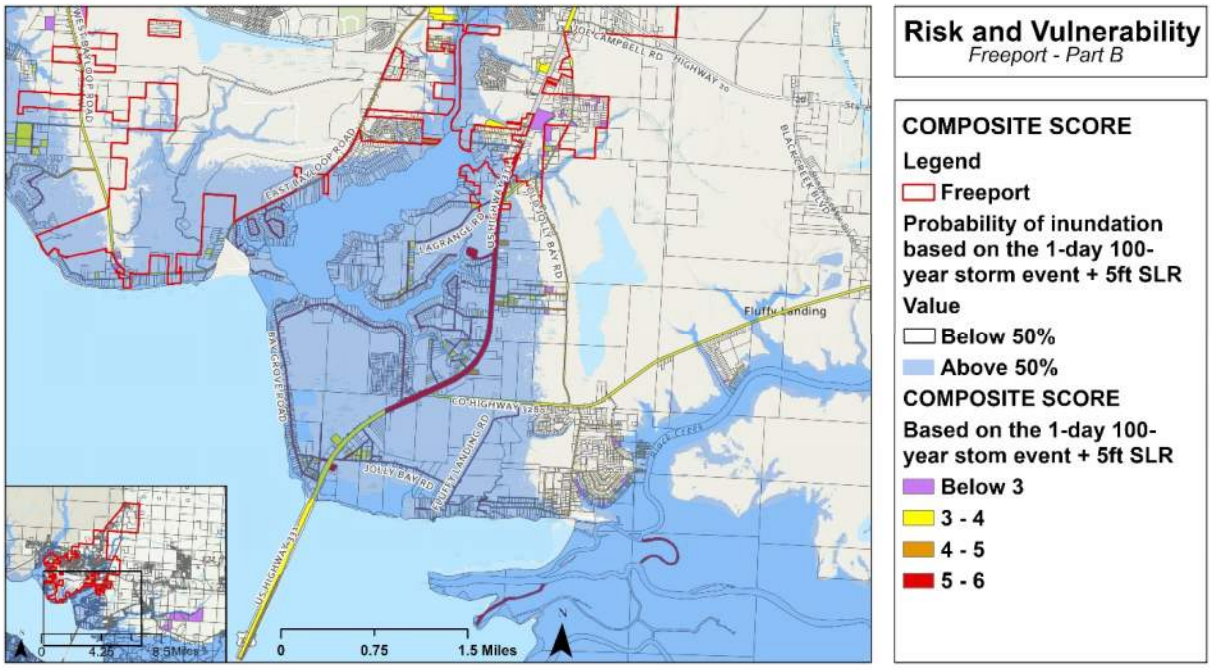

Figure 75. Composite Score map based on 1-day 100-year storm event + 5 feet SLR, overlaid in flooding layer for Freeport (part B). Processed by FAU.

2.5.3 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401020103. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.5.4 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401020103. Processed by FAU.

AREAS	ACRES
HUC-12 Sub-watershed: 031401020103	9956.92
All of the 1-day 100-year storm event inundation	**2806.83**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	615.71
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	2191.12
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	2191.12

2.5.5 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. Figure 76 indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

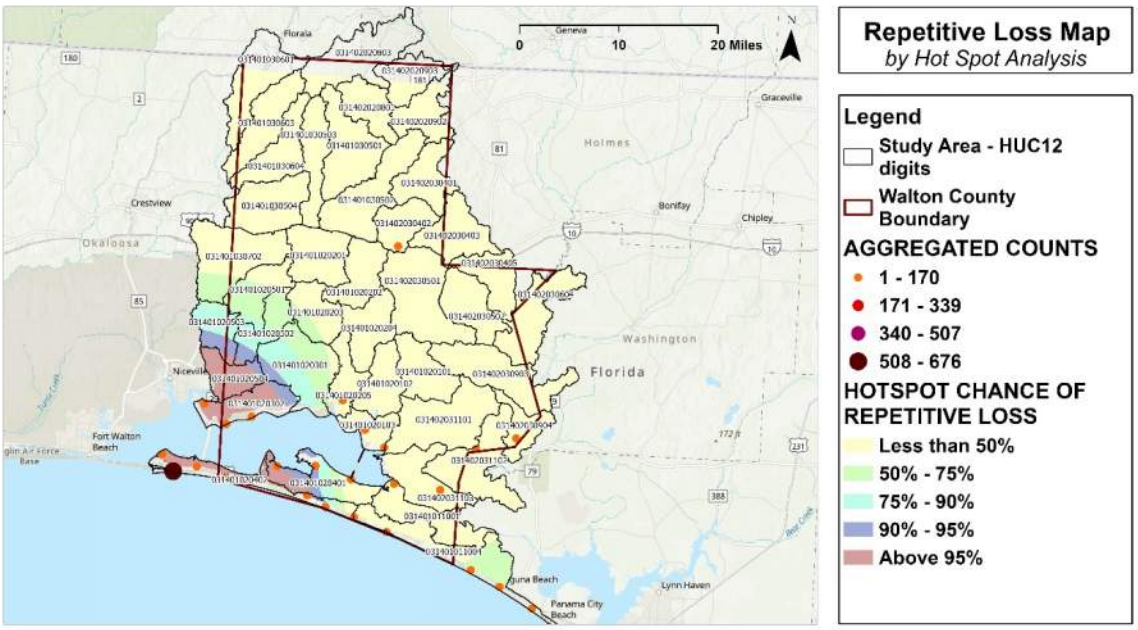

Figure 76. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.5.6. Priority Projects

The area displays a low-to-moderate level of development. Fortunately, there is only two critical facilities (tier 1) located within the flood zone, which are a public school and utility. Although there is no critical parcels classified as tier 2 that fall within the flood, there are a good amount of roads located within the flood, which need attention.

Regarding composite score, for the 1-day 100-year storm event + 5 feet of Sea Level Rise scenario, there are a great amount of parcels with score 5-6 that should receive the highest priority for intervention. Among them are 2 utilities, and 54 portion of roads, which the most important ones are US Highway 331, Bay Grove Road, Grove Lane, Mallet Bayou Rd, Fluffy Landing Rd, Jolly Bay Rd, Lagrange Rd, Bayside Drive, and Watson Road.

For score 4-5 there are 26 parcels as total, including five office buildings, one restaurant/cafeteria, two light manufacturing, and eighteen roads, such as Co Highway 3280, US Highway 331, West Bayloop Road, East Bayloop Road, Old Jolly Bay Rd, Shadow Lane, Bay Harbour Boulvard, and Marina Village Blvd.

APPENDIX G

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401020201

UPPER ALAQUA CREEK

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Co-Principal Investigators: Weibo Liu, Ph.D., Daniel Meeroff, Ph.D., Diana Mitsova, Ph.D., S. Nagarajan, Ph.D., Hongbo Su, Ph.D., Ramesh Teegavarapu, Ph.D., Zhixiao Xie, Ph.D., Yan Yong, Ph.D., and Caiyun Zhang, Ph.D., Ahmet Urusan, Ph.D., Shannon Egger, Eva Suarez, Ph.D.

Research Assistant: Leticia Sabio

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401020201) is highlighted among all the HUCs to help identifying its location.

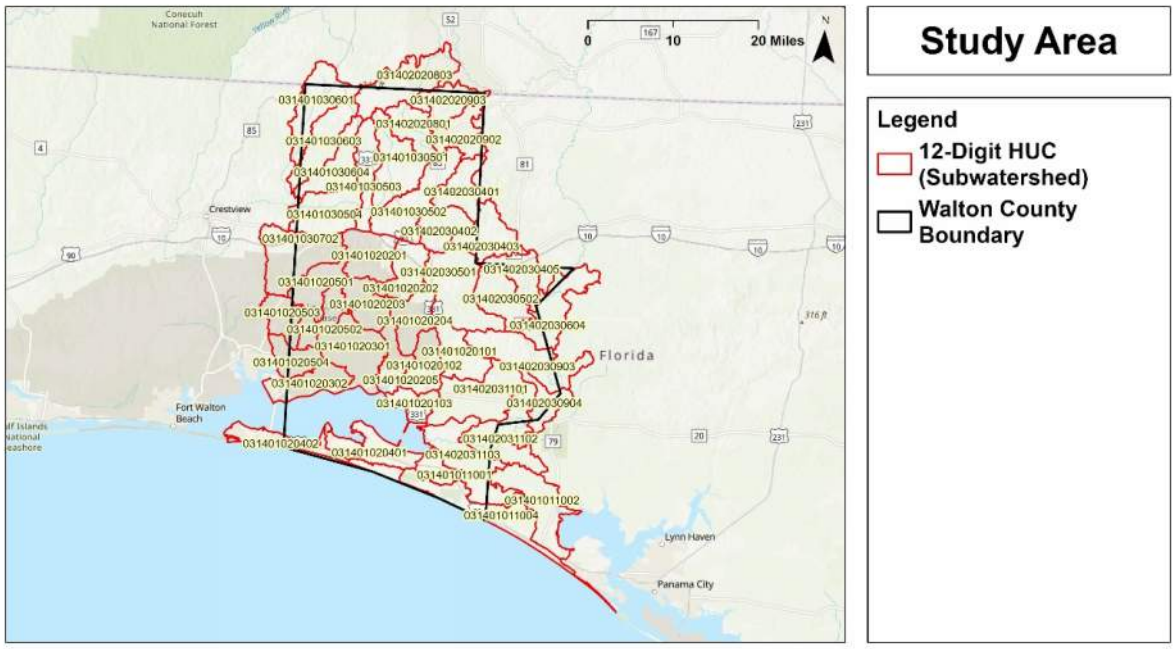
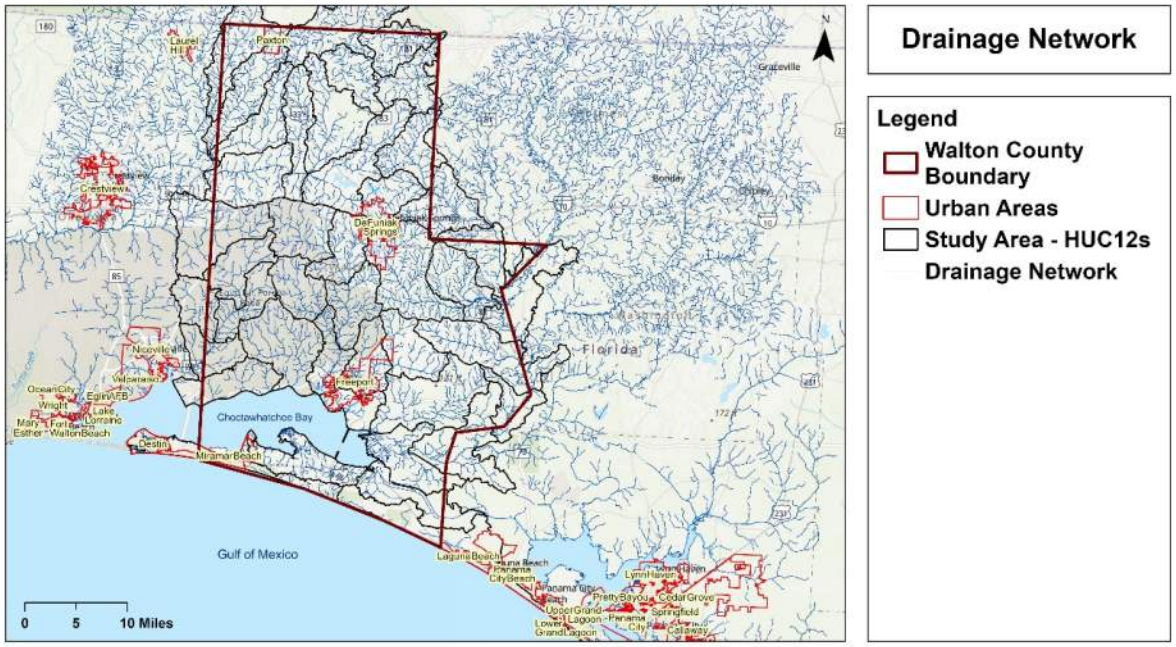


Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.



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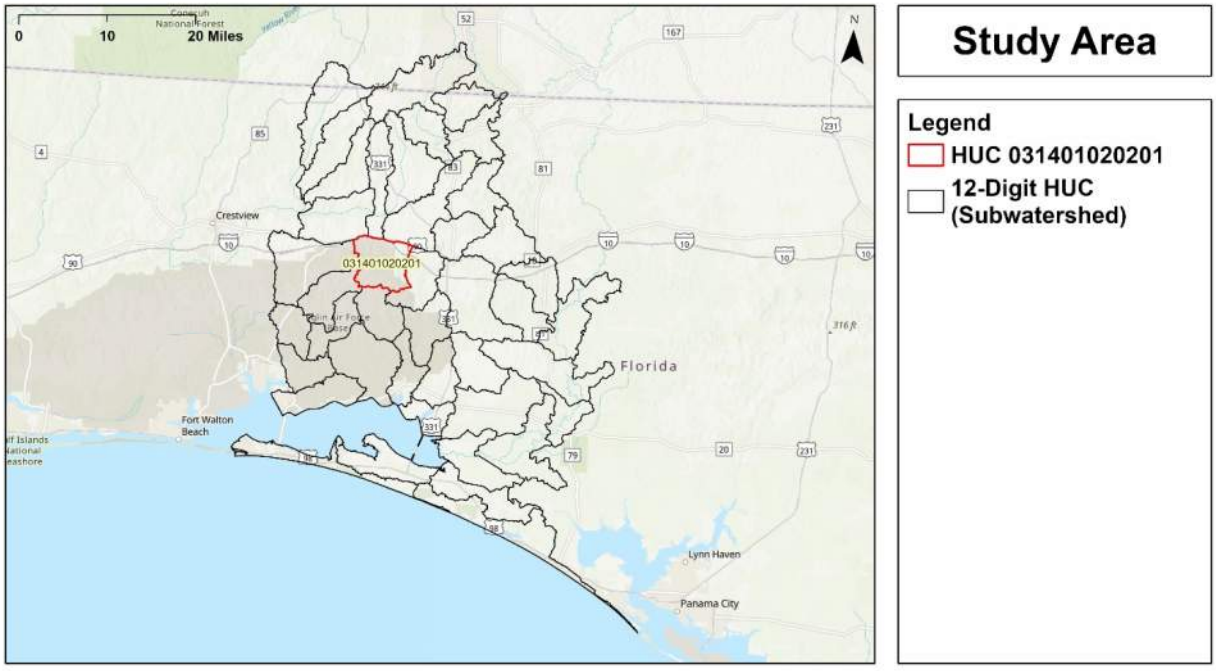

Figure 3. HUC 031401020201 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development, tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife

management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Figures 12 and 13 in the county-wide report show the current and projected land use for the County. Based on the 2017 future land use map for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.9	7.17%
Barren Land	9242.1	1.25%
Rangeland	40326.7	5.46%
Transportation, Communication, and Utilities	11815.7	1.60%
Upland Forest	356796.1	48.30%
Urban and Built-Up	52194.8	7.07%
Water	61593.9	8.34%
Wetlands	153759.9	20.82%
Total	**738687.9**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

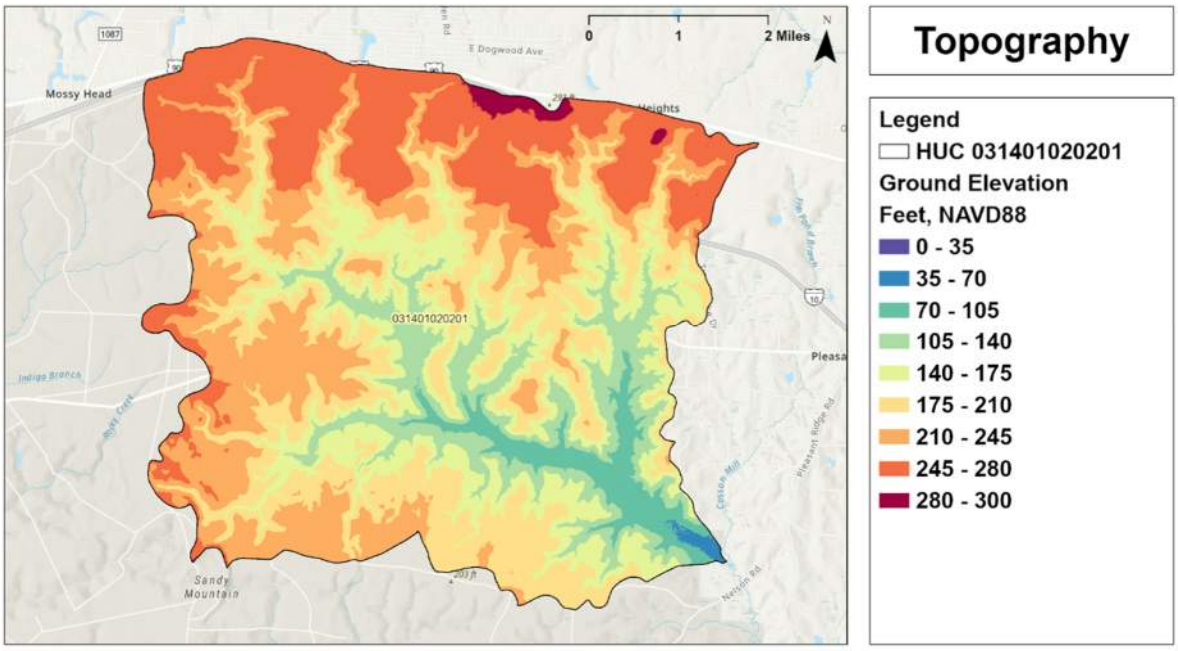

Figure 4. Topographic map of the HUC 031401020201 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401020201 sub-watershed is shown in **Error! Reference source not found.**.

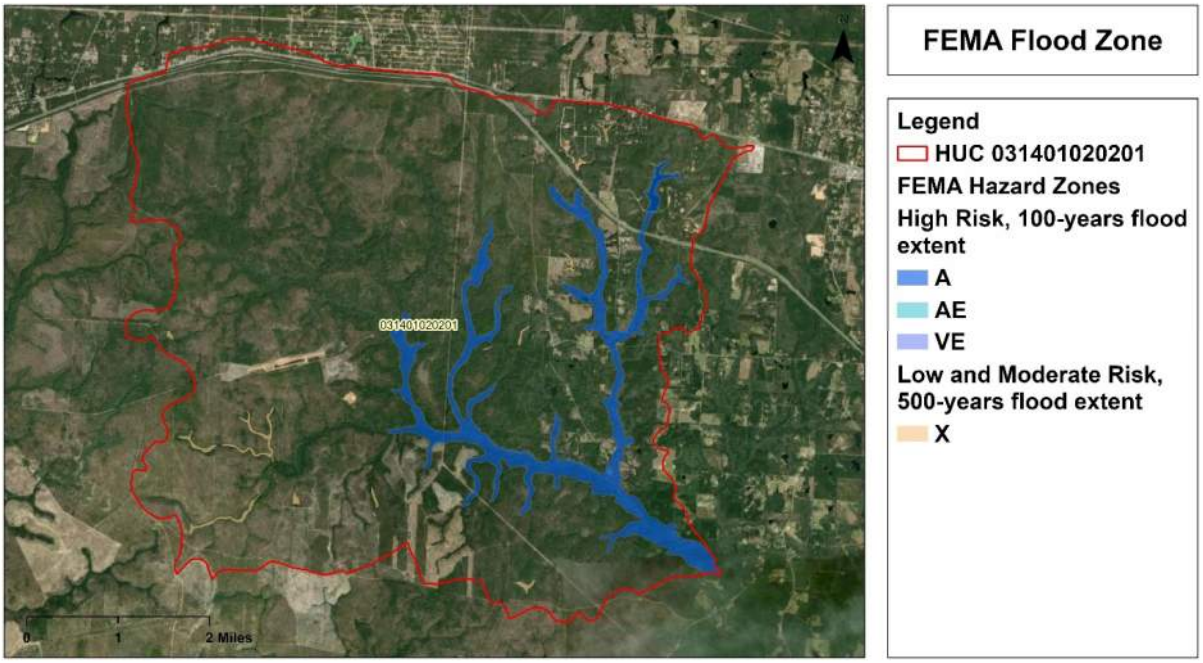

Figure 5. FEMA Flood Zone map (2020) for HUC 031401020201 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401020201 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including

various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

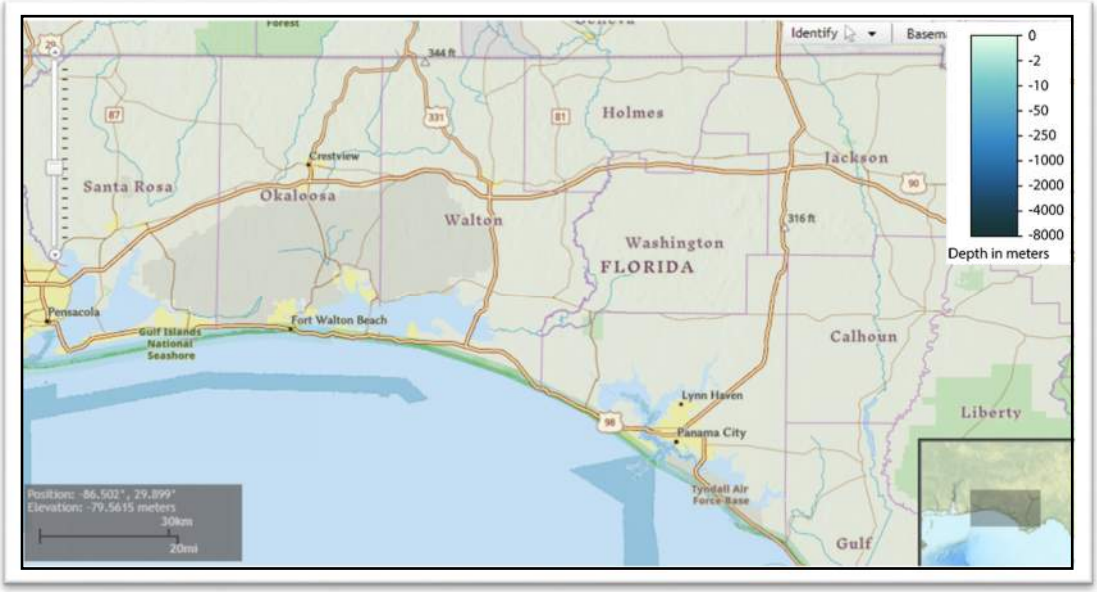

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

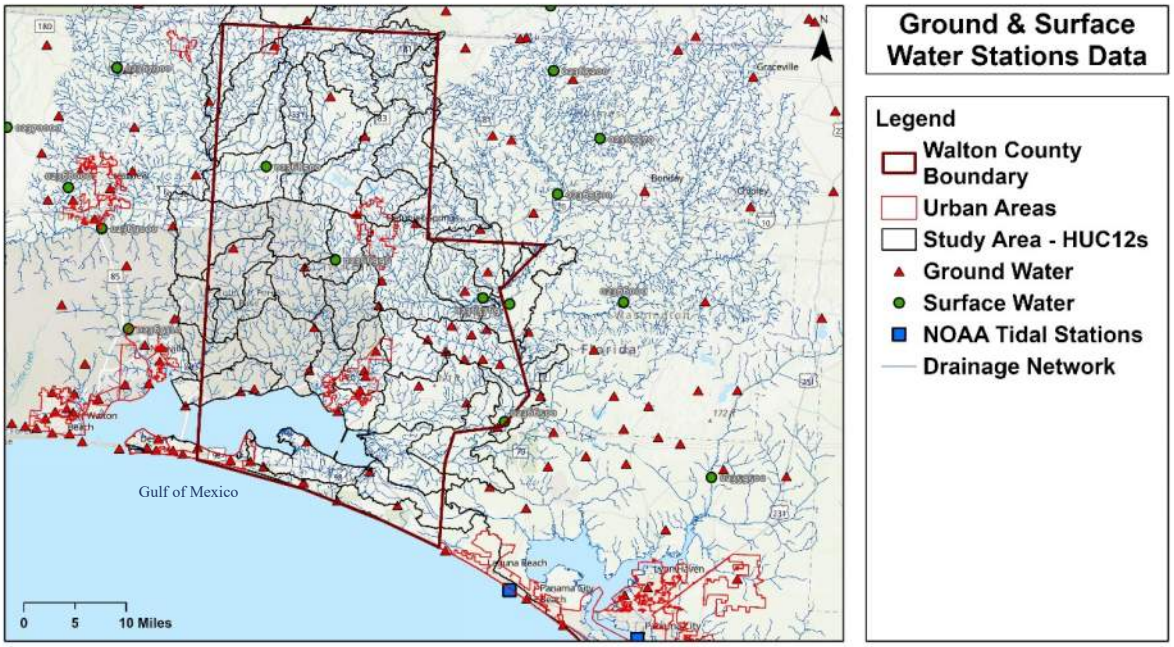

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031401020201 has no major rivers and canals, but creeks and branches, include:

- Alaqua Creek
- Bear Creek

- Bishop Branch
- Liveoak Branch
- White Head Spring Branch
- Bullhide Creek
- Buck Branch
- Bear Bay Branch
- Steep Head Branch

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366996. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401020201, which is USGS 02366996 Alaqua Creek Near Pleasant Ridge, FL.

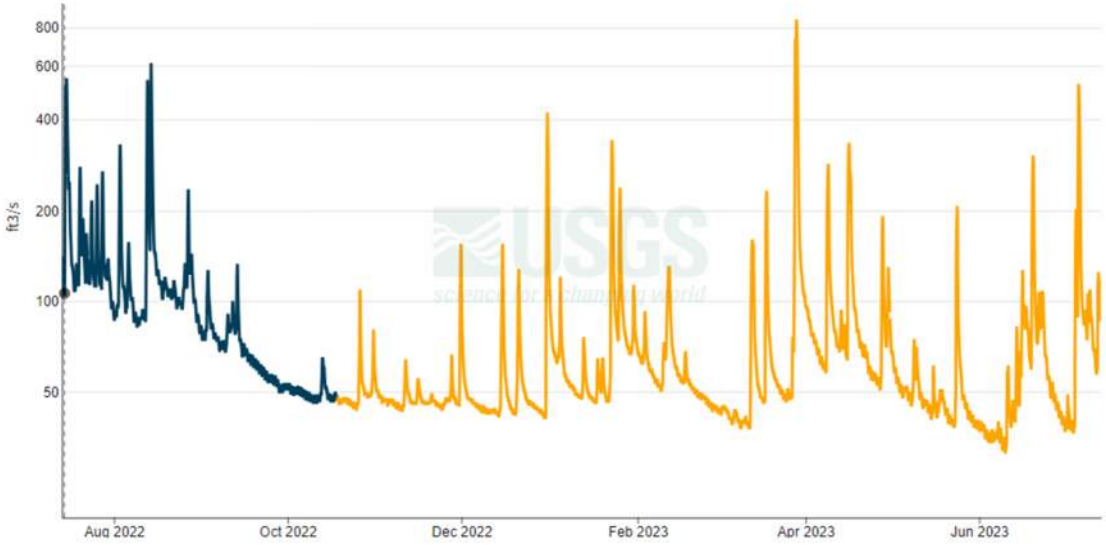

Figure 8. Average streamflow for Alaqua Creek Near Pleasant Ridge, FL (USGS 02366996 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366996/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the

database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401020201 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031401020201 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

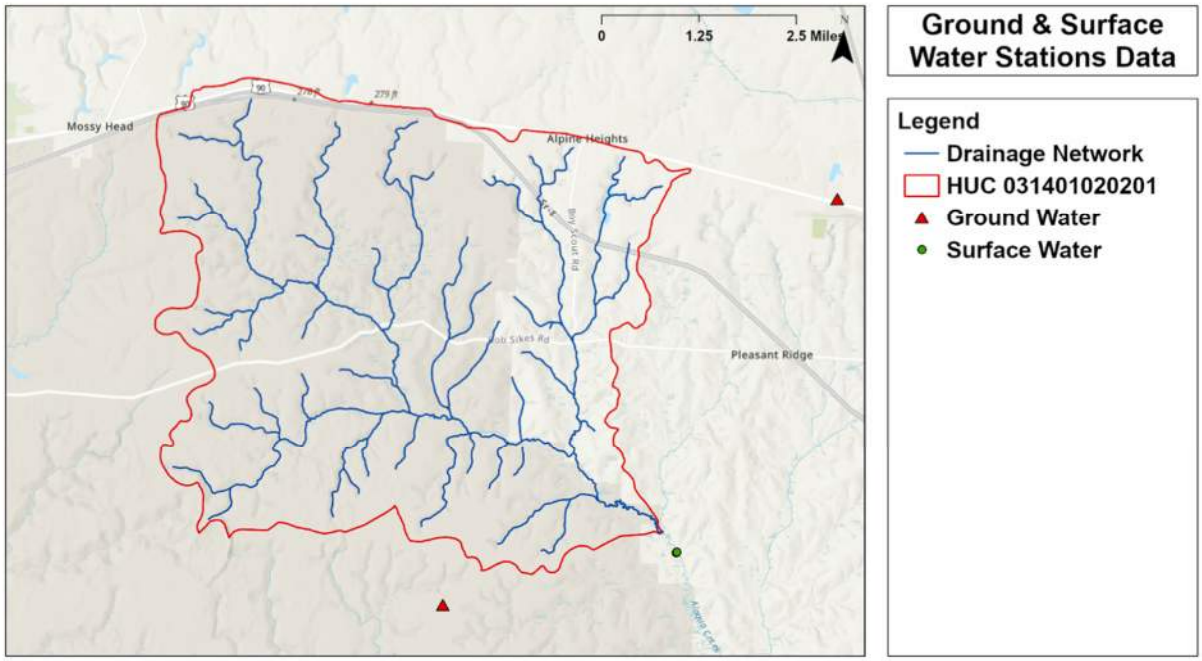

Figure 9. Ground and Surface Water Stations in the HUC 031401020201 sub-watershed, processed by FAU.

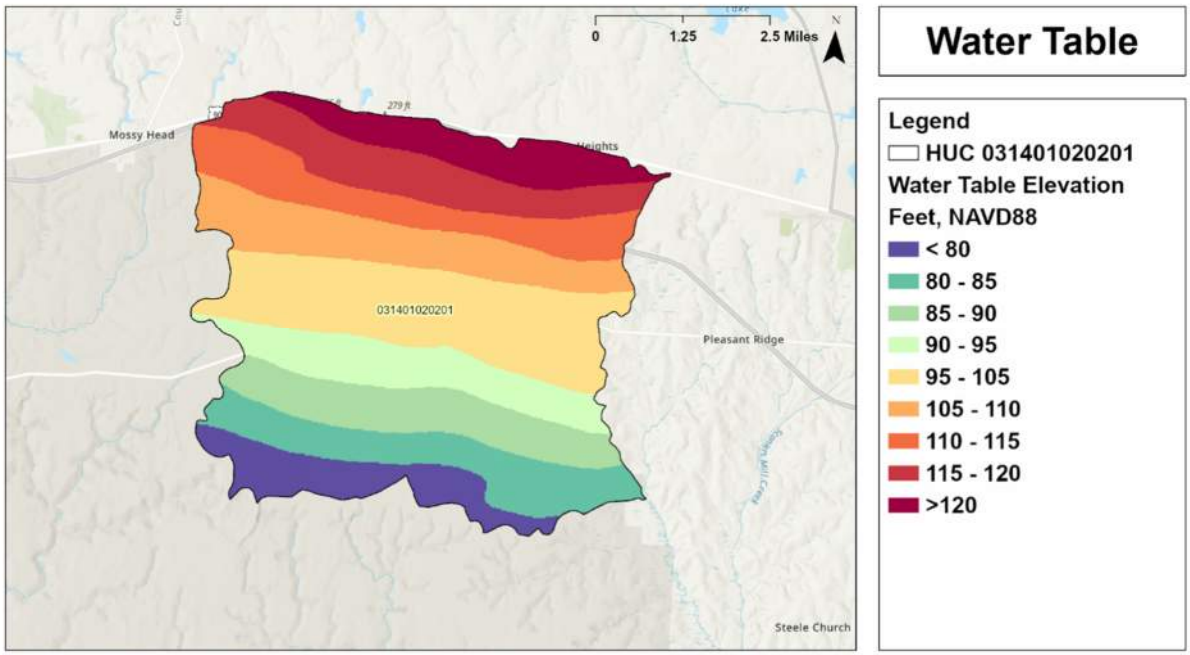

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401020201 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

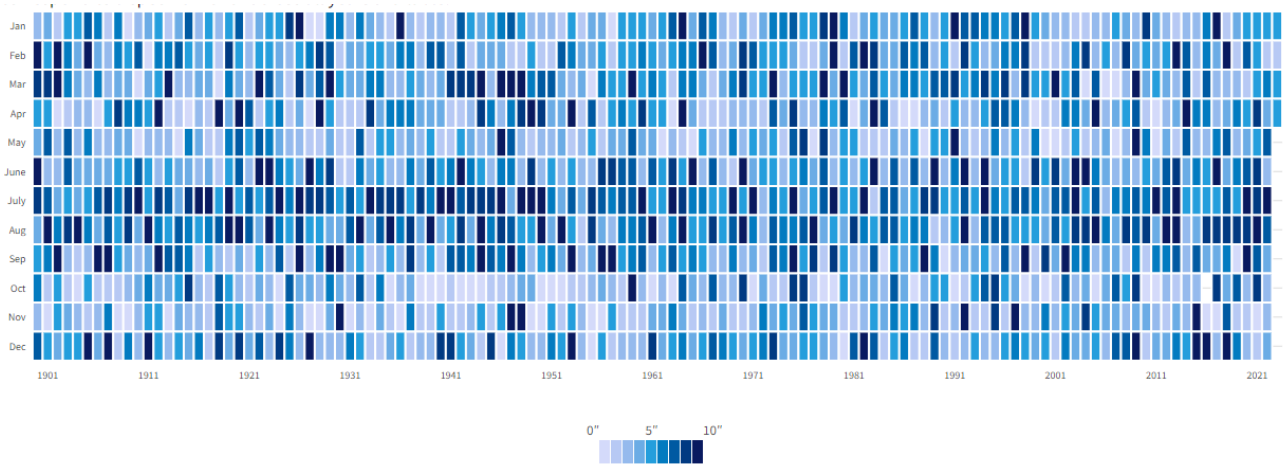

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation)

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there are no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

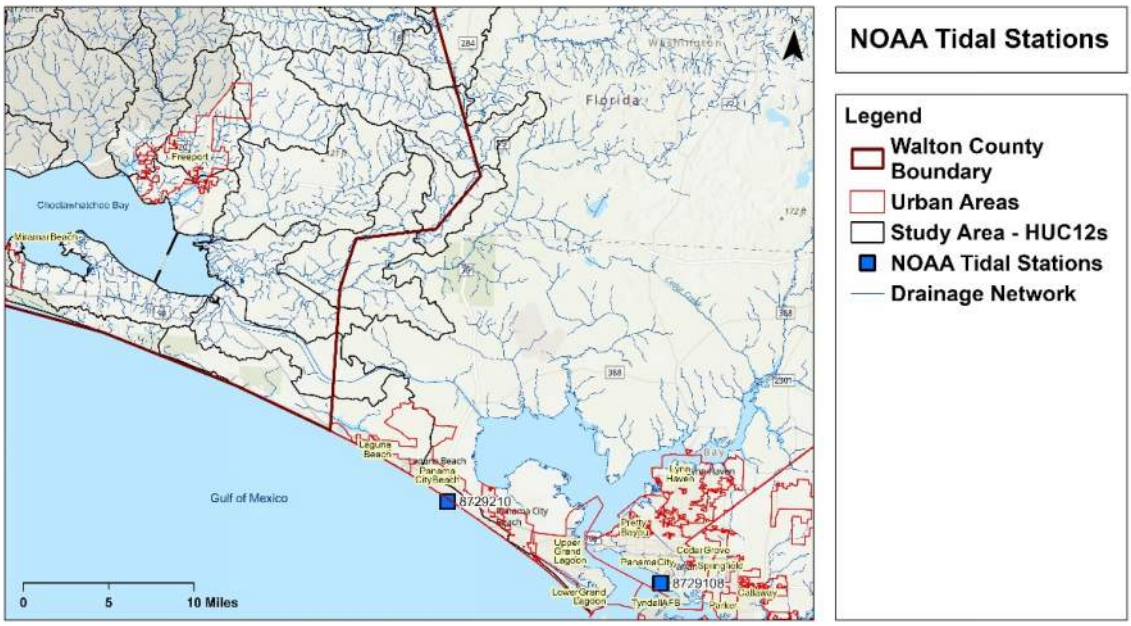

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

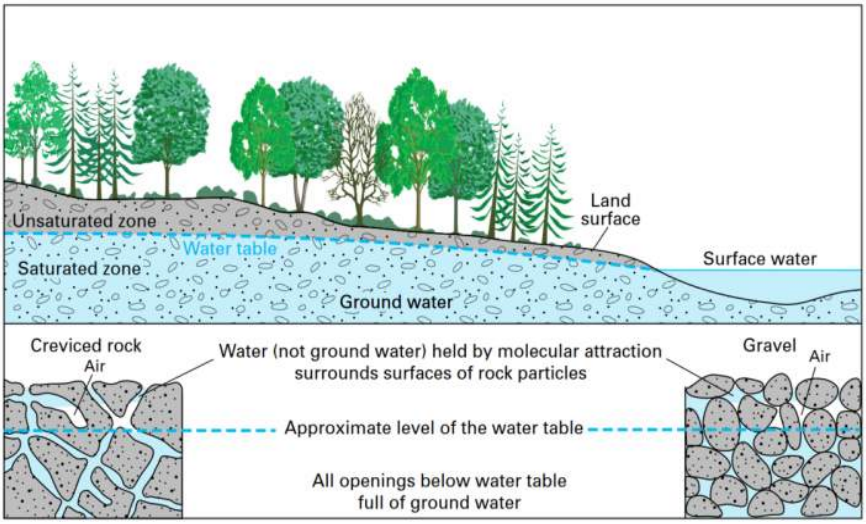

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

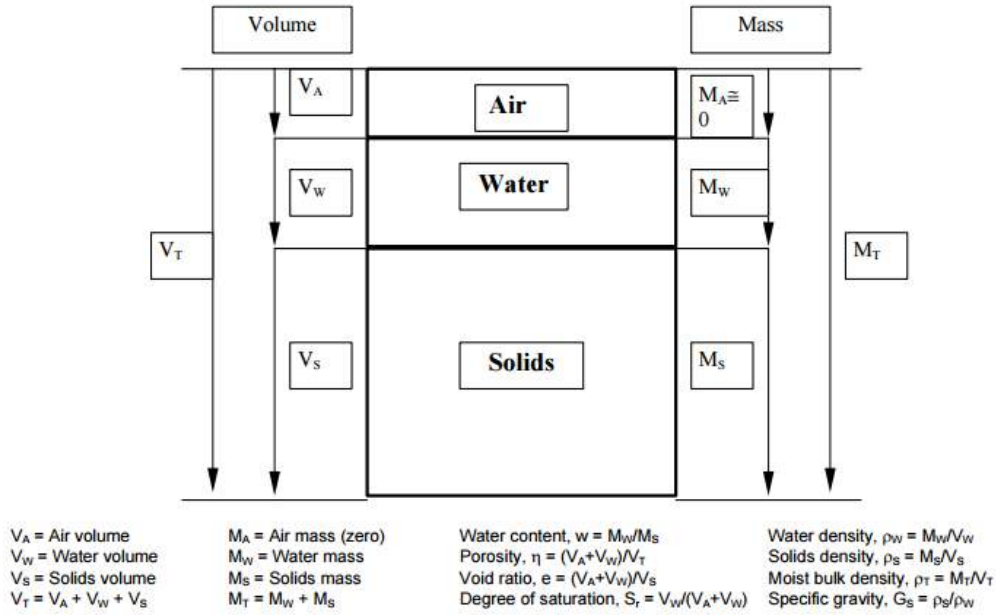

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

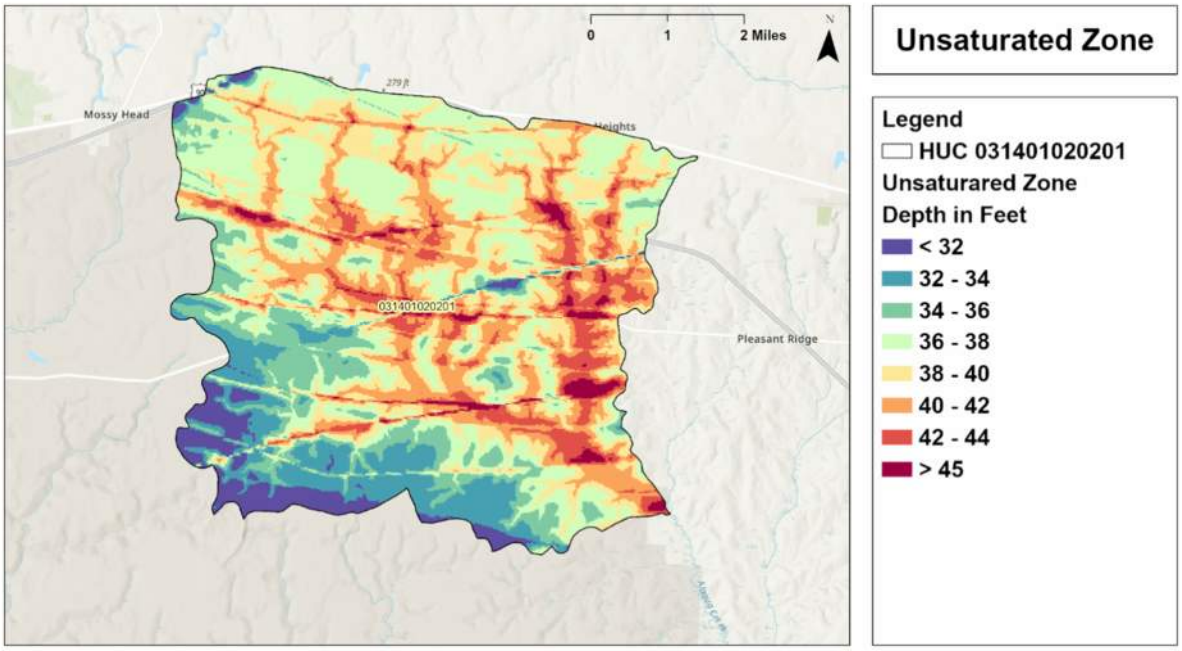

Figure 15. Unsaturated zone map for HUC 031401020201, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. Much of the basin has a medium amount of soil storage capacity, ranging between 30 to 33 inches of capacity left.

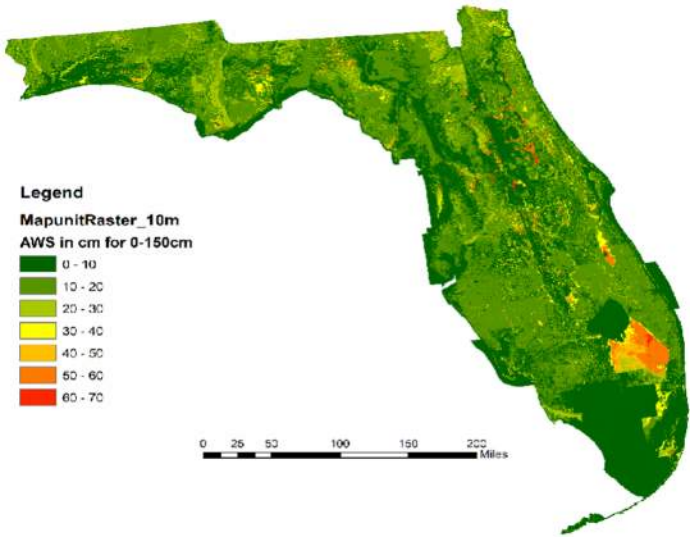

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

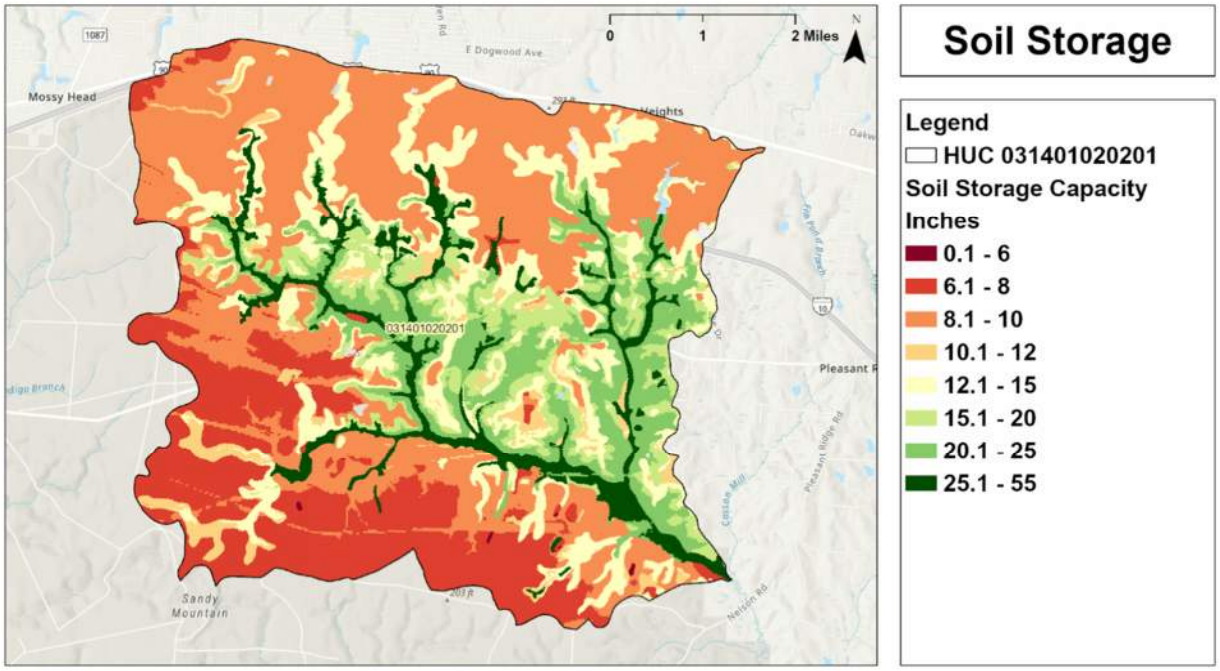

Figure 17. Water storage capacity of soil for the HUC 031401020201 (inches), processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

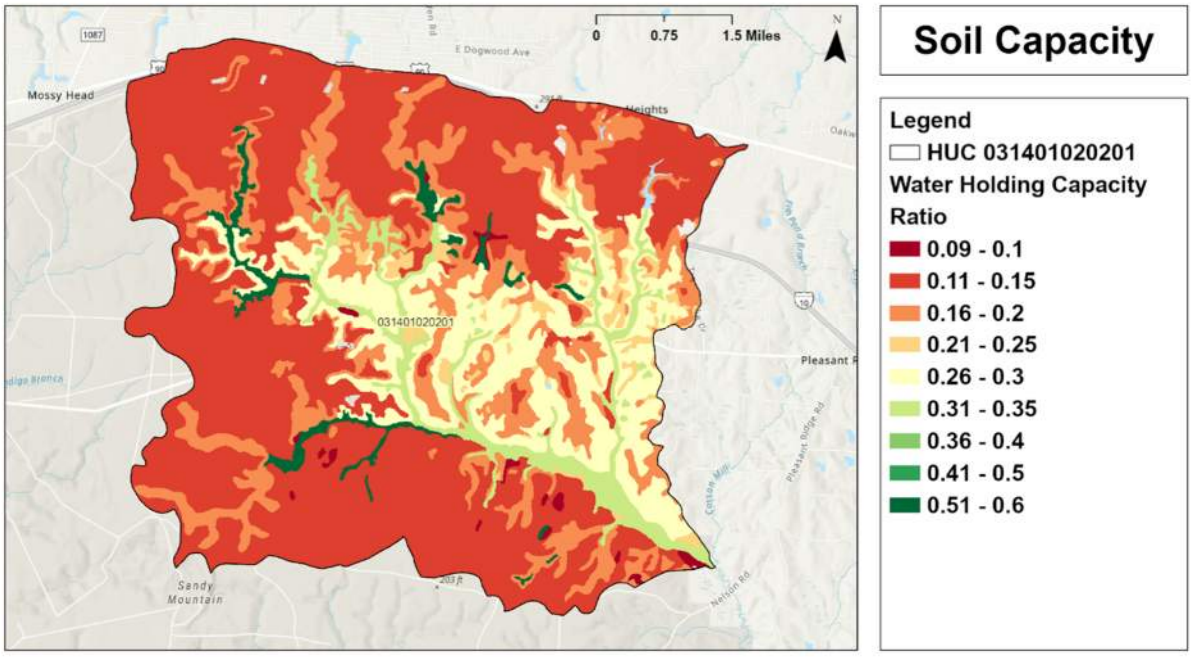

Figure 18. Water Holding Capacity (ratio) for the HUC 031401020201, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

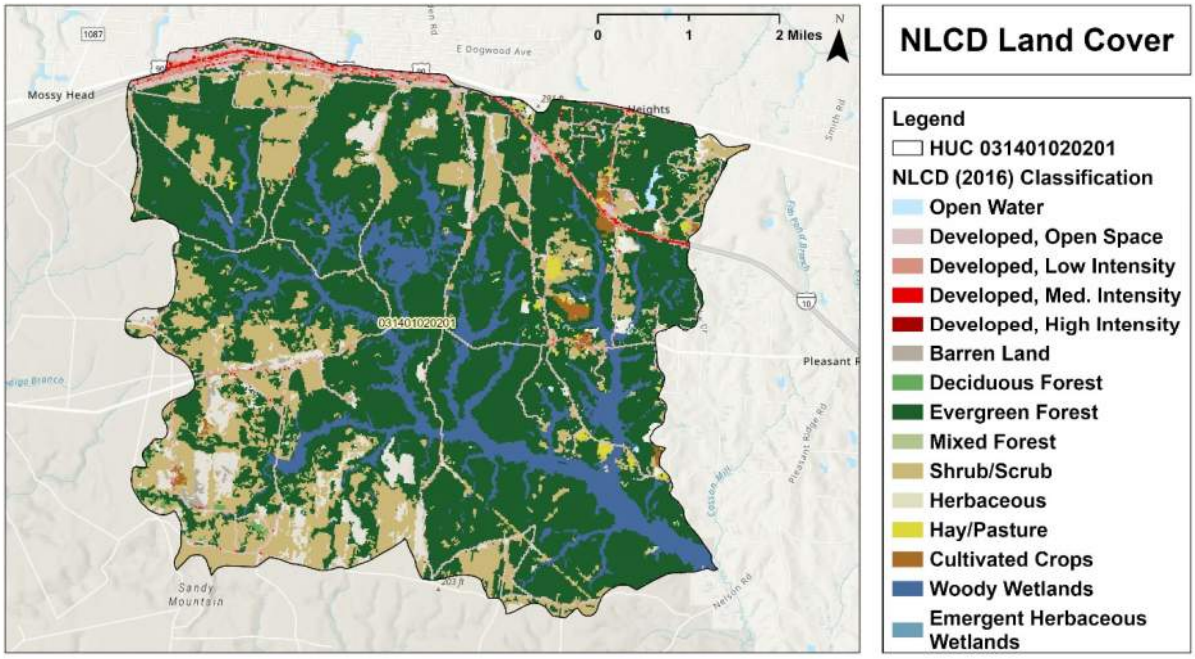

Figure 19. Land use in the HUC 031401020201 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

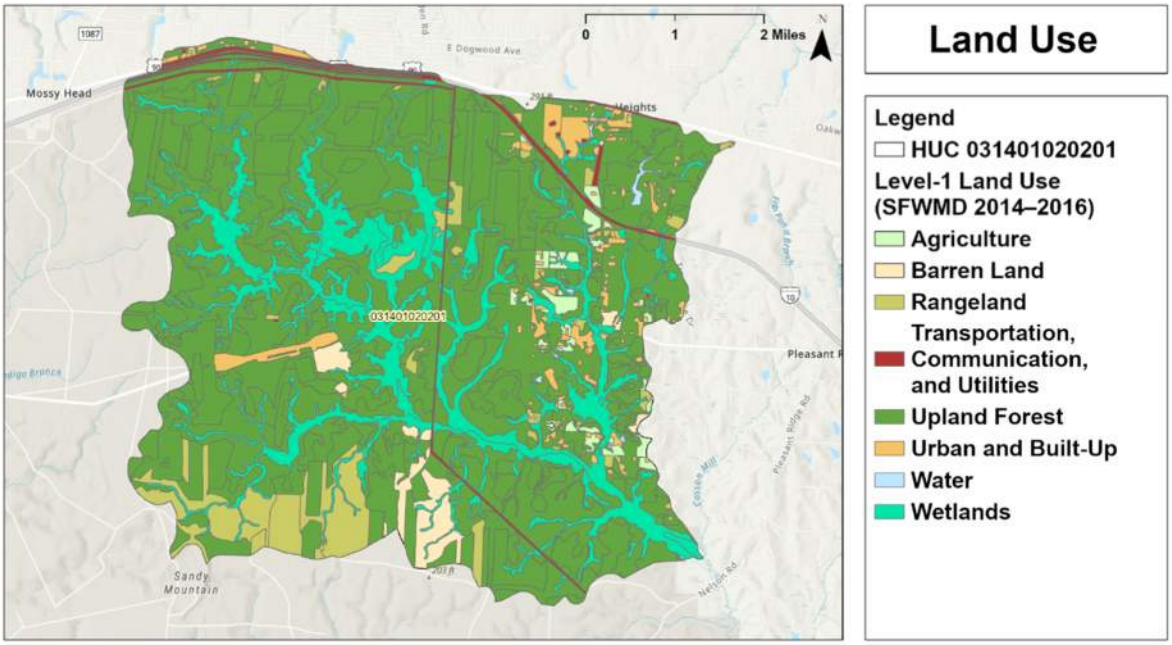

Figure 20. Land use in the HUC 031401020201 (2023 Florida Geographic Data Library (FGDL)), processed by FAU.

In the HUC 031401020201 sub-watershed, the predominant land cover is upland forest, accounting for 63.01% of the area. Wetlands comes in second at 12.11%, followed by Transportation, Communication, and Utilities at 11.21%. Developed land constitutes a minor portion, with only 4.48% categorized as urban and built-up, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031401020201 subwatershed 2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	383.10	1.38%
Barren Land	460.19	1.66%
Rangeland	1658.67	5.97%
Transportation, Communication, and Utilities	3113.39	11.21%
Upland Forest	17496.02	63.01%
Urban and Built-Up	1245.00	4.48%
Water	48.90	0.18%
Wetlands	3362.85	12.11%
Grand Total:	**27768.13**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

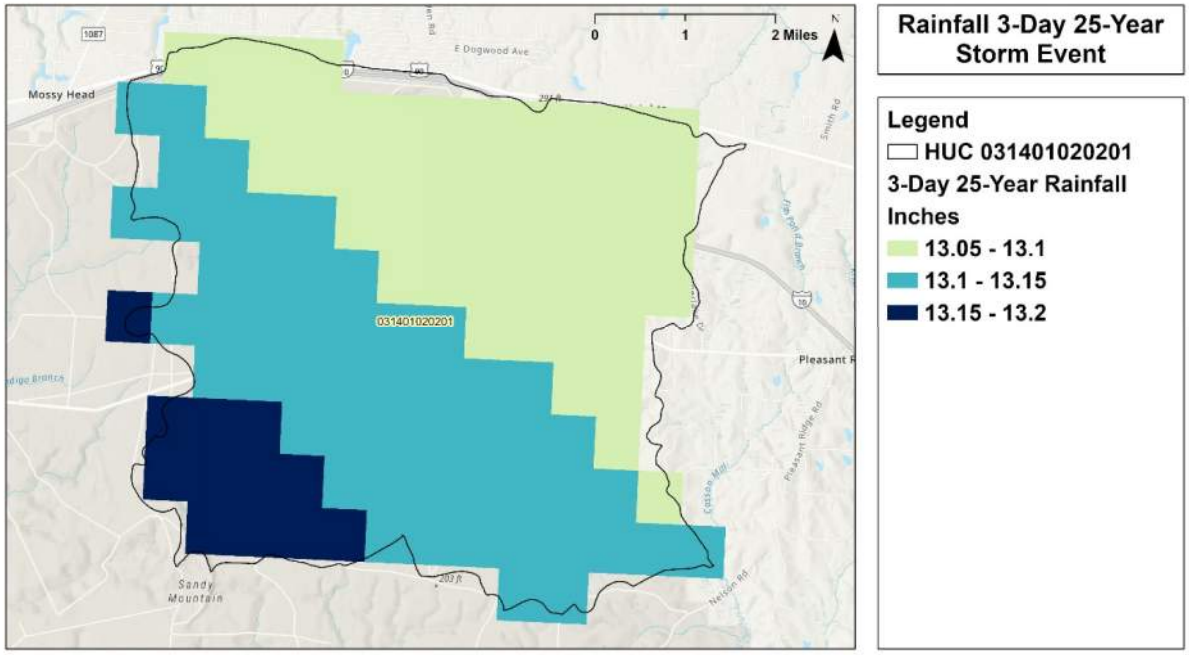

Figure 21. Rainfall distribution map across HUC 031401020201 sub-watershed, for 3-day 25-year storm event, processed by FAU.

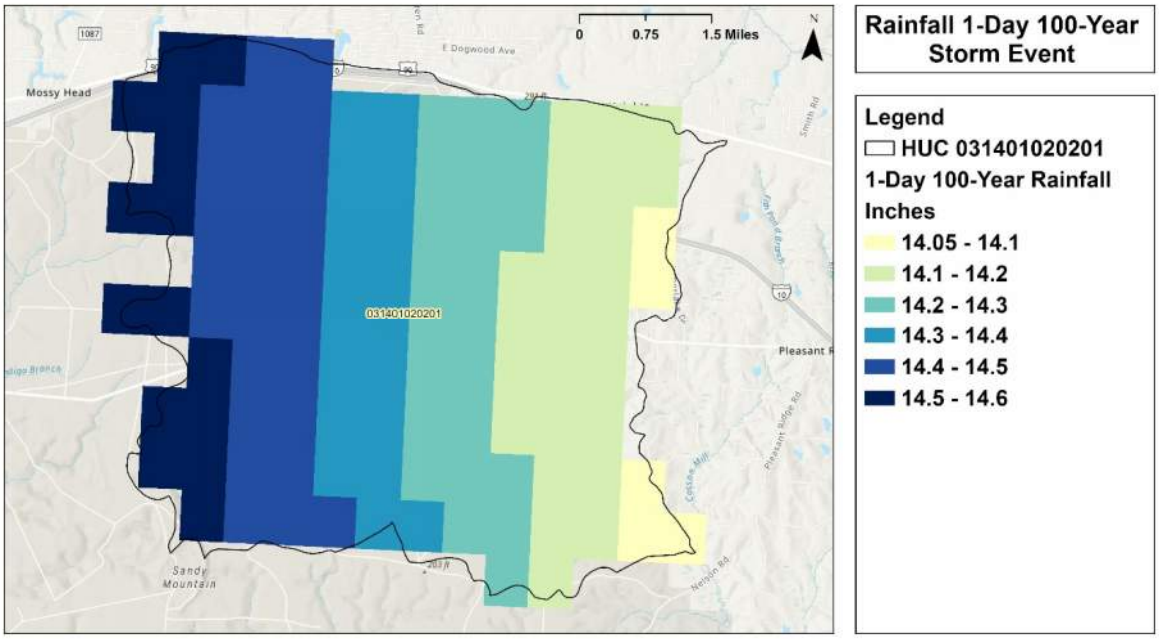

Figure 22. Rainfall distribution map across HUC 031401020201 sub-watershed, for 1-day 100-year storm event, processed by FAU.

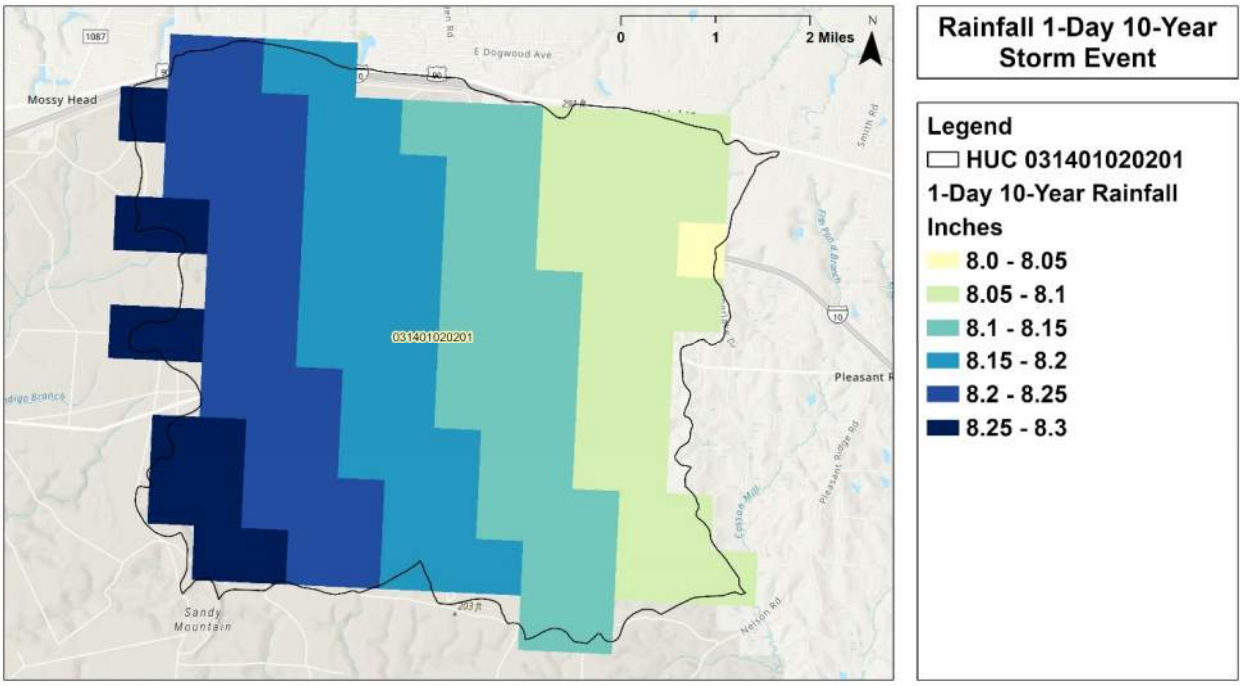

Figure 23. Rainfall distribution map across HUC 031401020201 sub-watershed, for 1-day 10-year storm event, processed by FAU.

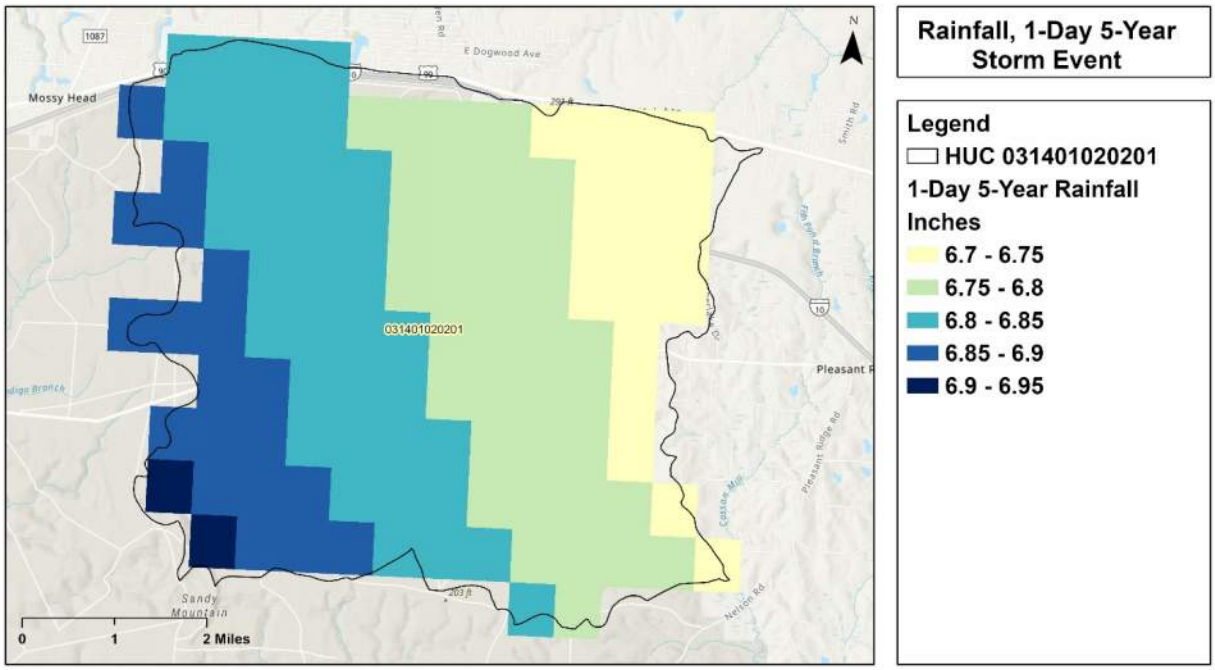

Figure 24. Rainfall distribution map across HUC 031401020201 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically

aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

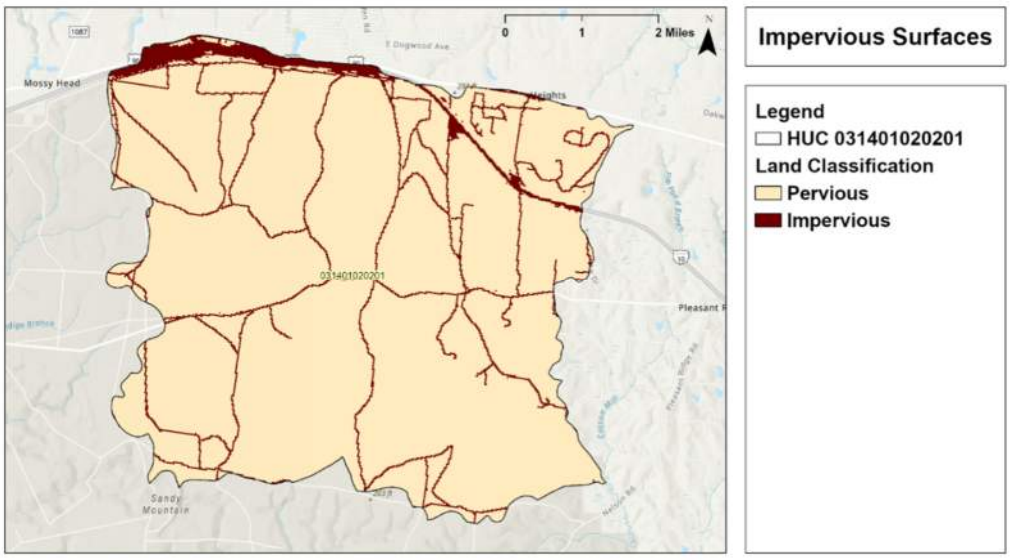

Figure 25. Impervious area map for the HUC 031401020201 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 2.4.

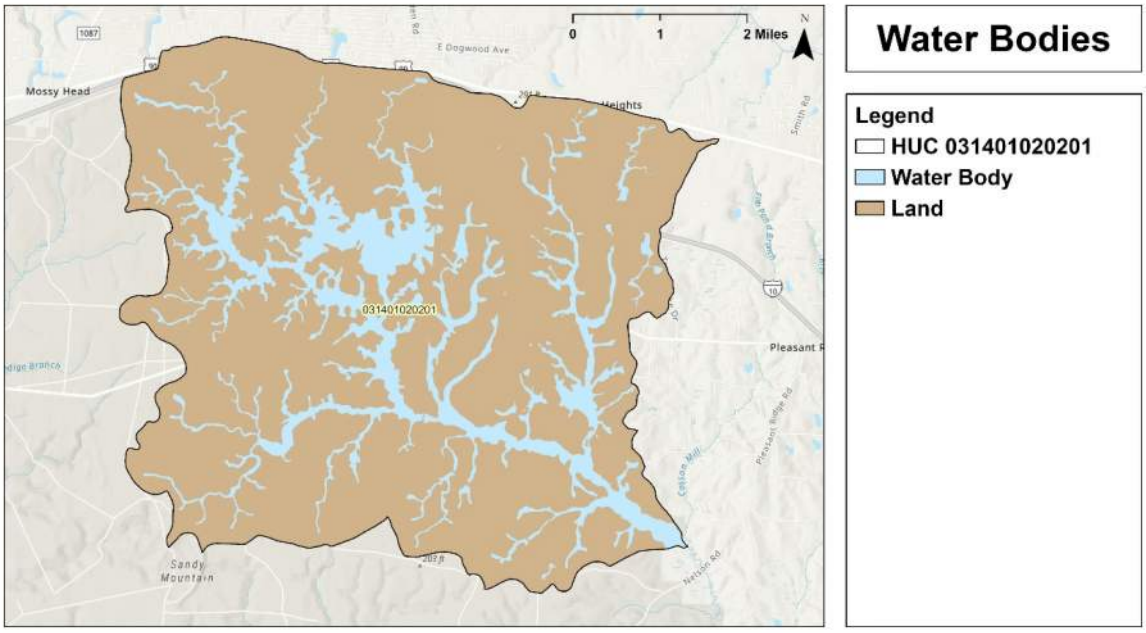

Figure 26. Water bodies map for the HUC 031401020201 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to

the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant

control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

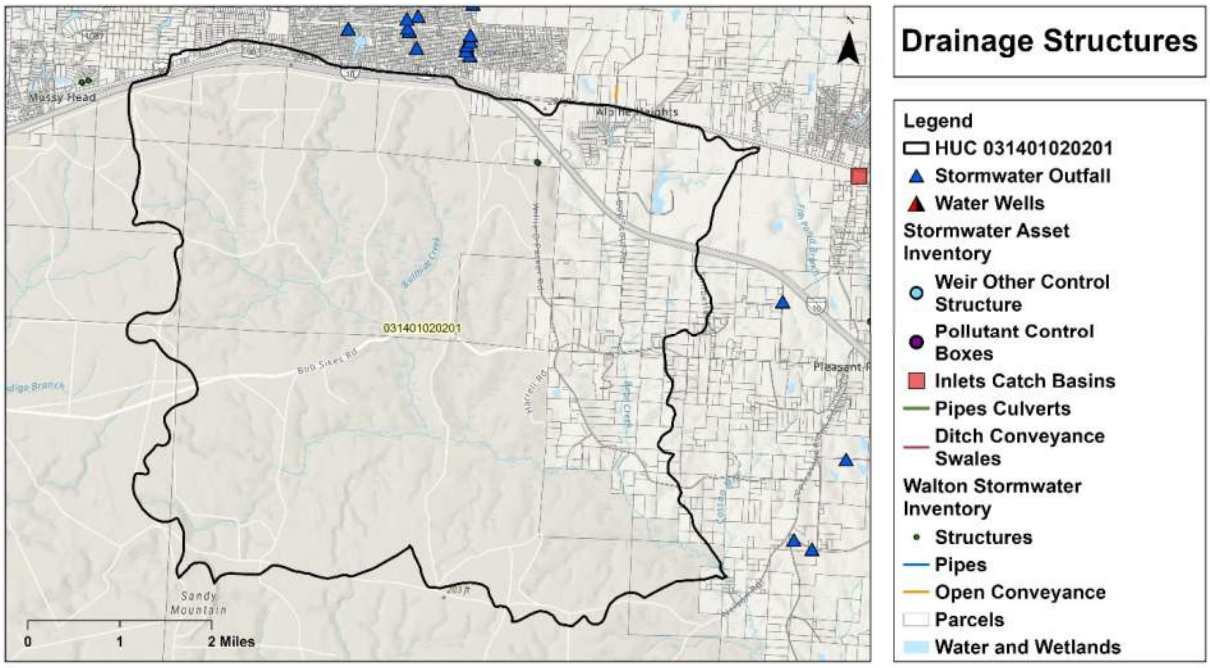

Figure 27. Stormwater Infrastructure for the HUC 031401020201. Processed by FAU.

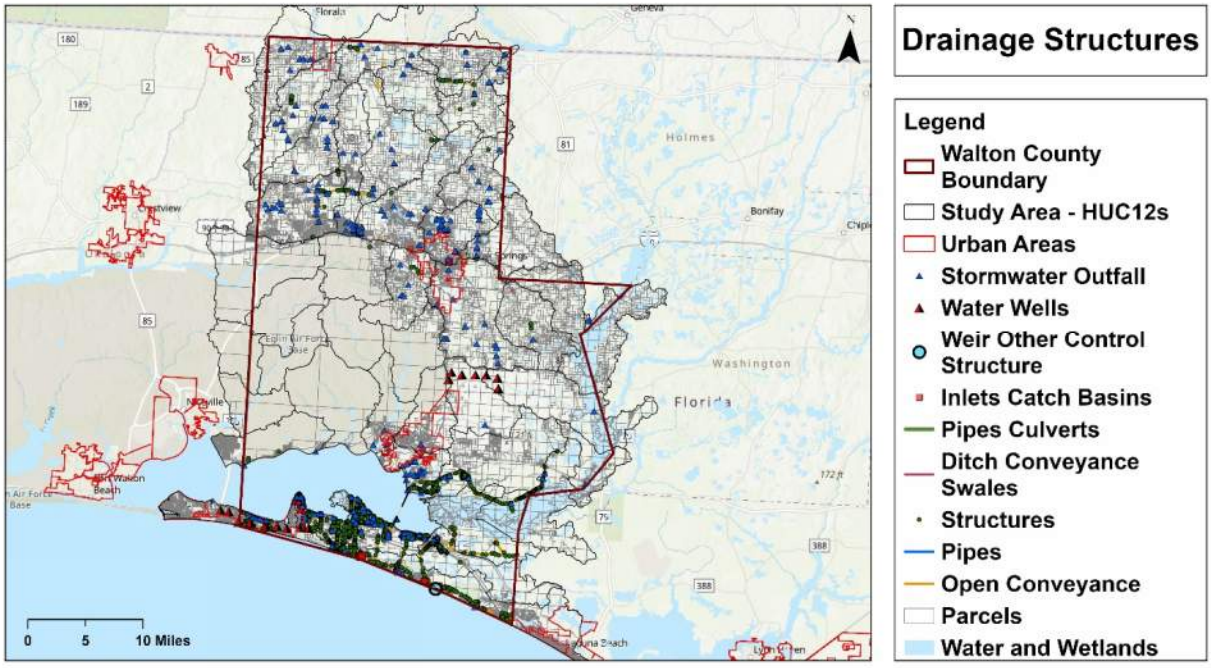

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in Table 5. The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings, as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Ground water	FL_GW	South FL Water Management District	Florida, Excel	Daily, 1980-2020	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_GW\South Florida District	140 M bytes, excel	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapter 1, and analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the 031401020201 HUC12 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the

coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. Figure 29 shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

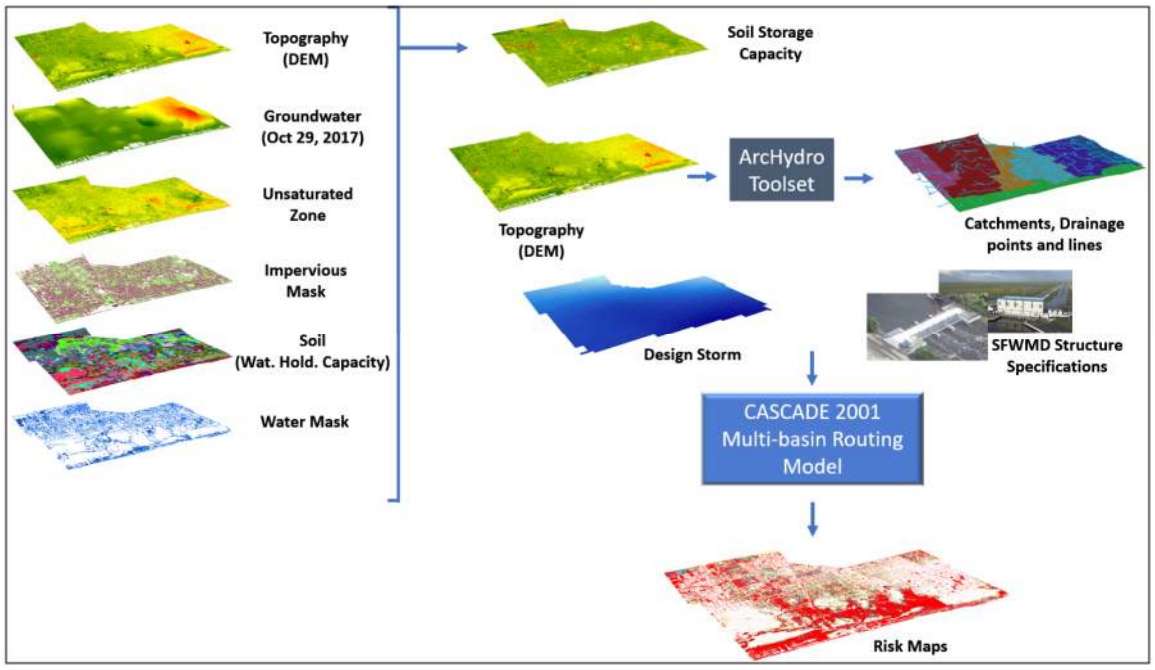

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are

critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

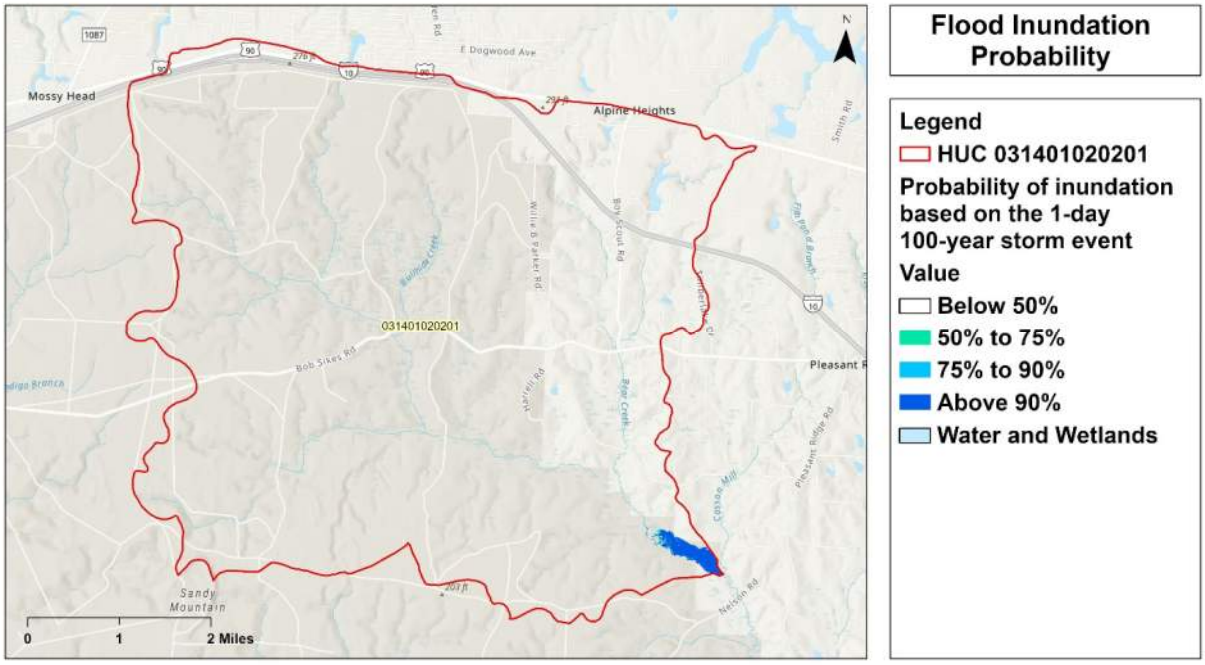

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401020201, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate

the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in

the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a small portion of flooding is noted at the entrance to the creek into the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, sea level rise should not impact the HUC, therefore SLR scenarios were not calculated.

The design storm simulation determined that approximately 0.2% of the HUC total area or 0.07 mi² has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 0.4% of the HUC's total area, or 0.13 mi² would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.2% of the HUC's total area, or 0.06 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0.2% of the HUC's total area, or 0.06 mi², would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401020201 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	31.92	0.07	99.8%	0.2%
1-day 100-year	31.87	0.13	99.6%	0.4%
1-day 10-year	31.93	0.06	99.8%	0.2%
1-day 5-year	31.94	0.06	99.8%	0.2%

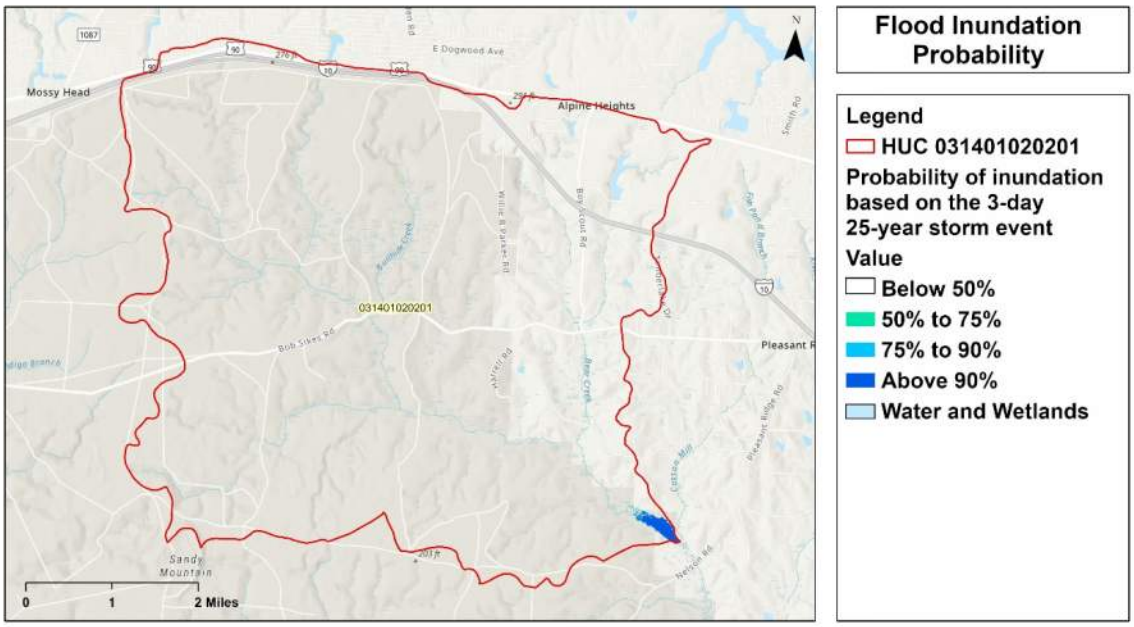

Figure 31. 3-day 25-year storm event for HUC 031401020201 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

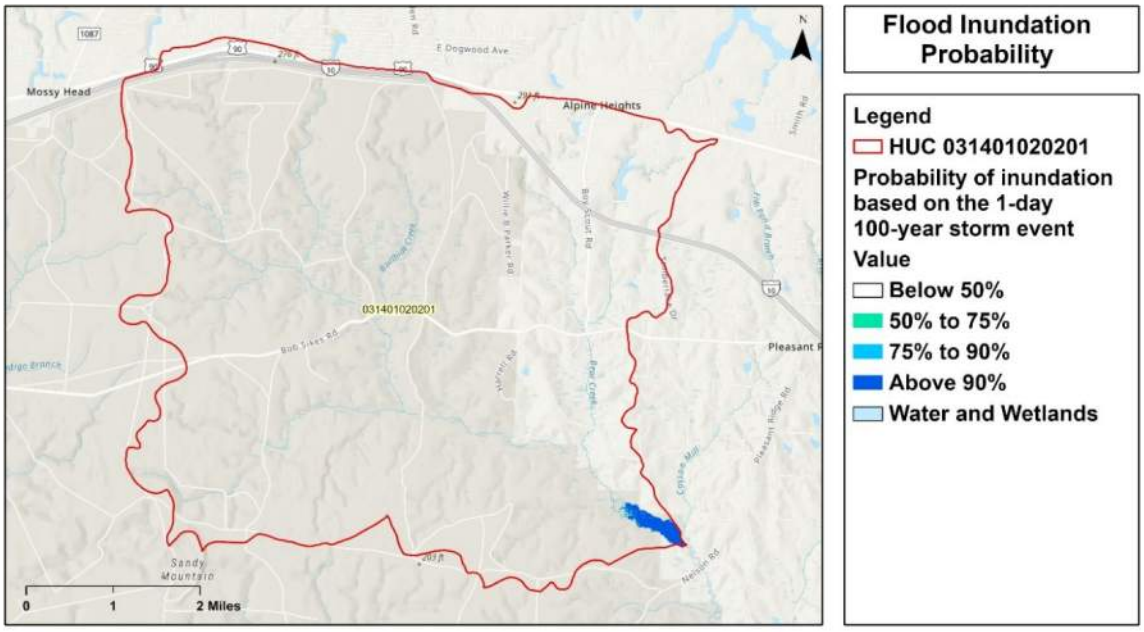

Figure 32. 1-day 100-year storm event for HUC 031401020201 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

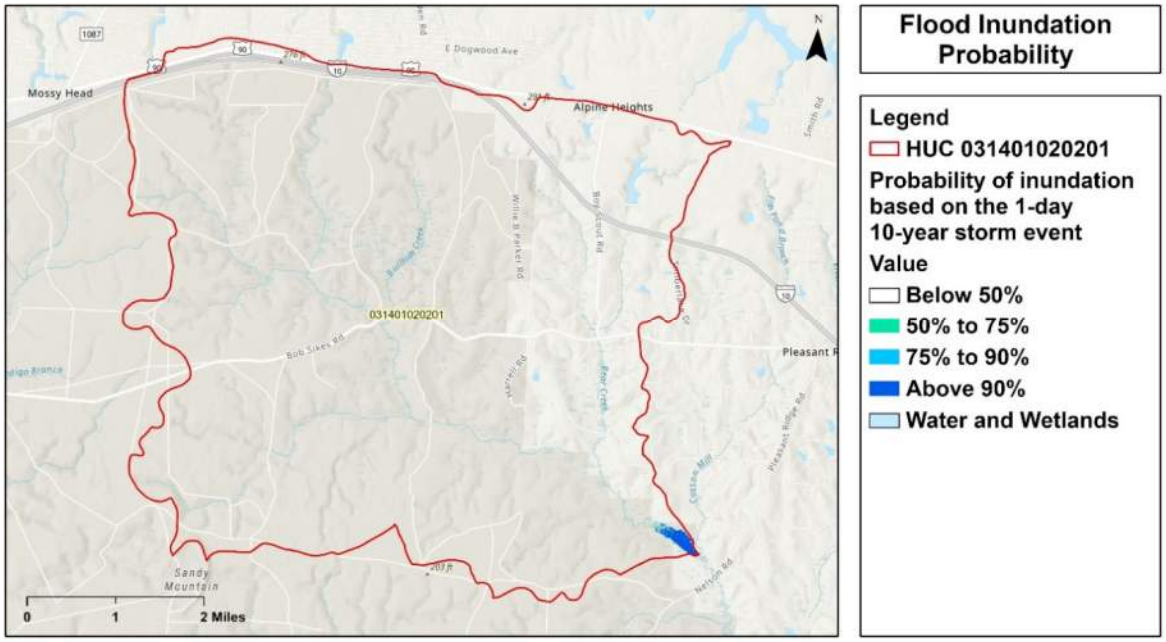

Figure 33. 1-day 10-year storm event for HUC 031401020201 sub-watershed
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

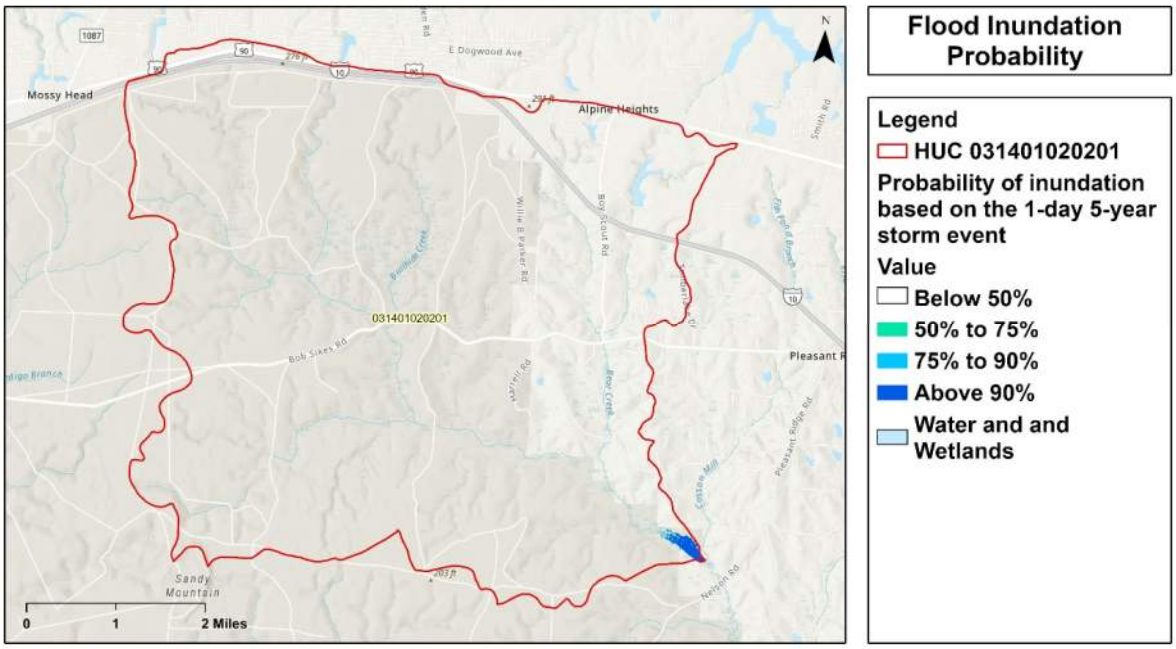

Figure 34. 1-day 5-year storm event for HUC 031401020201 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6

11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3

40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6

67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6

99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.**depict the HUC 031401020201 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.**is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.**illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

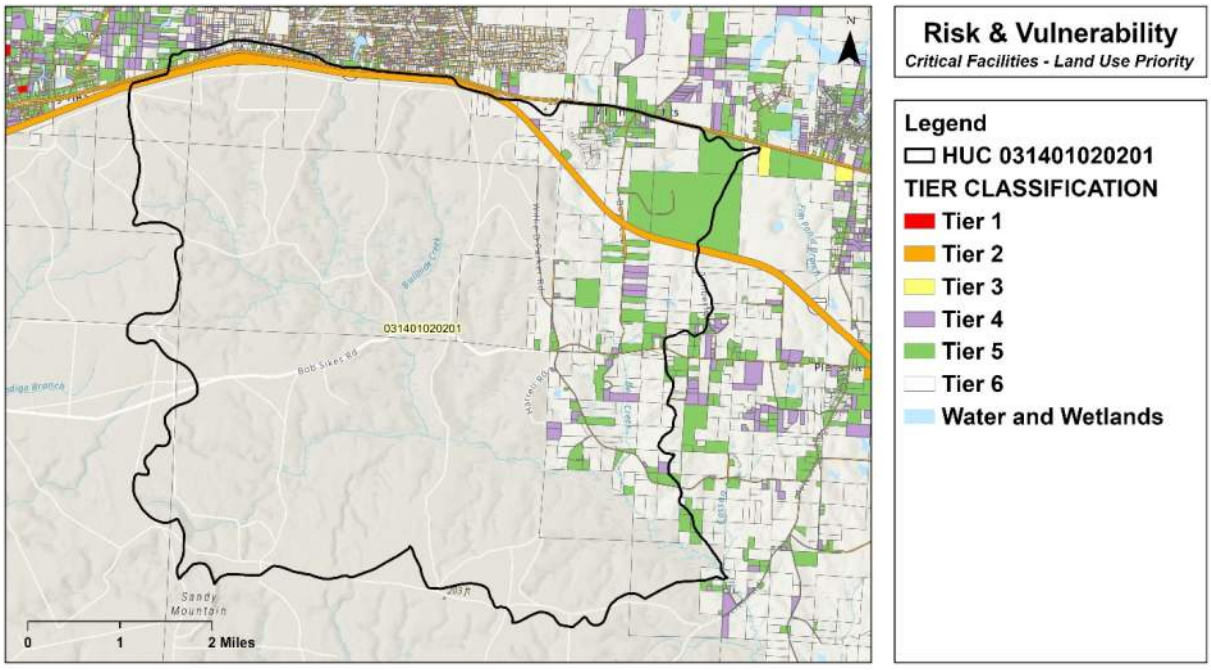

Figure 35. HUC 031401020201 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

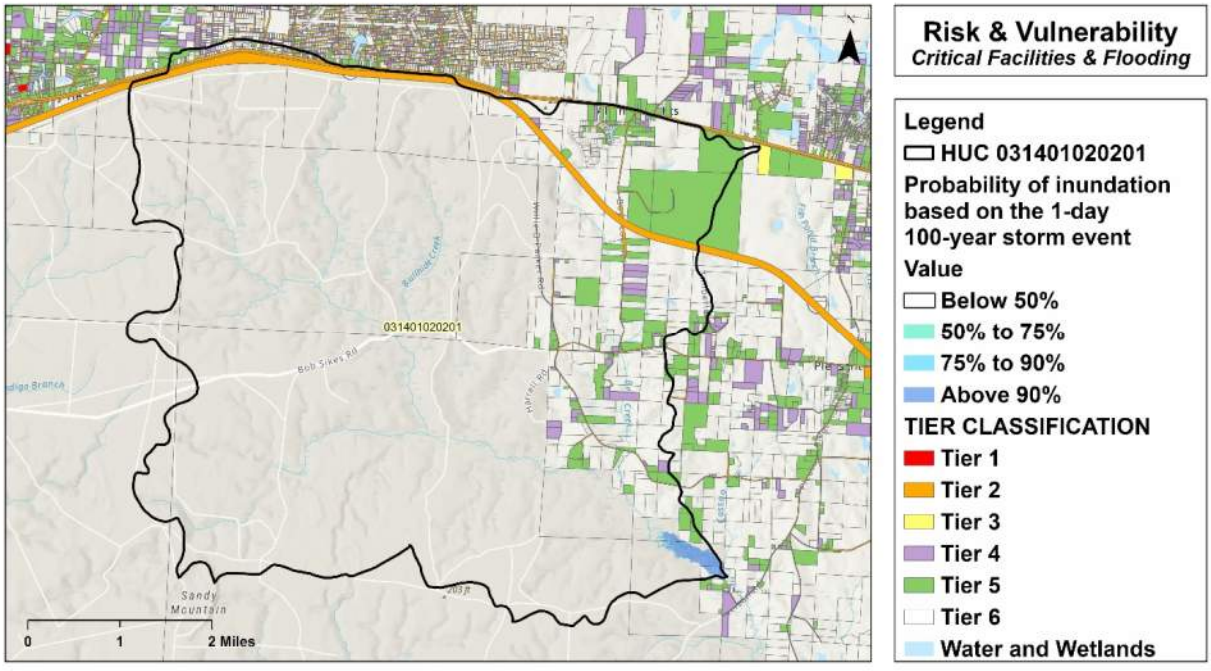

Figure 36. HUC 031401020201sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

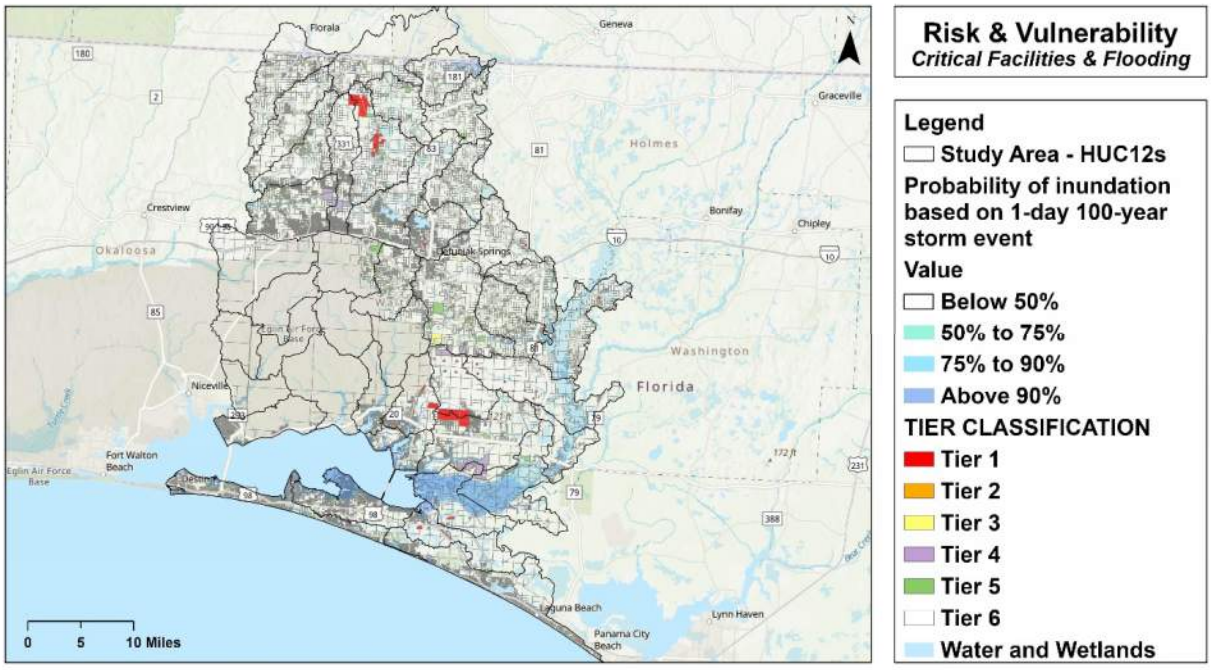

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

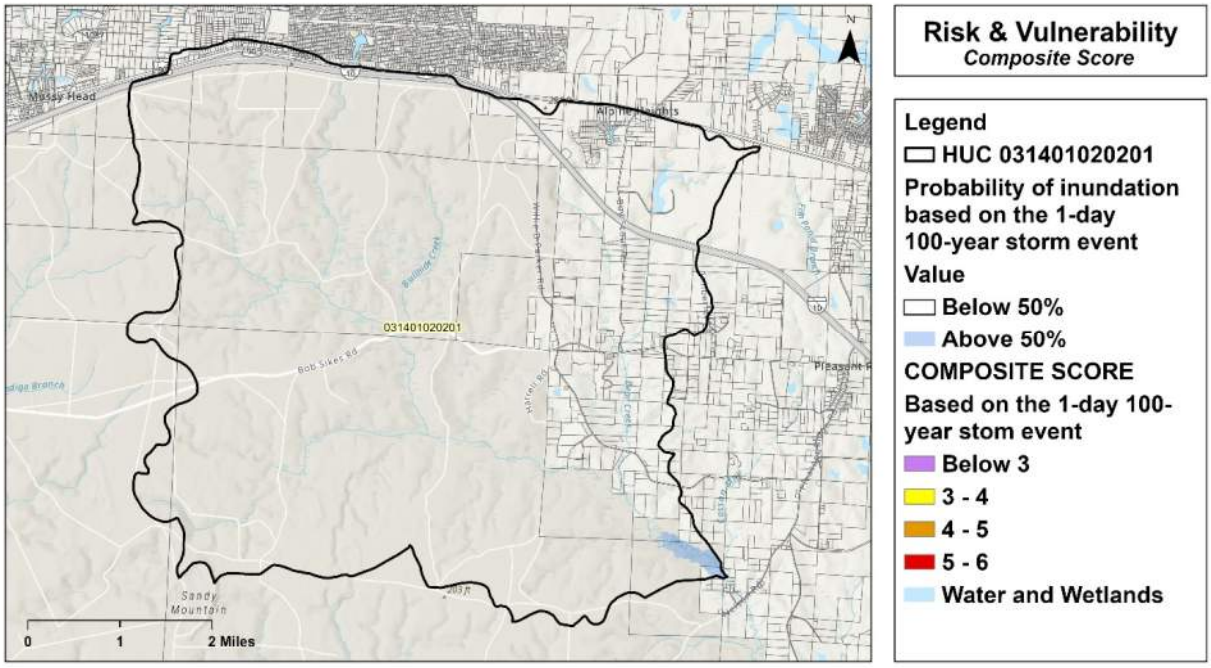

Figure 38. HUC 031401020201 sub-watershed Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

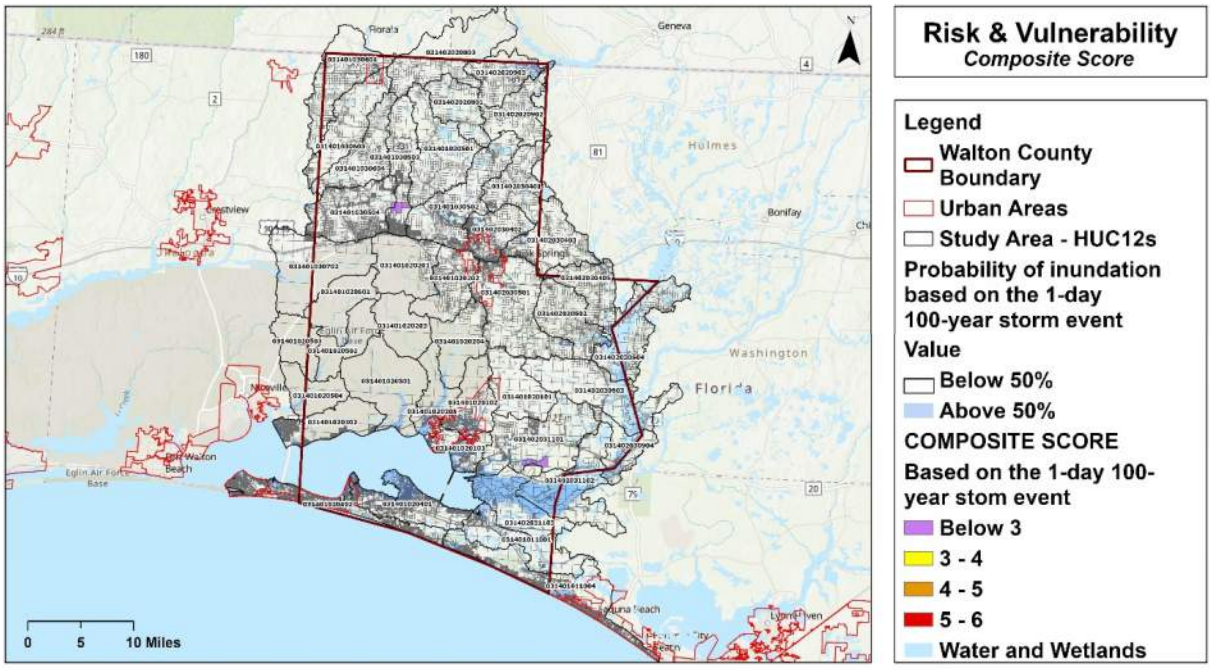

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.
Please note that due to the scale of the map, the composite score layer is not properly visible in this map.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401020201. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401020201. Processed by FAU.

AREAS	ACRES
HUC-12 Sub-watershed: 031401020201	20477.60
All of the 1-day 100-year storm event inundation	**82.59**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	69.74
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	12.85
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	12.85

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

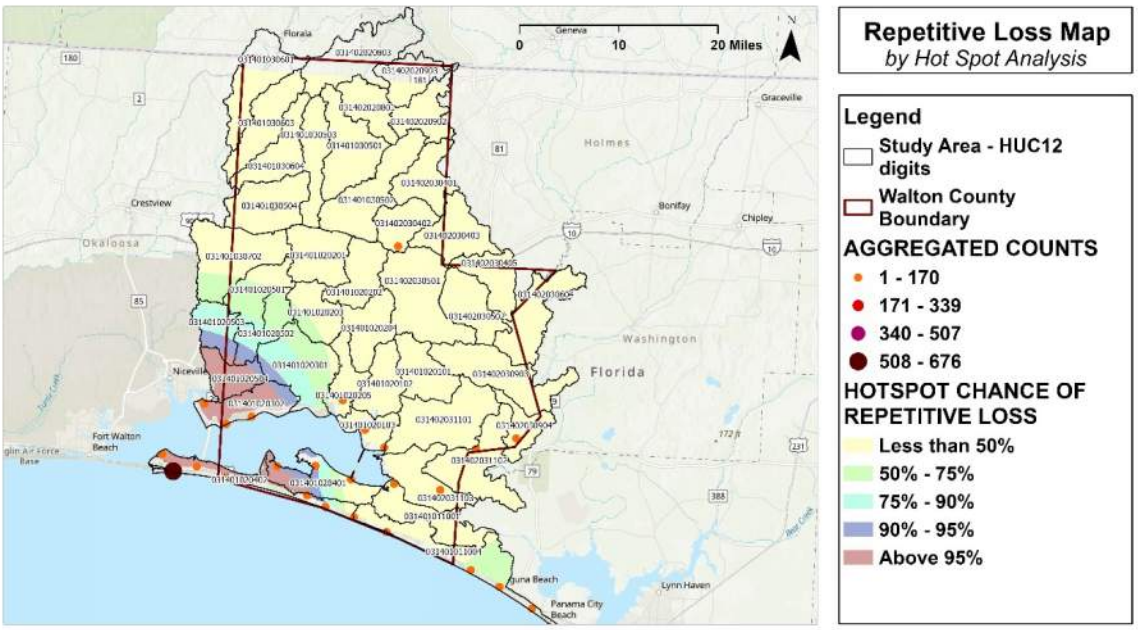

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5. Priority Projects

Considering the priority of land uses within the basin, there are a few parcels classified as tier 4 and 5, indicating a lower priority for intervention. Notably, there are no critical facilities (tier 1) within the basin, indicating that critical infrastructure is not directly affected by the flooding.

It is worth mentioning that there is one important road, the Interstate I-10, and other local roads, categorized as tier 2 within the basin. However, these roads are fortunately not situated in the flooding zone, suggesting that key transportation infrastructure remains unaffected by the current flood conditions in the area.

When considering the composite score, it notable that there is no critical facilities situated within the flooding zone, once flooding in the area is relatively minor and not alarming, indicating no necessity for priority projects intervention within the basin.

More detail about flood solutions are described in the community plan and in Section 5.5 where drilldown to specific neighborhoods is outlined.

APPENDIX H

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401020202

MIDDLE ALAQUA CREEK

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Research Assistant: Leticia Sabio

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401020202) is highlighted among all the HUCs to help identifying its location.

The city of DeFuniak Springs shares a portion of its boundary with the basin. Demographics data and other considerations of DeFuniak Springs, along with other cities in Walton County, will be discussed later.

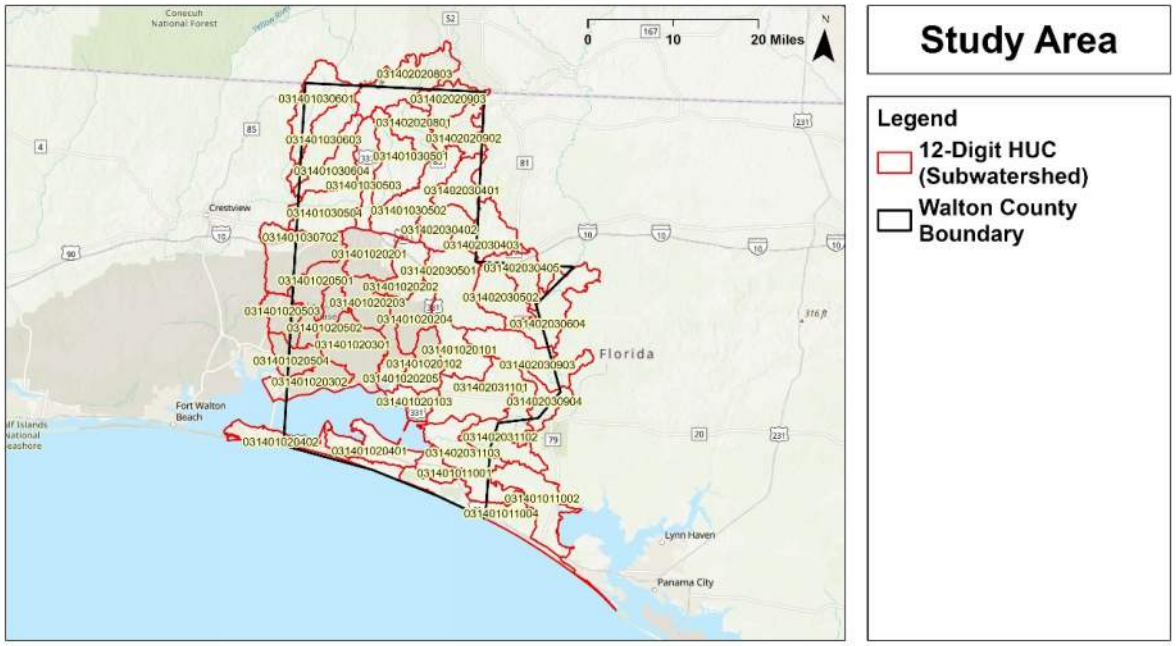

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

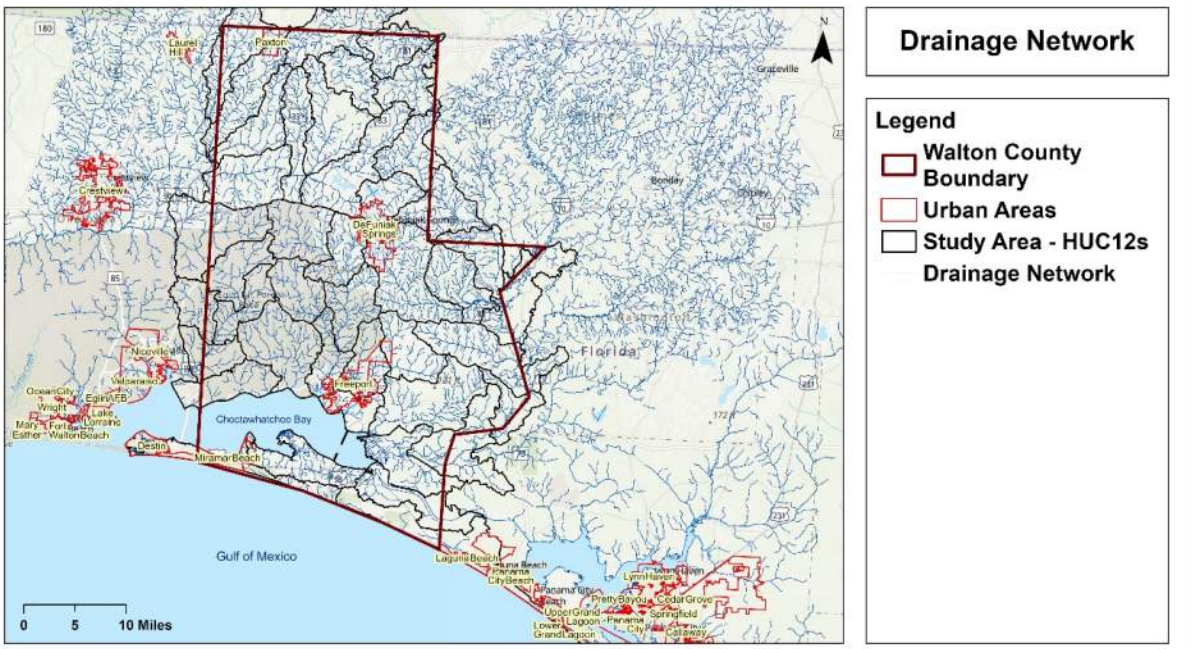

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

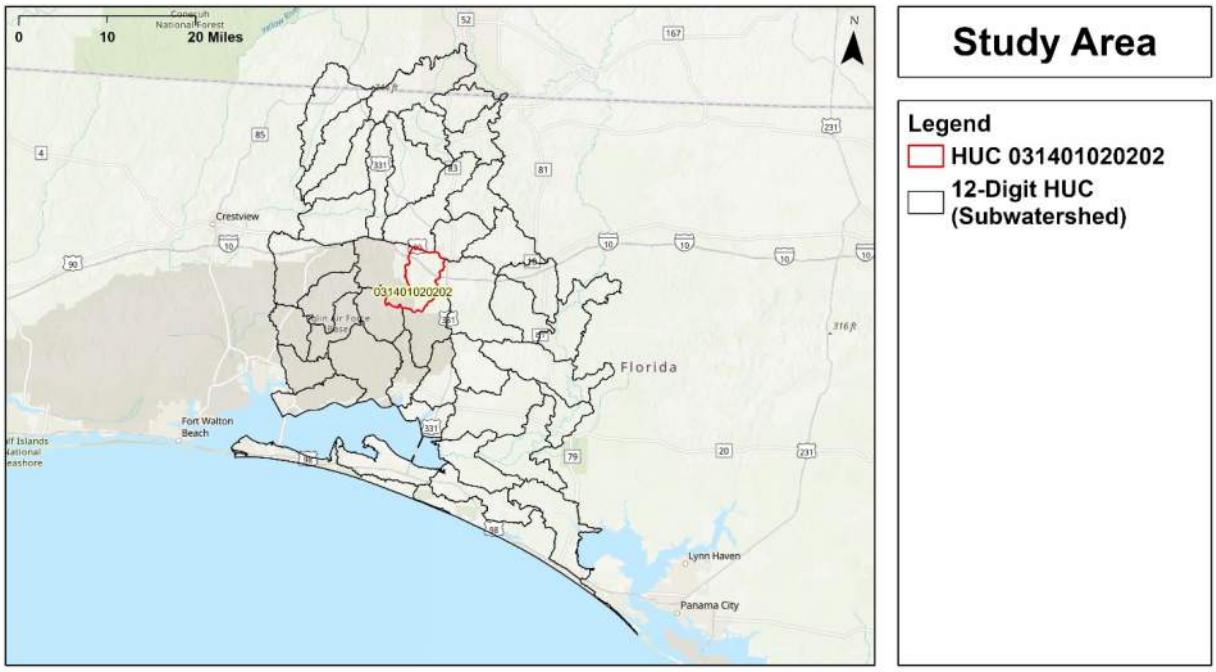

Figure 3. HUC 031401020202 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development, tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Based on the future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with

high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

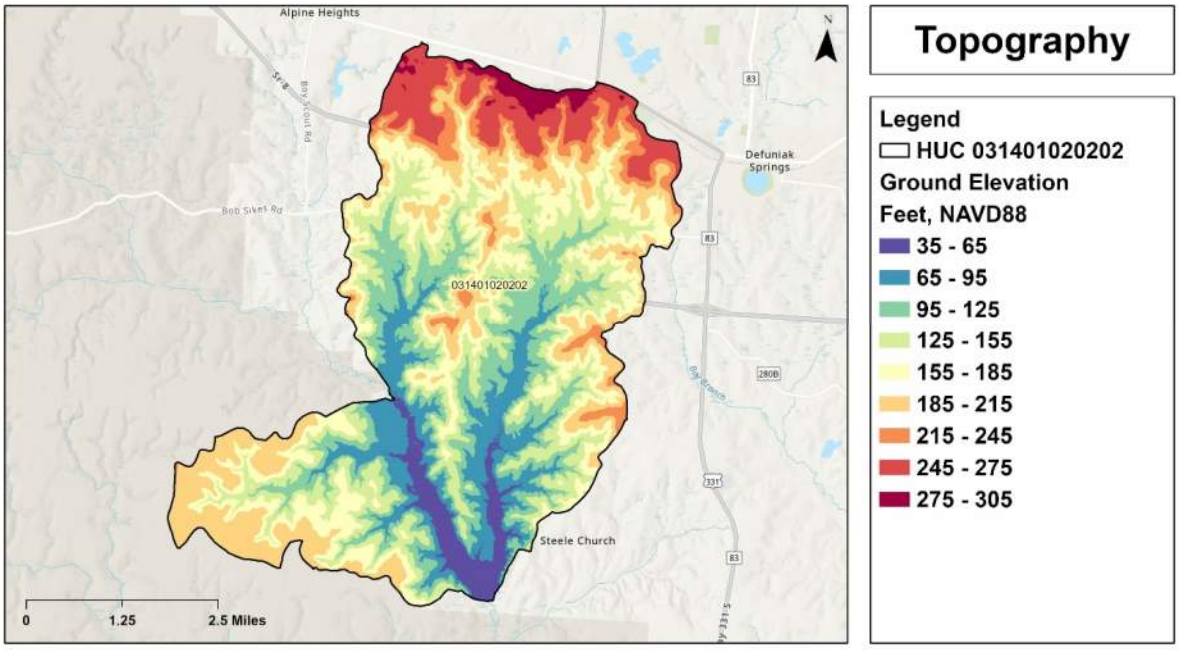

Figure 4. Topographic map of the HUC 031401020202 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of

wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401020202 sub-watershed is shown in **Error! Reference source not found.**.

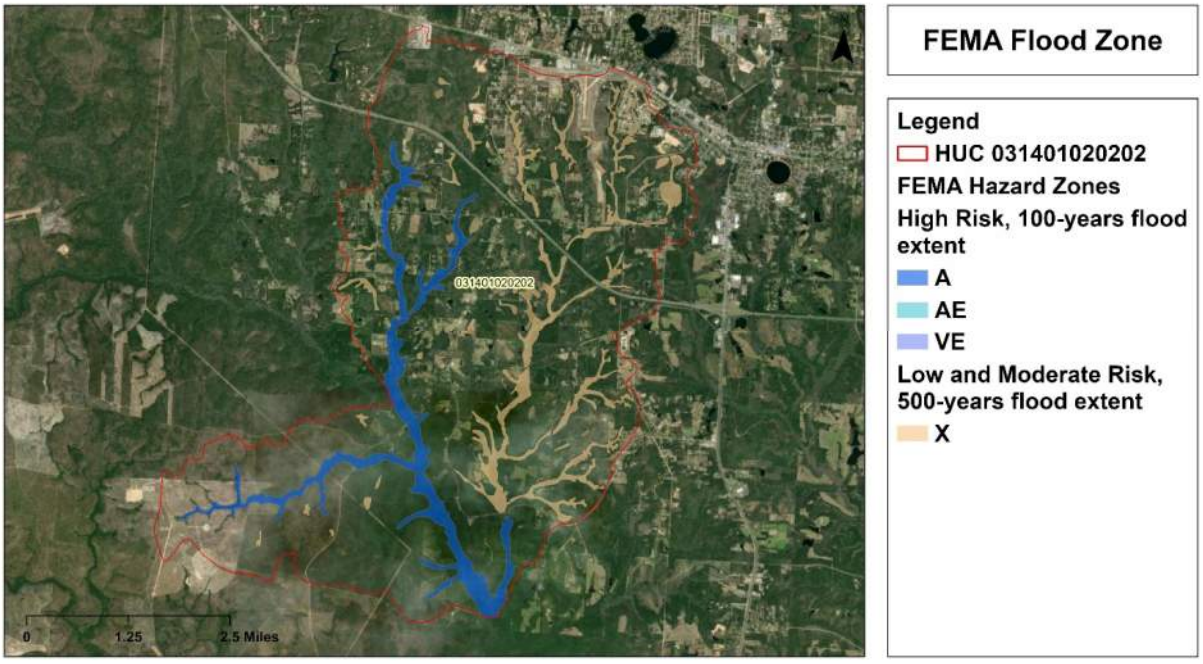

Figure 5. FEMA Flood Zone map (2020) for HUC 031401020202 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself

characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401020202 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

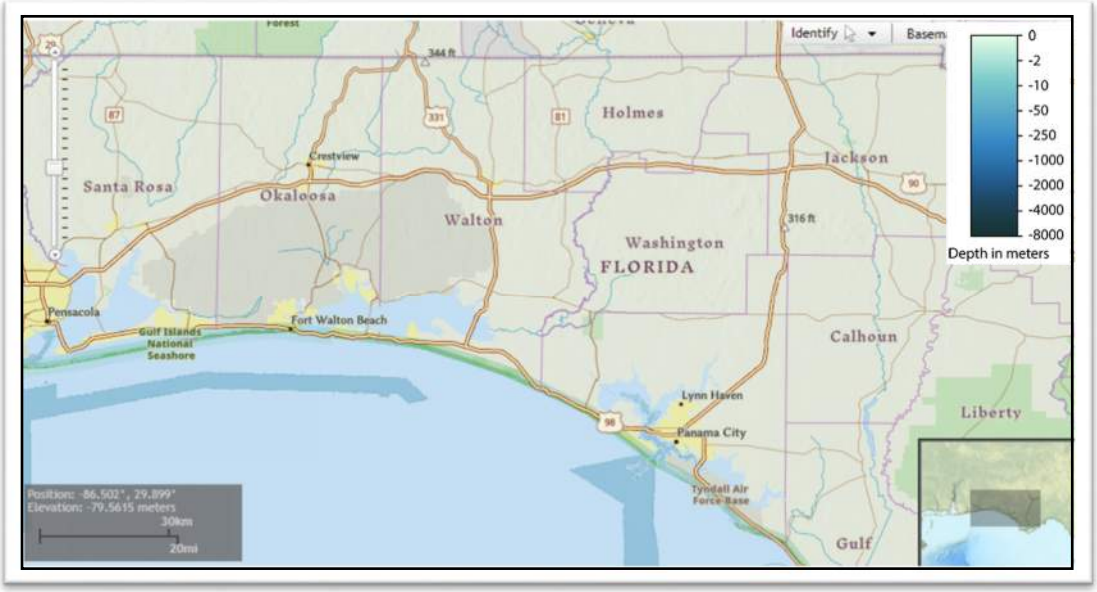

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

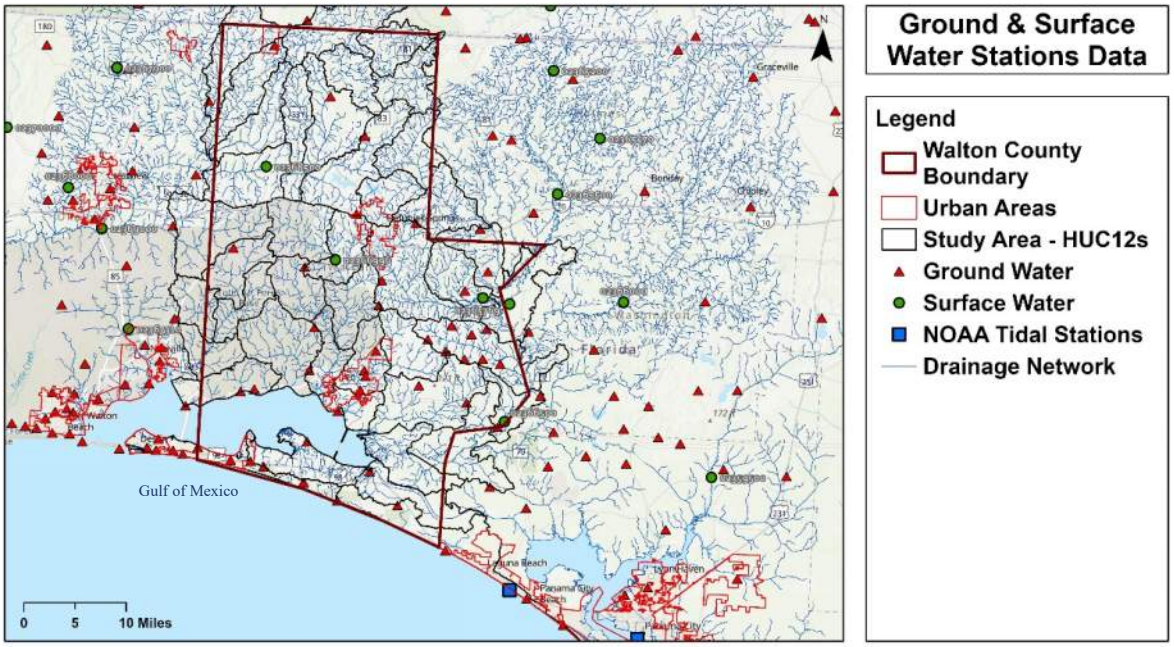

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031401020202 has no major rivers and canals, but creeks and branches, include:

- Alaqua Creek
- Sconiers Mill Creek
- Oakie Creek
- Cosson Mill
- Fish Pond Branch
- Heidelberg Branch
- Stage Stand Branch
- Kiser Branch

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366996. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401020202, which is USGS 02366996 Alaqua Creek Near Pleasant Ridge, FL.

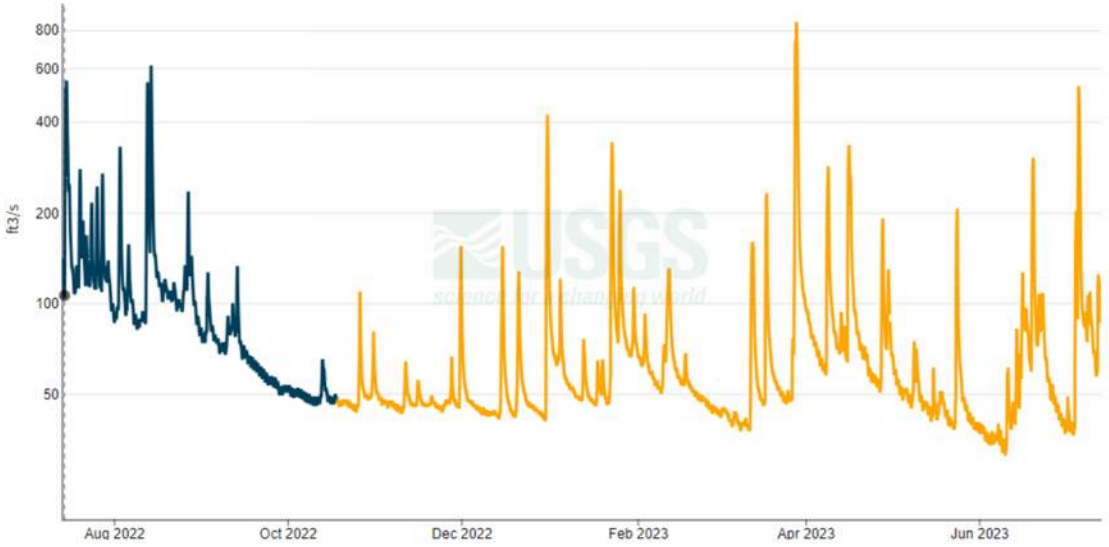

Figure 8. Average streamflow for Alaqua Creek Near Pleasant Ridge, FL (USGS 02366996 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366996/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish

a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401020202 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031401020202 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

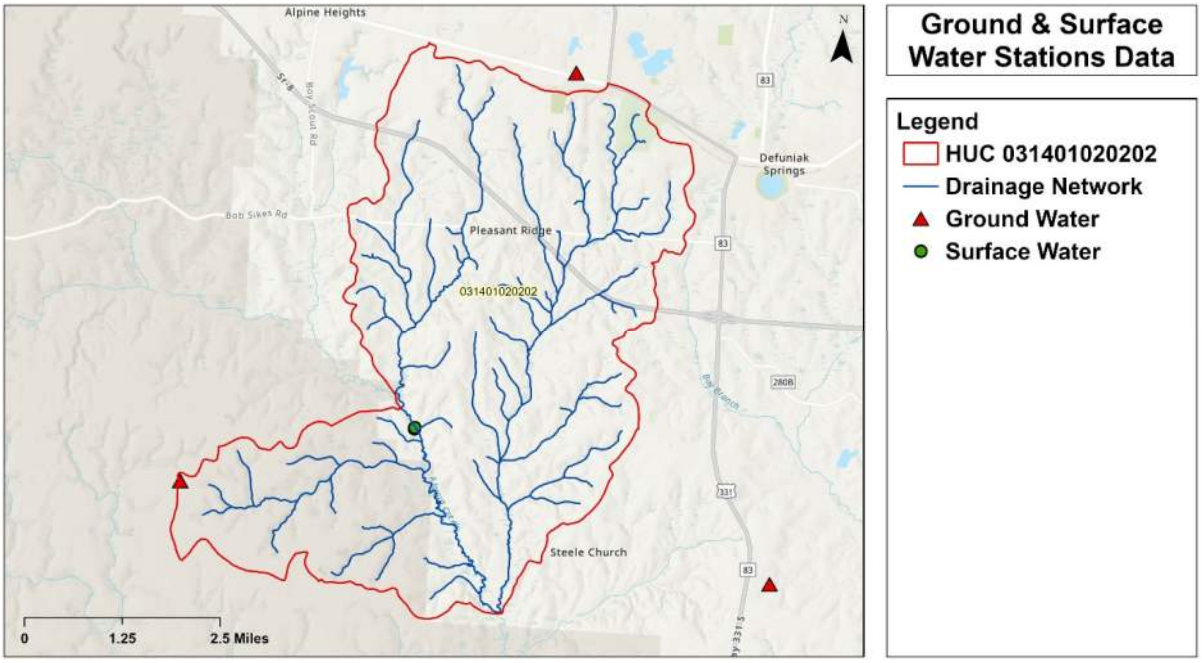

Figure 9. Ground and Surface Water Stations in the HUC 031401020202 sub-watershed, processed by FAU.

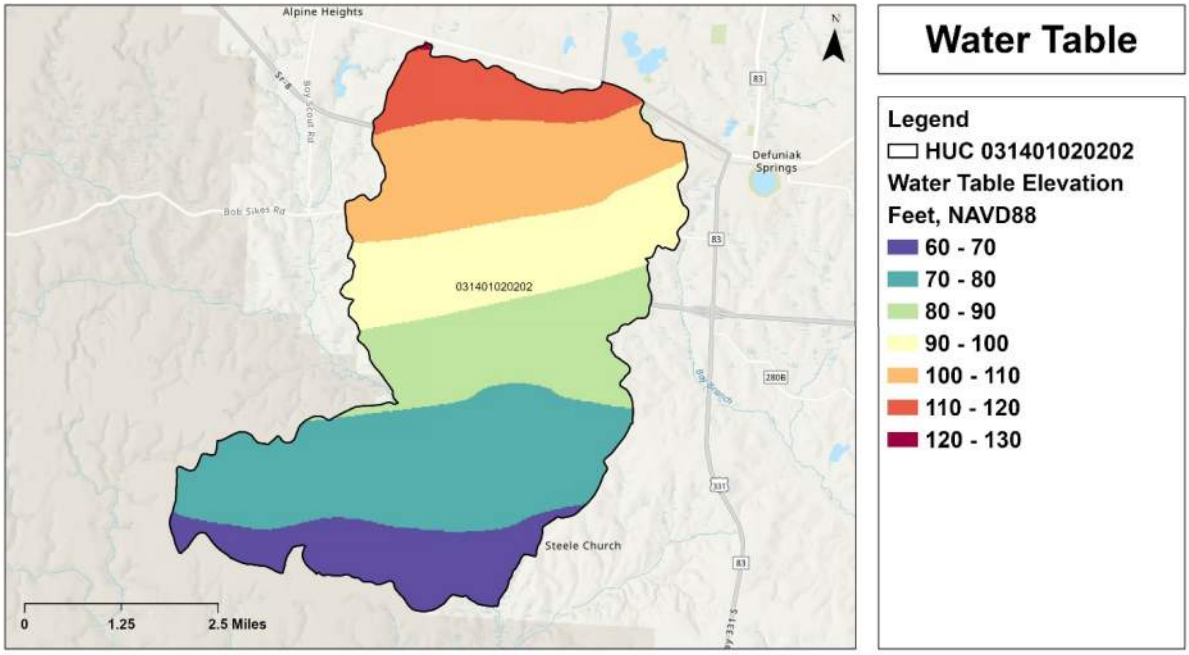

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401020202 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

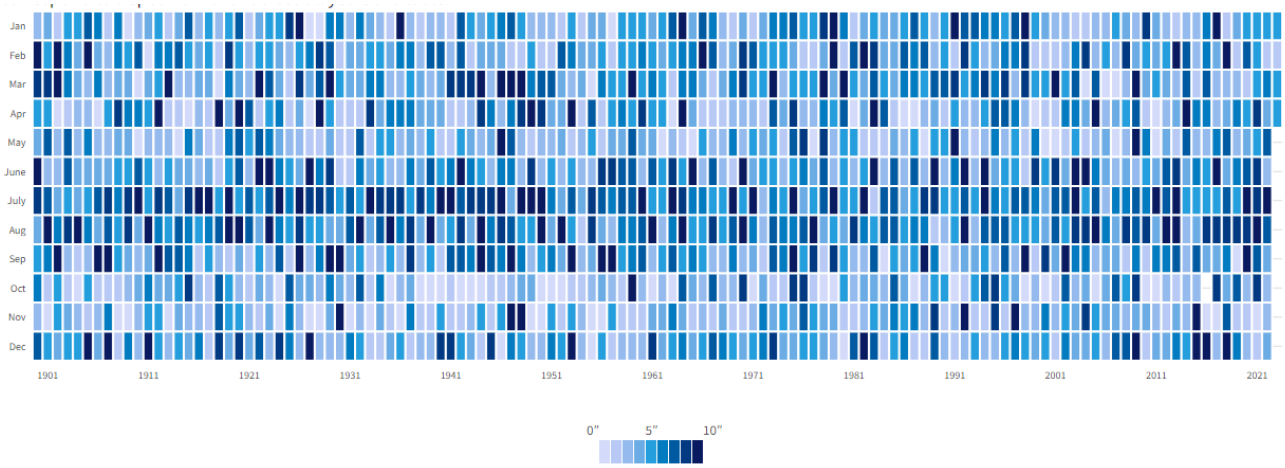

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation)

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

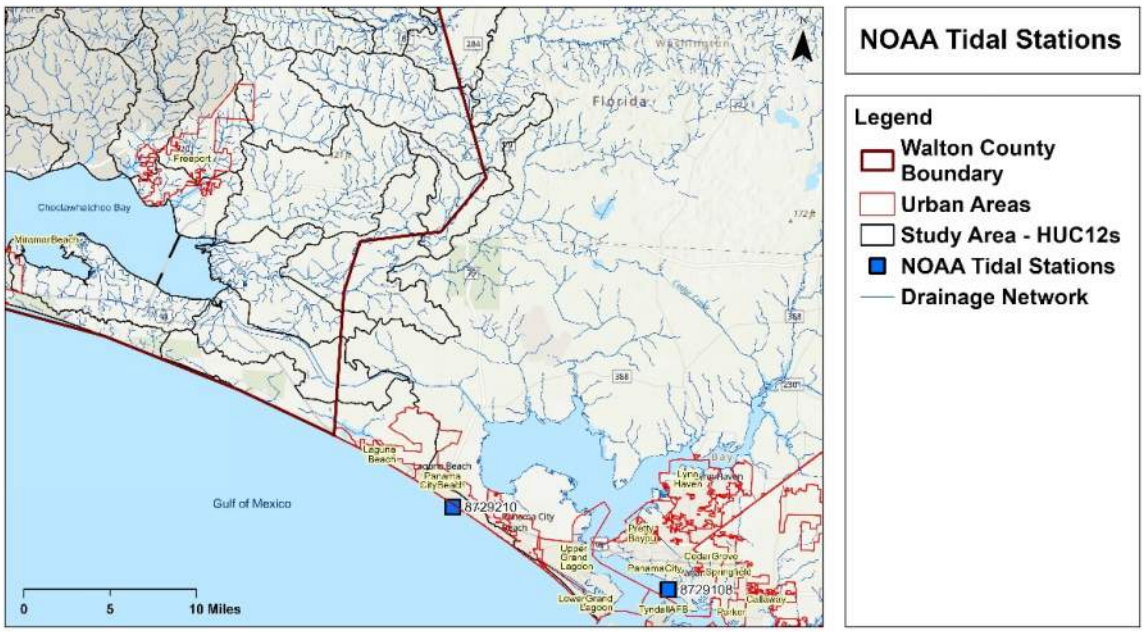

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

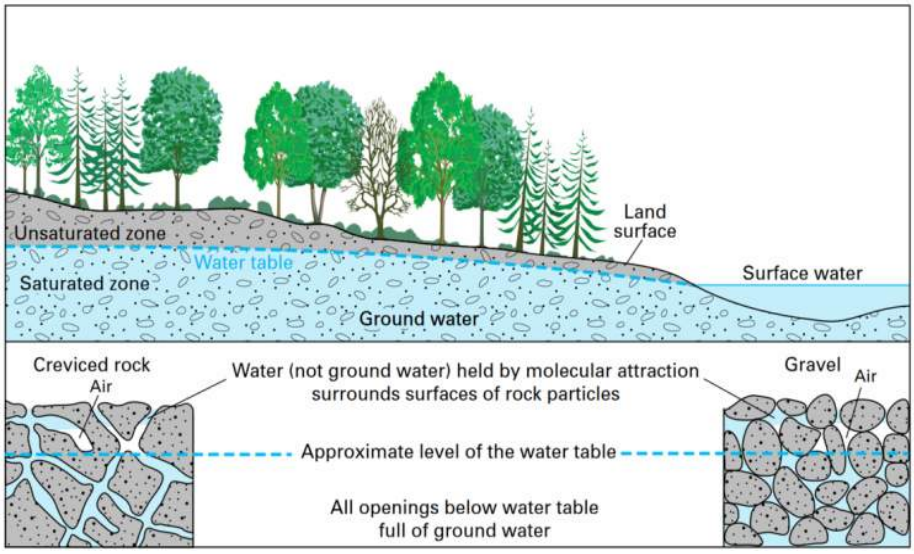

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

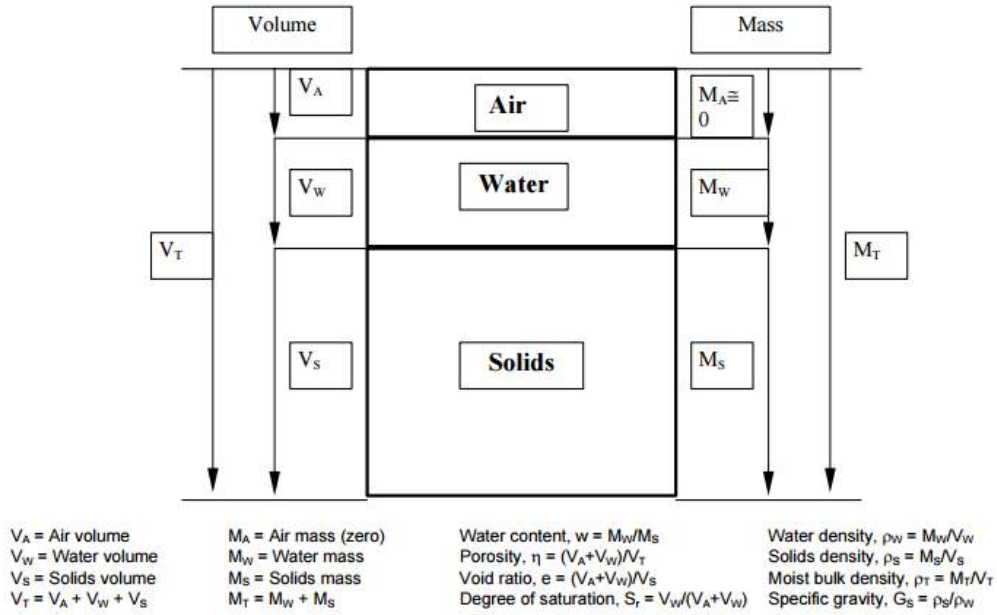

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). Figure 15 shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

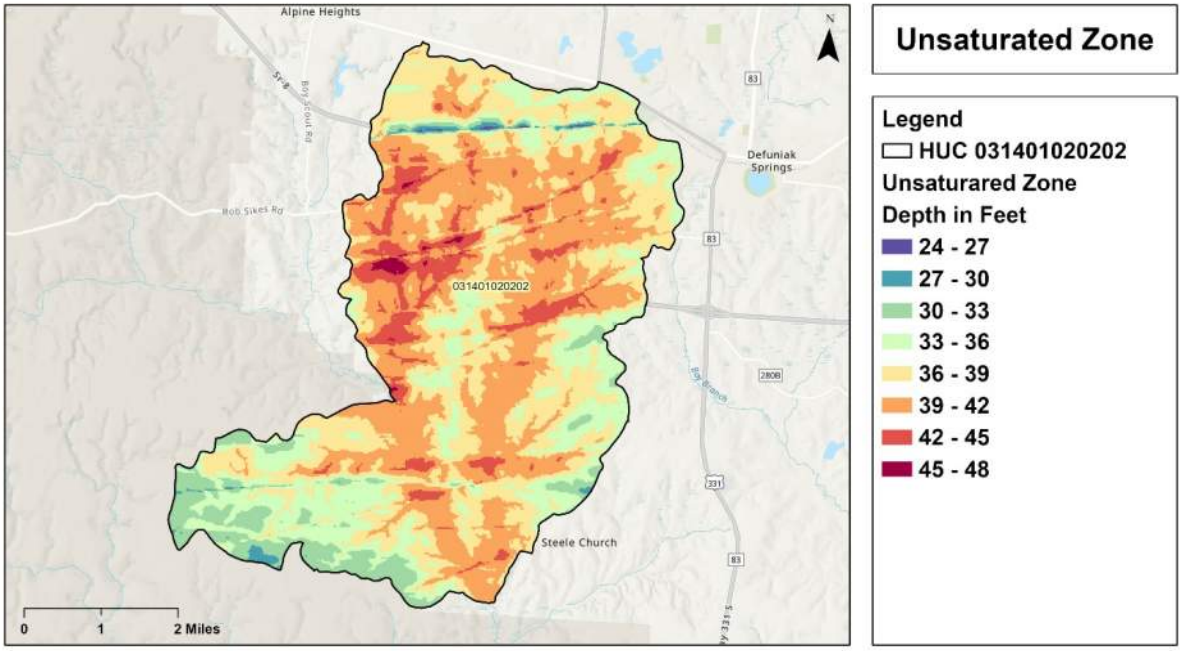

Figure 15. Unsaturated zone map for HUC 031401020202, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately favorable soil storage capacity, falling within the range of 30 to 42 feet of remaining capacity.

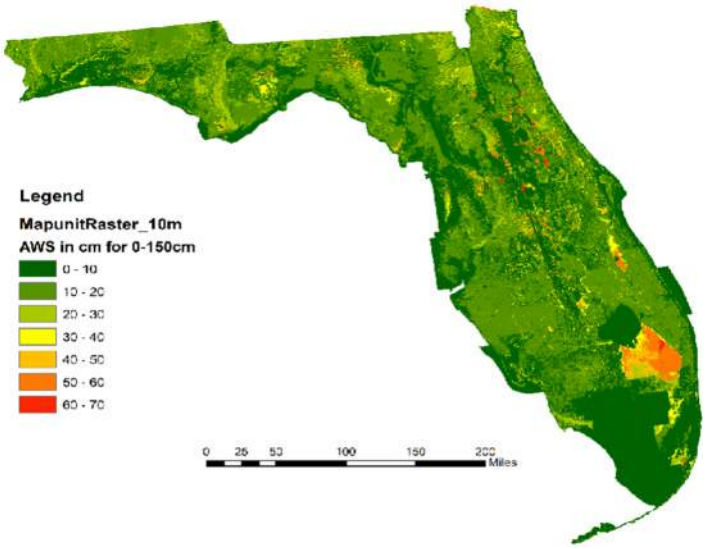

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

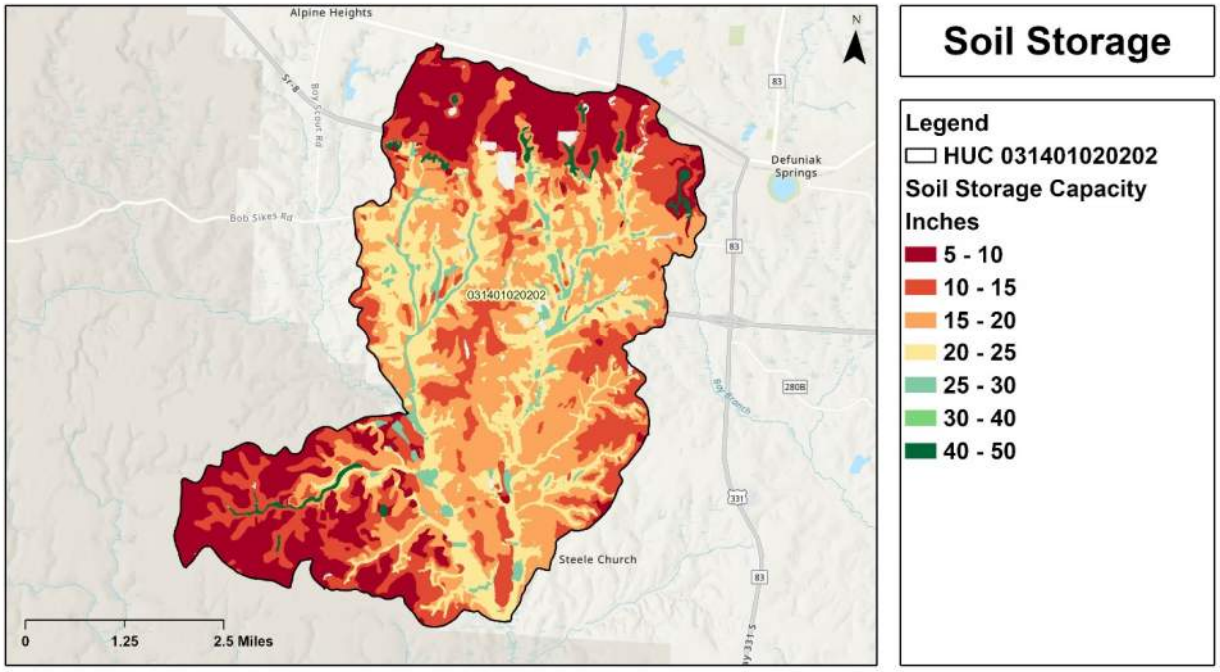

Figure 17. Water storage capacity of soil for the HUC 031401020202, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

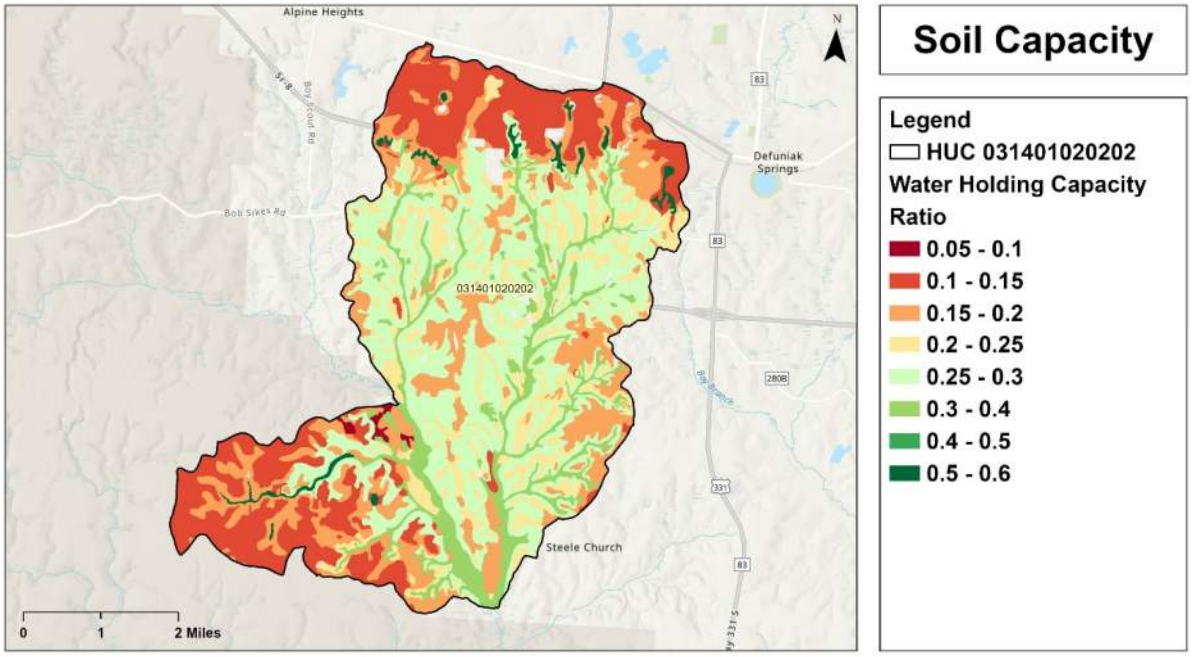

Figure 18. Water Holding Capacity (ratio) for the HUC 031401020202, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

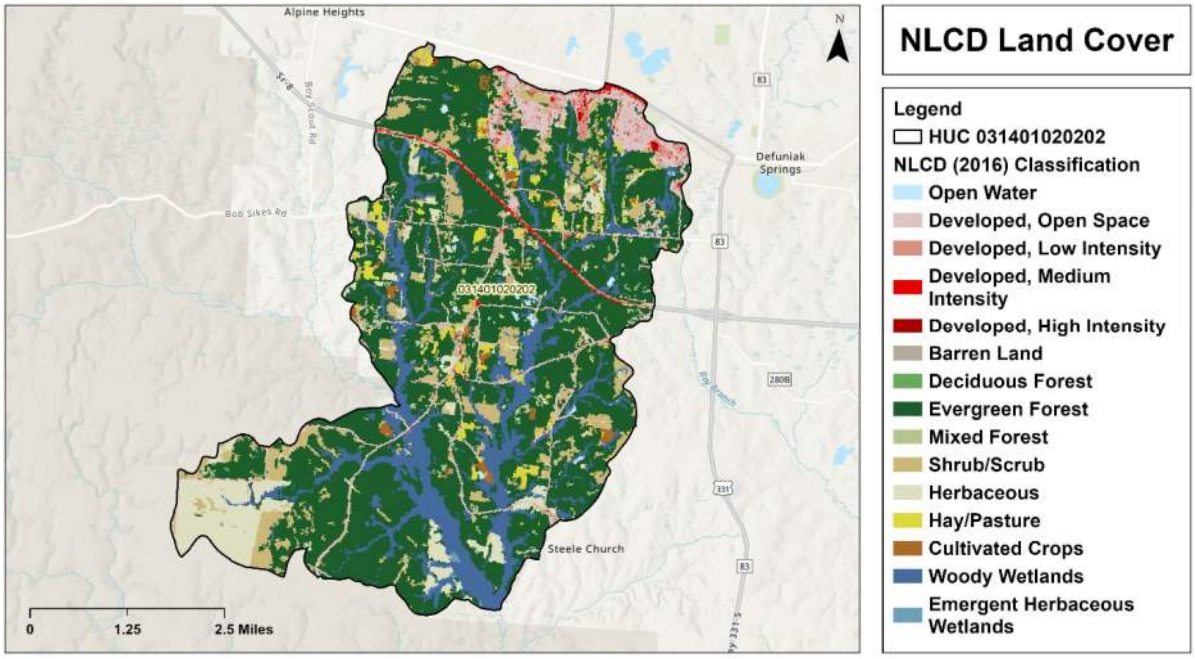

Figure 19. Land use in the HUC 031401020202 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

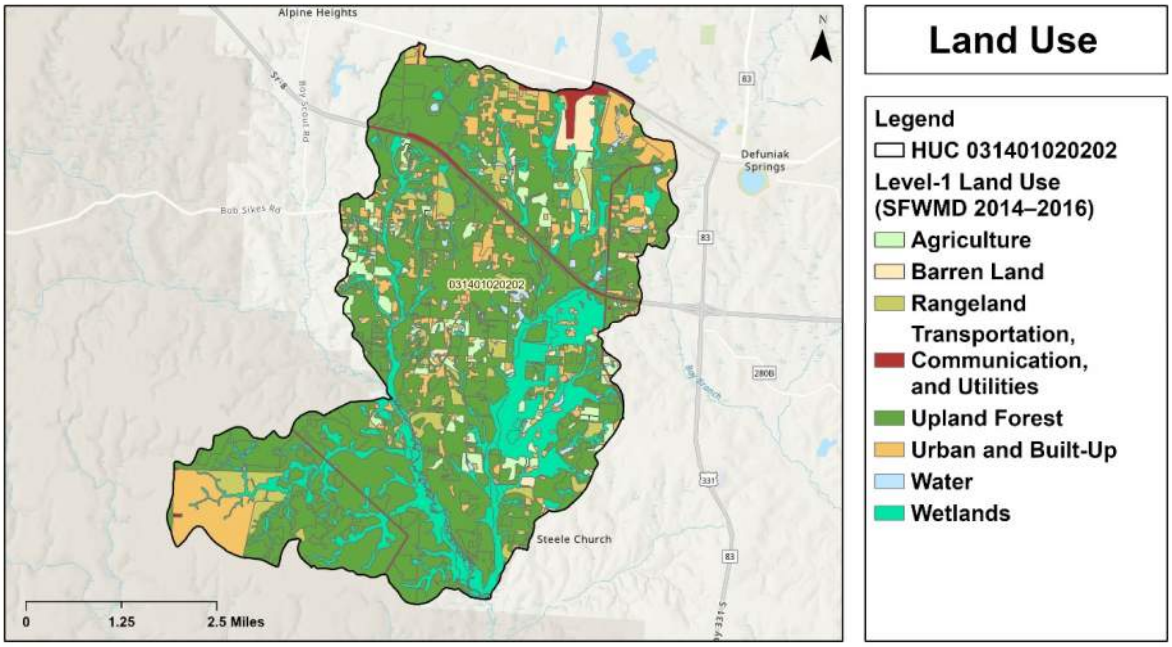

Figure 20. Land use in the HUC 031401020202 (2023 Florida Geographic Data Library (FGDL)processed by FAU.

In the HUC 031401020202 sub-watershed, he predominant land cover is upland forest, accounting for 50.89% of the area. Wetlands comes in second at 15.84%, followed by Transportation, Communication, and Utilities at 12.32%, as shown in **Error! Reference source not found.**. Developed land constitutes also a good portion, with 11.44% categorized as urban and built-up, once the basin encompasses part of the city of DeFuniak Springs. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031401020202 subwatershed (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	820.63	3.14%
Barren Land	267.16	1.02%
Rangeland	1053.79	4.03%
Transportation, Communication, and Utilities	3222.13	12.32%
Upland Forest	13308.36	50.89%
Urban and Built-Up	2992.49	11.44%
Water	342.17	1.31%
Wetlands	4142.76	15.84%
Grand Total:	**26149.50**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

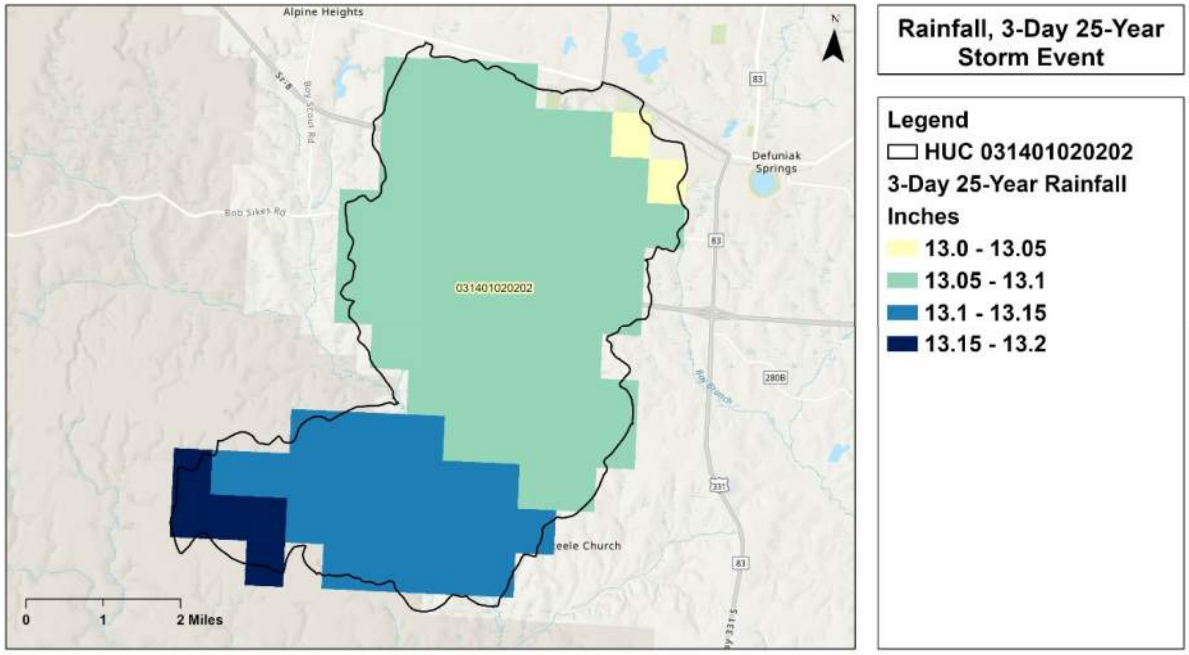

Figure 21. Rainfall distribution map across HUC 031401020202 sub-watershed, for 3-day 25-year storm event, processed by FAU.

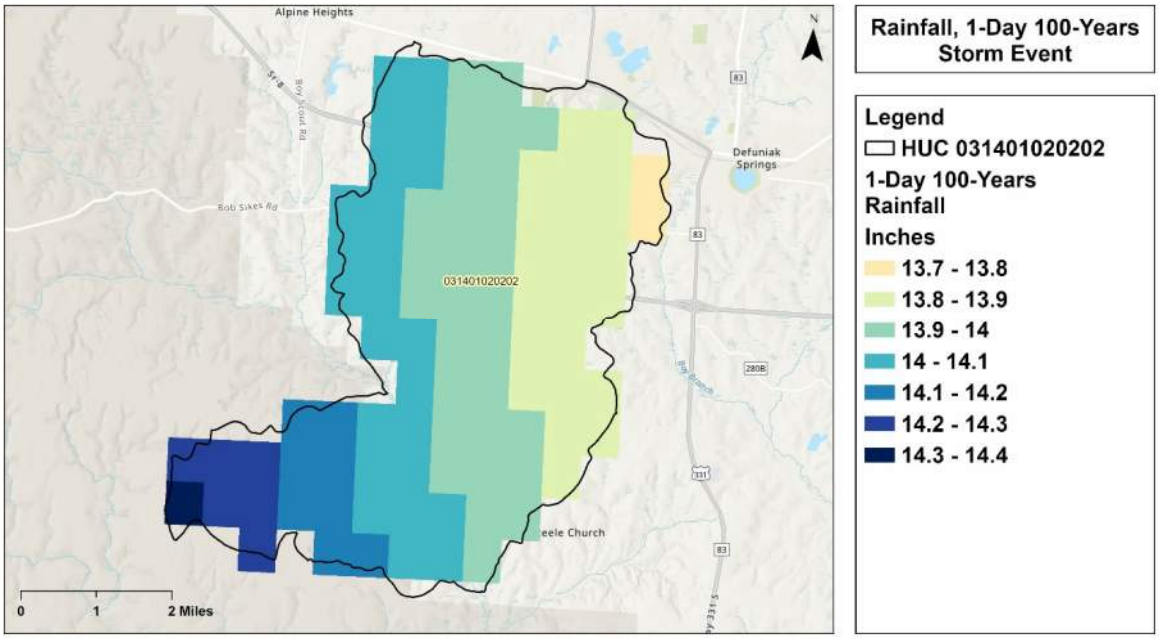

Figure 22. Rainfall distribution map across HUC 031401020202 sub-watershed, for 1-day 100-year storm event, processed by FAU.

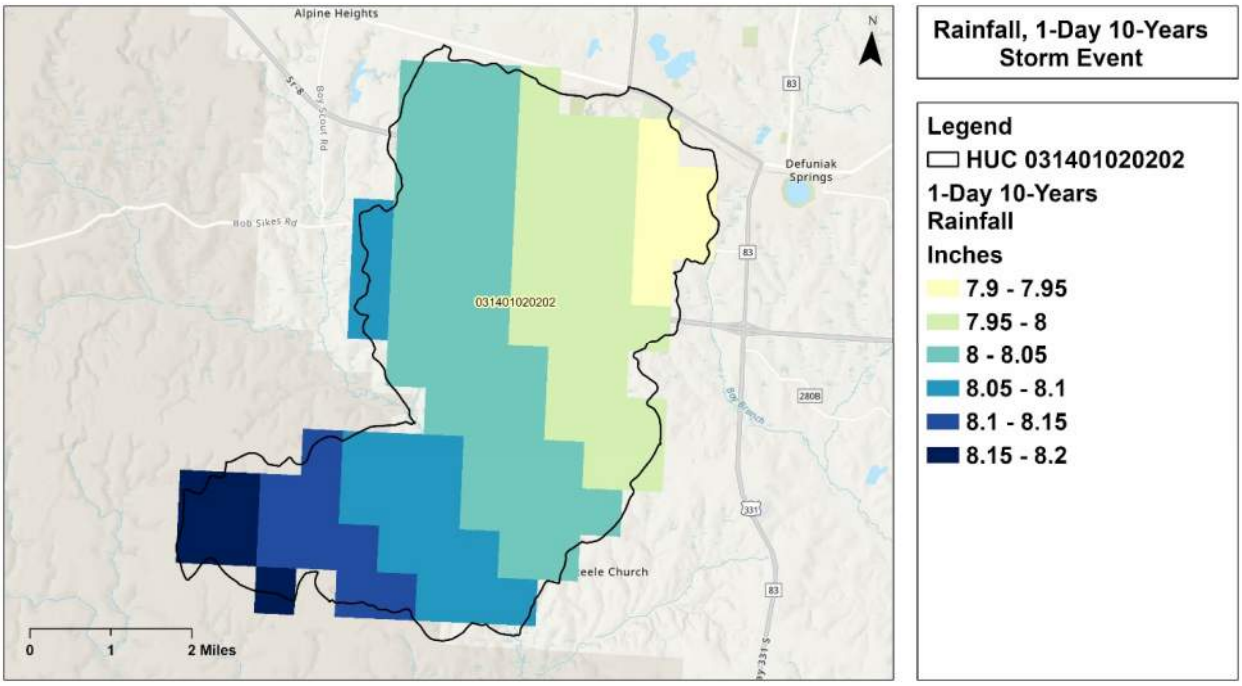

Figure 23. Rainfall distribution map across HUC 031401020202 sub-watershed, for 1-day 10-year storm event, processed by FAU.

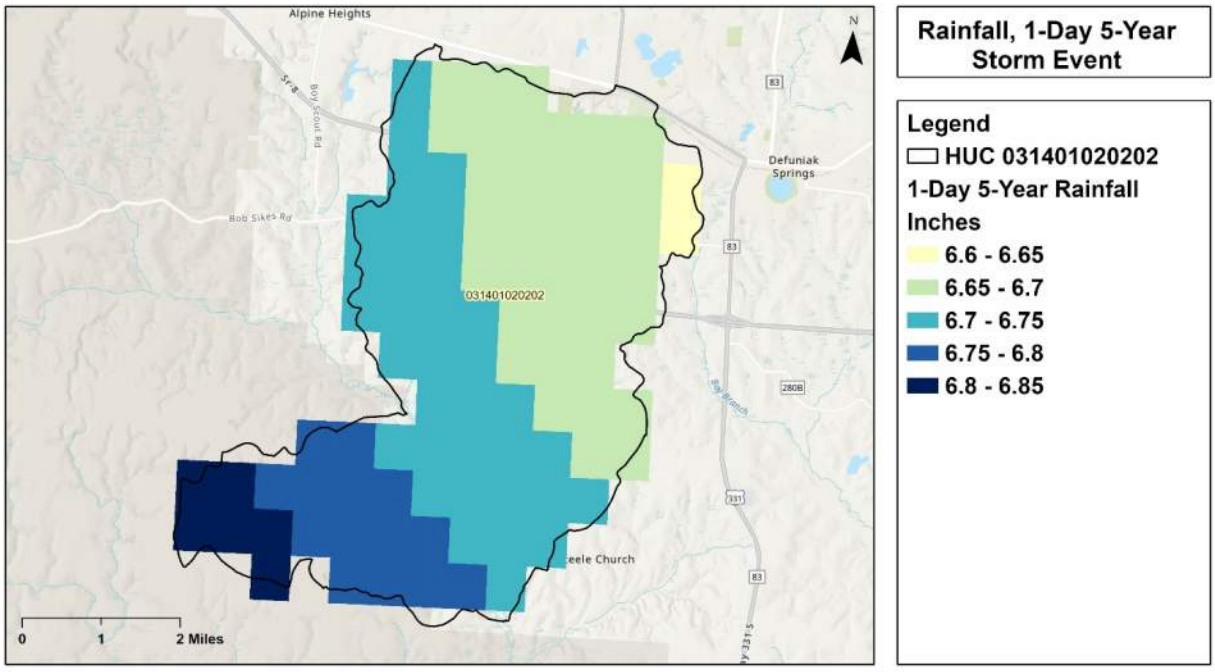

Figure 24. Rainfall distribution map across HUC 031401020202 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, whi1ch serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer

was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

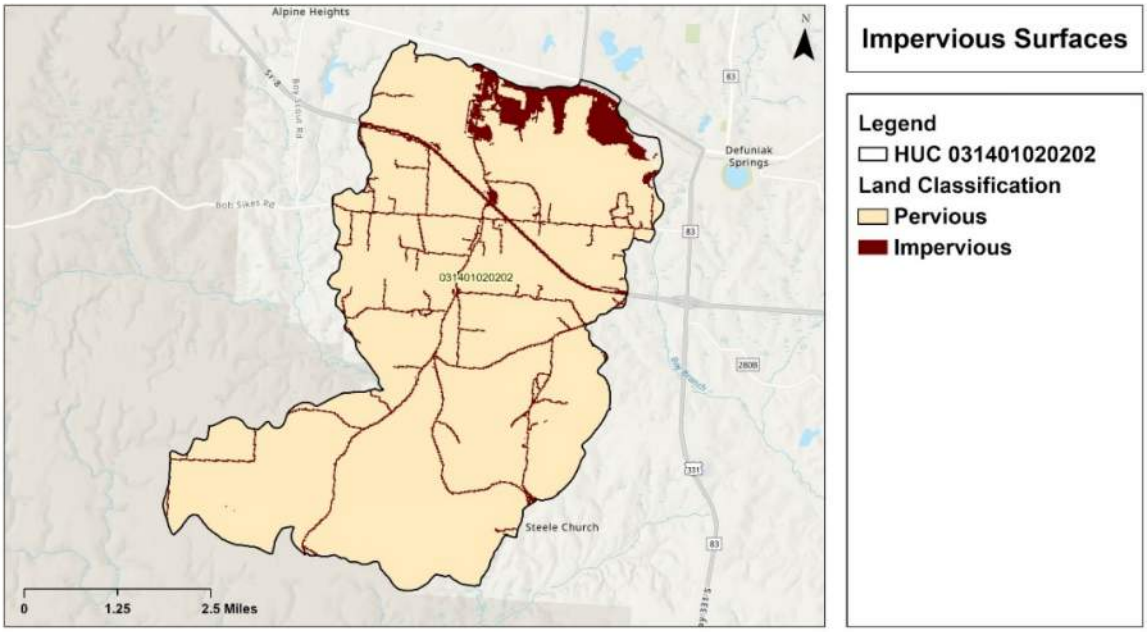

Figure 25. Impervious area map for the HUC 031401020202 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

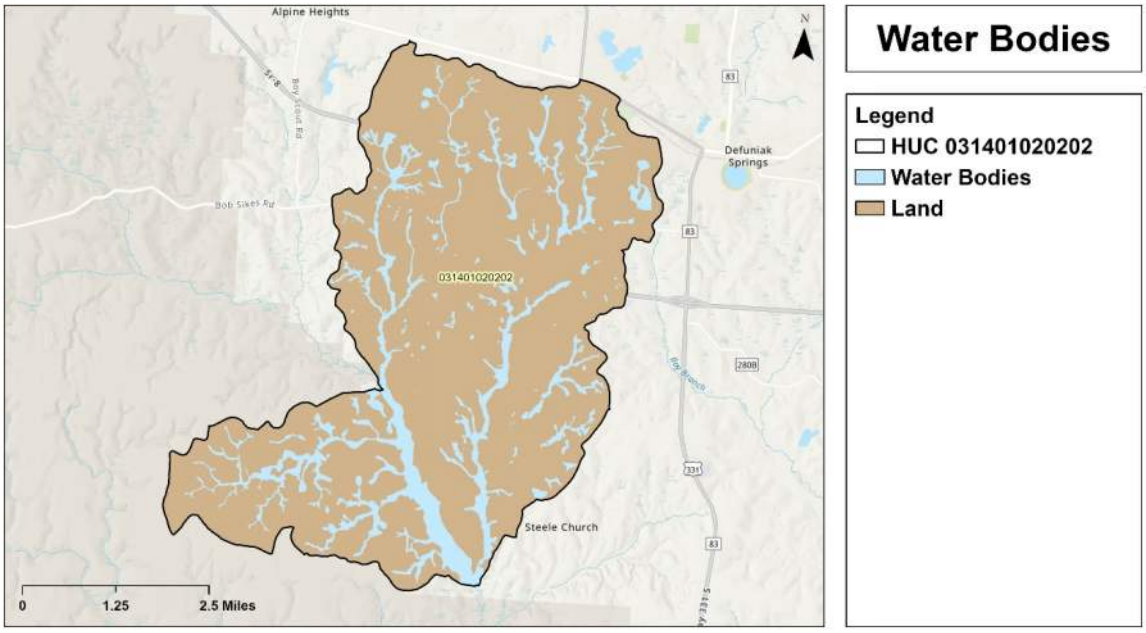

Figure 26. Water bodies map for the HUC 031401020202 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to

the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant

control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

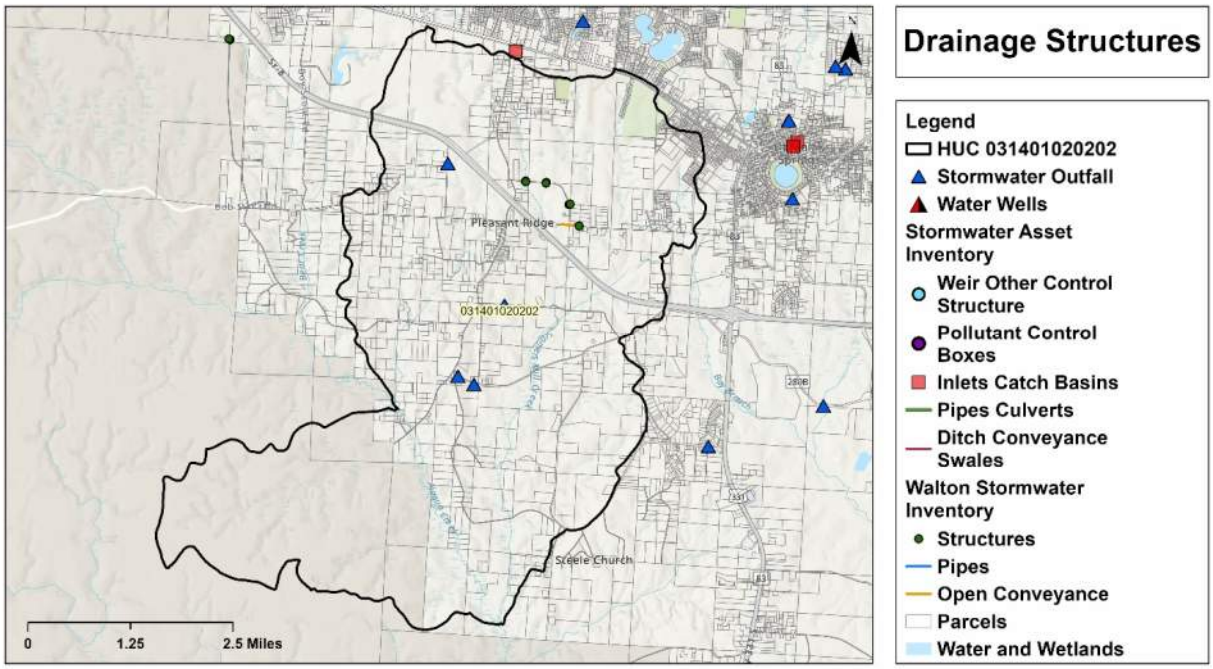

Figure 27. Stormwater Infrastructure for the HUC 031401020202. Processed by FAU.

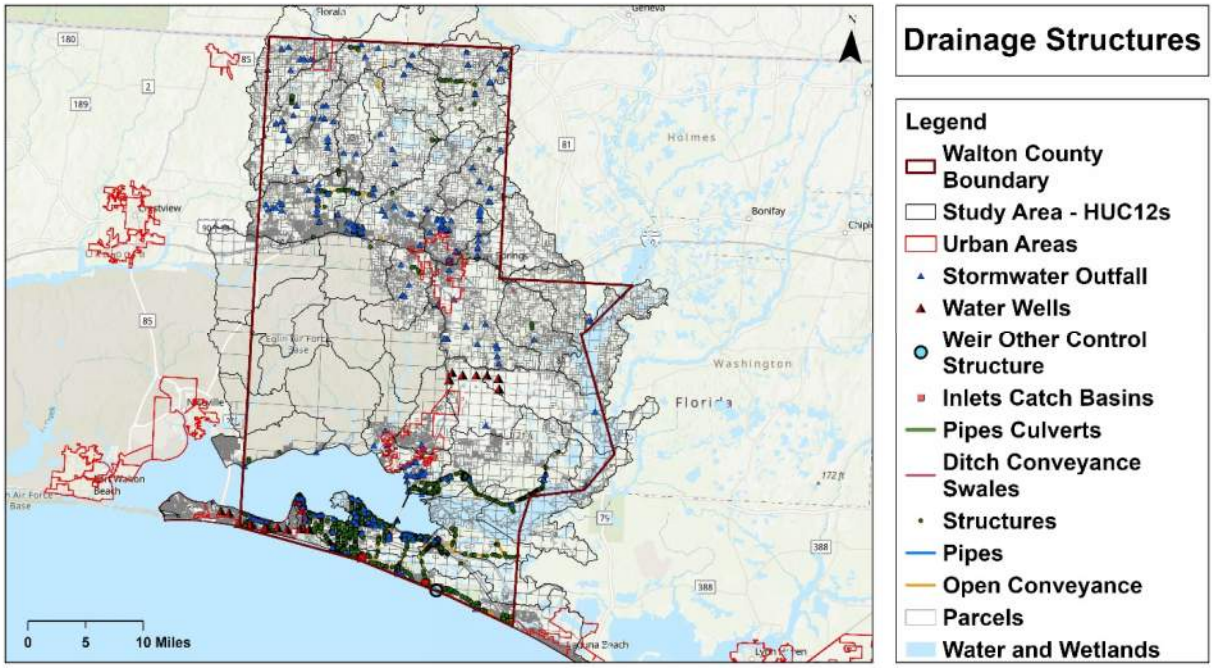

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the 031401020202 HUC 12 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. Figure 29 shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

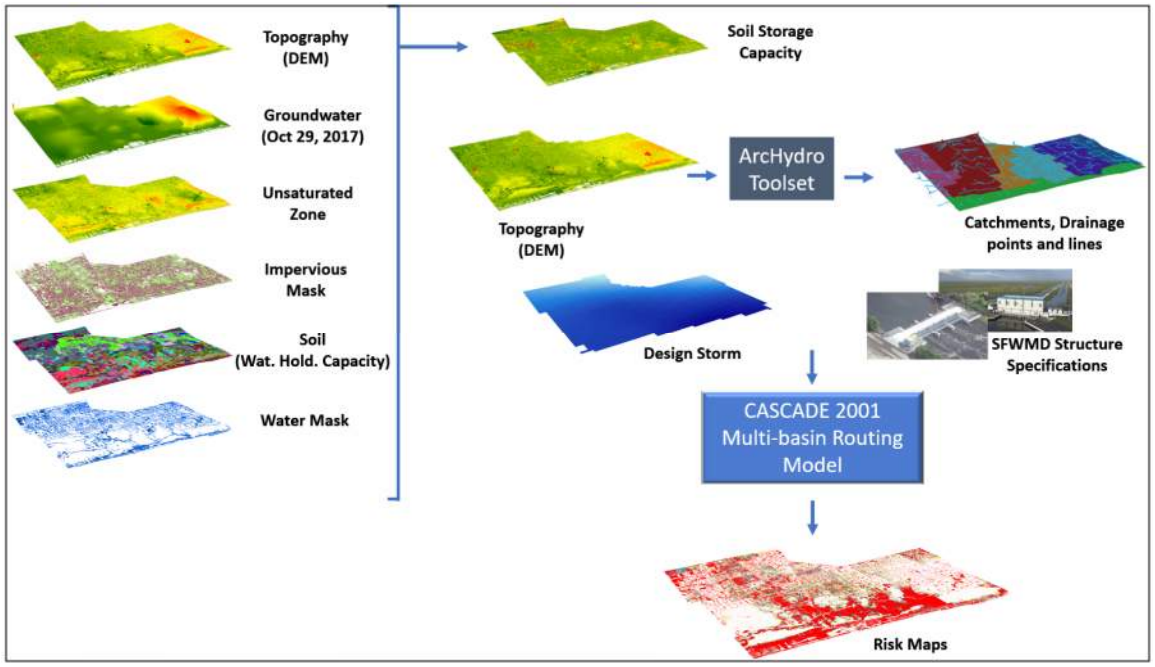

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

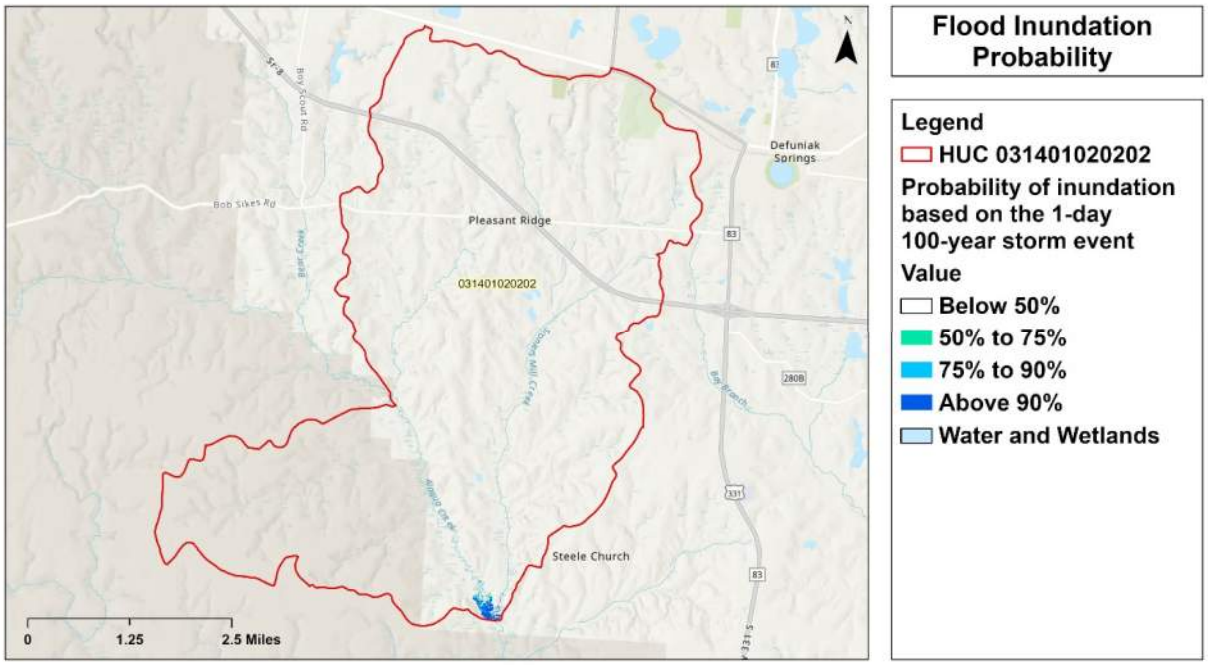

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401020202, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is

used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not

eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a very small portion of flooding is noted at the entrance to the creek into the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, sea level rise should not impact the HUC, therefore SLR scenarios were not calculated.

The design storm simulation determined that approximately 0.2% of the HUC total area or 0.04 mi² has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 0.2% of the HUC's total area, or 0.05 mi² would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.1% of the HUC's total area, or 0.02 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0.1% of the HUC's total area, or 0.02 mi², would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events..

Table 7. HUC 031401020202 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	26.27	0.05	99.8%	0.2%
1-day 100-year	26.27	0.05	99.8%	0.2%
1-day 10-year	26.29	0.02	99.9%	0.1%
1-day 5-year	26.30	0.02	99.9%	0.1%

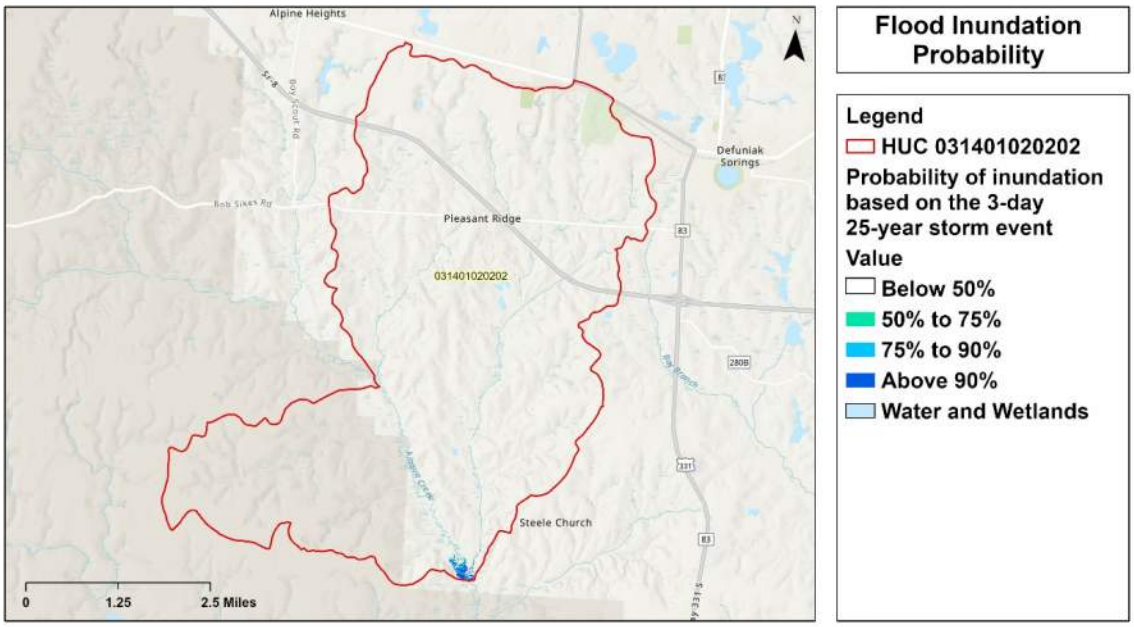

Figure 31. 3-day 25-year storm event for HUC 031401020202 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

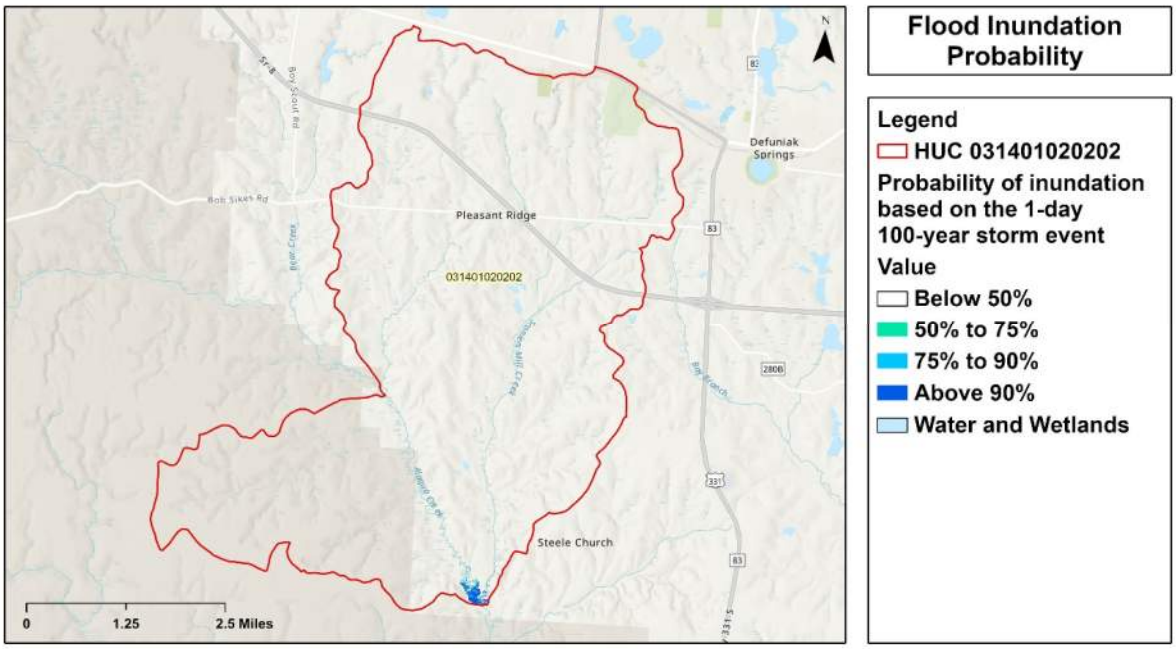

Figure 32. 1-day 100-year storm event for HUC 031401020202 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

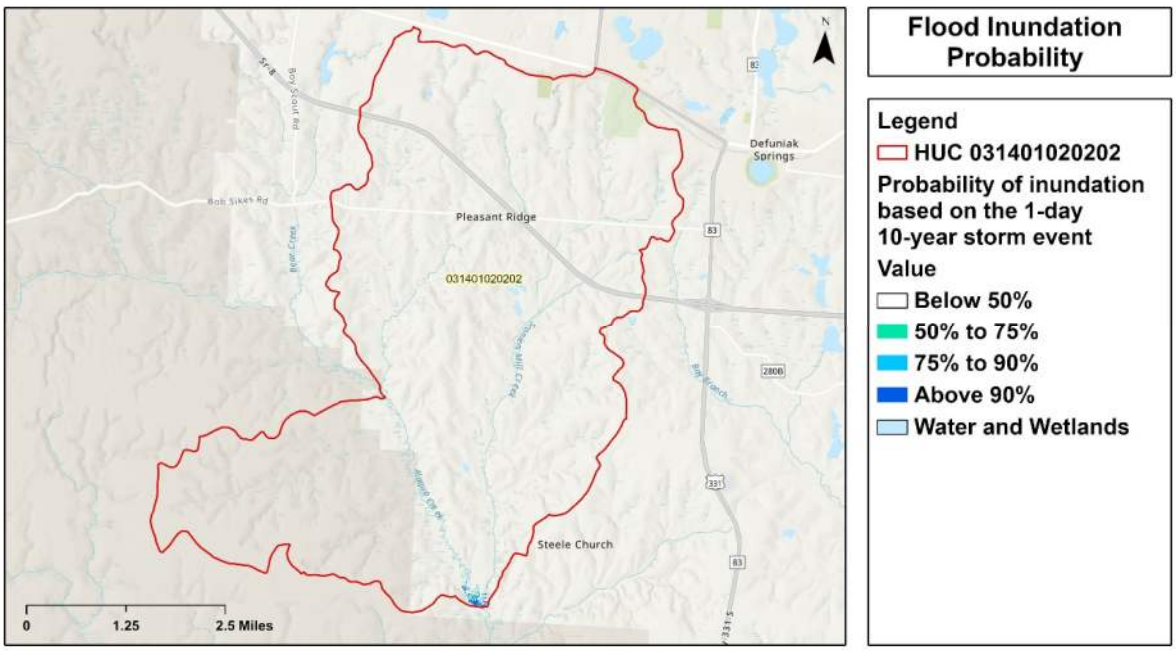

Figure 33. 1-day 10-year storm event for HUC 031401020202 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

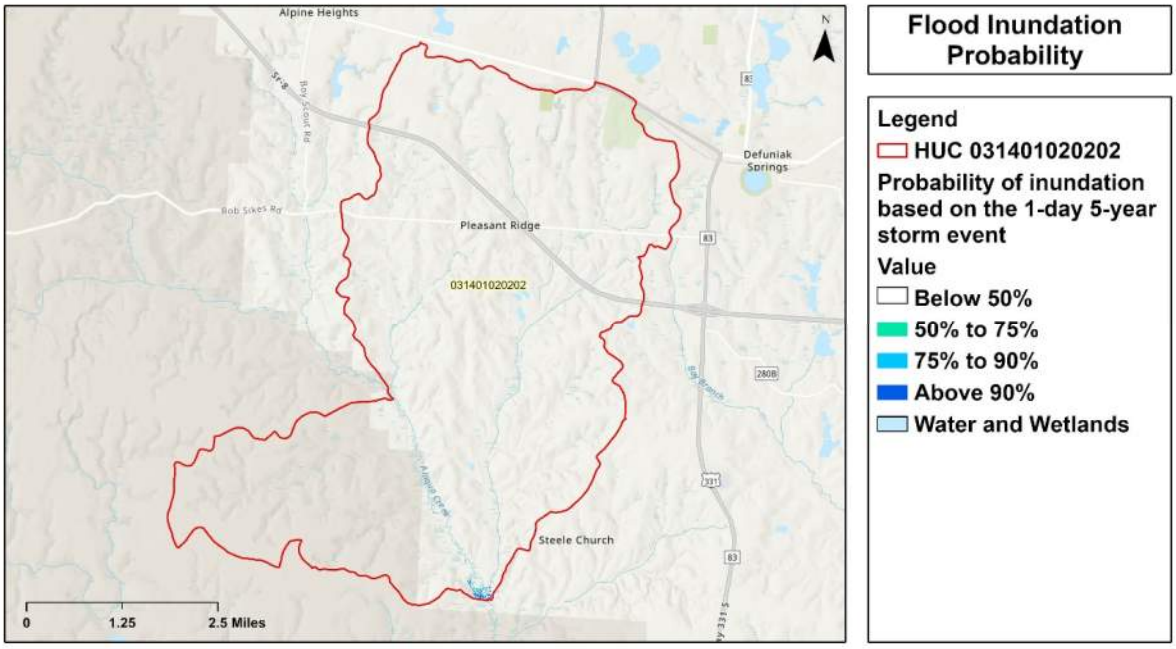

Figure 34. 1-day 5-year storm event for HUC 031401020202 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6

11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3

43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5

78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031401020202 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.**is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.**illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers,

and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

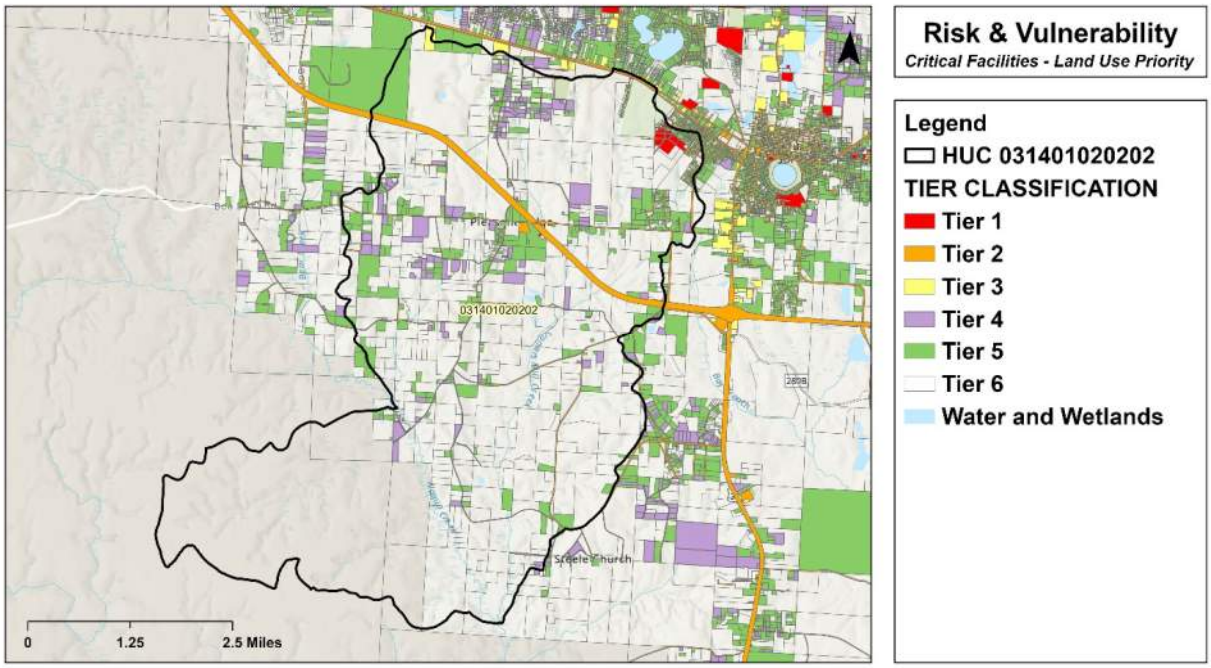

Figure 35. HUC 031401020202 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

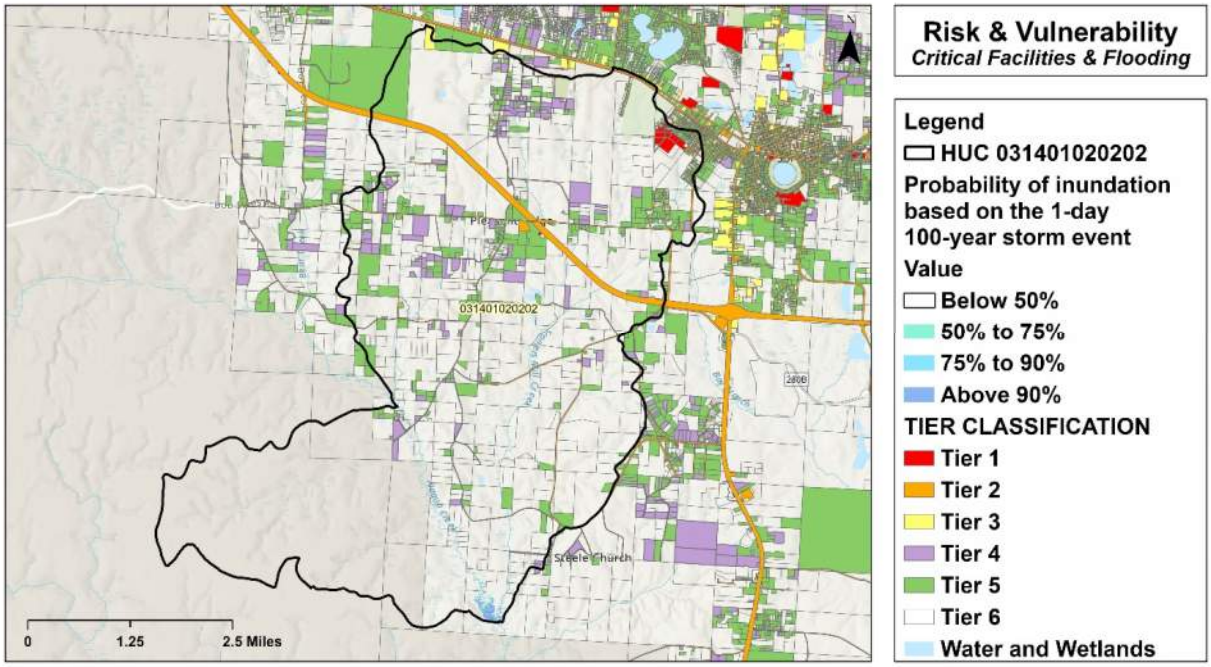

Figure 36. HUC 031401020202 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

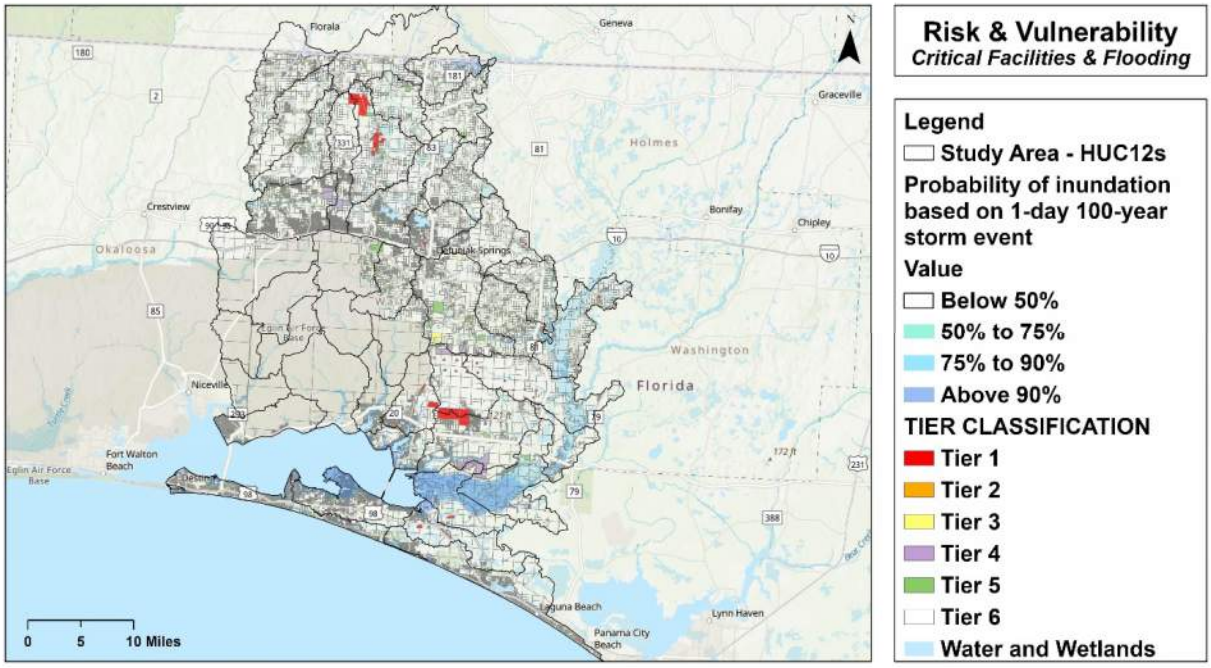

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

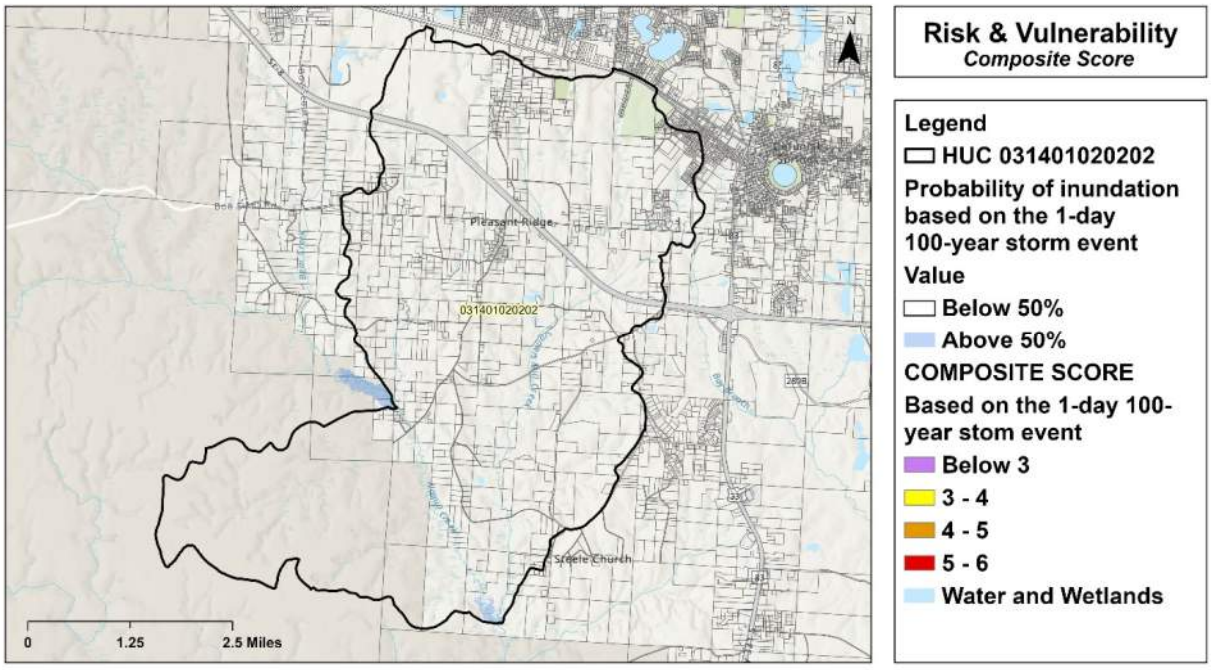

Figure 38. HUC 031401020202 sub-watershed Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

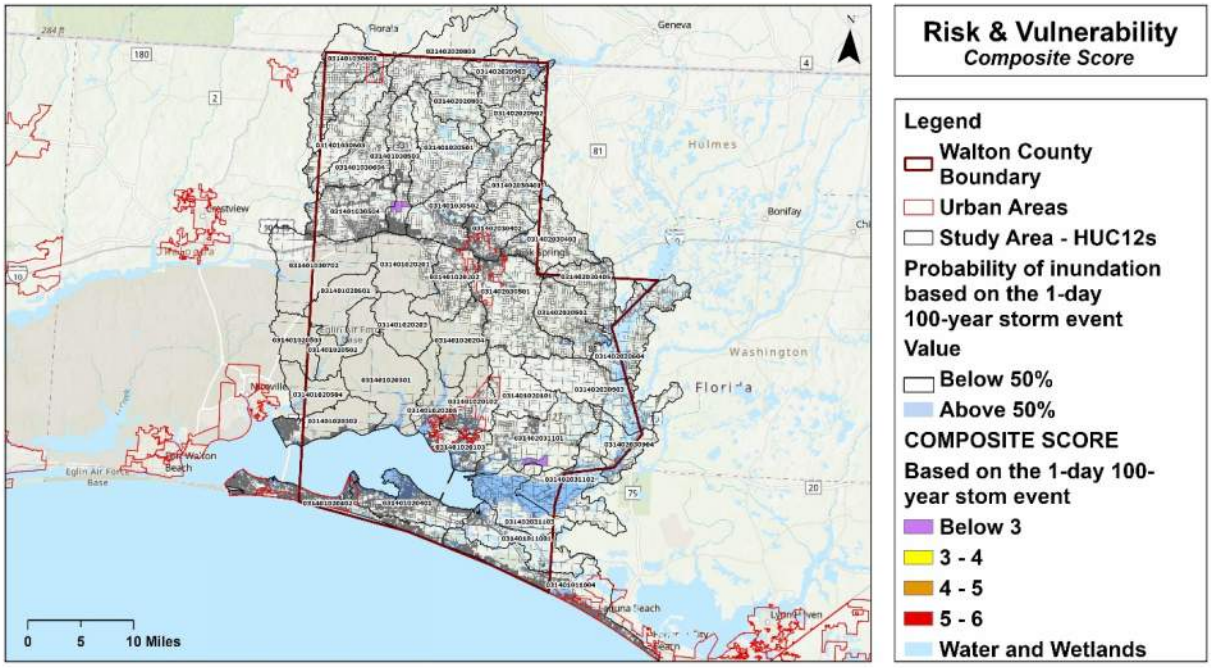

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

Please note that due to the scale of the map, the composite score layer is not properly visible in this map.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

2.4.2 Drill-down – DeFuniak Springs

For enhanced visualization of the urban areas within this HUC 031401020202, Figure 40 to Figure 44 illustrate the same results for critical facilities (land use priorities) and composite scores, but on a reduced scale, which better facilitates the examination of finer details within the urban area (DeFuniak Springs). These maps cover both the 1-day 100-year scenario and the 1-day 100-year + 5 feet SLR scenario, although the results for Sea Level Rise is null due to distance of the basin to the coast and its high elevation.

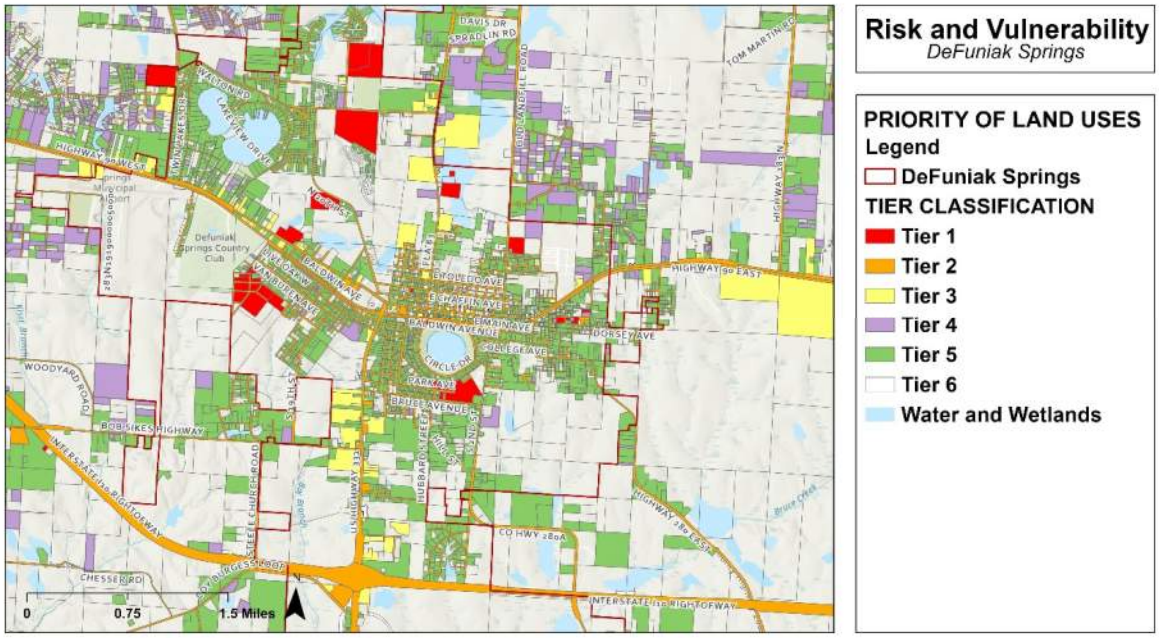

Figure 40. Critical Facilities (priority of land uses) map for DeFuniak Springs. Processed by FAU.

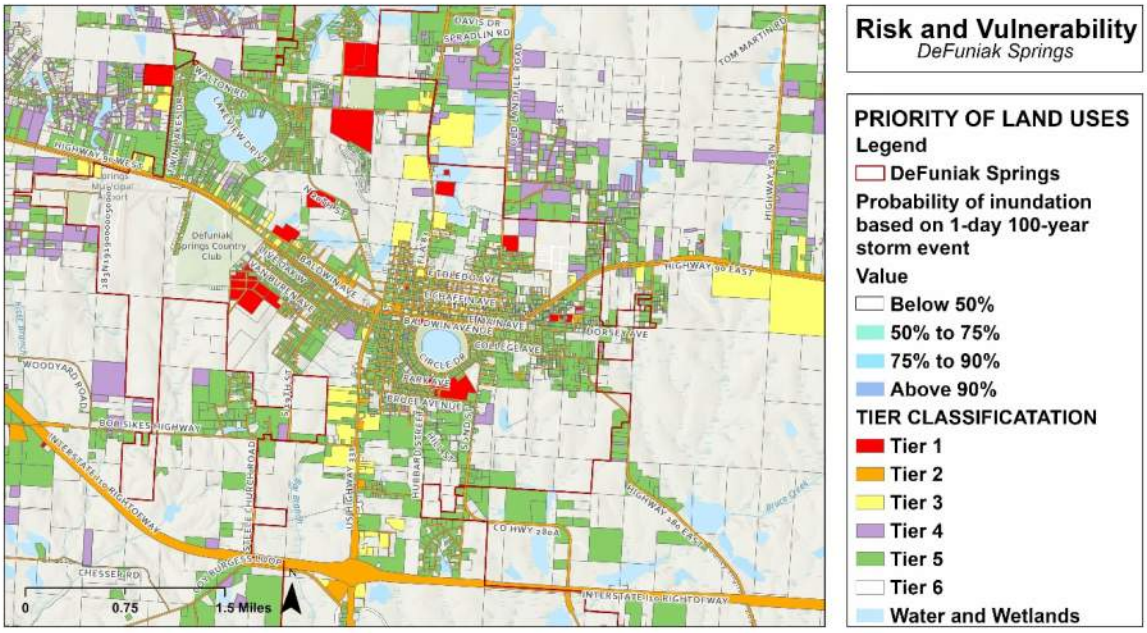

Figure 41. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event for DeFuniak Springs. Processed by FAU.

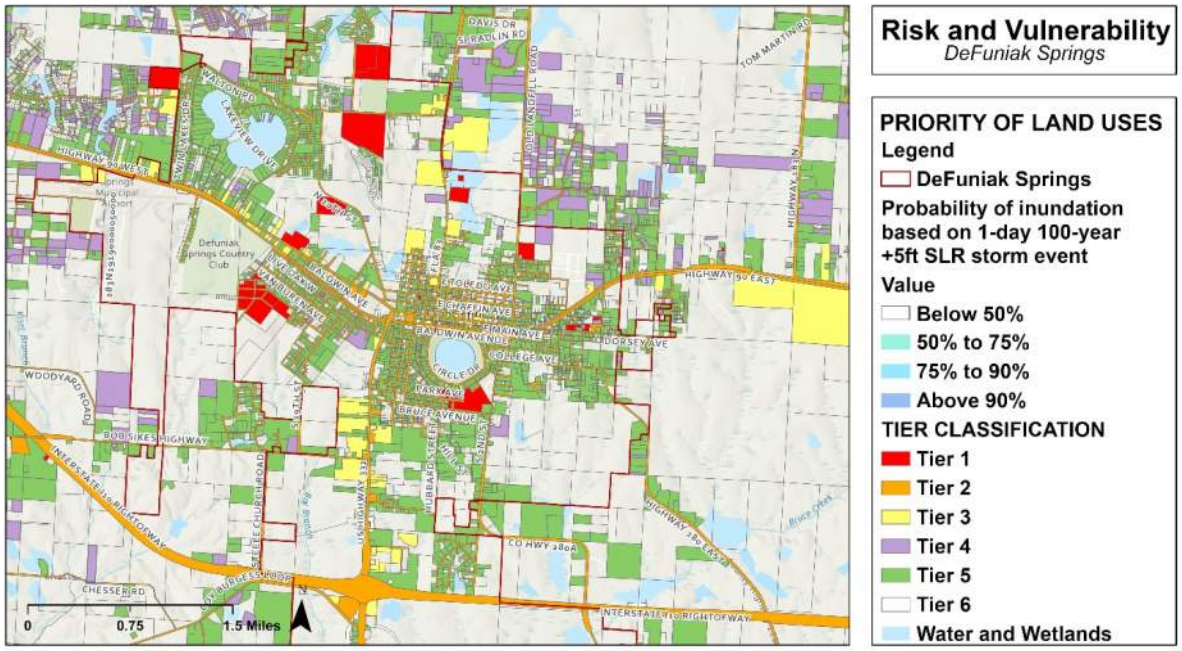

Figure 42. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event + 5ft SLR for DeFuniak Springs. Processed by FAU.

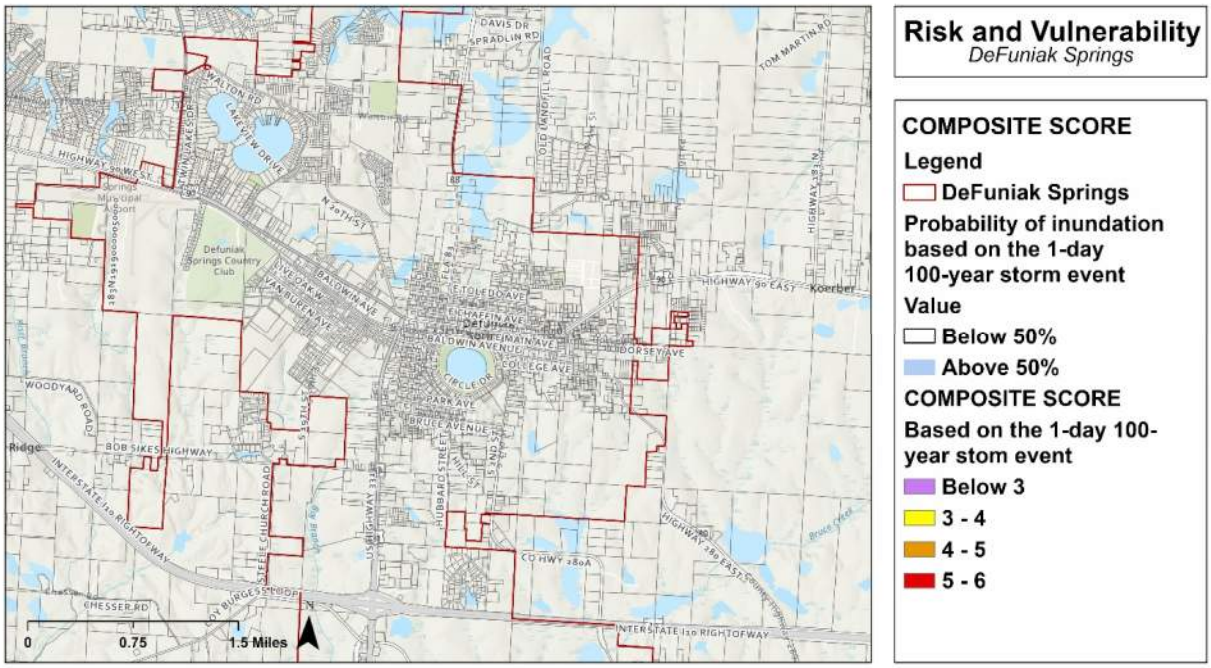

Figure 43. Composite Score map based on 1-day 100-year storm event, overlaid in flooding layer for DeFuniak Springs. Processed by FAU.

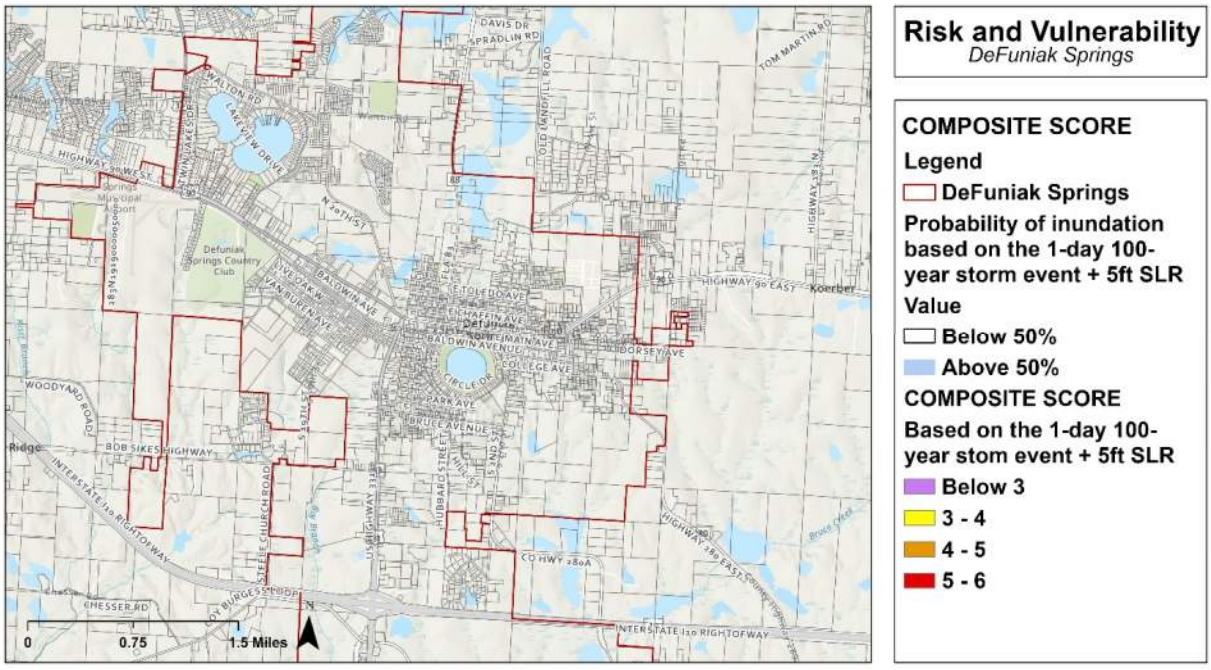

Figure 44. Composite Score map based on 1-day 100-year storm event + 5 feet SLR, overlaid in flooding layer for DeFuniak Springs. Processed by FAU.

The composite score results for this location are null, as the city of DeFuniak Springs shows no indication of flooding in both the 1-day 100-year and 1-day 100-year + 5ft SLR flooding scenarios.

2.4.3 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401020202. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.4 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands: This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands: In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401020202. Processed by FAU.

AREAS	ACRES
HUC-12 Sub-watershed: 031401020202	16841.19
All of the 1-day 100-year storm event inundation	**31.08**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	0.02
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	31.06
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	31.06

2.4.5 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. Figure 45 indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

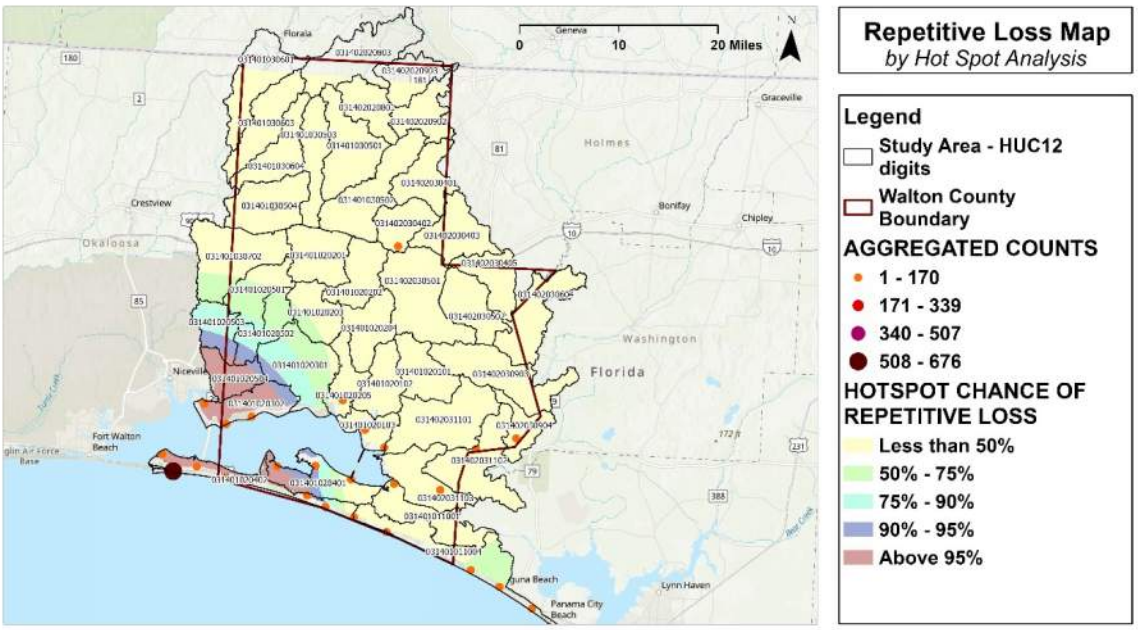

Figure 45. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.6. Priority Projects

Although some parcels fall within classification tiers 1 to 3 and a significant number fall within tiers 4 and 5 for priority land use, none of these are located within the flooding zone. The minor and non-alarming nature of flooding in the area becomes evident when examining the composite score, which reveals that there are no critical facilities situated within the flooding zone. As a result, there is no immediate need for priority project interventions within the basin.

APPENDIX I

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401020203

LITTLE ALAQUA CREEK

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Co-Principal Investigators: Weibo Liu, Ph.D., Daniel Meeroff, Ph.D., Diana Mitsova, Ph.D., S. Nagarajan, Ph.D., Hongbo Su, Ph.D., Ramesh Teegavarapu, Ph.D., Zhixiao Xie, Ph.D., Yan Yong, Ph.D., and Caiyun Zhang, Ph.D., Ahmet Urusan, Ph.D., Shannon Egger, Eva Suarez, Ph.D.

Research Assistant: Leticia Sabio

This resource was funded in part, through a grant agreement from the Florida Division of Emergency Management's (FDEM) Bureau of Mitigation, by a grant provided by through the Hazard Mitigation Grant Program (HMGP) DR-4337-004-P, as approved by FDEM and the Federal Emergency Management Agency (FEMA) to create and update Watershed Master Plans (WMP) throughout the state of Florida. The views, statements, findings, conclusions, and recommendations expressed herein are those of the authors and do not necessarily reflect the views of the State of Florida, FEMA, or any of their sub-agencies.

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401020203) is highlighted among all the HUCs to help identifying its location.

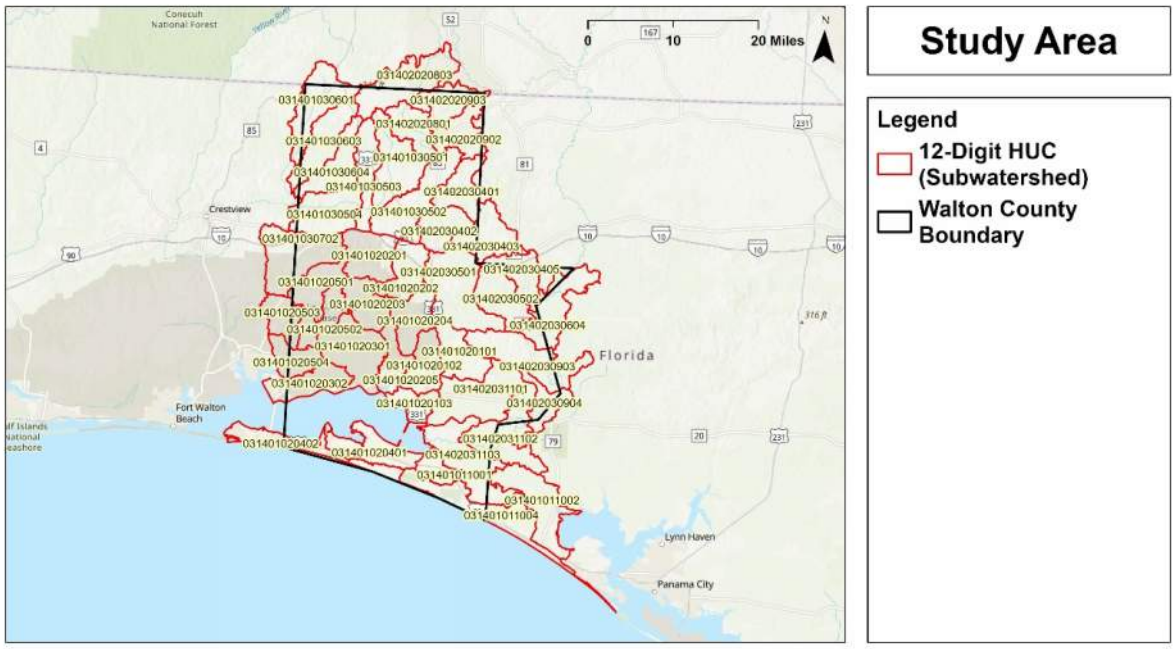

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

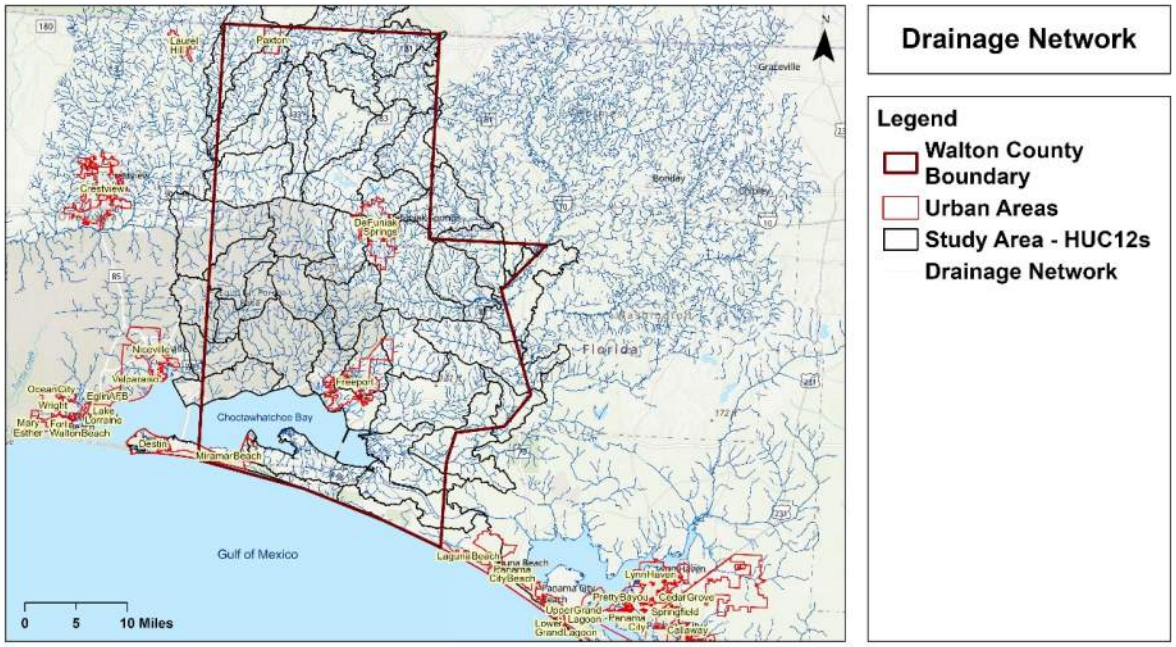

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

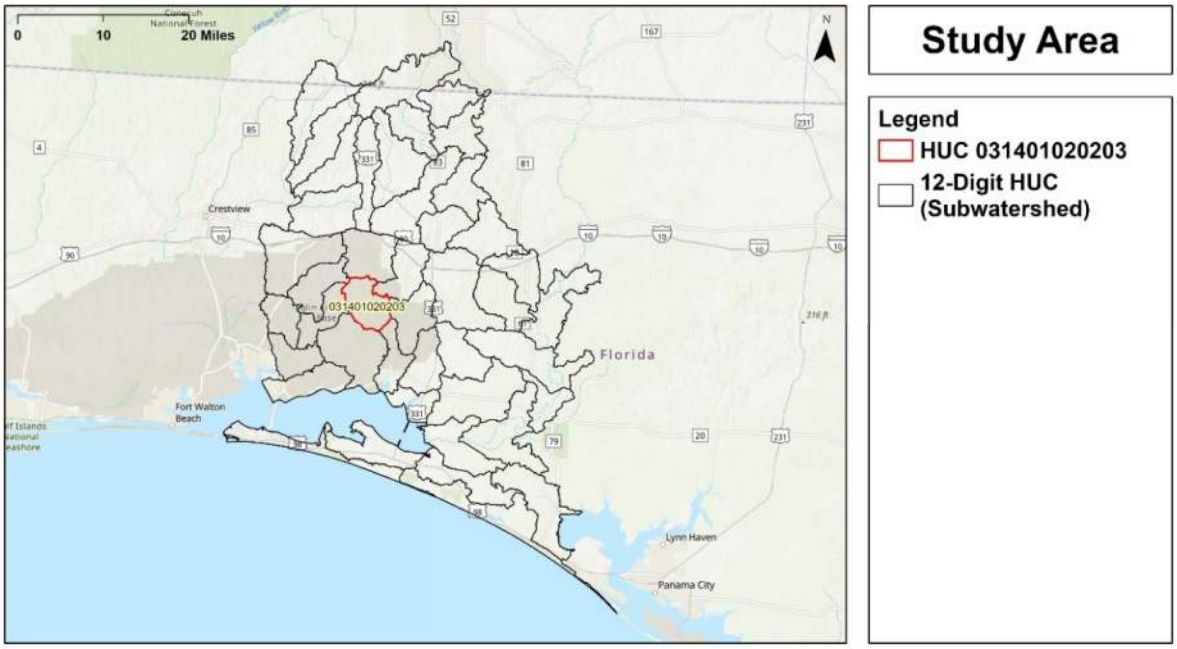

Figure 3. HUC 031401020203 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Figures 12 and 13 in the county-wide report show the current and projected land use for the County. Based on the 2017 future land use map for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.9	7.17%
Barren Land	9242.1	1.25%
Rangeland	40326.7	5.46%
Transportation, Communication, and Utilities	11815.7	1.60%
Upland Forest	356796.1	48.30%
Urban and Built-Up	52194.8	7.07%
Water	61593.9	8.34%
Wetlands	153759.9	20.82%
Total	**738687.9**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding.

The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

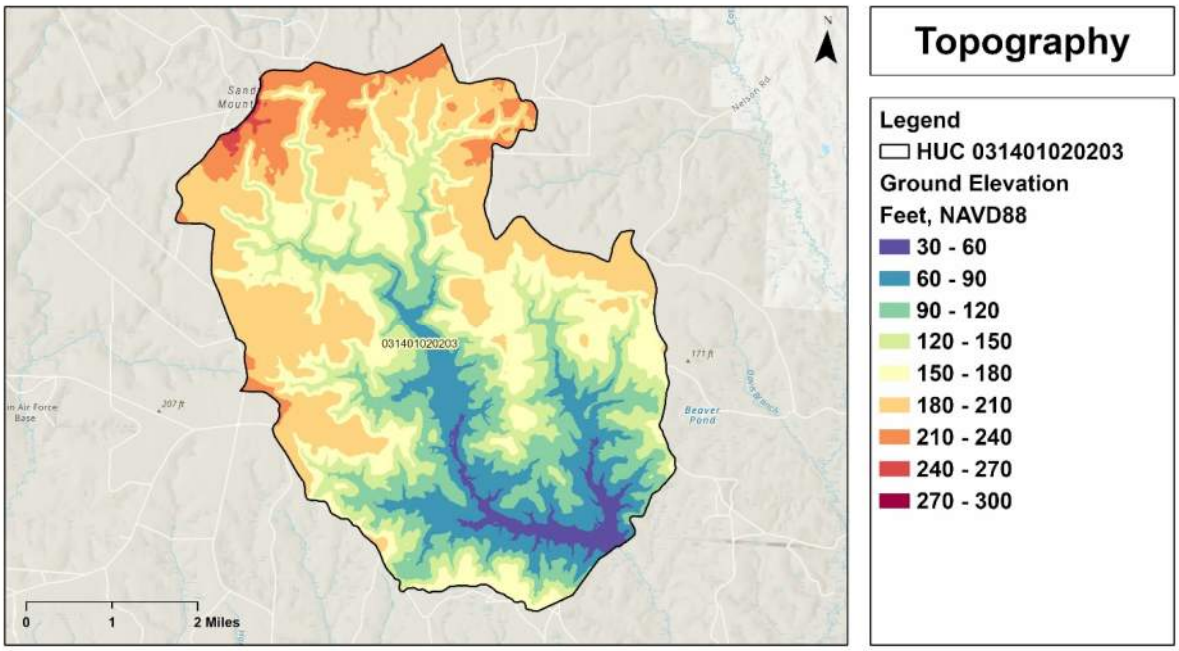

Figure 4. Topographic map of the HUC 031401020203 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401020203 sub-watershed is shown in **Error! Reference source not found.**.

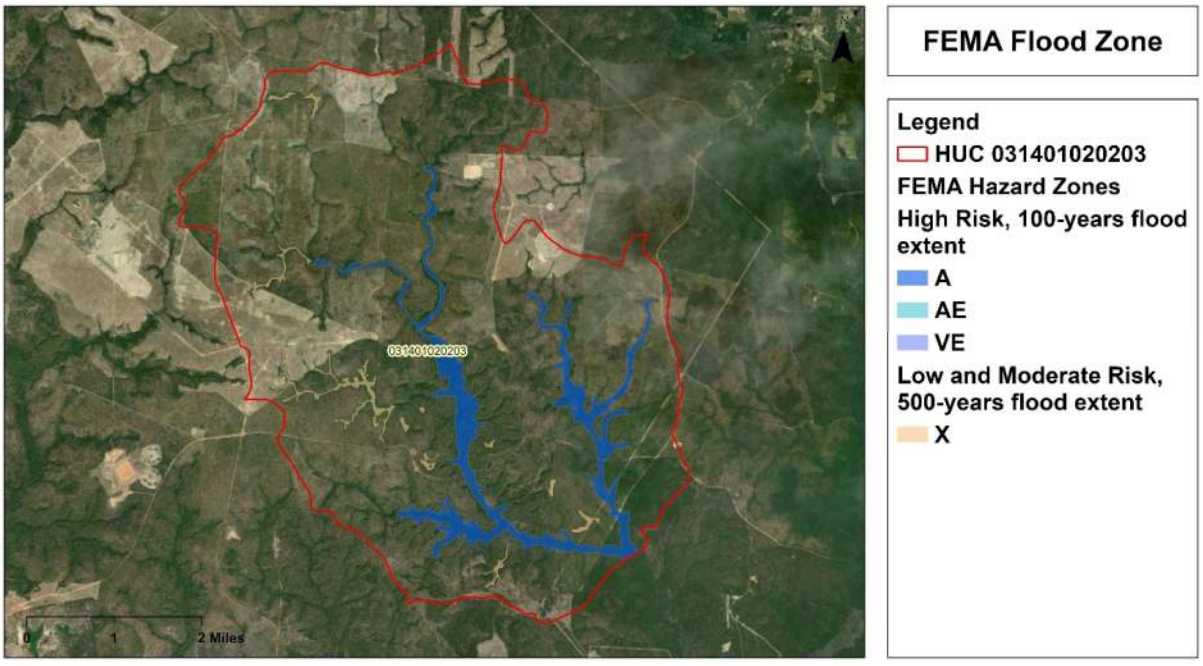

Figure 5. FEMA Flood Zone map (2020) for HUC 031401020203 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401020203 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

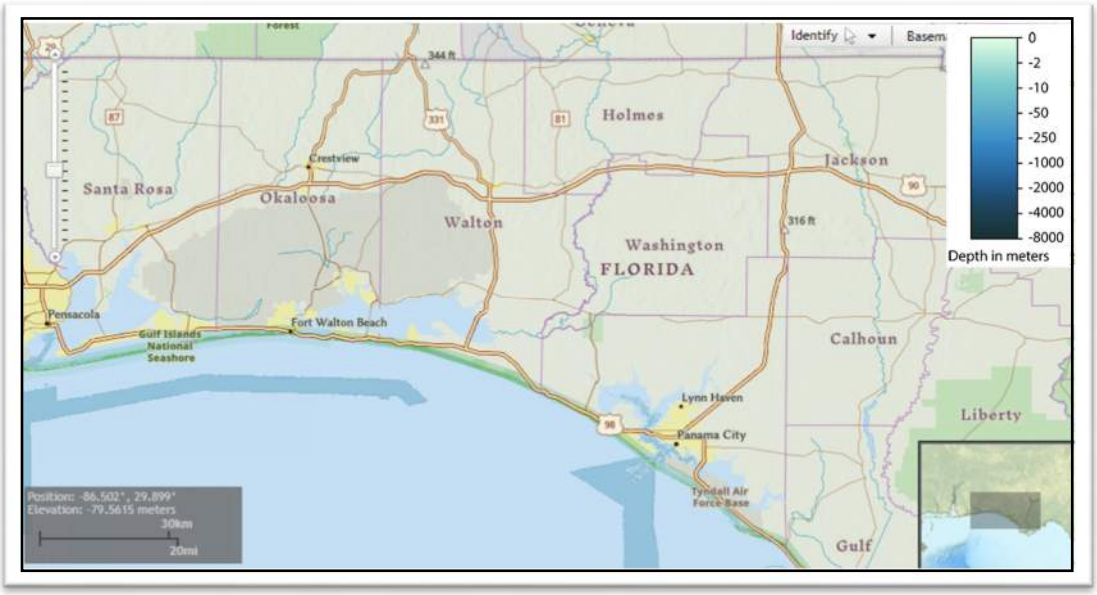

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

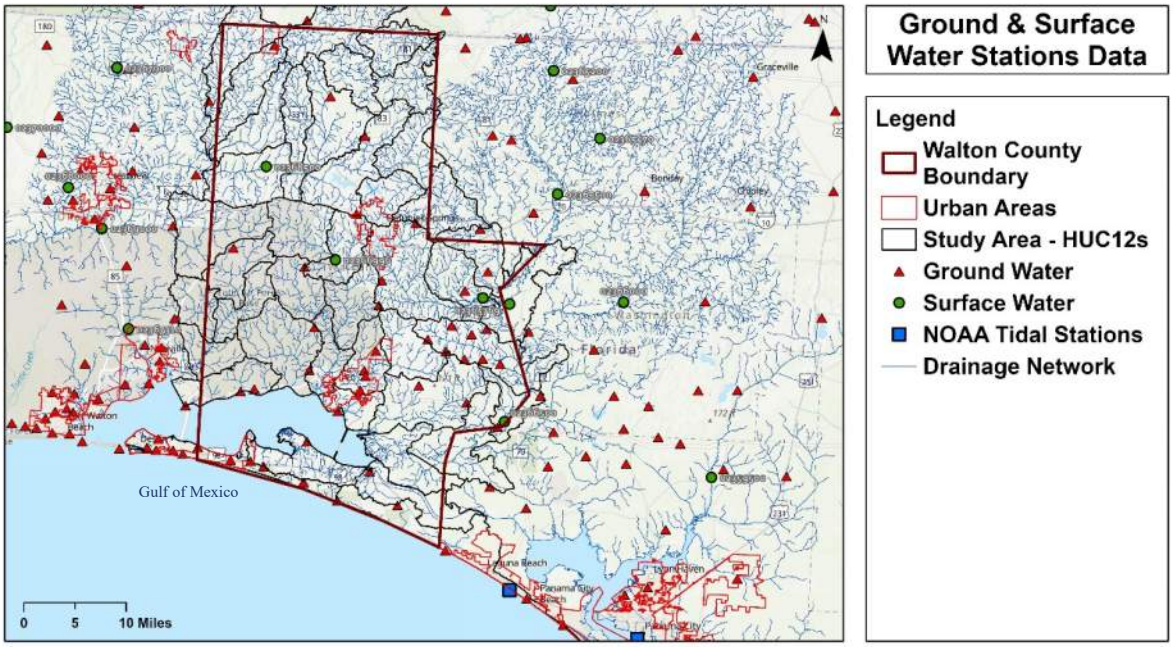

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031401020203 has no major rivers and canals, but creeks and branches, include:

- Little Alaqua Creek
- Burntout Creek

- Fishpond Branch
- Long Branch
- Brier Creek
- Blount Mill Creek

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366996. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401020203, which is USGS 02366996 Alaqua Creek Near Pleasant Ridge, FL.

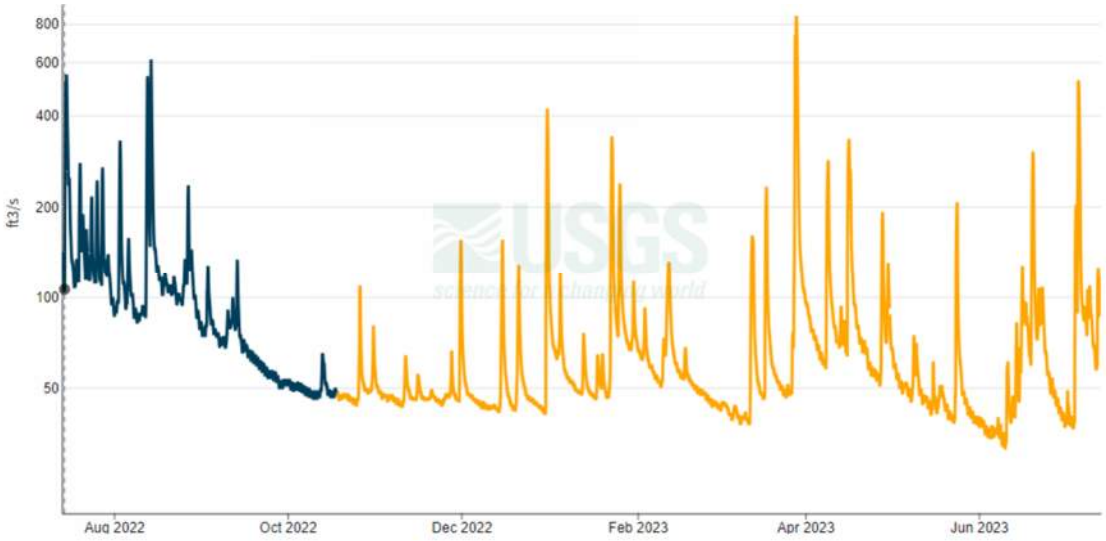

Figure 8. Average streamflow for Alaqua Creek Near Pleasant Ridge, FL (USGS 02366996 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366996/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific

mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401020203 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031401020203 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

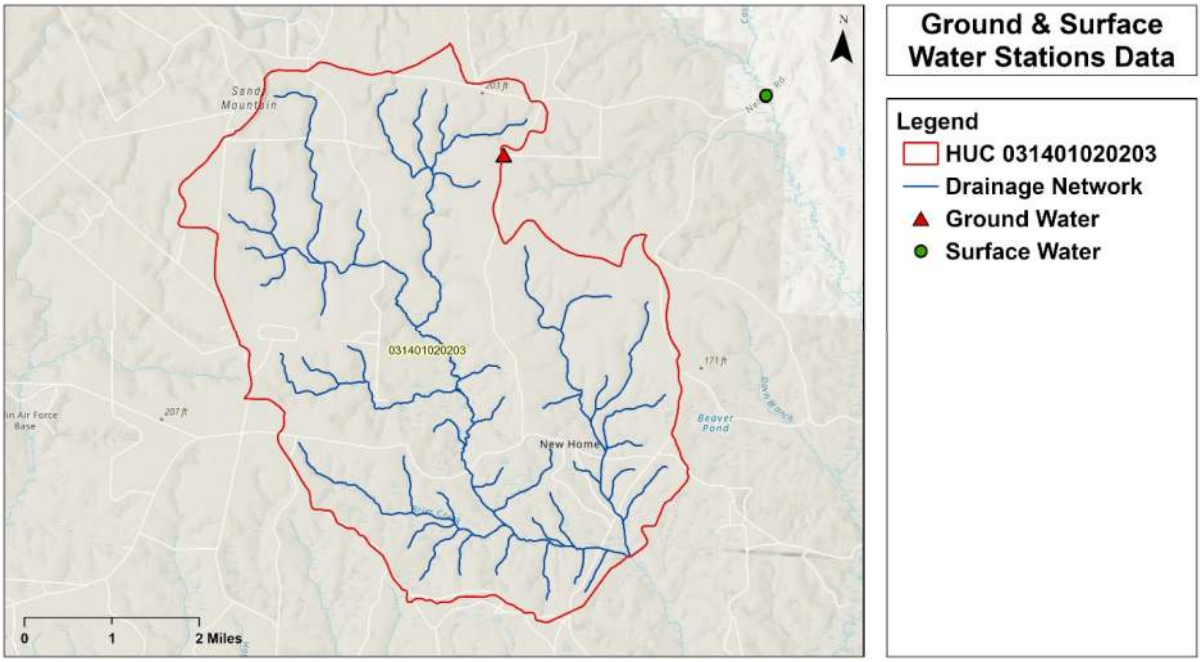

Figure 9. Ground and Surface Water Stations in the HUC 031401020203 sub-watershed, processed by FAU.

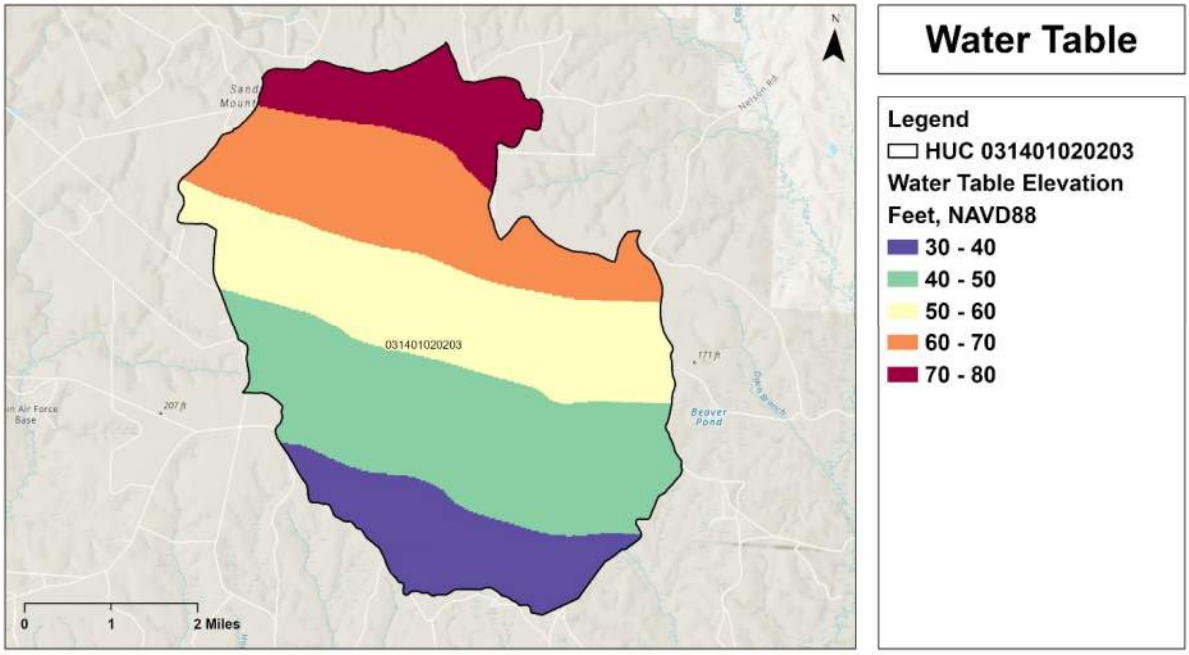

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401020203 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

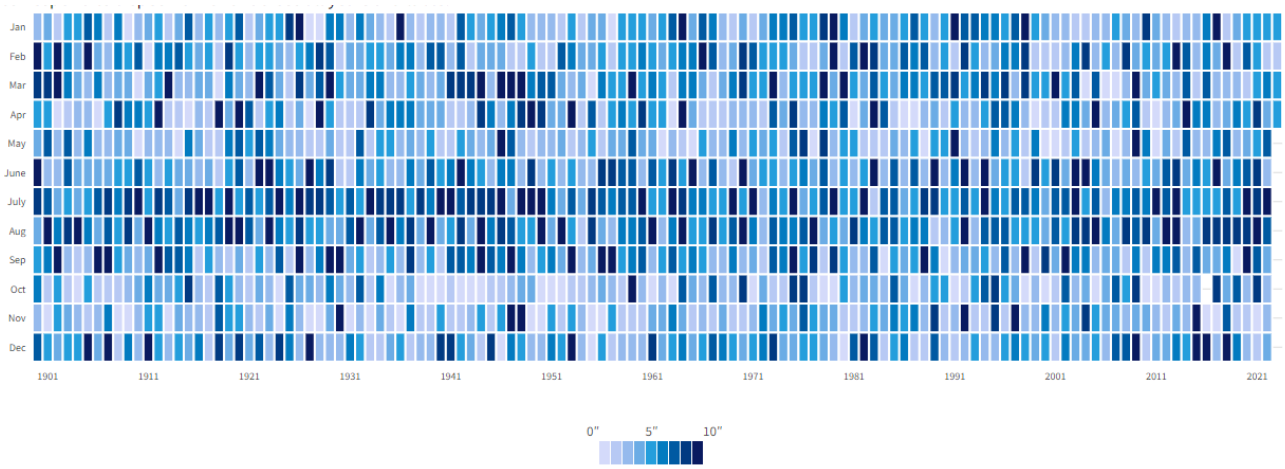

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation)

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there are no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

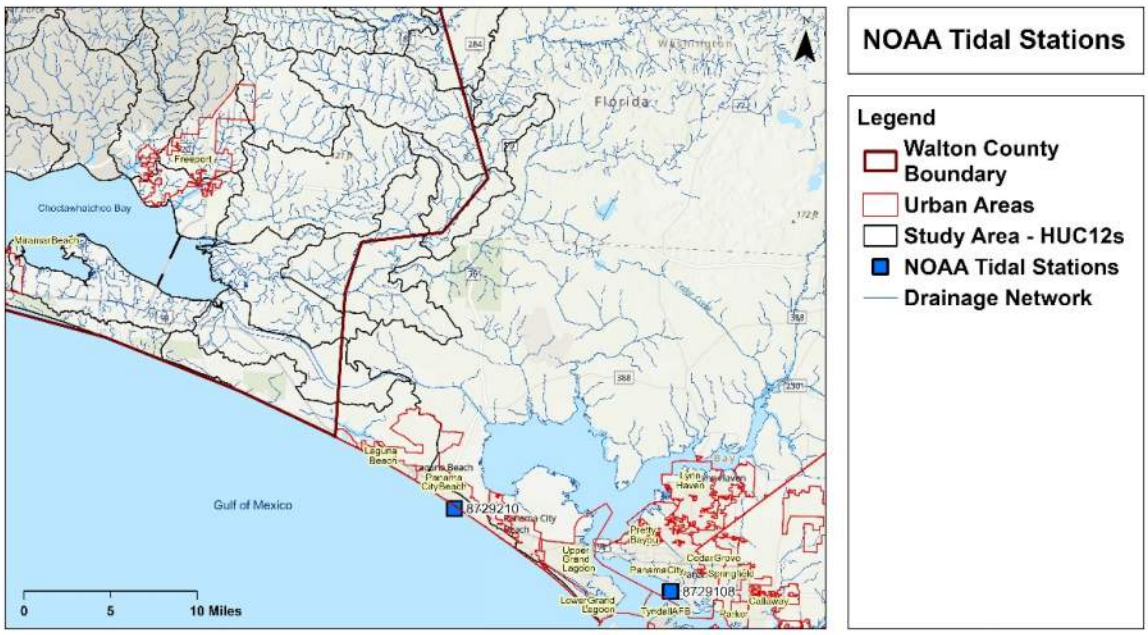

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

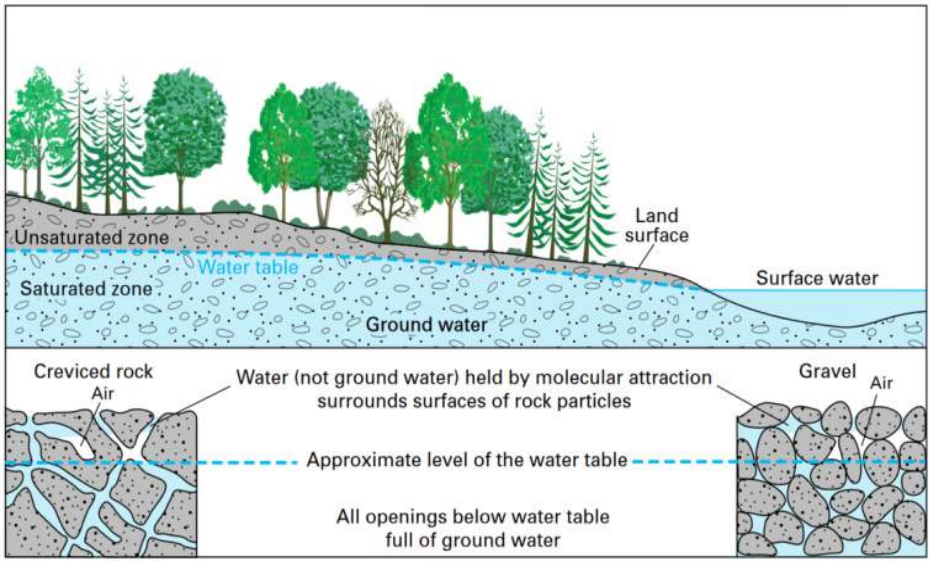

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

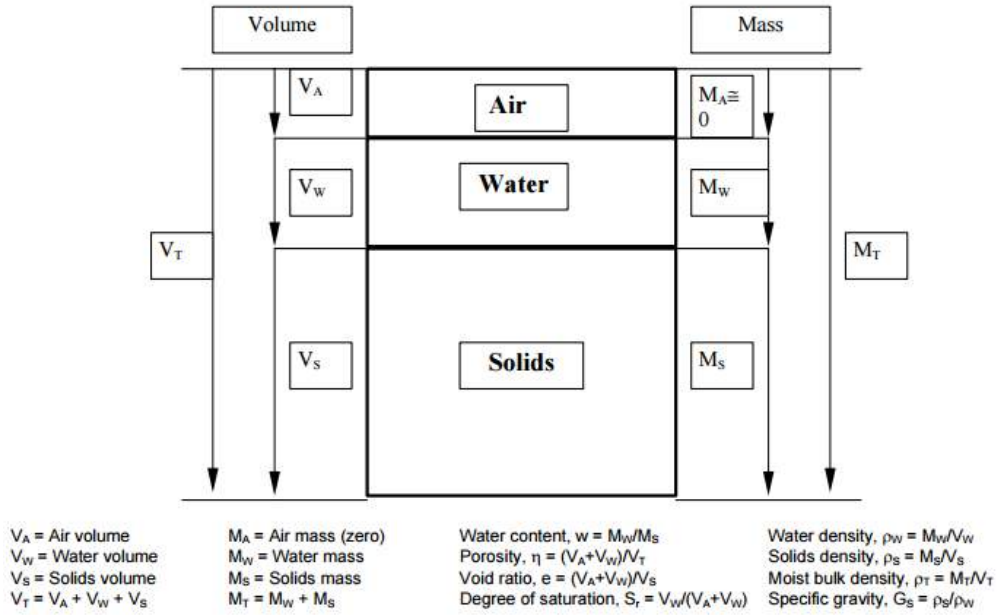

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

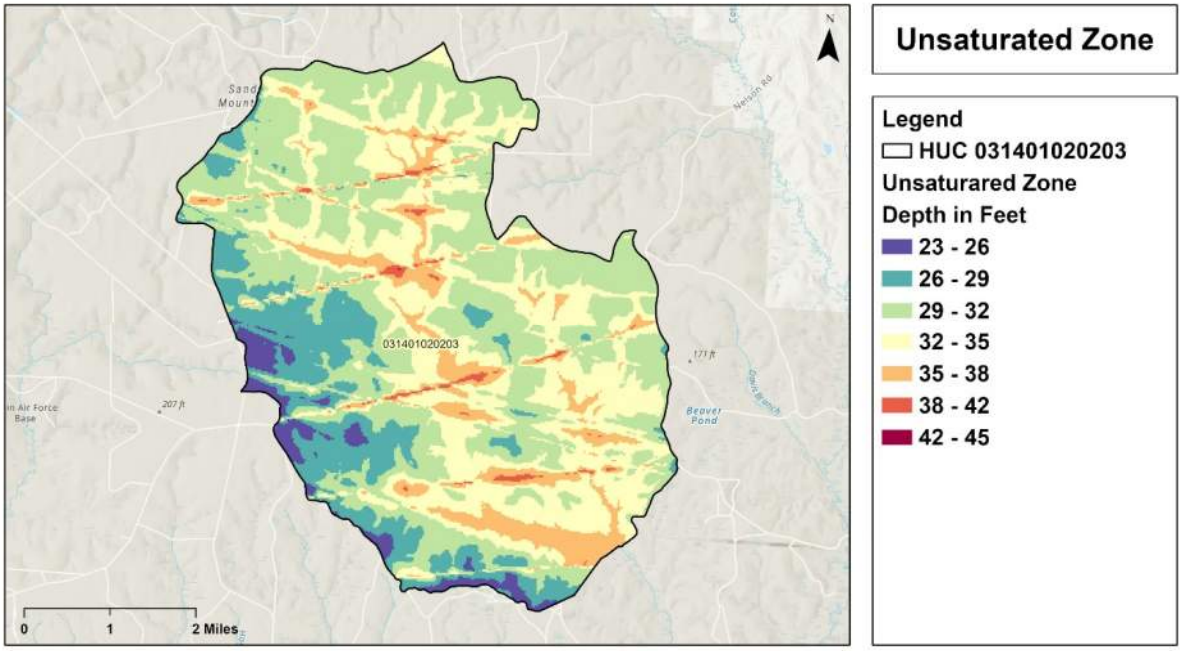

Figure 15. Unsaturated zone map for HUC 031401020203, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. Much of the basin has a medium amount of soil storage capacity, ranging between 30 to 33 inches of capacity left.

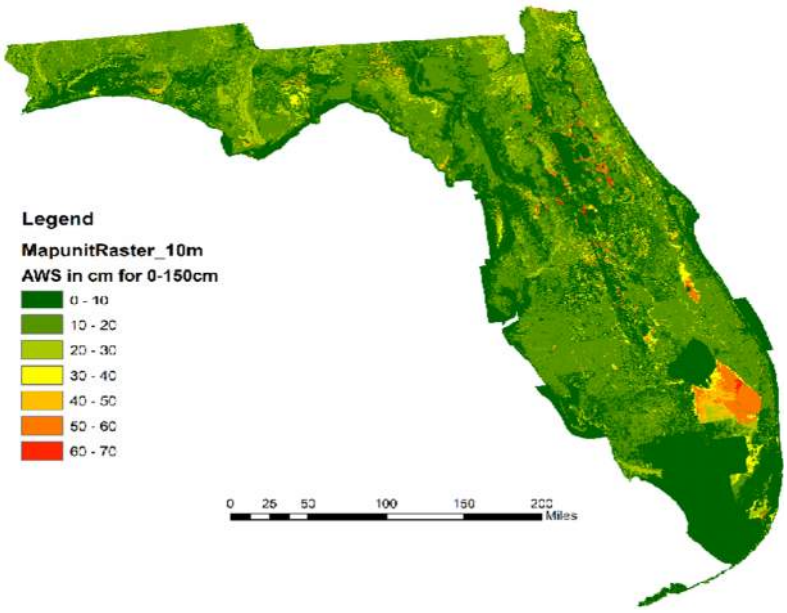

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

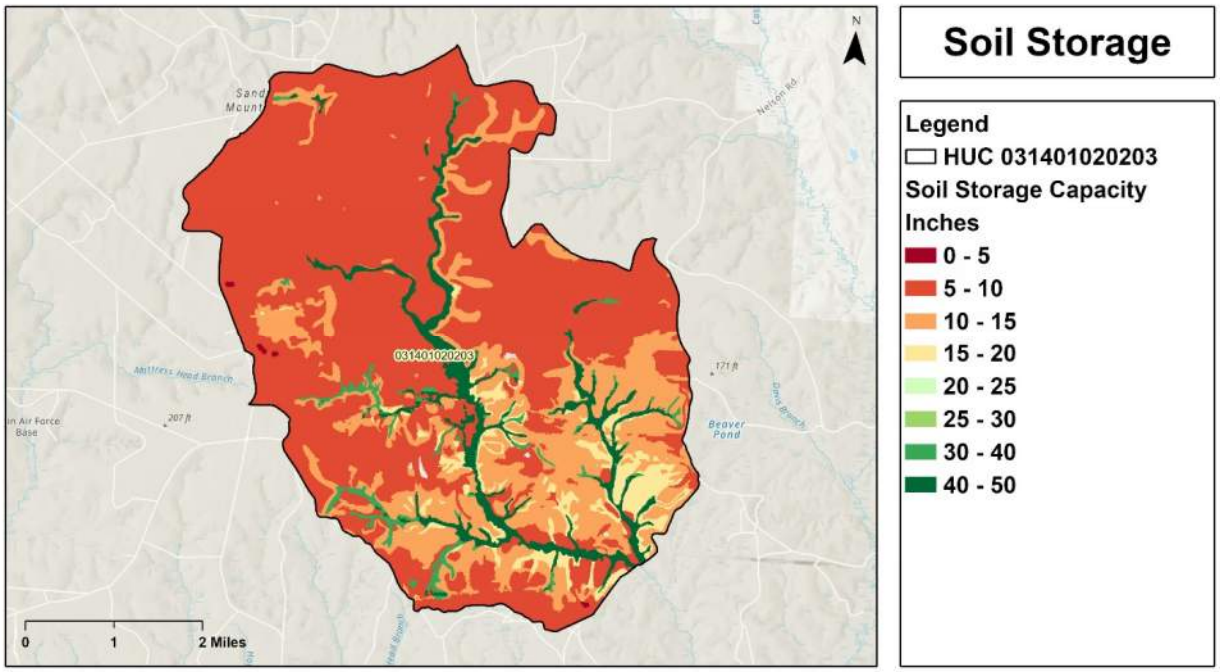

Figure 17. Water storage capacity of soil for the HUC 031401020203, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

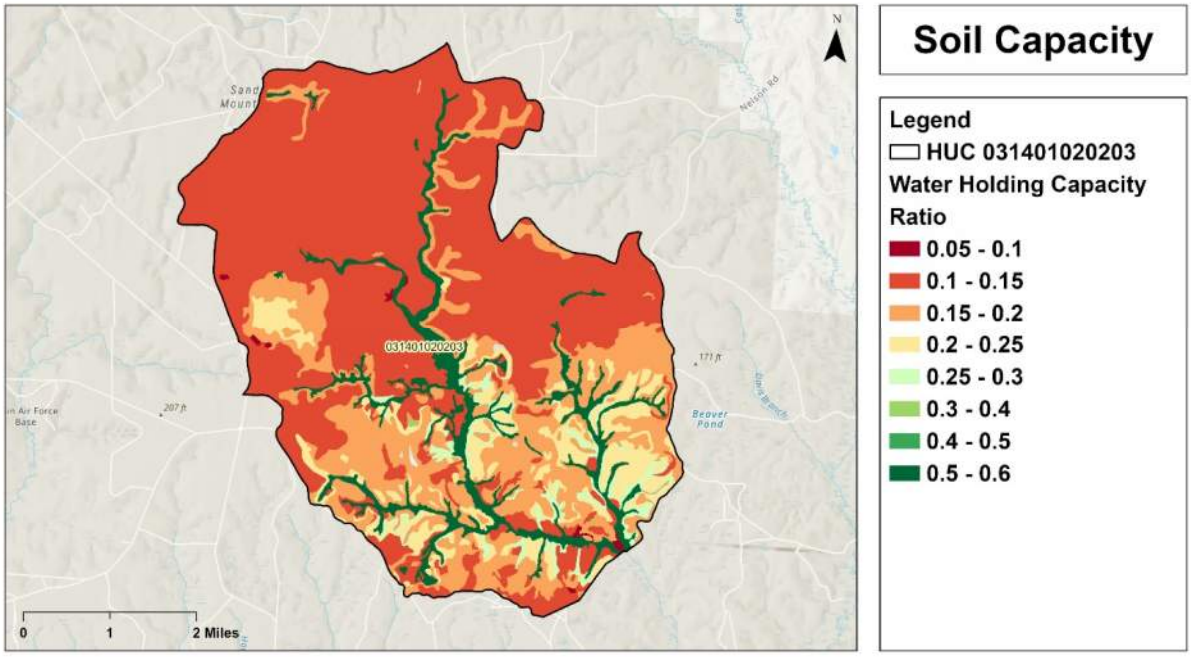

Figure 18. Water Holding Capacity (ratio) for the HUC 031401020203, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

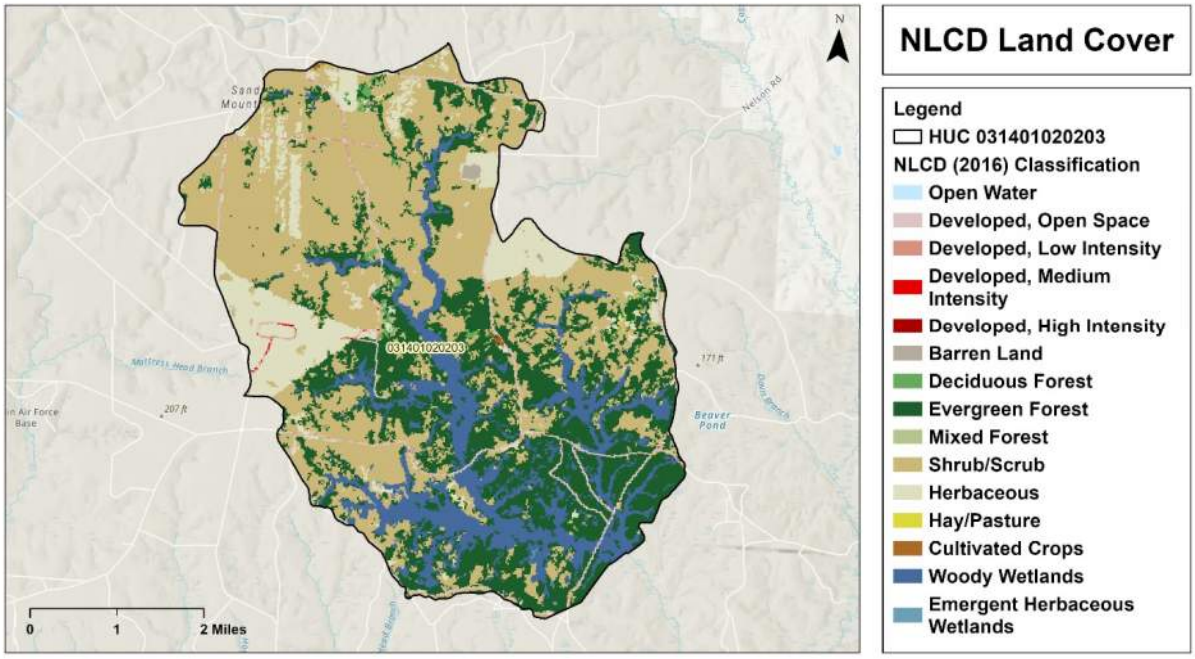

Figure 19. Land use in the HUC 031401020203 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

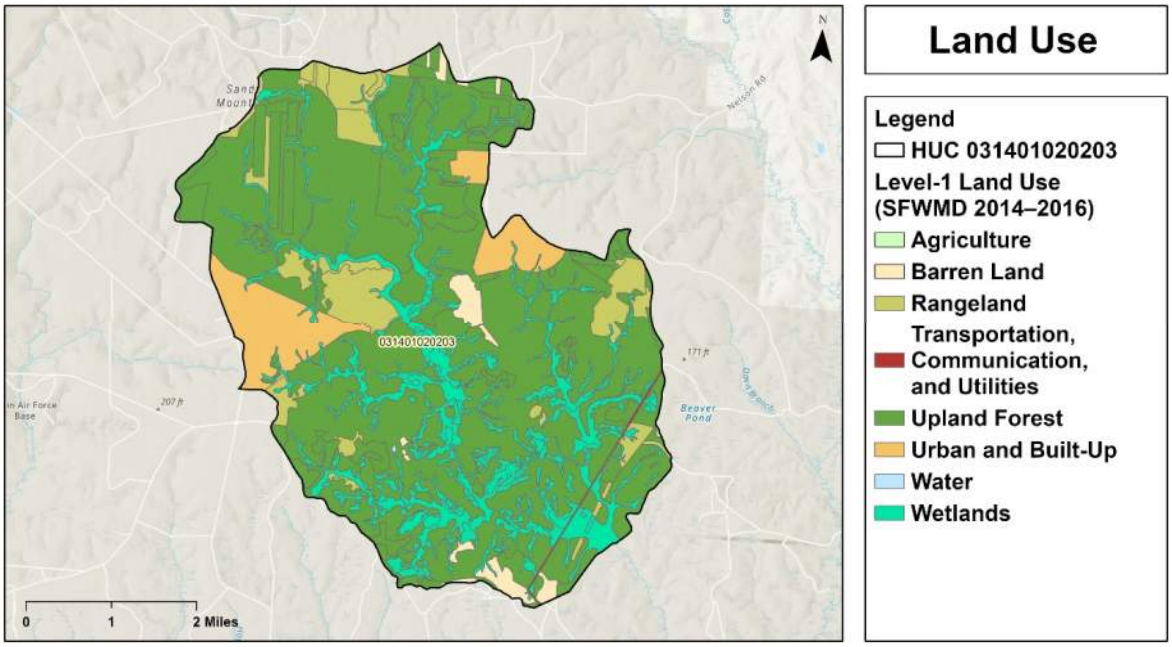

Figure 20. Land use in the HUC 031401020203 (2023 Florida Geographic Data Library (FGDL)), processed by FAU.

In the HUC 031401020203 sub-watershed, the predominant land cover is upland forest, accounting for 62.90% of the area. Urban and built-up comes in second at 13.92%, followed by wetlands at 10.80%, and rangeland at 9.73%, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031401020203 subwatershed (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	0.00	0.00%
Barren Land	624.27	2.38%
Rangeland	2554.60	9.73%
Transportation, Communication, and Utilities	71.47	0.27%
Upland Forest	16521.38	62.90%
Urban and Built-Up	3656.82	13.92%
Water	2.15	0.01%
Wetlands	2836.63	10.80%
Grand Total:	**26267.32**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

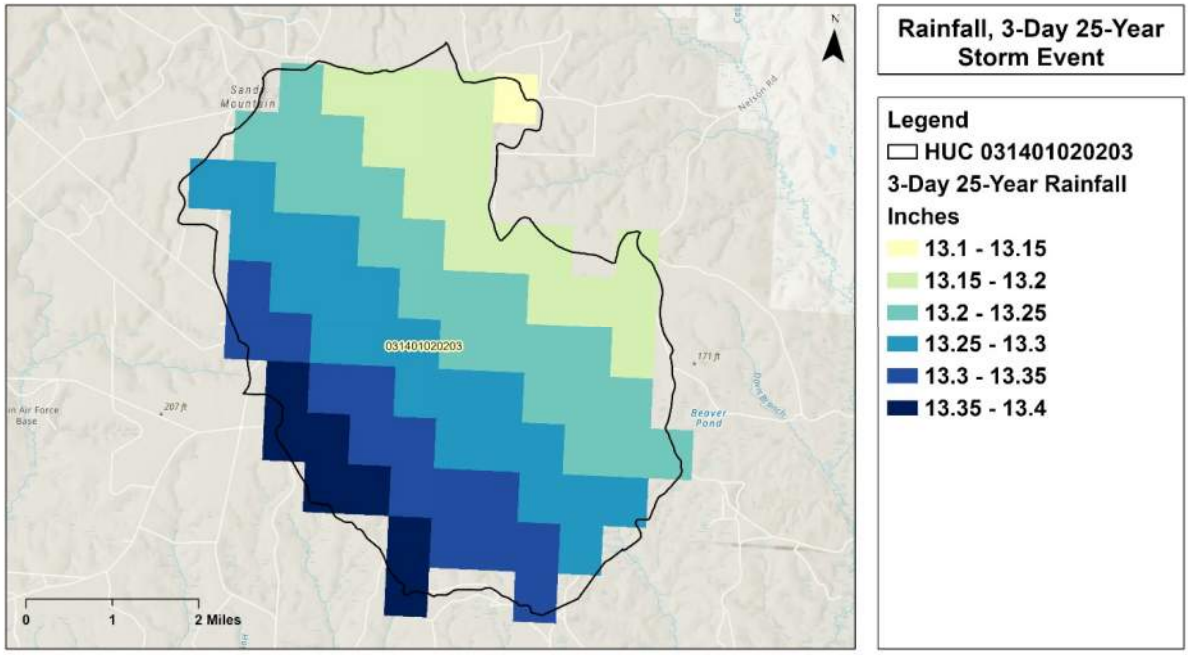

Figure 21. Rainfall distribution map across HUC 031401020203 sub-watershed, for 3-day 25-year storm event, processed by FAU.

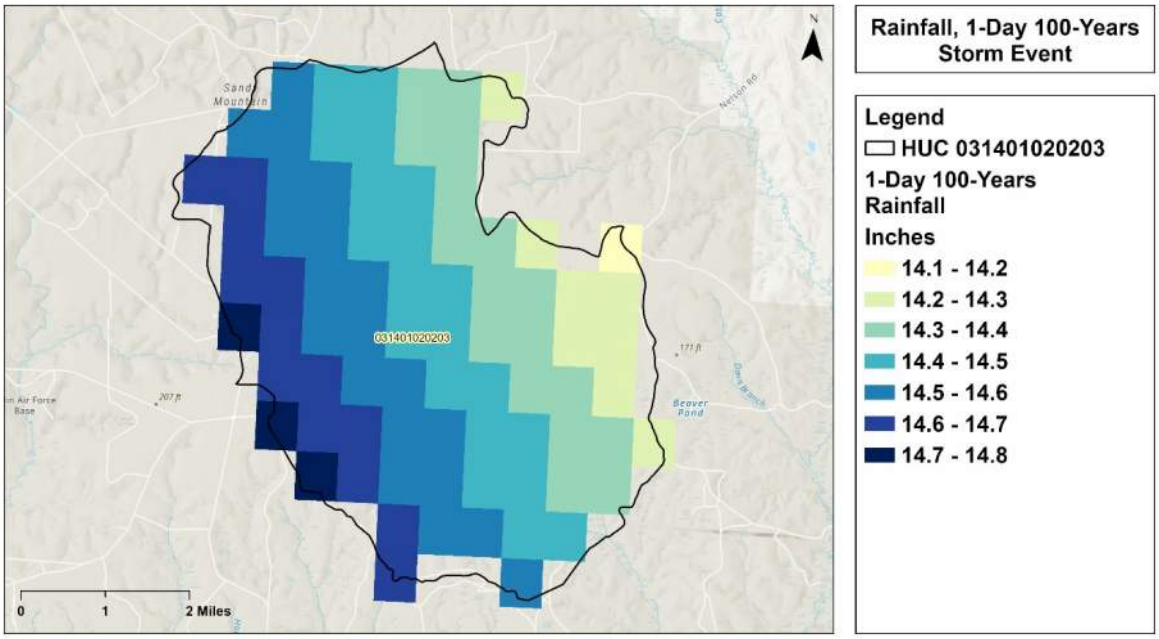

Figure 22. Rainfall distribution map across HUC 031401020203 sub-watershed, for 1-day 100-year storm event, processed by FAU.

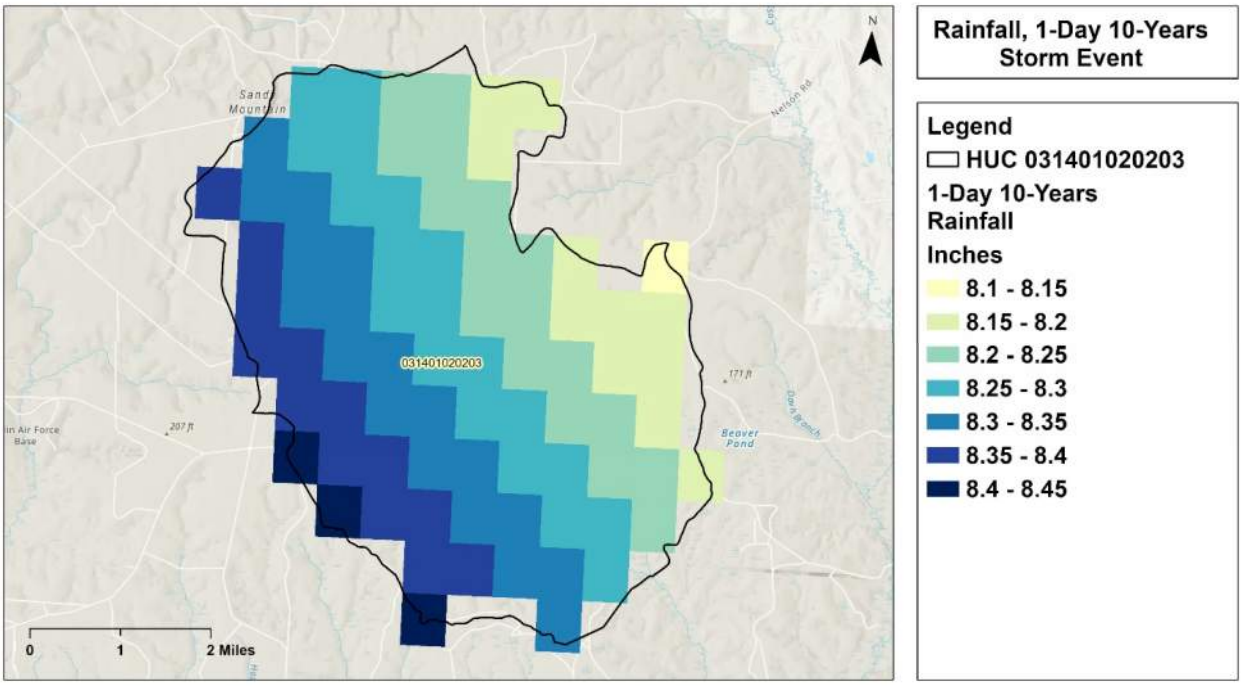

Figure 23. Rainfall distribution map across HUC 031401020203 sub-watershed, for 1-day 10-year storm event, processed by FAU.

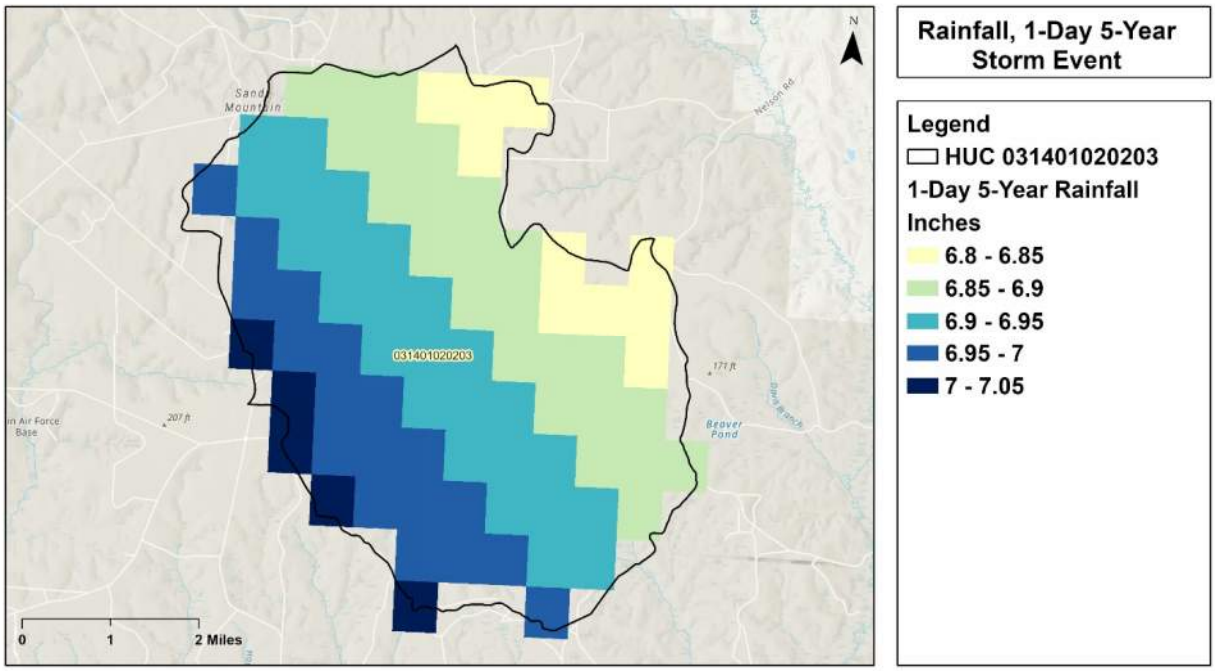

Figure 24. Rainfall distribution map across HUC 031401020203 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer

was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

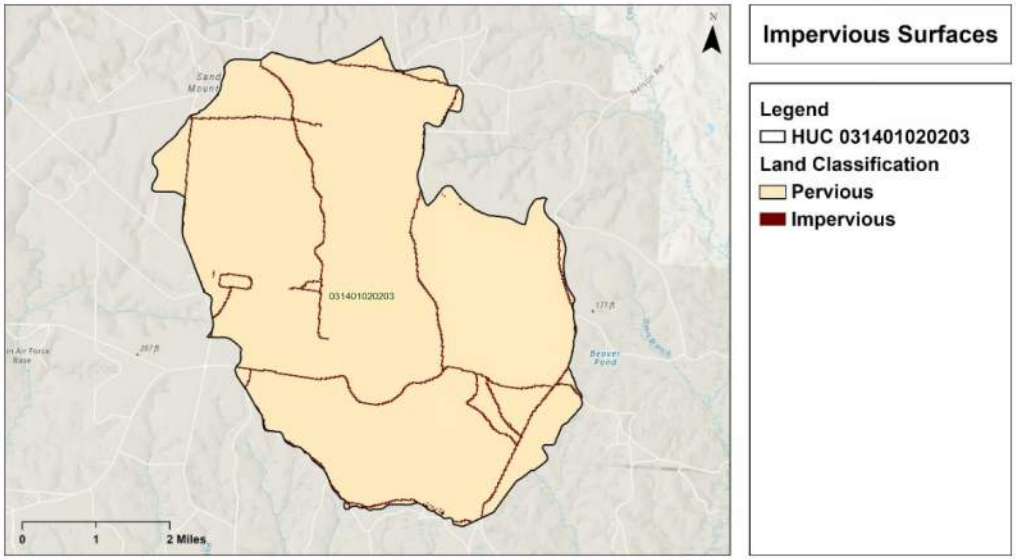

Figure 25. Impervious area map for the HUC 031401020203 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

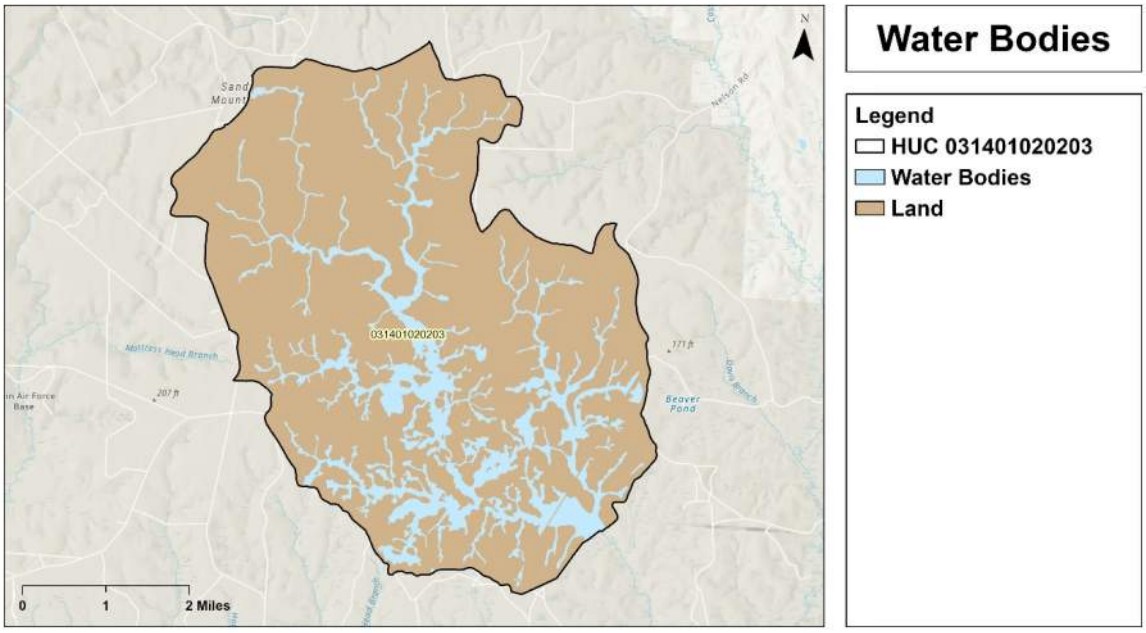

Figure 26. Water bodies map for the HUC 031401020203 sub-watershed, processed by FAU.

1.10. Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.

- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

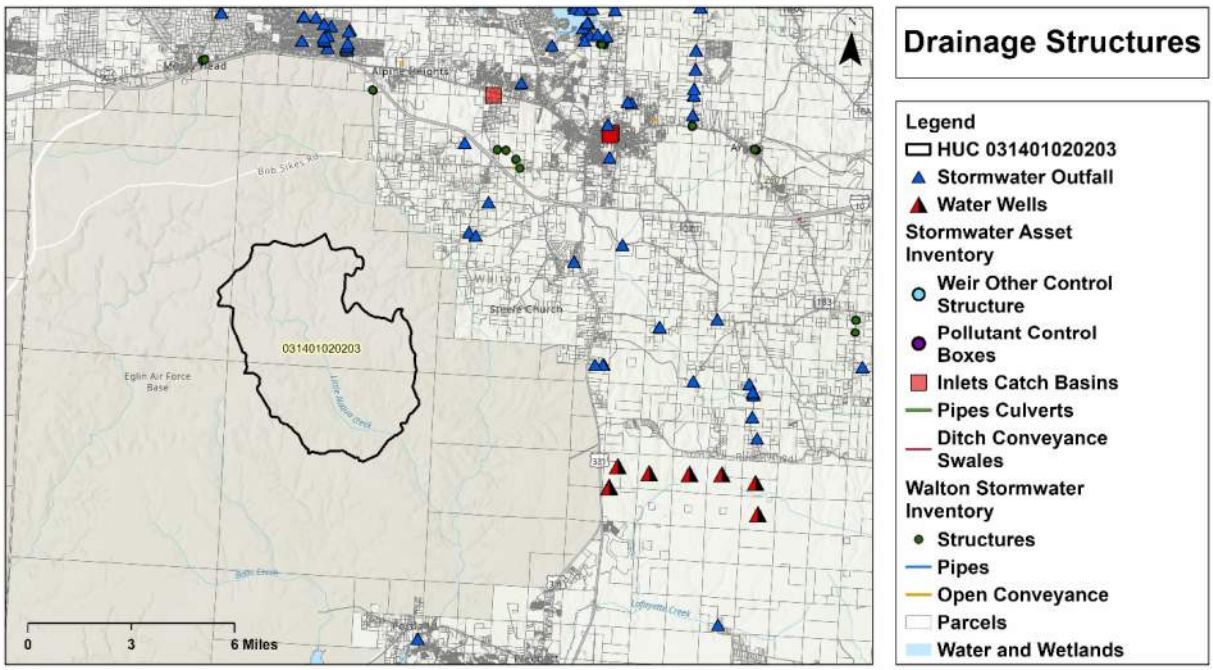

Figure 27. Stormwater Infrastructure for the HUC 031401020203. Processed by FAU.

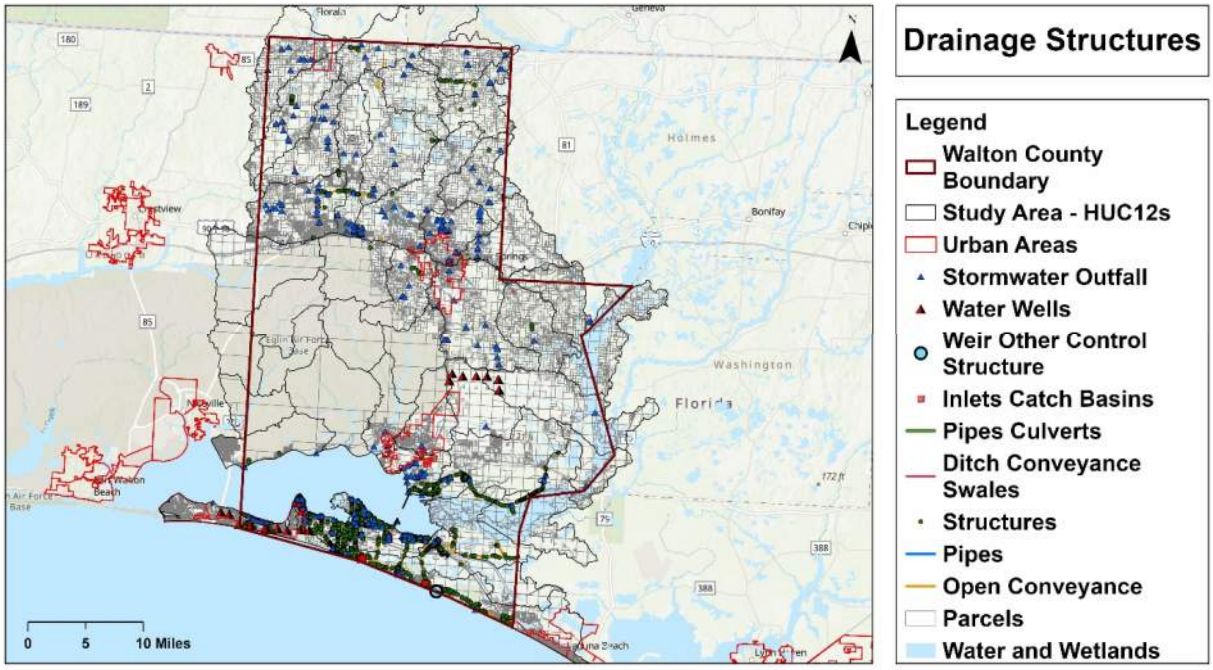

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage / Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native

Data Category	Dataset Name	Original Source	Spatial Coverage / Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_masterrcopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_masterrcopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_masterrcopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage / Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapter 1, and analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401020202 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species

while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. Figure 29 shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

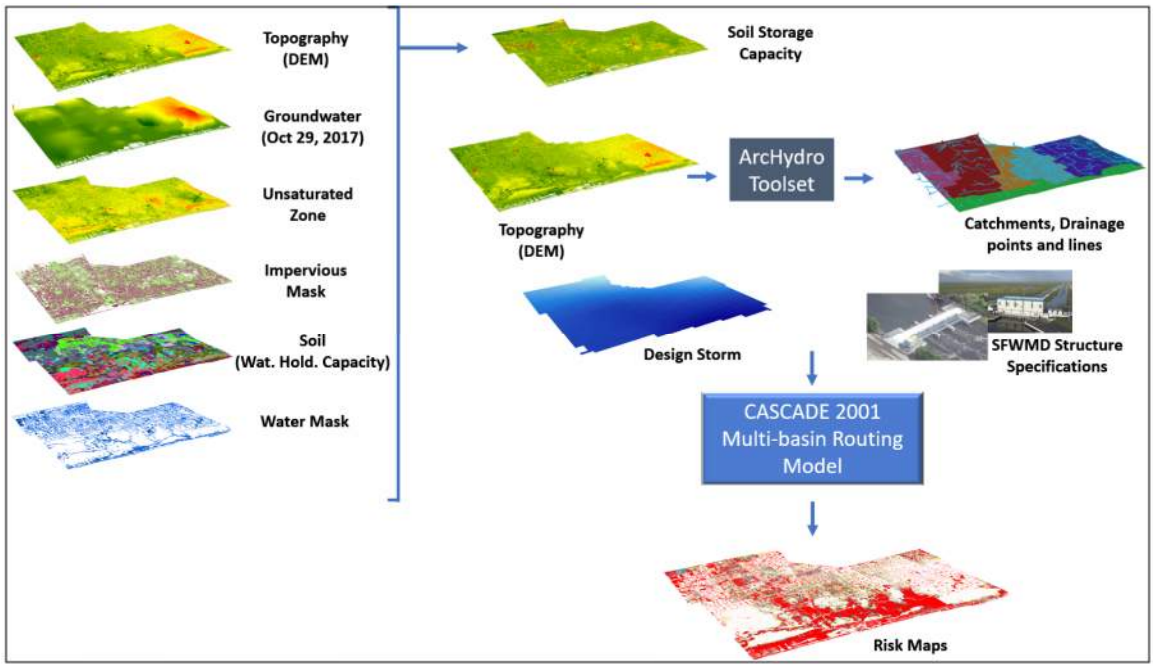

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are

critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

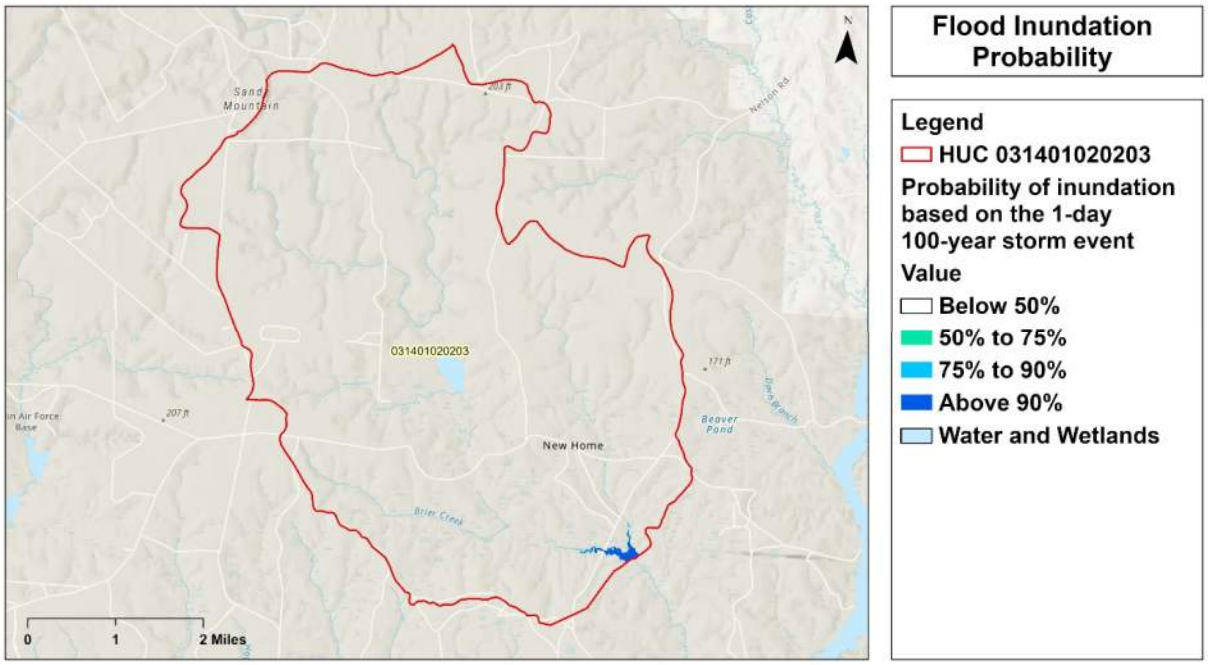

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401020203, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate

the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed later in this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in

the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Figure 31 to Figure 34 are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 31)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 32)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 33)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 34)

In all storm event scenarios, a very small portion of flooding is noted at the entrance to the creek into the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, sea level rise should not impact the HUC, therefore SLR scenarios were not calculated.

The design storm simulation determined that approximately 0.1% of the HUC total area or 0.03 mi² has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 0.2% of the HUC's total area, or 0.05 mi² would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.1% of the HUC's total area, or 0.03 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0.1% of the HUC's total area, or 0.03 mi², would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401020203 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	24.09	0.03	99.9%	0.1%
1-day 100-year	24.08	0.05	99.8%	0.2%
1-day 10-year	24.10	0.03	99.9%	0.1%
1-day 5-year	24.10	0.03	99.9%	0.1%

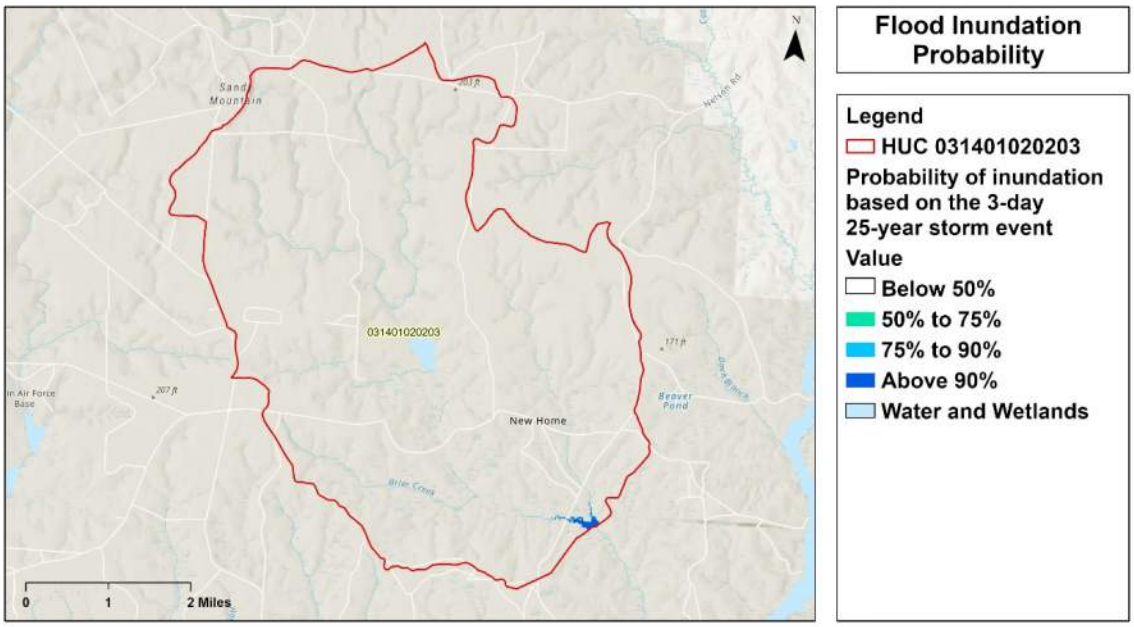

Figure 31. 3-day 25-year storm event for HUC 031401020203 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

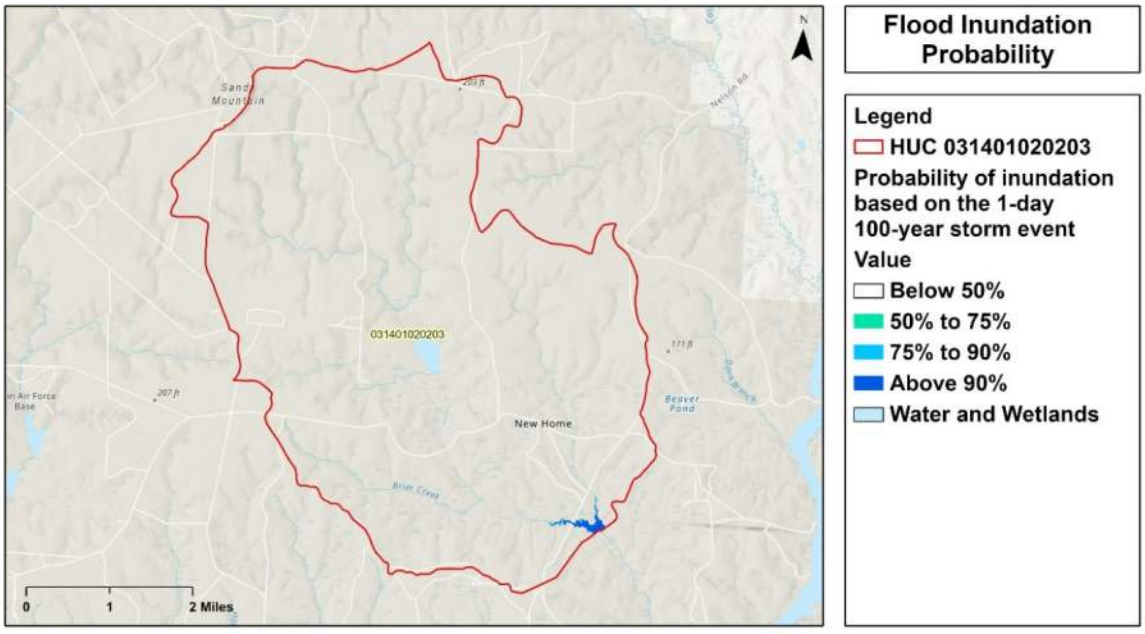

Figure 32. 1-day 100-year storm event for HUC 031401020203 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

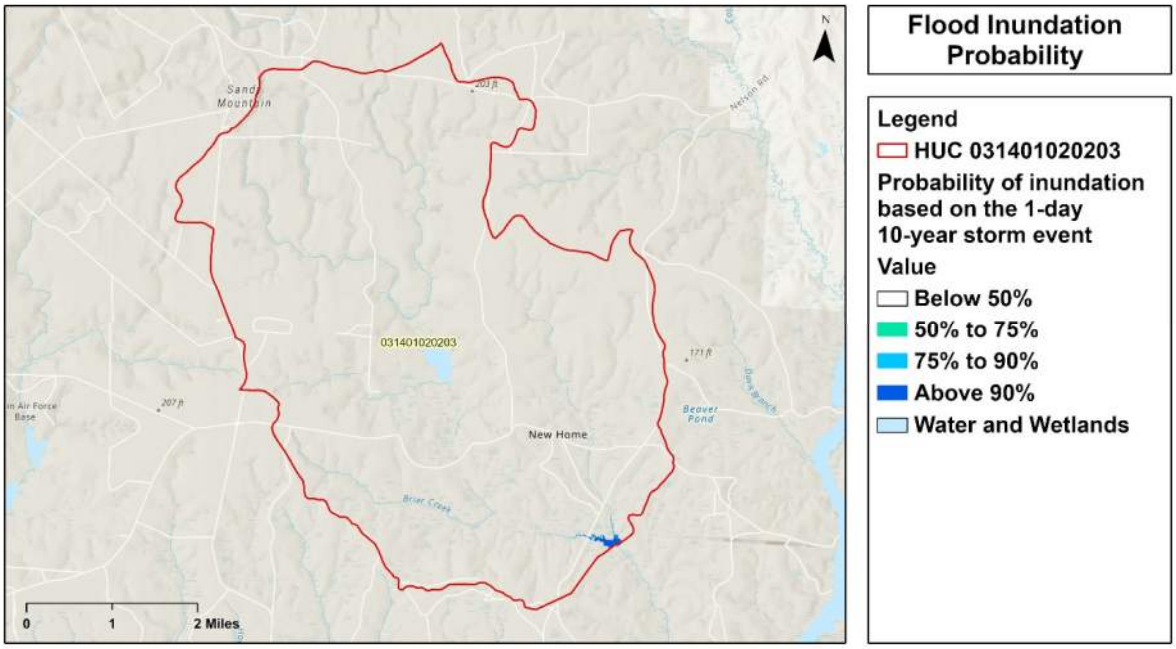

Figure 33. 1-day 10-year storm event for HUC 031401020203 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

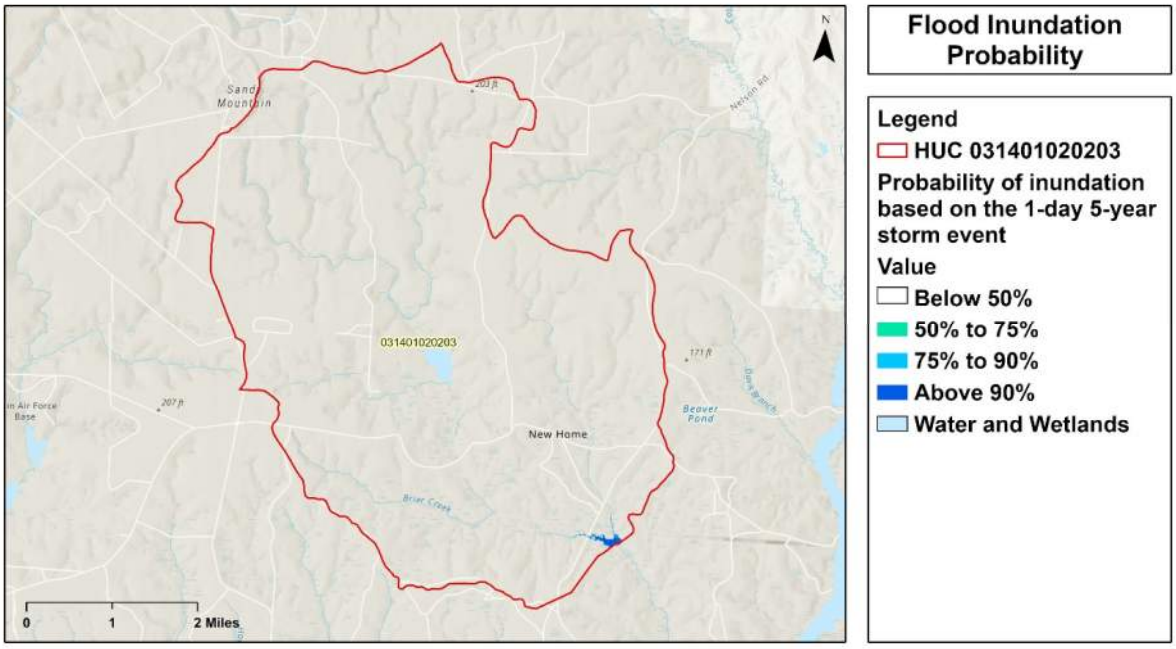

Figure 34. 1-day 5-year storm event for HUC 031401020203 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	Description	TIER (Priority of Land Use)
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6

11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3

40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6

67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6

99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Figure 35 and Figure 36 depict the HUC 031401020203 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (Figure 35) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 36) overlays critical facilities onto the 1-day 100-year storm event scenario. Figure 37is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, Figure 38illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, Figure 39 is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

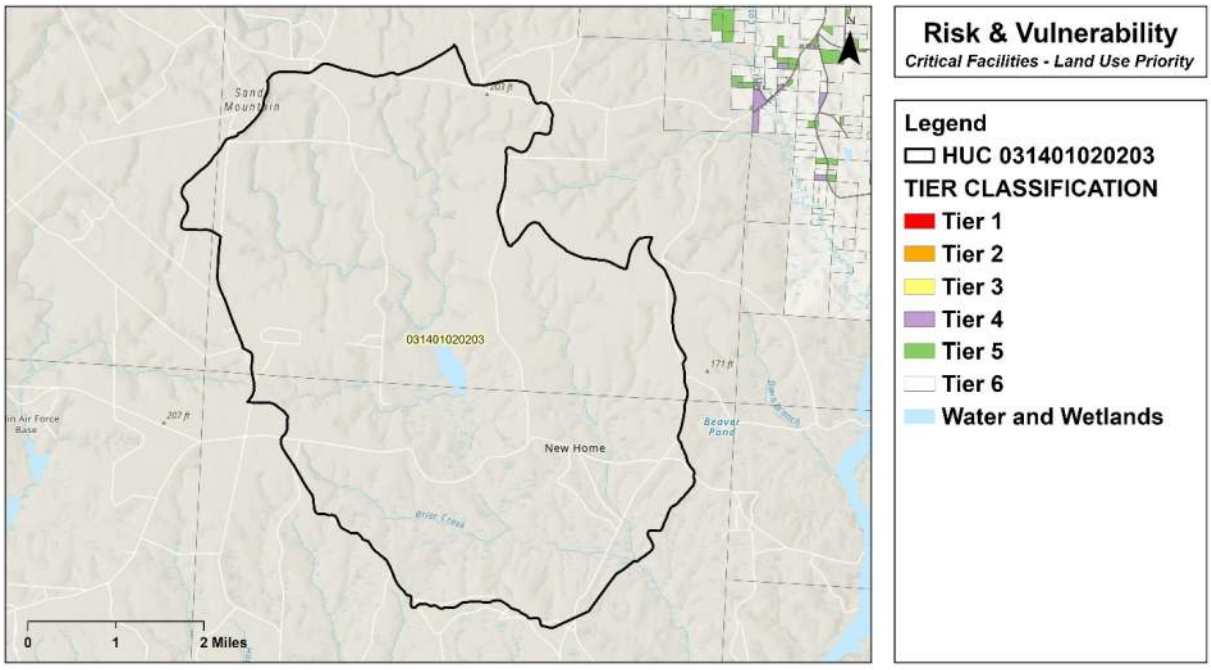

Figure 35. HUC 031401020203 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

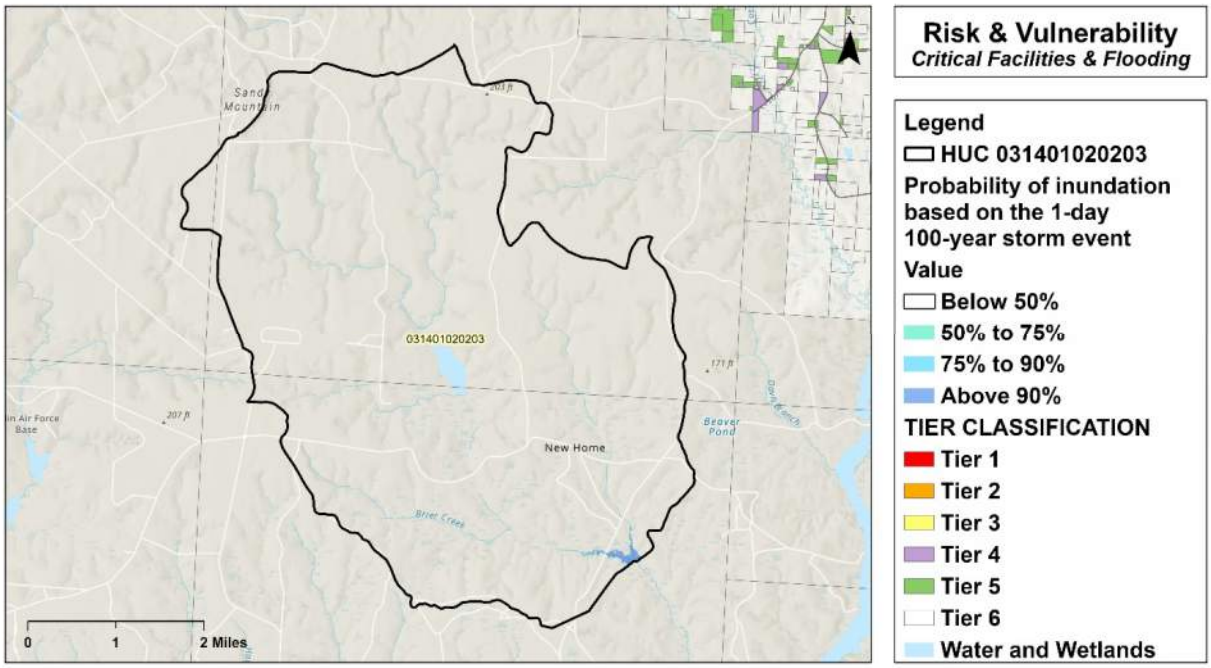

Figure 36. HUC 031401020203 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

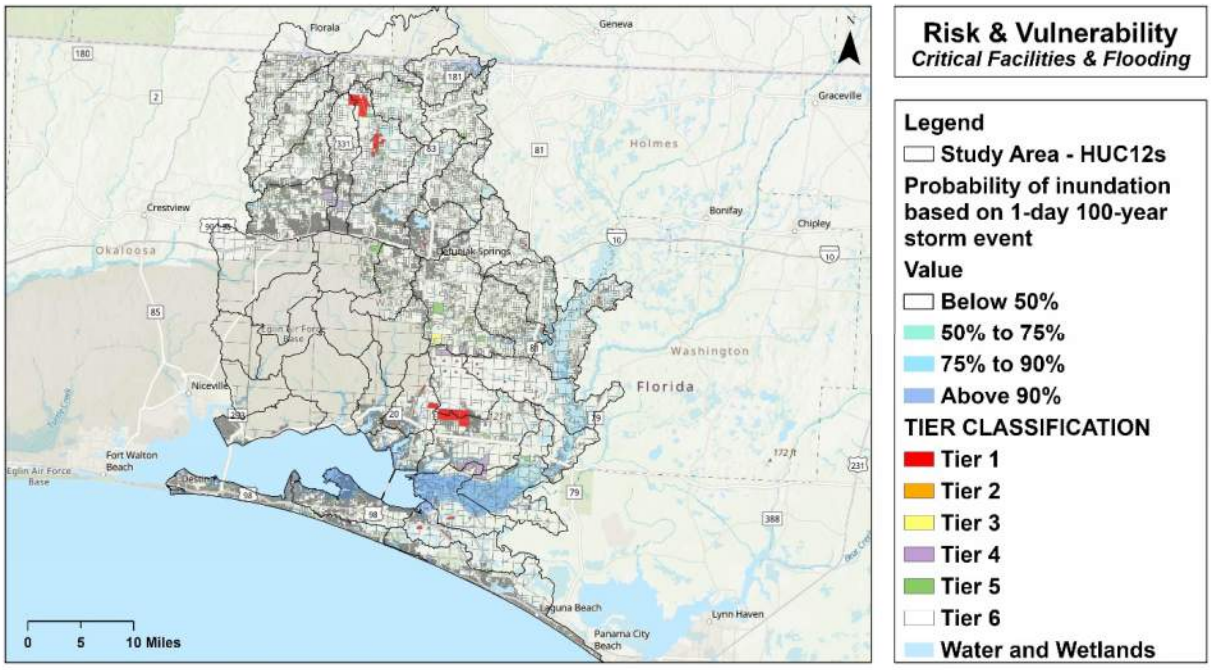

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

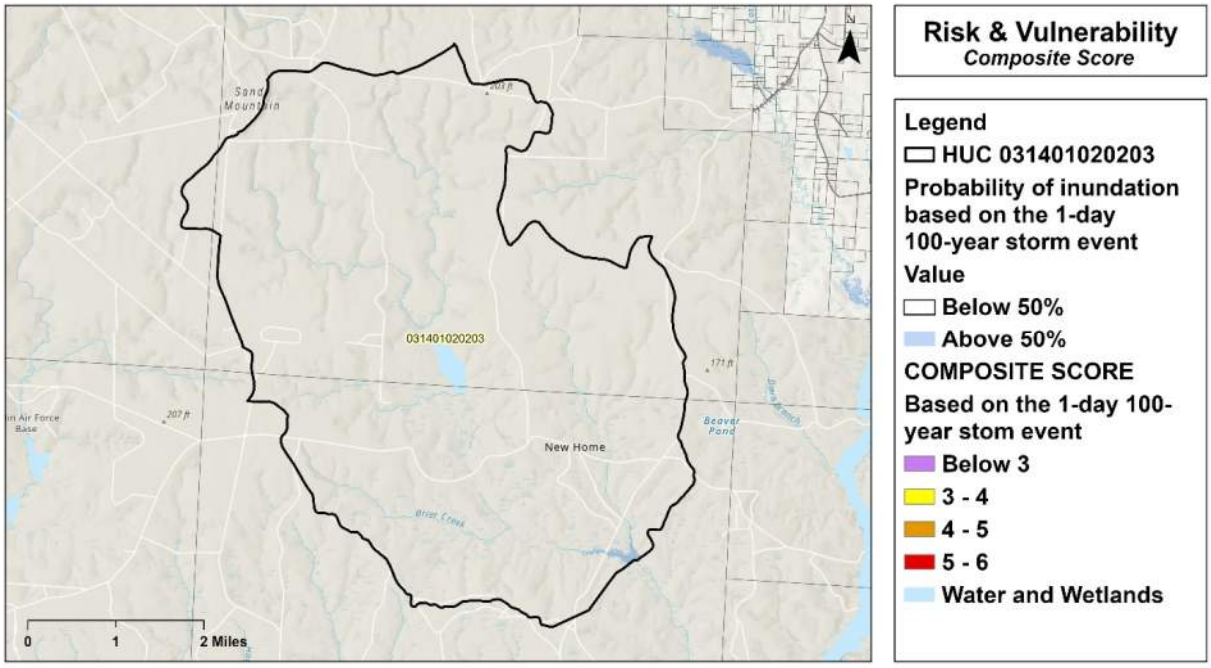

Figure 38. HUC 031401020203 sub-watershed Composite Score Risk map, with calculation based on 1-day 100-year storm event. Processed by FAU.

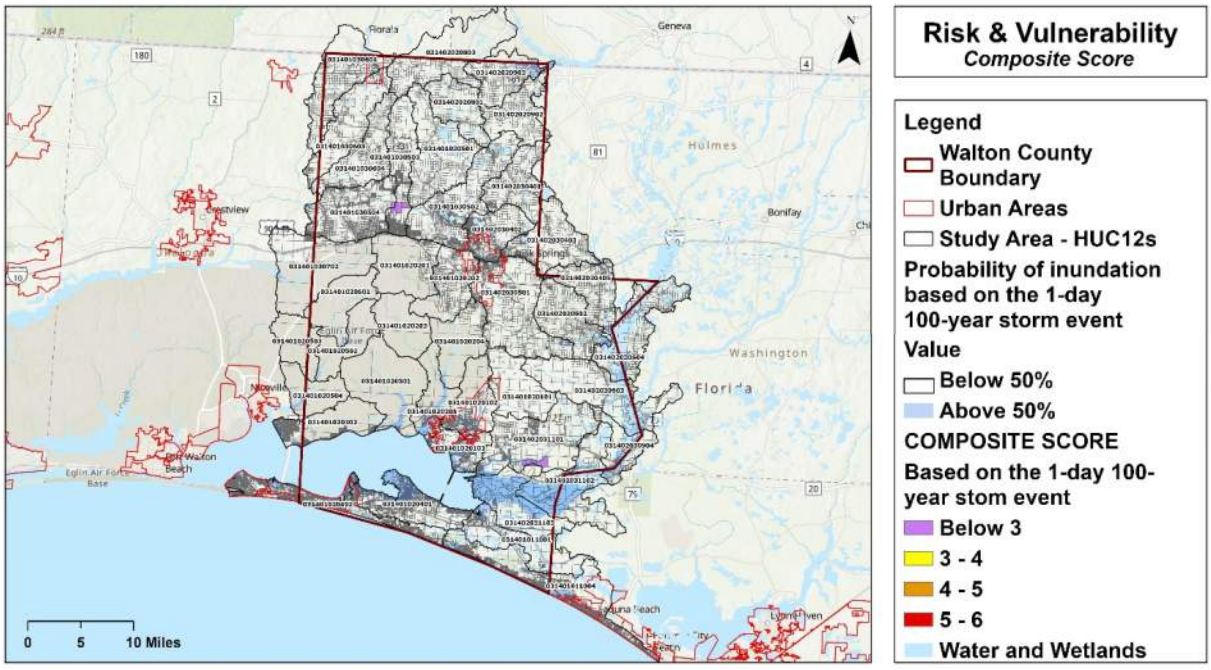

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.
Please note that due to the scale of the map, the composite score layer is not properly visible in this map.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401020203. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401020203. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401020203	15442.49
All of the 1-day 100-year storm event inundation	**31.56**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	31.56
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	0.00
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	0.00

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. Figure 40 indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

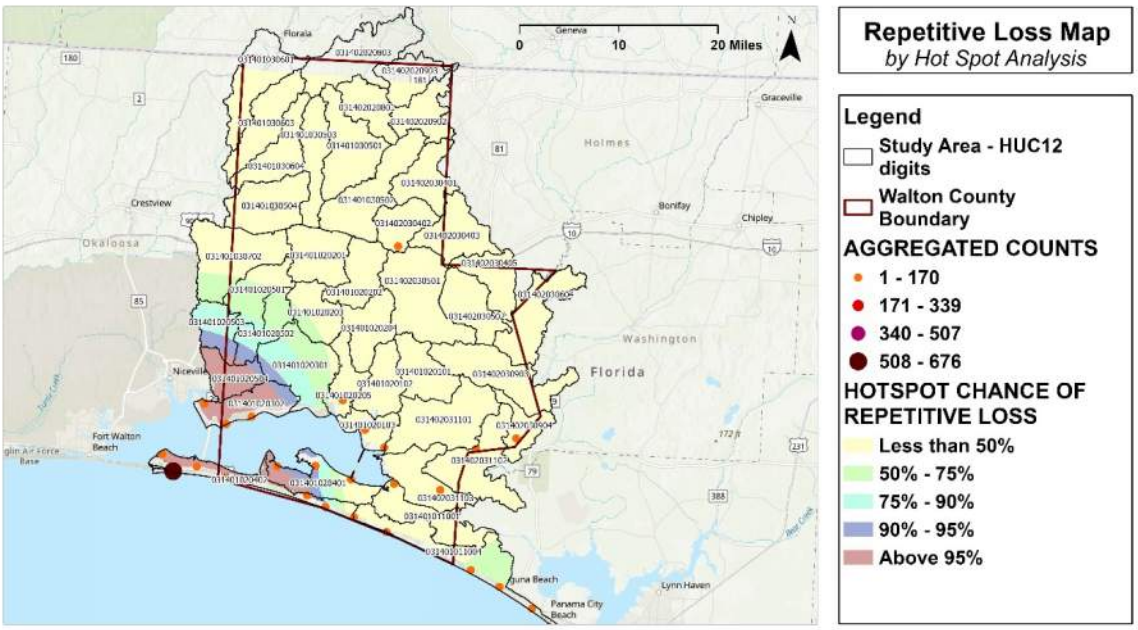

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5 Priority Projects

The entire HUC area is undeveloped and non-coastal. As a result, there are no critical facilities or other land uses that require priority intervention. The minor flooding and null composite score indicate that the HUC is not significantly affected by flooding, and there are no pressing priorities for interventions to address inundation impacts.

More detail about flood solutions are described in the community plan and in Section 5.5 where drilldown to specific neighborhoods is outlined.

APPENDIX J

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401020204

LOWER ALAQUA CREEK

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Co-Principal Investigators: Weibo Liu, Ph.D., Daniel Meeroff, Ph.D., Diana Mitsova, Ph.D., S. Nagarajan, Ph.D., Hongbo Su, Ph.D., Ramesh Teegavarapu, Ph.D., Zhixiao Xie, Ph.D., Yan Yong, Ph.D., and Caiyun Zhang, Ph.D., Ahmet Urusan, Ph.D., Shannon Egger, Eva Suarez, Ph.D.

Research Assistant: Leticia Sabio

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 sub-watershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (Figure 1). Figure 2 shows Walton County Drainage Network and the location of urban areas (cities and towns). In Figure 3, the HUC-12 digits (031401020204) is highlighted among all the HUCs to help identifying its location. (Figure 3).

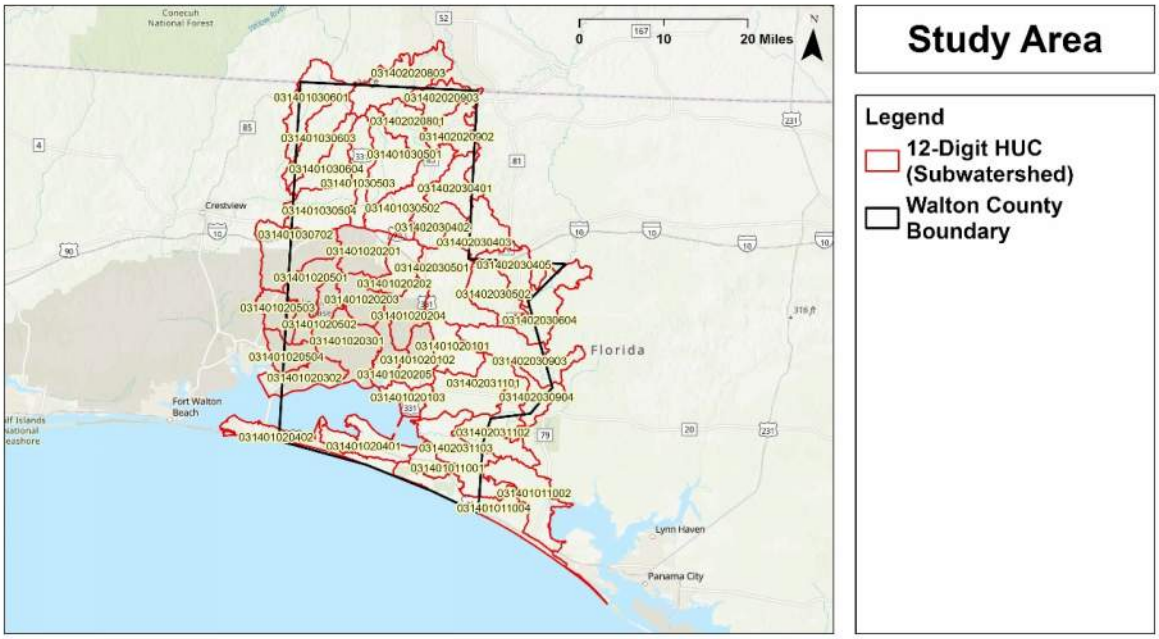

Figure 1. Walton County and all HUCs 12-digit sub-watershed, processed by FAU.

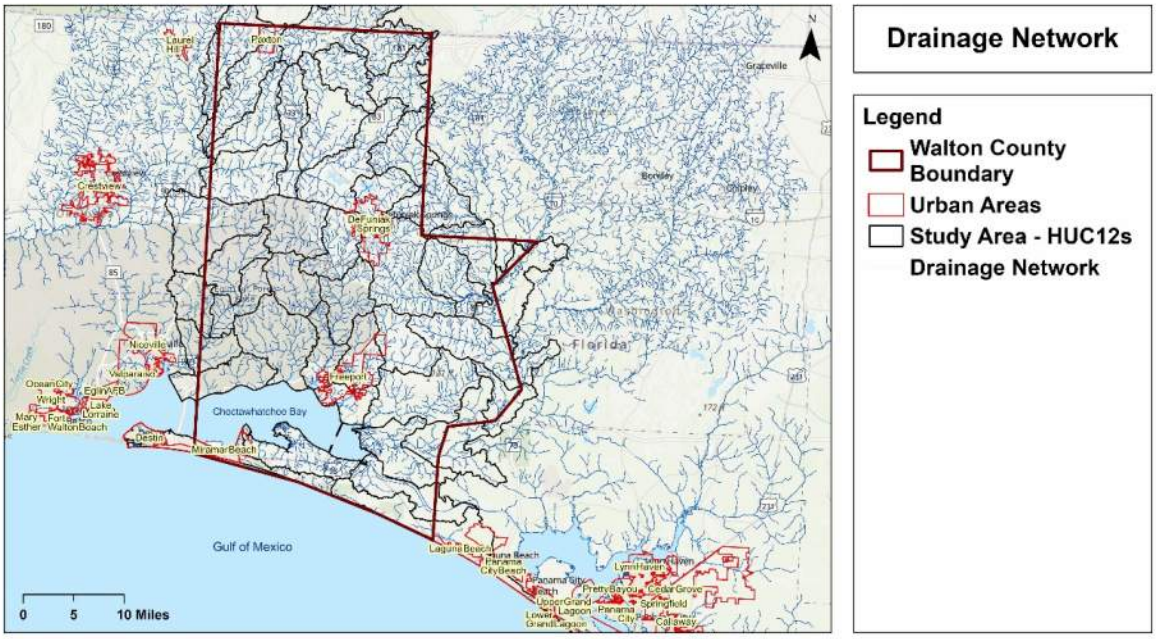

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

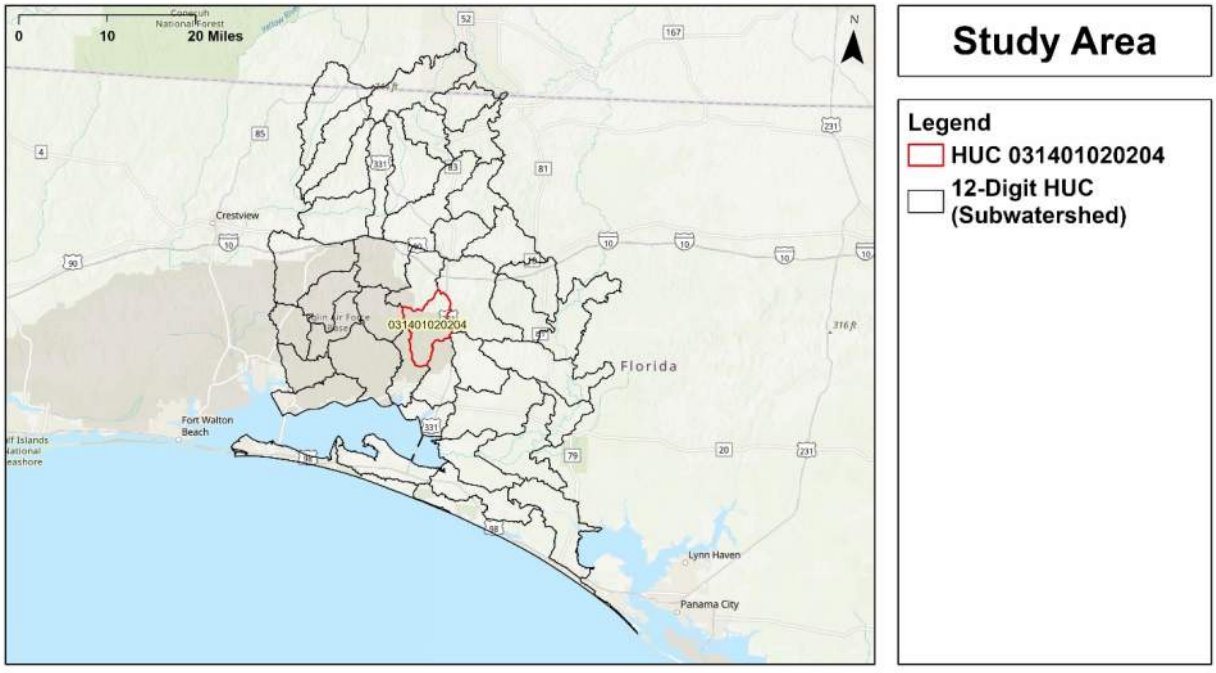

Figure 3. HUC 031401020204 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Figures 12 and 13 in the county-wide report show the current and projected land use for the County. Based on the 2017 future land use map for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.9	7.17%
Barren Land	9242.1	1.25%
Rangeland	40326.7	5.46%
Transportation, Communication, and Utilities	11815.7	1.60%
Upland Forest	356796.1	48.30%
Urban and Built-Up	52194.8	7.07%
Water	61593.9	8.34%
Wetlands	153759.9	20.82%
Total	**738687.9**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

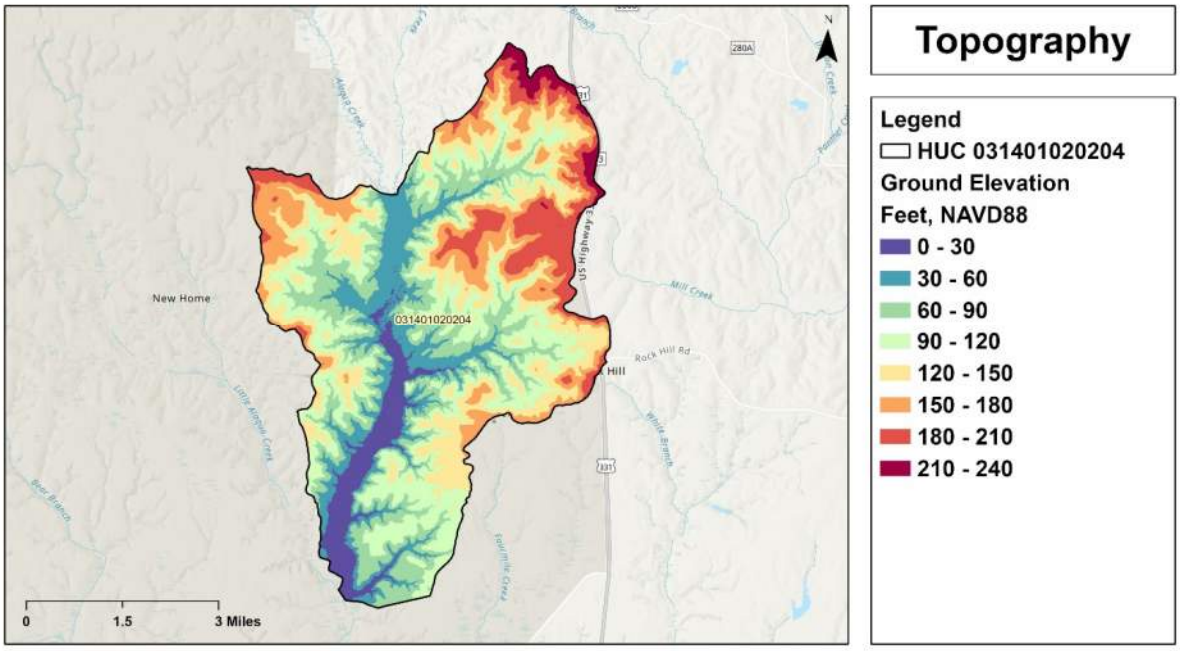

Figure 4. Topographic map of the HUC 031401020204 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401020204 sub-watershed is shown in **Error! Reference source not found.**..

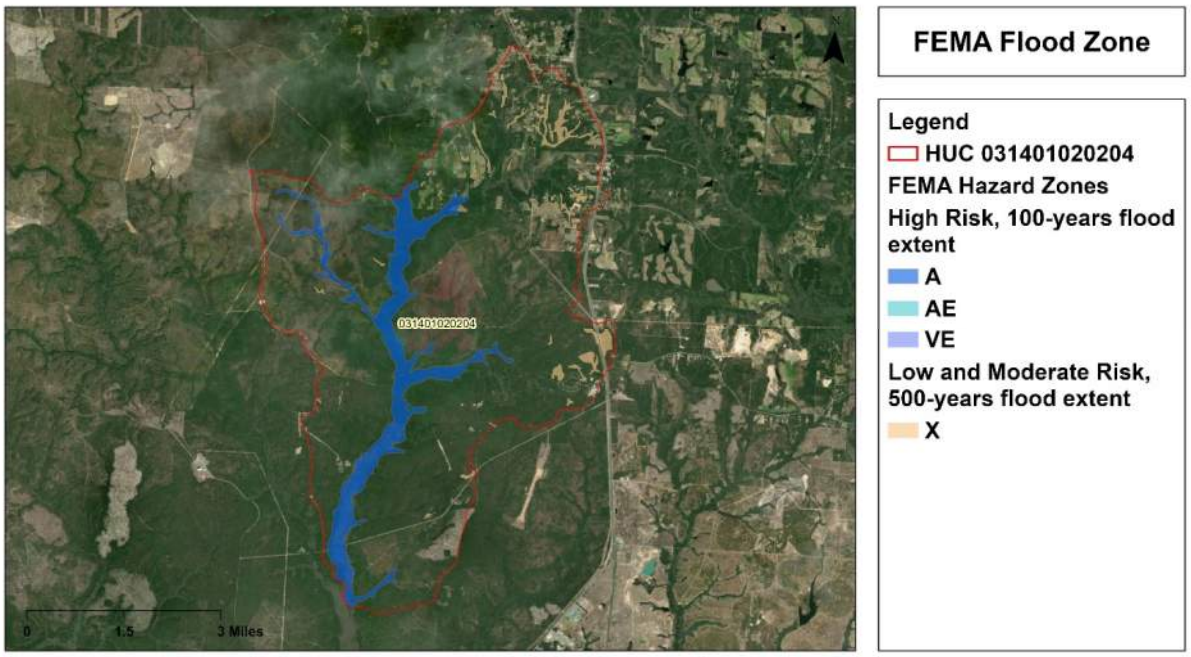

Figure 5. FEMA Flood Zone map (2020) for HUC 031401020204 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401020204 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

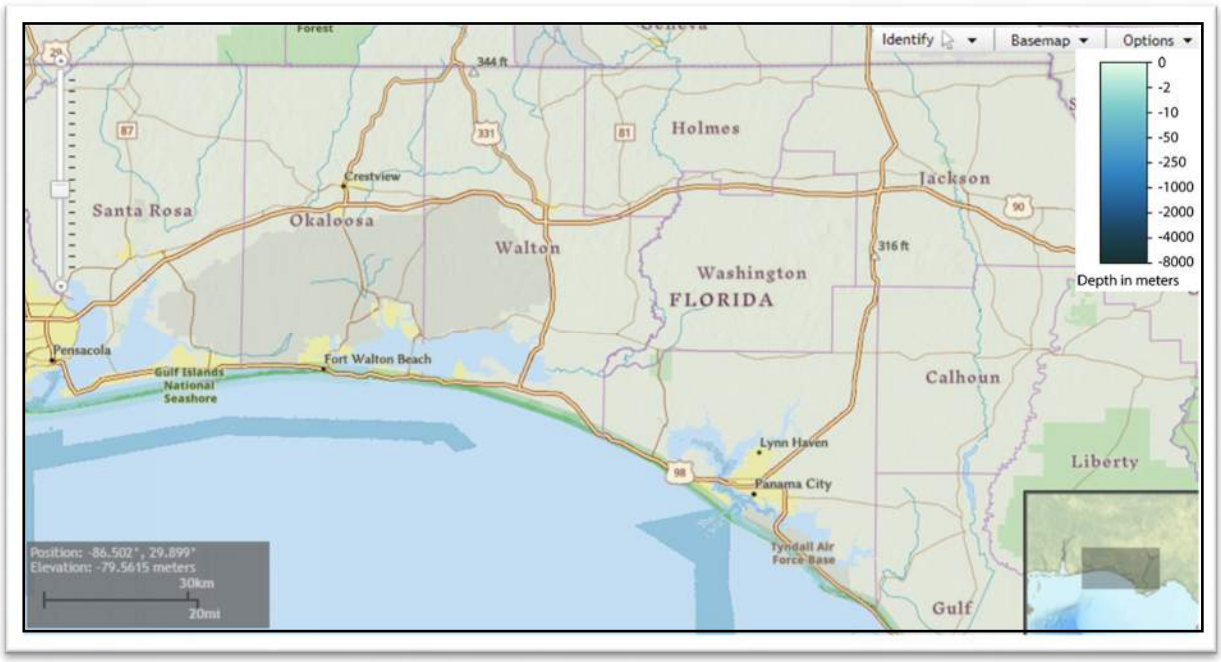

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

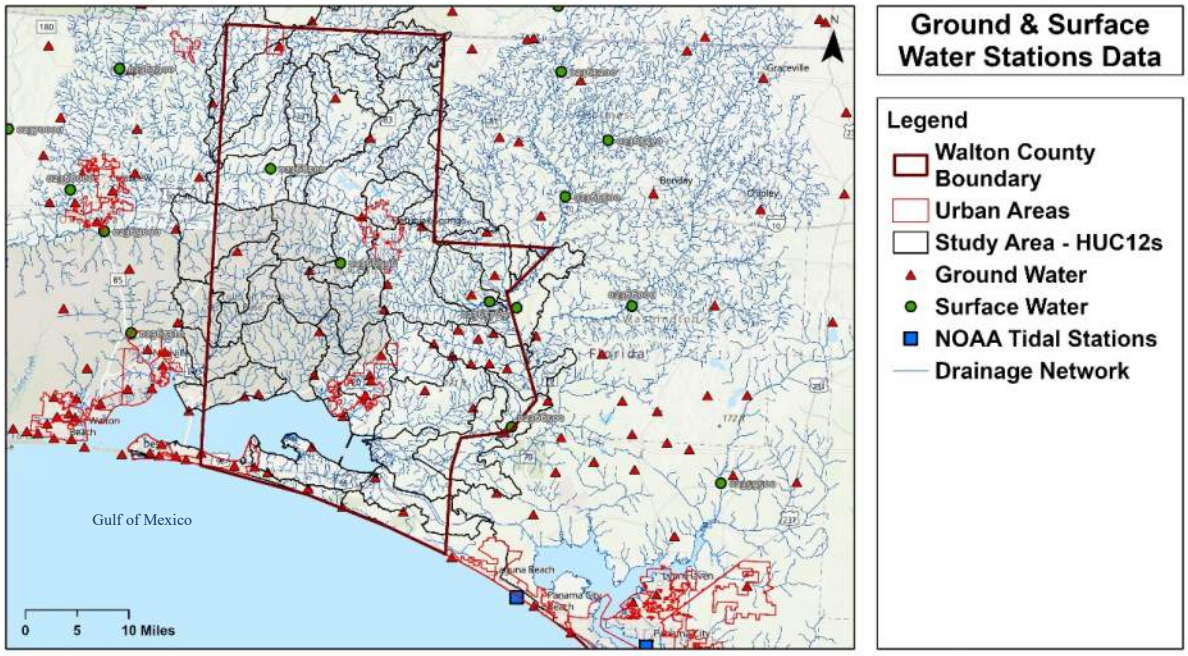

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The water bodies within the HUC 031401020204 sub-watershed include:

- Alaqua Creek
- Alice Creek
- Blount Creek
- Brushy Head

- College Head
- Davis Branch
- Little Alaqua Creek
- McQuage Branch
- Sweetwater Branch
- Ward Branch
- White Branch

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366996. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401020204, which is USGS 02366996 Alaqua Creek Near Pleasant Ridge, FL.

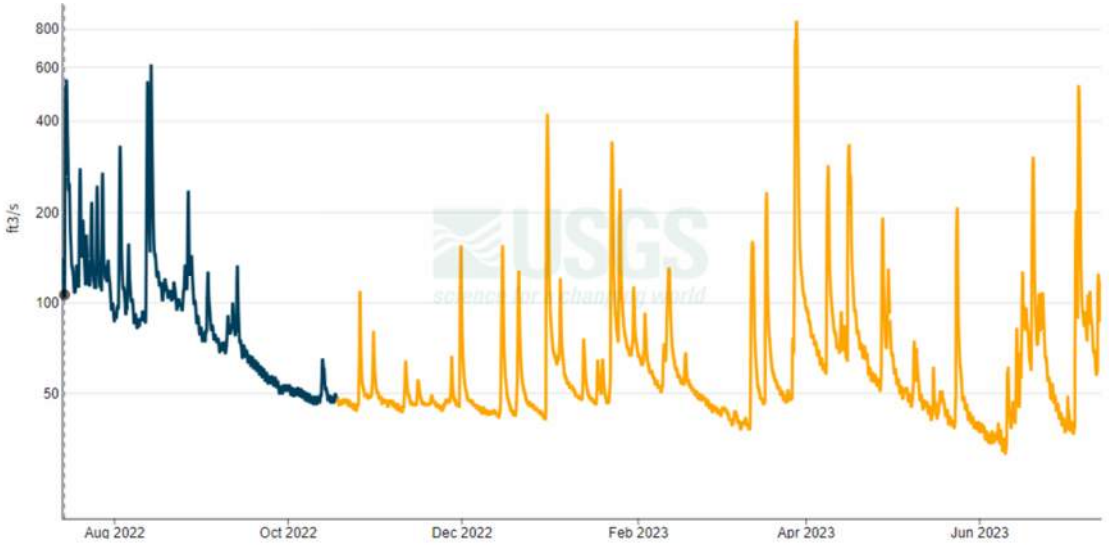

Figure 8. Average streamflow for Alaqua Creek Near Pleasant Ridge, FL (USGS 02366996 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366996/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the

database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401020204 and points out the location of the ground water and surface water stations in the surroundings. A groundwater-surface layer for the HUC 031401020204 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

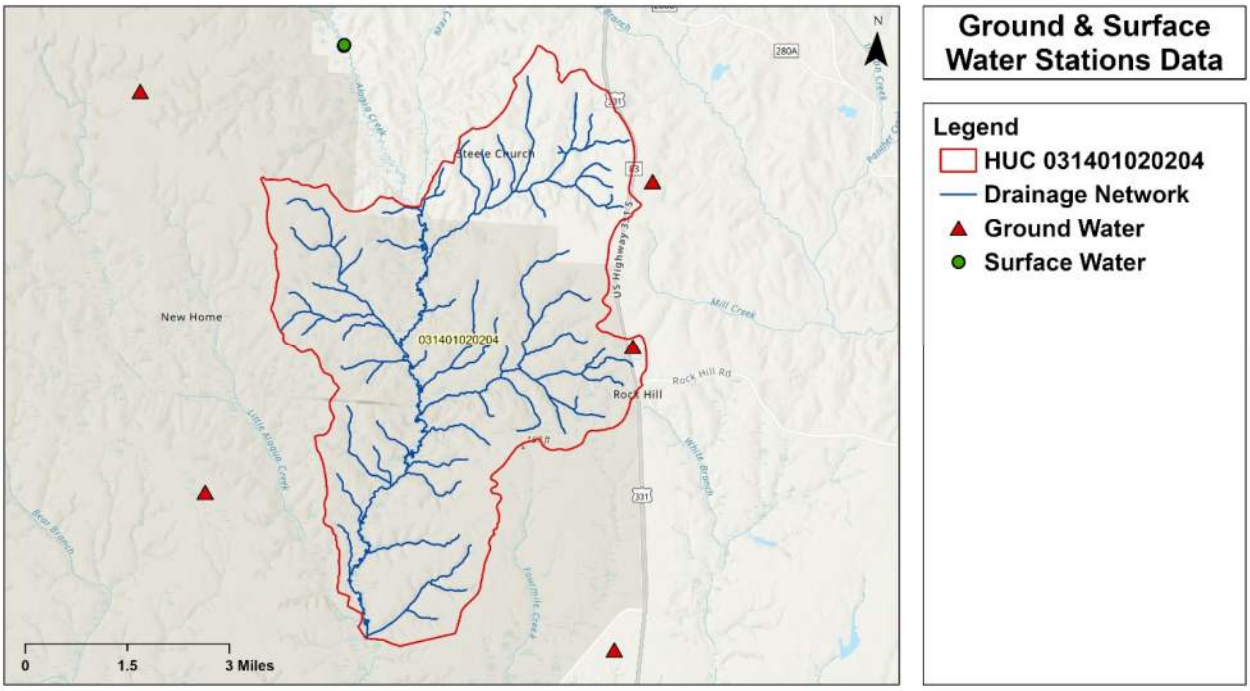

Figure 9. Ground and Surface Water Stations in the HUC 031401020204 sub-watershed, processed by FAU.

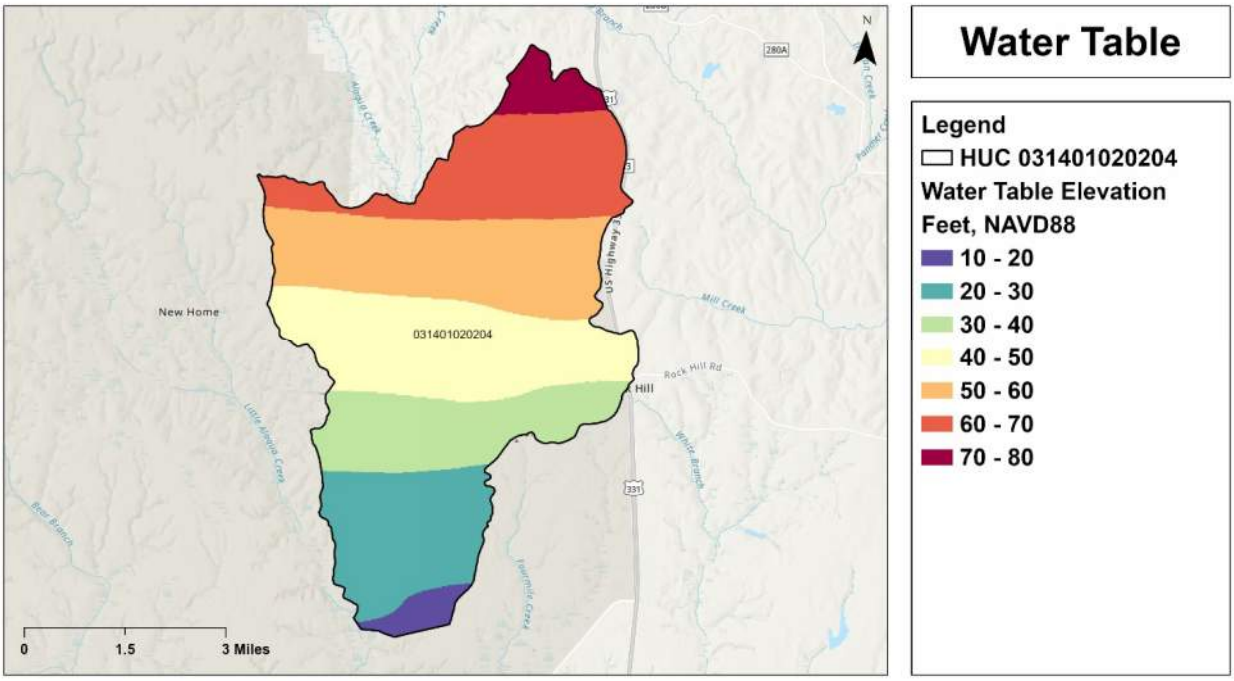

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401020204 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU

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1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

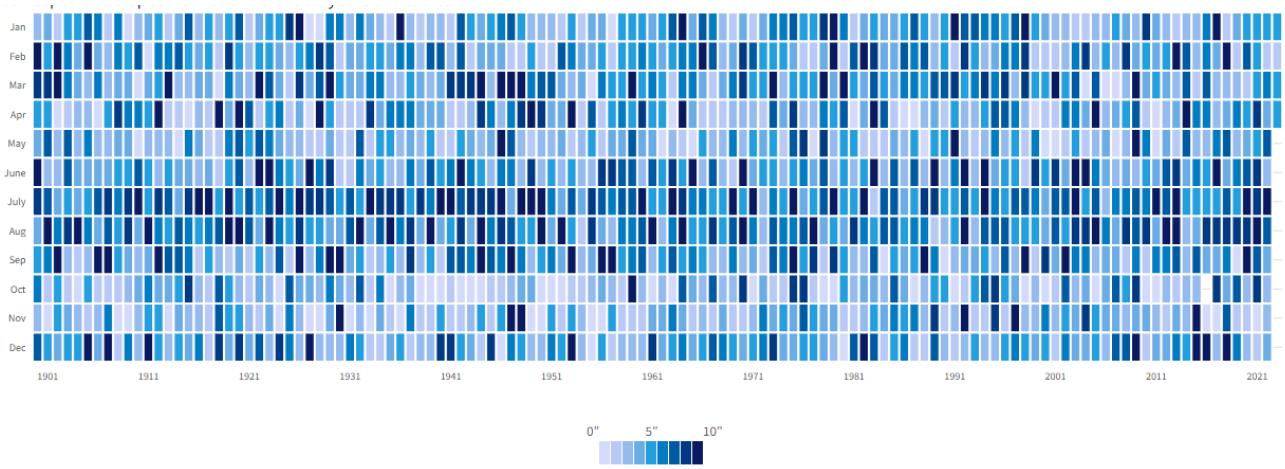

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation)

While the topography (Section 2.1) and native soil (Section 2.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there are no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

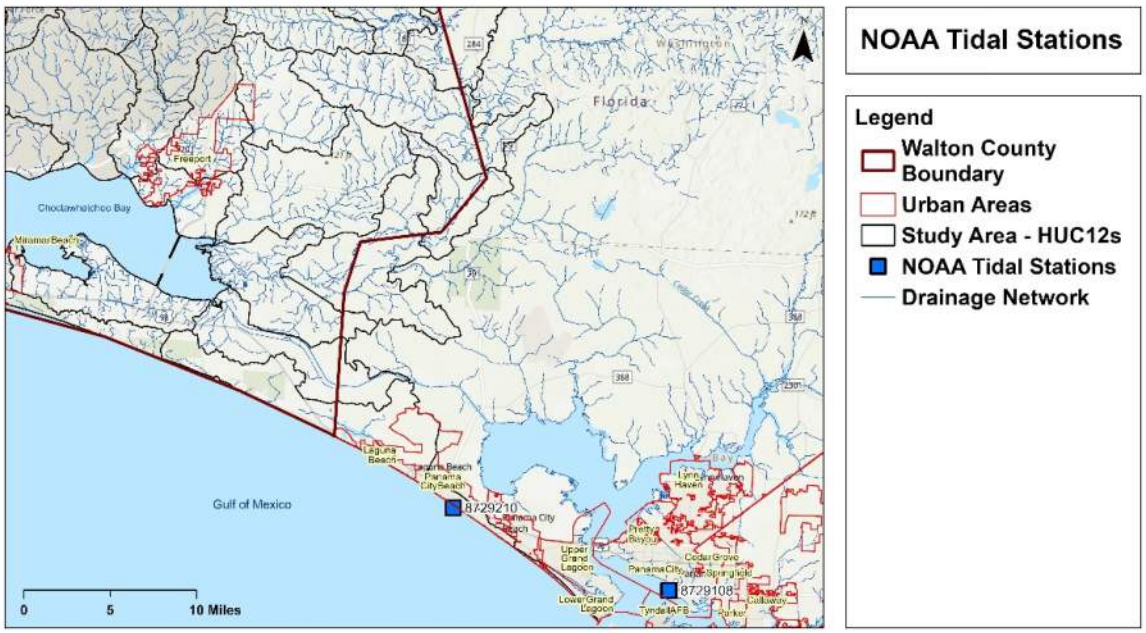

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

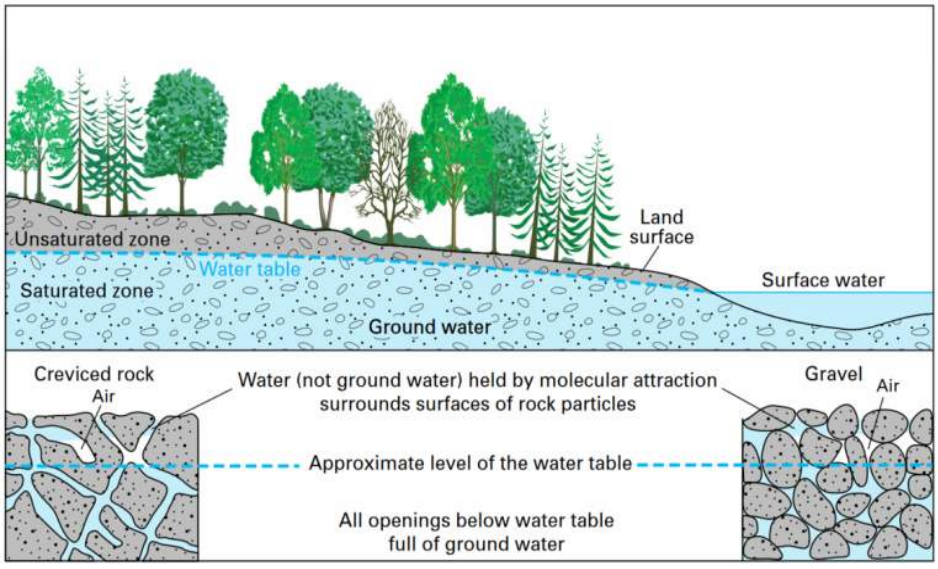

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

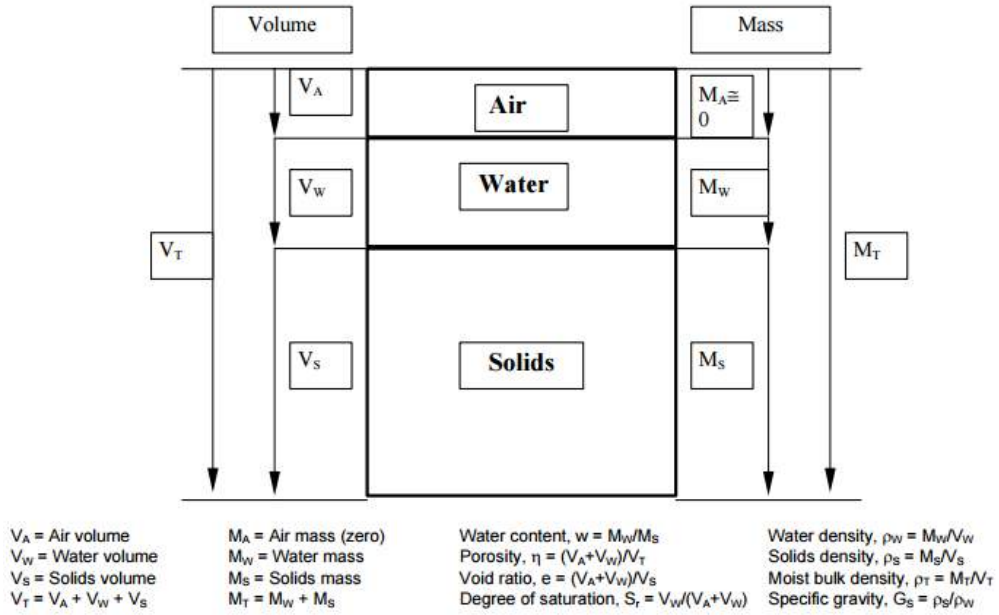

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

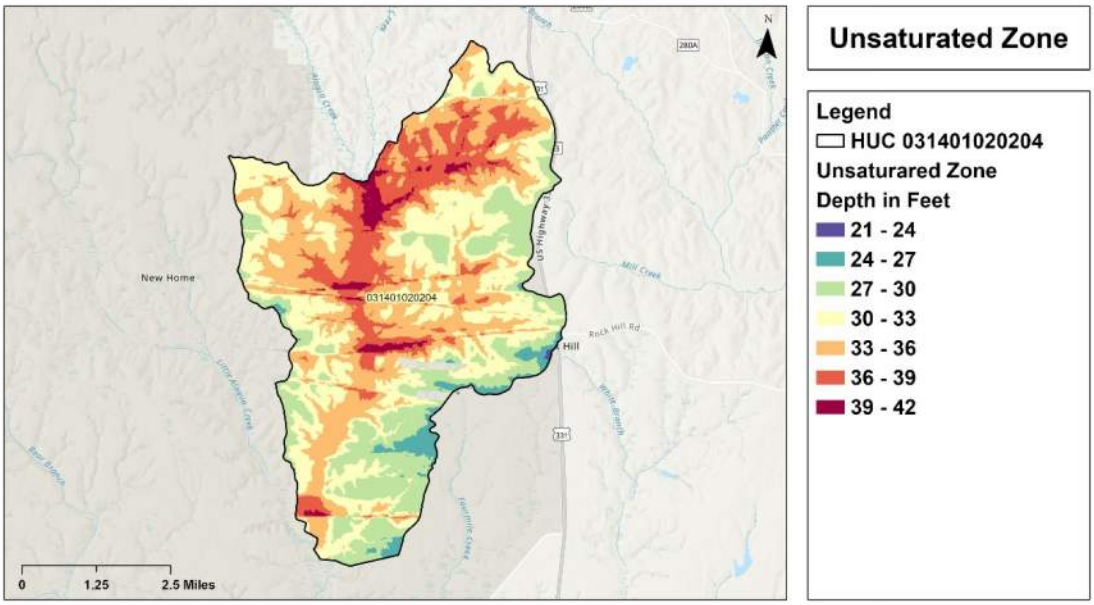

Figure 15. Unsaturated zone map for HUC 031401020204, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. Much of the basin has a medium amount of soil storage capacity, ranging between 30 to 33 inches of capacity left.

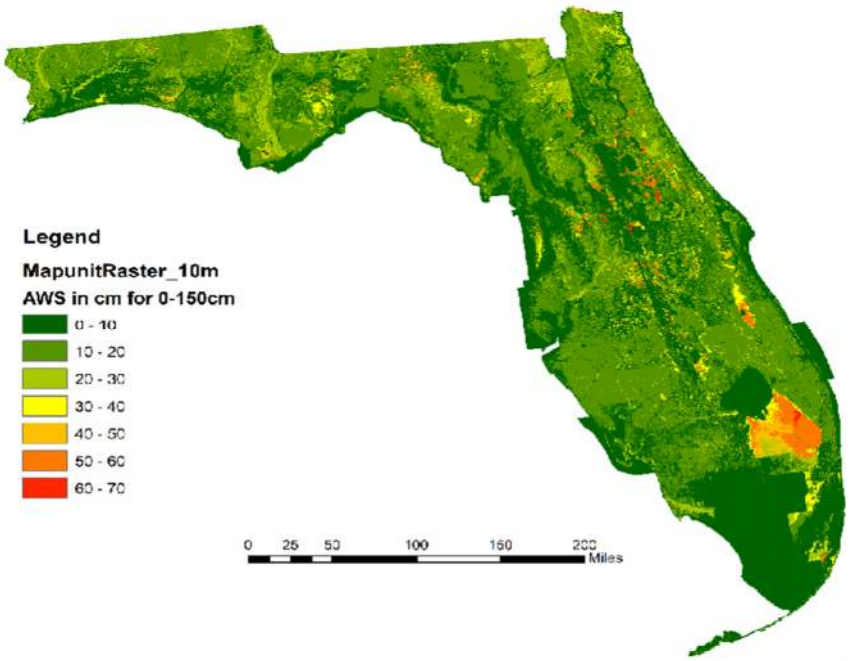

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

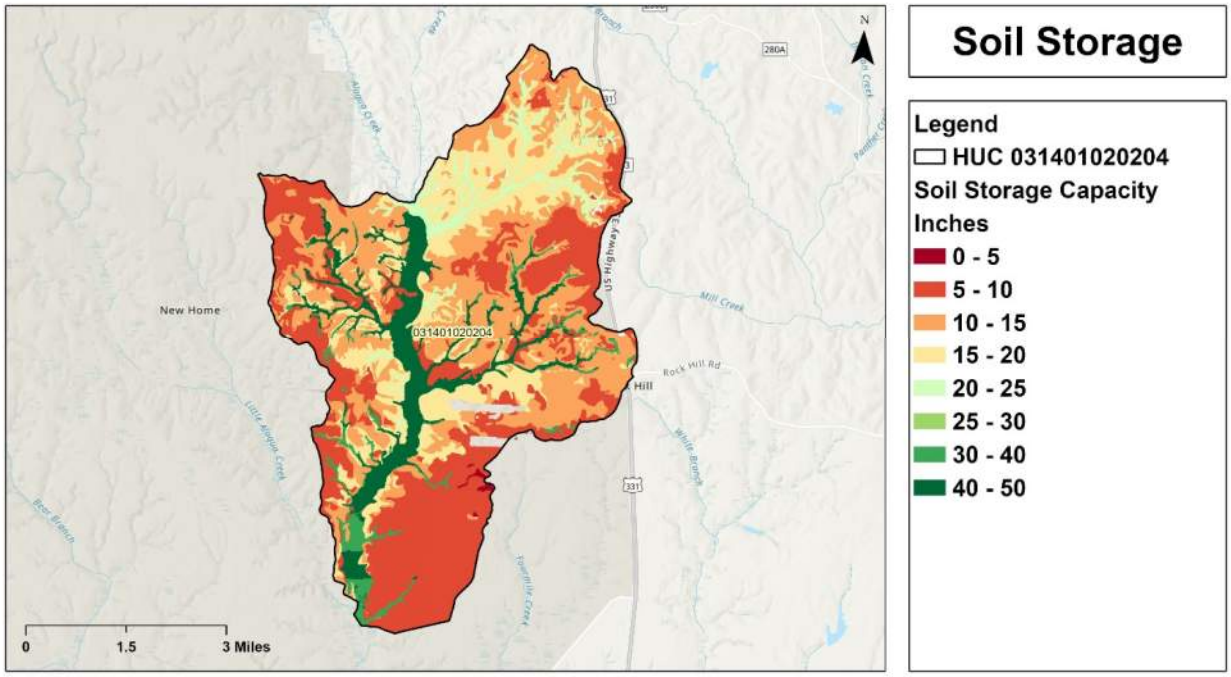

Figure 17. Water storage capacity of soil for the HUC 031401020204 (inches), processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

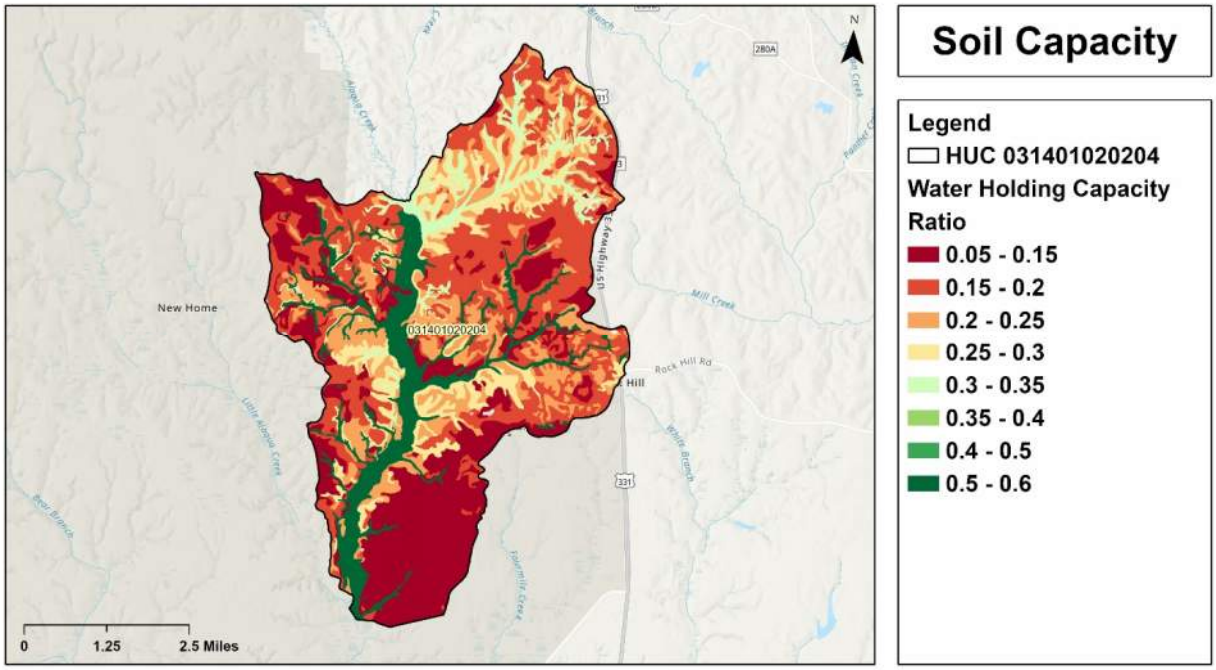

Figure 18. Water Holding Capacity (ratio) for the HUC 031401020204, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

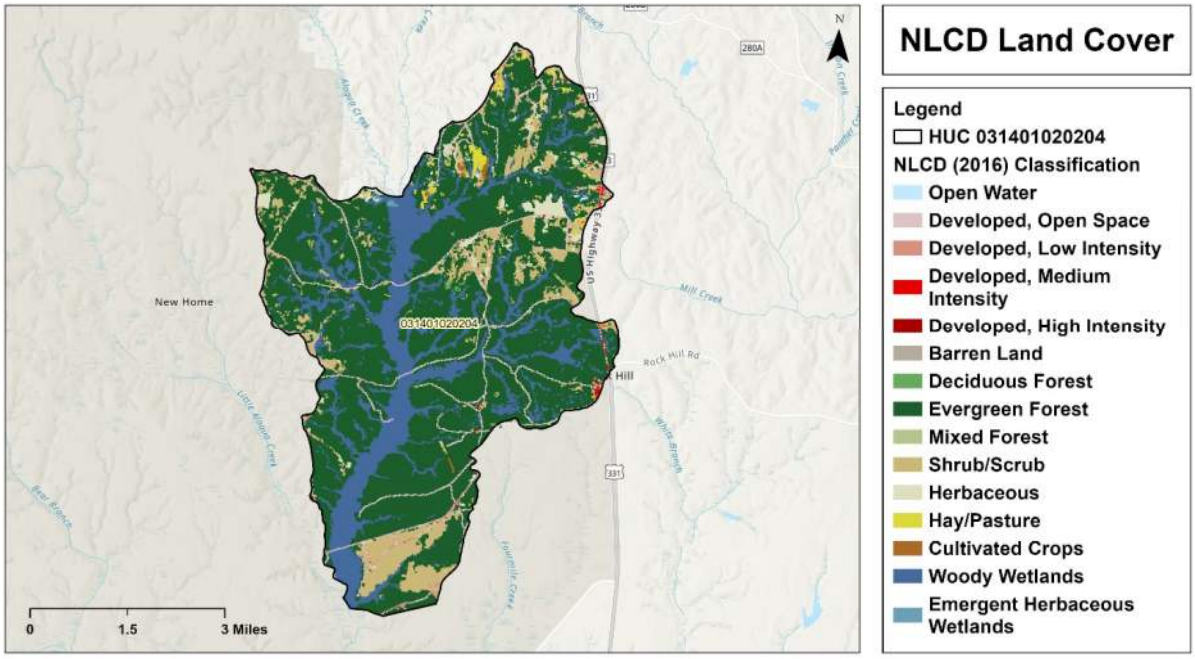

Figure 19. Land use in the HUC 031401020204 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

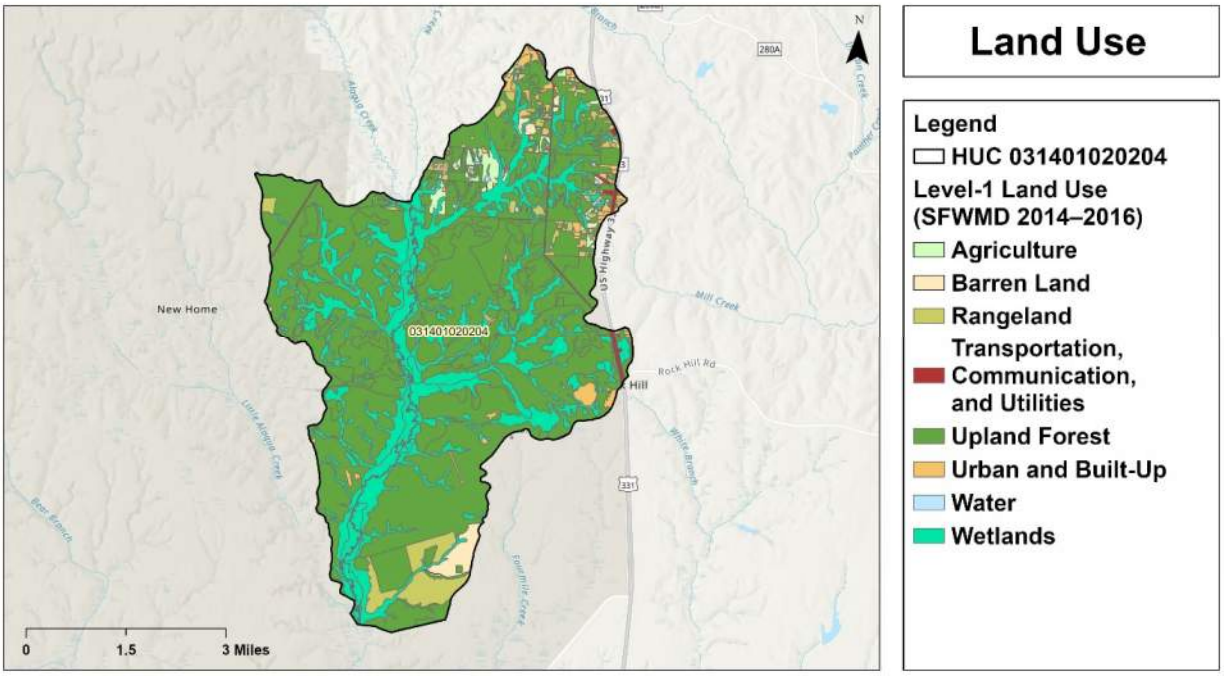

Figure 20. Land use in the HUC 031401020204 (2023 Florida Geographic Data Library (FGDL)), processed by FAU.

In the HUC 031401020204 sub-watershed, the predominant land cover is upland forest, accounting for 61.37% of the area. Wetlands comes in second at 19.04%, followed by Transportation, Communication, and Utilities at 11.15%. Developed land constitutes a minor portion, with only 3.37% categorized as urban and built-up, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031401020204 sub-watershed (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	260.90	0.97%
Barren Land	248.48	0.93%
Rangeland	906.38	3.38%
Transportation, Communication, and Utilities	2994.39	11.15%
Upland Forest	16477.98	61.37%
Urban and Built-Up	636.73	2.37%
Water	212.50	0.79%
Wetlands	5112.73	19.04%
Grand Total:	**26850.09**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

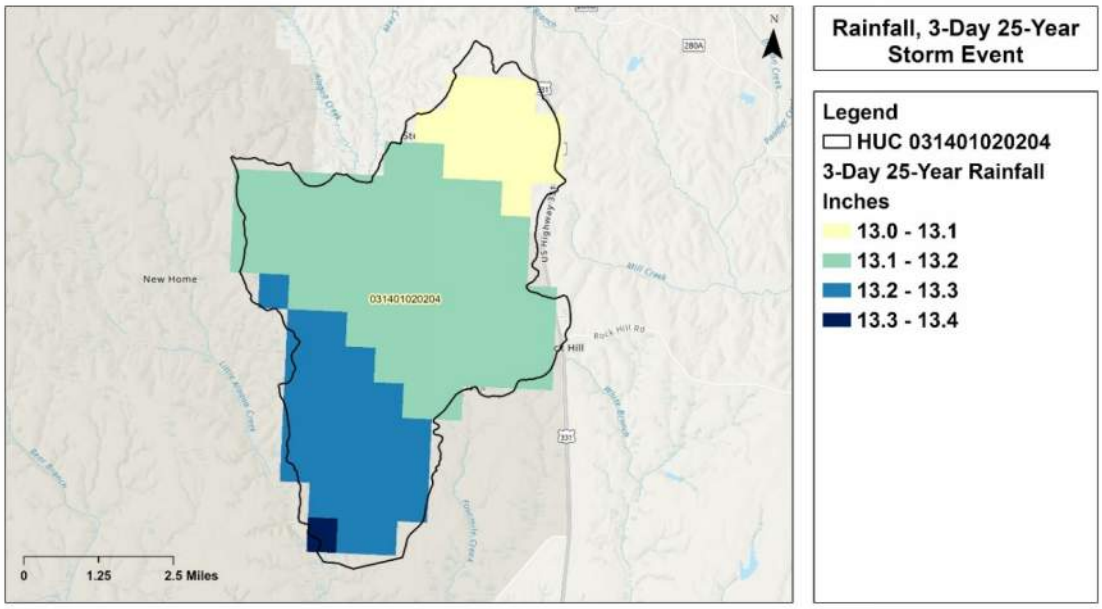

Figure 21. Rainfall distribution map across HUC 031401020204 sub-watershed, for 3-day 25-year storm event, processed by FAU.

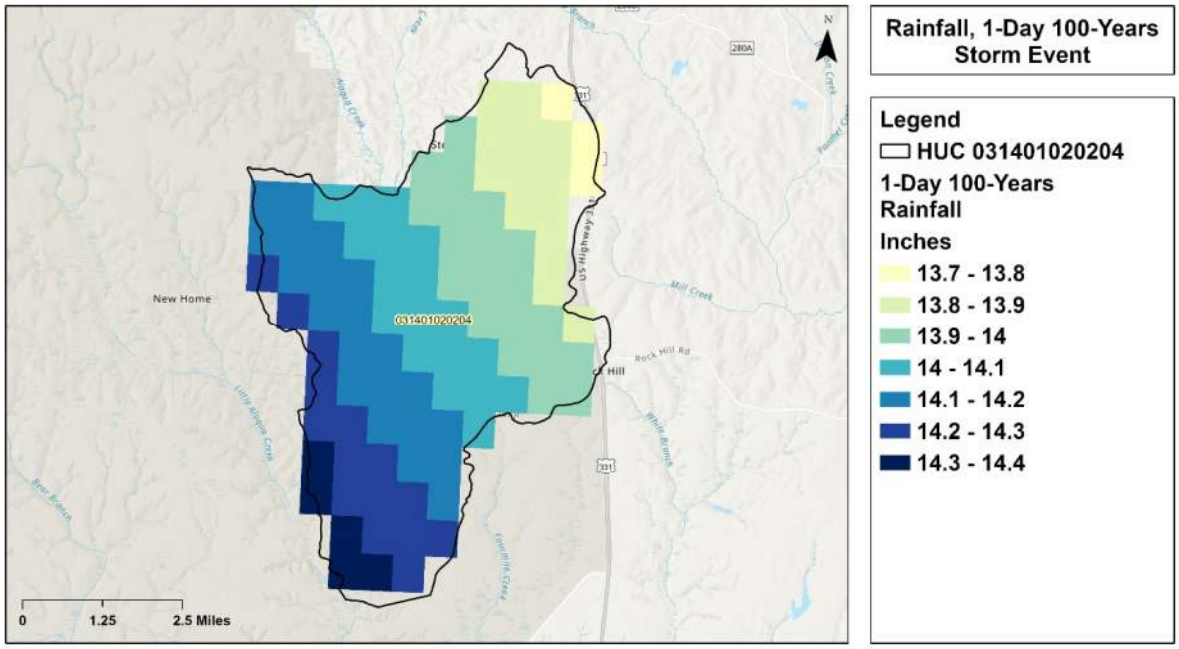

Figure 22. Rainfall distribution map across HUC 031401020204 sub-watershed, for 1-day 100-year storm event, processed by FAU.

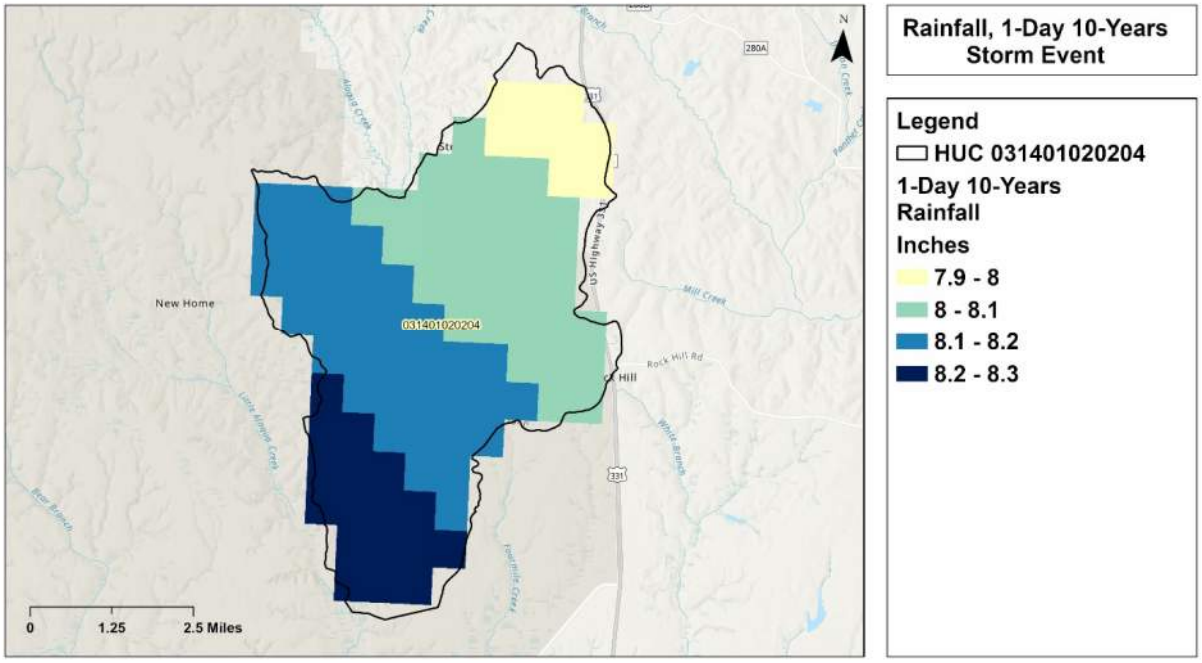

Figure 23. Rainfall distribution map across HUC 031401020204 sub-watershed, for 1-day 10-year storm event, processed by FAU.

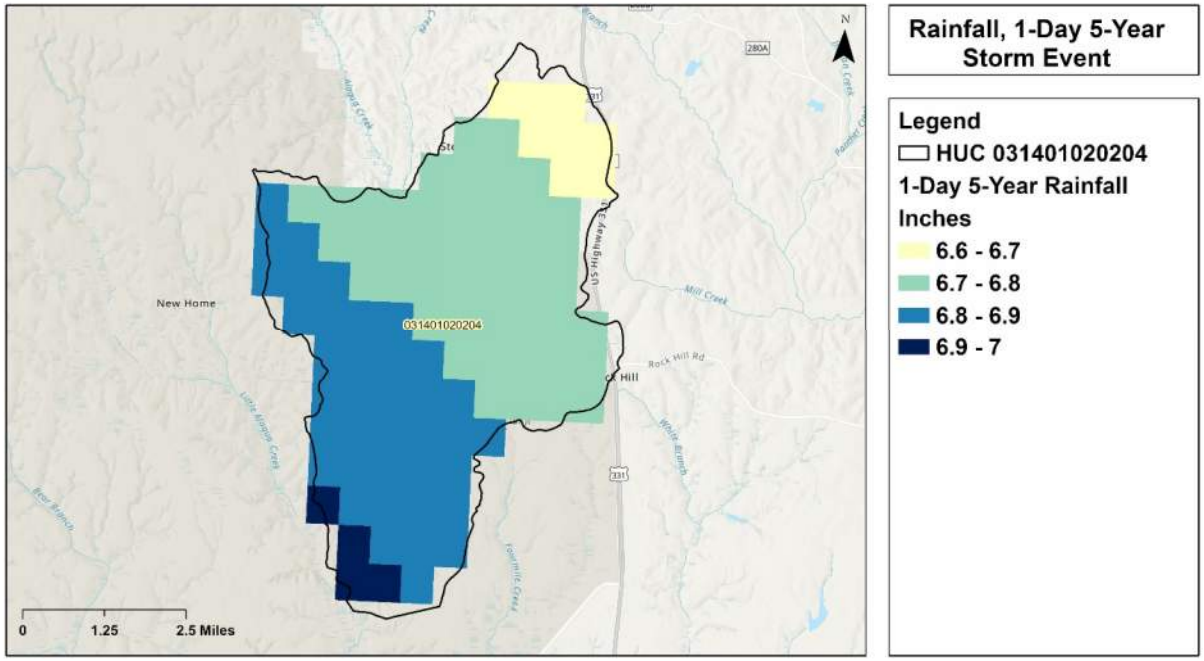

Figure 24. Rainfall distribution map across HUC 031401020204 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically

aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

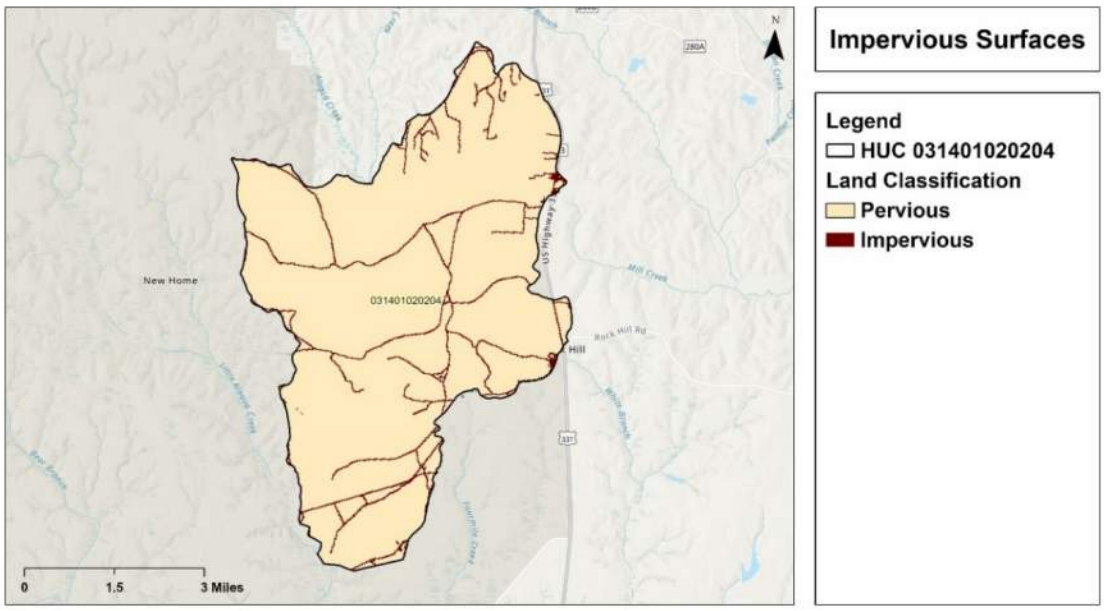

Figure 25. Impervious area map for the HUC 031401020204 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

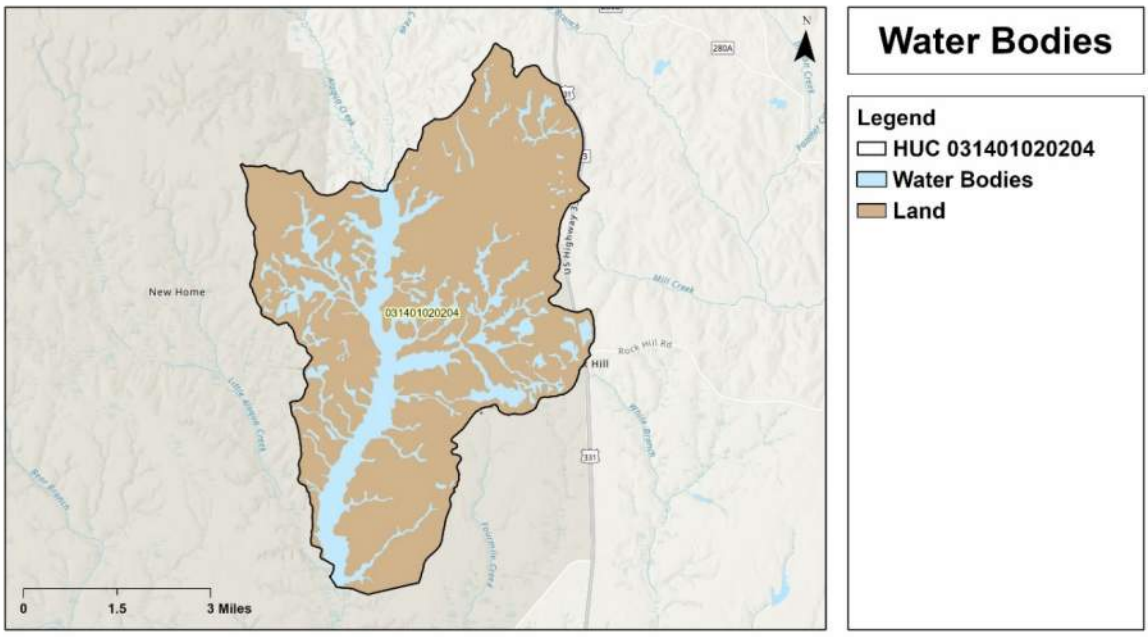

Figure 26. Water bodies map for the HUC 031401020204 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other

waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant

control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

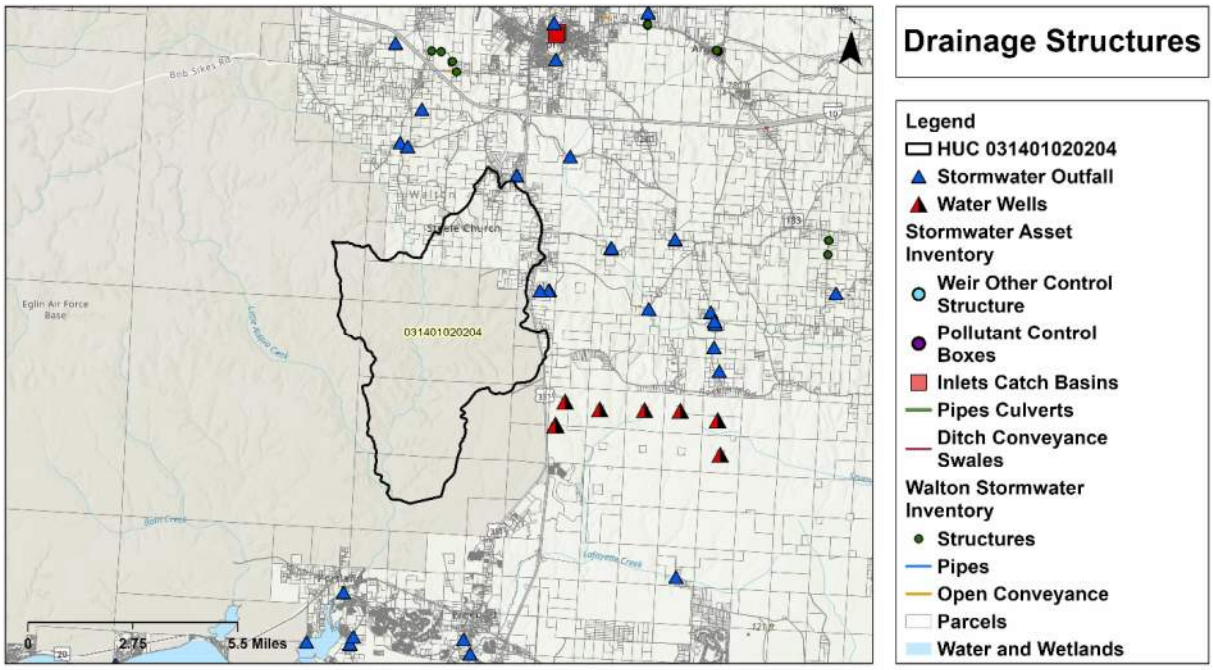

Figure 27. Stormwater Infrastructure for the HUC 031401020204. Processed by FAU.

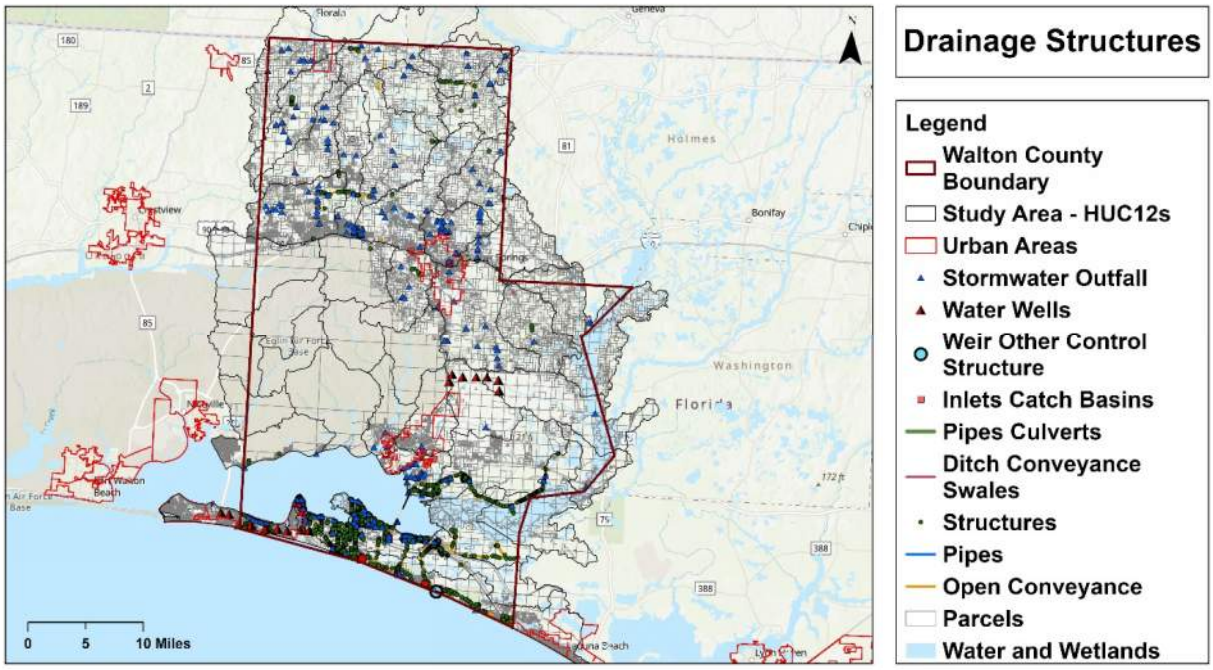

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in Table 5. The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Ground water	FL_GW	South FL Water Management District	Florida, Excel	Daily, 1980-2020	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_GW\South Florida District	140 M bytes, excel	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapter 1, and analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401020204 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the

coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. Figure 29 shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

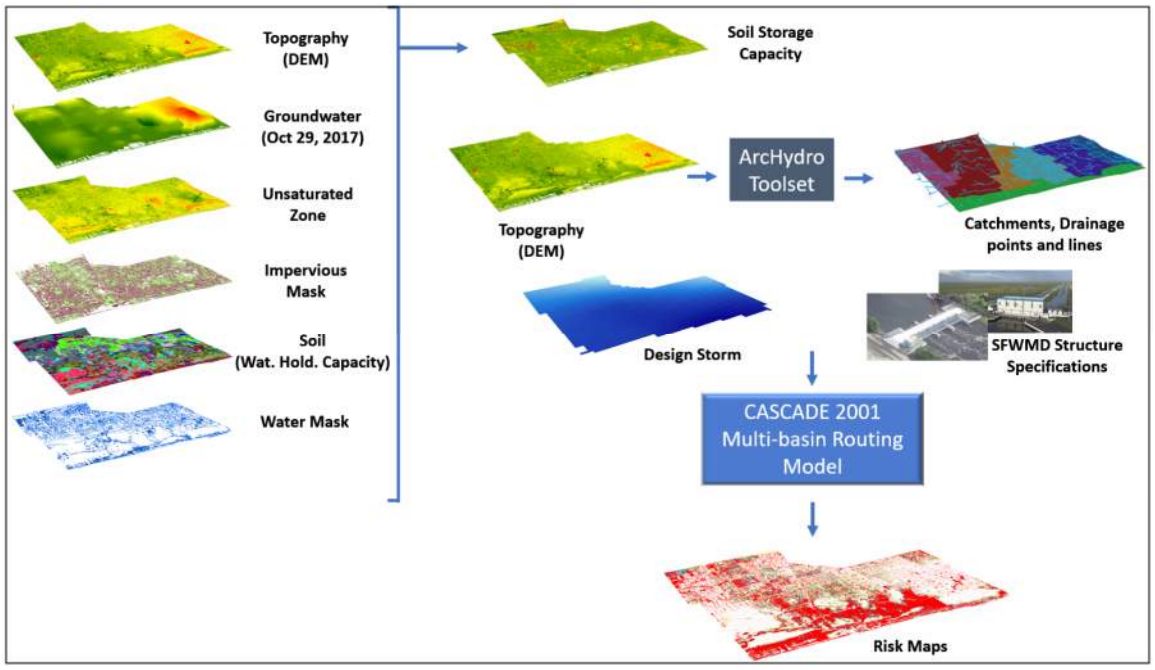

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are

critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

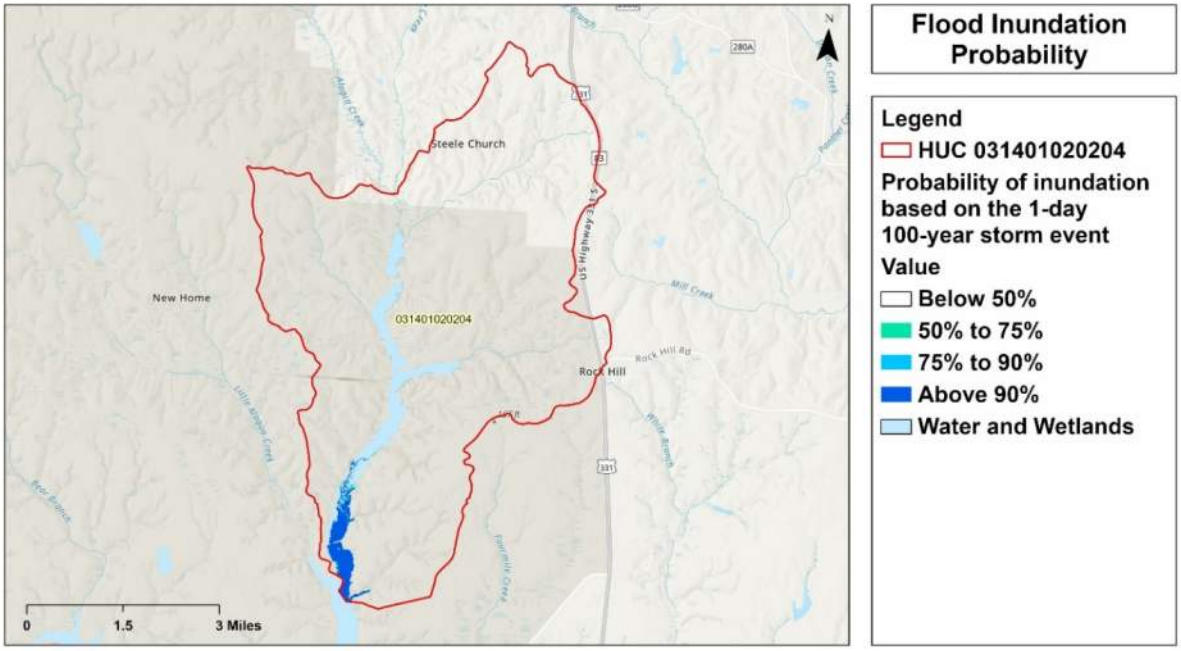

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401020204, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output

table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not

eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Future Challenges of Sea Level Rise and Climate Change

Global observations from satellites and long-term data collection have made it possible to document and analyze patterns in the Earth's climate. Scientific analysis of the impact of these changes has helped to improve the understanding of future flood hazard driving forces and long-term impacts on human activities and watershed master planning (http://www.research.noaa.gov/climate/t_observing.html). Examples of impacts are rising global average air and ocean temperatures, increased and earlier snow and ice melt, shorter subtropical rainy seasons, shifted seasons, sea level rise and greater variations in temperature and precipitation (IPCC, 2013; Freas et al., 2008; Marshall et al., 2004; Bloetscher et al., 2010). Marshall et al. (2004) specifically focused on the Florida peninsula to predict changes in rainfall and warmer temperatures but interspersed lower low temperatures due to the potential loss of wetlands.

Future changes in climate will add to the existing impacts, at a time when the population of the state is expected to nearly double by 2030. Additional research and high-resolution climate modeling for the Florida peninsula and local jurisdictions is needed to help guide long-term plans like WMPs.

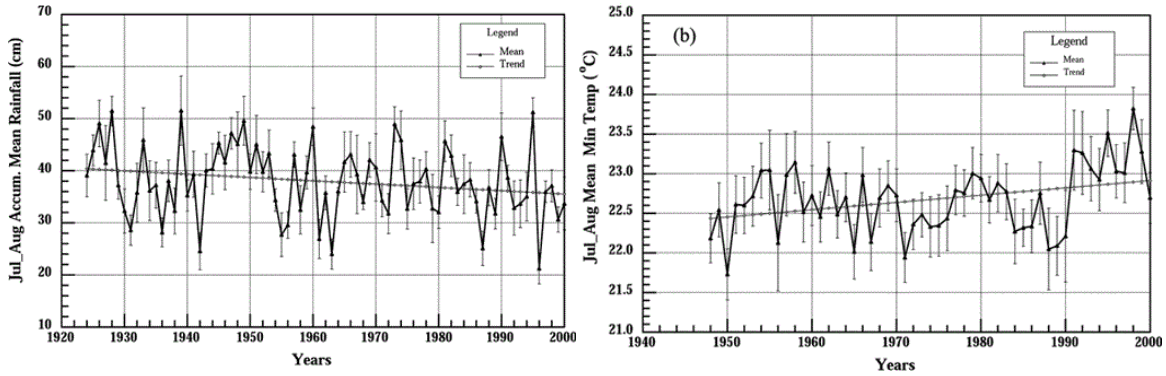

Figure 31. Change in average rainfall and change in average temp 1924 to 2000. Note the reversed trend, which means groundwater input variability is lessened. Source: Marshall et al., 2004.

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water

gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3 feet. Accompanying these drivers are potential changes in storm frequency and intensity, desertification, population migration, ocean acidification and coastal flooding (IPCC, 2007), exacerbated by the land cover and land use changes, which are substantially impacted by the fluxes, timing and quality of precipitation (Adrians et al., 2003; Scanlon et al., 2005; Marshall et al., 2004; Salmun and Molod, 2006), and leading to changes in the timing of peak flows and volumes (Richey and Costa-Cabral, 2006).

The results of these climatic changes are likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly An outcome of these climatic patterns is that during the past 140 years, an increase in sea levels has been observed (Bloetscher, 2012), a worrying pattern since sea level rise is a permanent phenomenon, that can be catastrophic to low lying areas in the long-term. The question is how much and how soon? Various studies (Bindoff et al., 2007; Domingues et al., 2008; Edwards, 2007; Gregory, 2008; Vermeer and Rahmstorf, 2009; Jevrejeva, Moore and Grinsted, 2010; Bloetscher, 2010, 2011; IPCC, 2007; Heimlich et al., 2009) indicate large uncertainty in projections of sea level rise by 2100. Gregory et al. (2012) note that during the last two decades, the global rate of sea level rise has been larger than the 20th-century time-mean, and Church et al. (2011) suggested that the cause was increased rates of thermal expansion, glacier mass loss, and ice discharge from icesheets. Gregory et al. (2012) suggested that there may also be increasing contributions to global sea level rise from the effects of groundwater depletion, reservoir impoundment, and loss of storage capacity in surface waters due to siltation. Measurements of Florida's east coast (Maul, 2008) show an average rate of sea level rise of 2.27 ± 0.04 mm per year from 1915 to 1992 based on tide gauge readings. Analyzing the tidal gauge readings for Florida shows that:

1. Florida average sea level rise is 2.10 ± 0.49 mm/yr
2. All but one location is within the 95% confidence limit range (the exception is Panama City where there is evidence of submergence and other land-based issues)
3. None of the Florida sea level rise rates differ statistically

4. Average global sea level rise for 1920-2000 was 2.0 mm/yr – within 95% confidence limit for Florida locations

From 1929 to 1992, over eight inches of sea, with another 6 inches added since 1992, which is already having significant impacts on coastal communities where population growth has increased the need for improved flood management strategies (Bloetscher, 2008; Parkinson, 2010; Zhang et al., 2011, 2011a; NFIP, 2011; Schmidt et al., 2011; Warner et al., 2012).

As a result, the SFRCCC (2015) adopted USACE's methodology to derive scenarios of sea level change intermediate to high rates of sea level rise for years 2030 (3" to 7") and 2060 (9" to 24") as the consensus projection to guide future planning. The path keeps increasing – now 14 inches since 1929 (**Error! Reference source not found.**) caused by thermal expansion of the ocean and melting ice caps (Jevrejeva et al., 2010; Vermeer and Rahmstorf, 2009). Sea level rise is a major concern in Florida, including Walton County, since the majority of the state's population live on the coast, involving most major commercial, residential, and economic enterprises. Figure 32 demonstrate the estimated sea level change for Panama City, considering the predictions of NOAA 2017. For NOAA high scenario SLR change scenario, the estimated level change is higher than 8 ft., while for the intermediate and low scenarios are about 3.9 feet and 1.7 feet respectively.

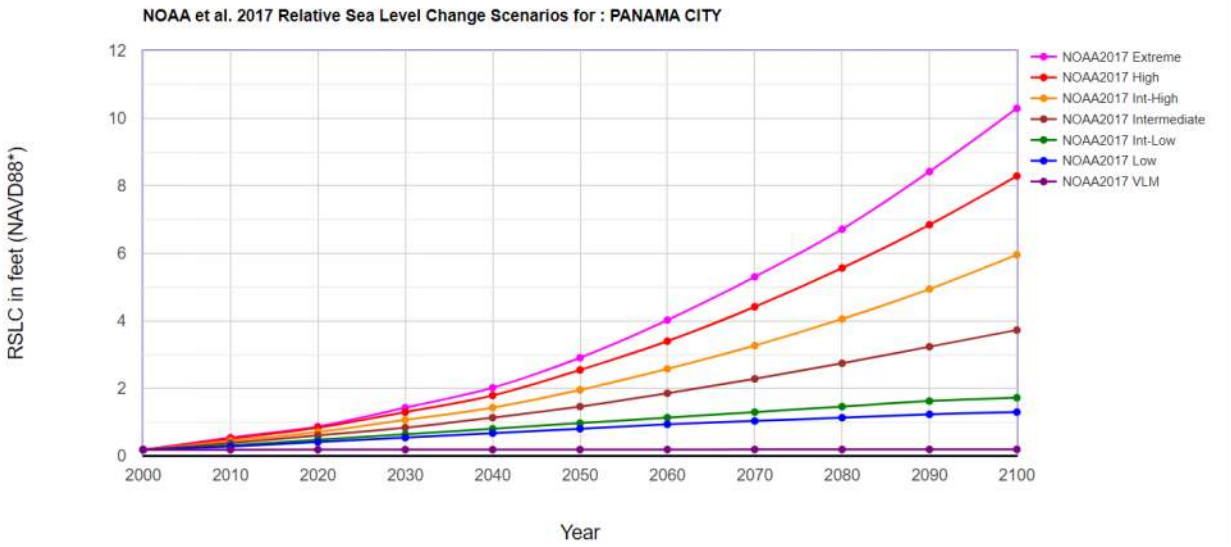

Figure 32. Relative Sea Level Change Scenarios for gauge 8729108, Panama City, FL. Source: NOAA, 2017 (https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html)

NOAA (2017) outlines five scenarios for sea level rise. The NFIP proposes the use of the intermediate high projection, which is 1.2 meters or 4 ft globally from current sea level elevations (**Error! Reference source not found.**).

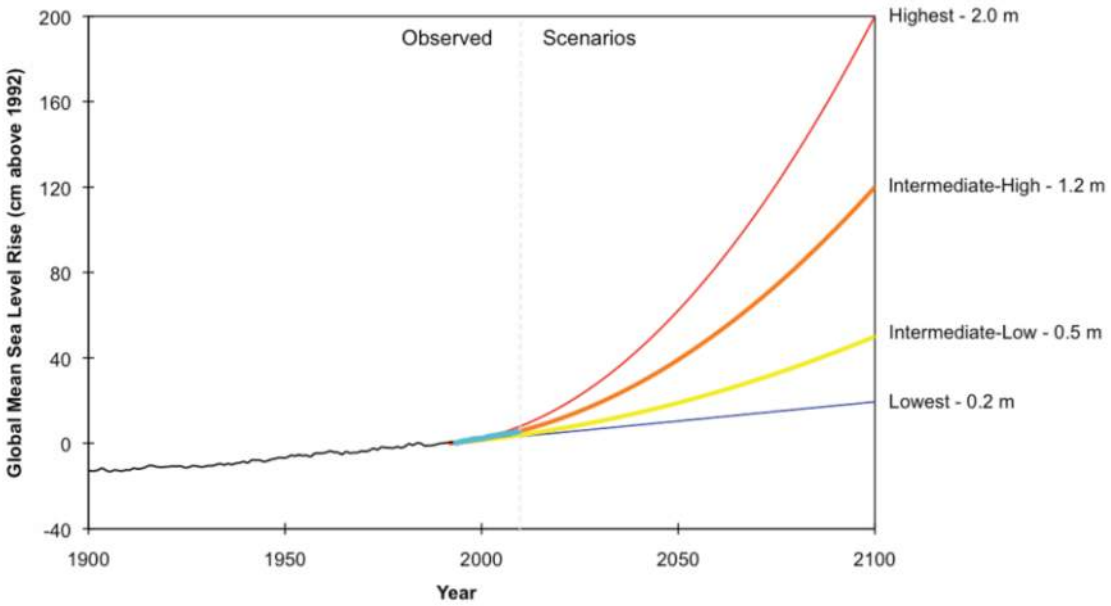

Figure 33. Graphic of global sea level rise projections.
Source: NOAA, 2017
(https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf)

As sea level rises, access to roads, bridges, rail, and transit could be at risk of flooding, causing the effects of sea level rise to spread indirectly throughout the entire transportation network, affecting the overall system performance. For example, the flooding of a critical road or facility access can cause a shifting of traffic flow causing congested conditions in other roadways that are not actually flooded. Since the roadway network would be unable to carry the traffic demand, the system would experience operational failure; as a result, causing travel times and delays. Moreover, the inundation of a critical access could cause transportation connectivity problems to essential infrastructure like ports or airports. Transportation infrastructure relies on the effectiveness of flood control and stormwater drainage systems for the transportation corridors. Road integrity relies on adequate drainage. The increased risk of severe flooding in Florida's low-lying terrain can adversely affect transportation infrastructure along the coastline; roads can be inundated, and roadway beds can be damaged. Sea level rise will cause increased water table levels (FDOT, 2012), as regional water tables cannot exist naturally below mean high tide (2 feet in Florida). Adding 3 feet of sea level rise on top of groundwater would compound the risk of flooding in low-lying areas. Road bases below 5 feet NVGD would become saturated under this scenario, likely causing premature base failure. As soil storage capacity is diminished due to rising groundwater elevations associated with sea level rise, the potential for more frequently flooded roadways would likely damage pavements (FDOT, 2012). Hence sea level rise must be accounted for in WMPs in coastal areas. To allow flexibility in the analysis due to the range of increases within the different time periods, an approach that uses incremental increases of 1, 2, and 3 feet of sea level rise is suggested for modeling. The increments can work as threshold values in planning

considerations in terms of allowing planners the ability to know ahead of time where the next set of vulnerable areas will be, to allow for a proactive response approach that can be matched to the observed future rates. Sea level rise is a major concern since nearly half the US population lives within 50 miles of the coast, involving most major commercial, residential, and economic enterprises. The effects of 5 ft sea level rise, King tide, and 1-day 100-year storm event are shown in **Error! Reference source not found.**.

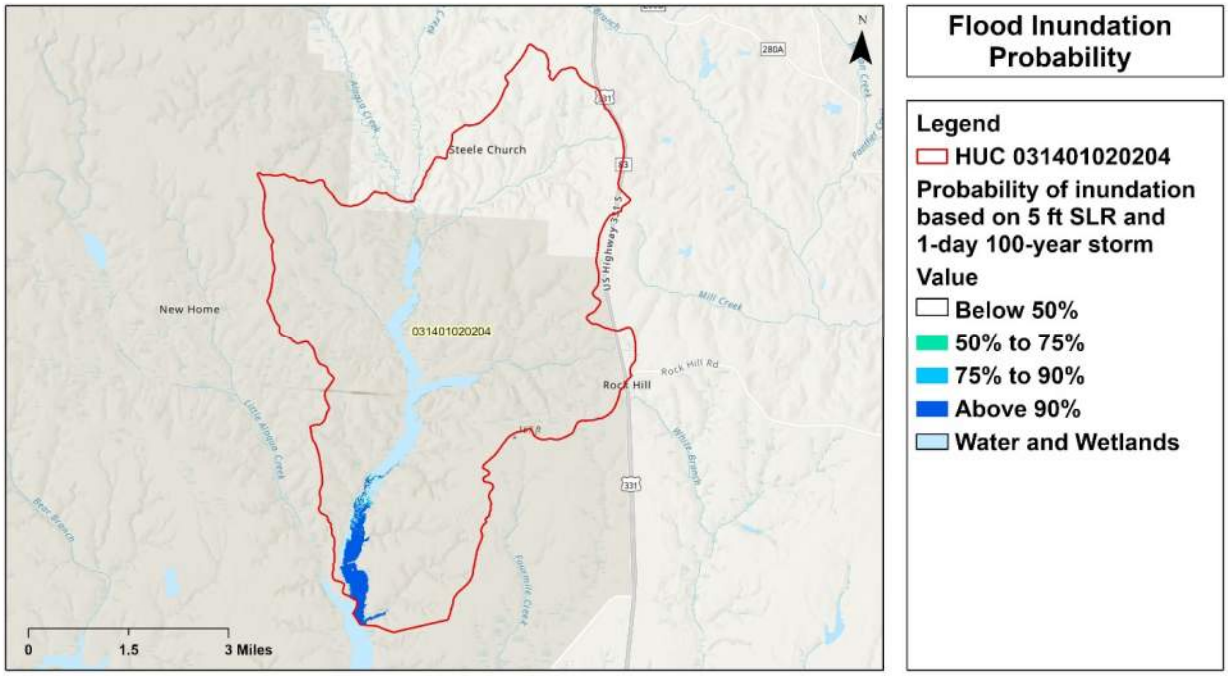

Figure 34. Flood Inundation Probability for a Sea level rise of 5 ft + 1-day 100-year storm event for HUC 031401020204 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Dark blue is area under 5 ft NAVD88 and potentially inundated at the 99th percentile tidal conditions. Processed by FAU.

2.4 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. **3-day 25-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 35)
2. **1-day 100-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 36)
3. **1-day 10-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 37)

4. **1-day 5-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 38)
5. **Sea level rise of 1 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 39)
6. **Sea level rise of 1 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations storm (Figure 40)
7. **Sea level rise of 1 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 41)
8. **Sea level rise of 1 ft + 1-da 5-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 42)
9. **Sea level rise of 2 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 43)
10. **Sea level rise of 2 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 44)
11. **Sea level rise of 2 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 45)
12. **Sea level rise of 2 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 46)
13. **Sea level rise of 3 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 47)
14. **Sea level rise of 3 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 48)
15. **Sea level rise of 3 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 49)
16. **Sea level rise of 3 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 50)

17. **Sea level rise of 4 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 51)
18. **Sea level rise of 4 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 52)
19. **Sea level rise of 4 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 53)
20. **Sea level rise of 4 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 54)
21. **Sea level rise of 5 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 55)
22. **Sea level rise of 5 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 56)
23. **Sea level rise of 5 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 57)
24. **Sea level rise of 5 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 58)

In all scenarios, a small amount of flooding is noted at the river entrance to the HUC, following the flow path. As this basin connects to the ocean via Alaqua Creek, SLR scenarios plays an important hole, implying a considered growth as the projected scenario of rising tides rises.

The design storm simulation determined that approximately 0.8% of the HUC total area or 0.21 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 1.4% of the HUC's total area, or 0.39 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.6% of the HUC's total area, or 0.16 mi^2, would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0.5% of the HUC's total area, or 0.15 mi^2, would be expected to be inundated during the 1-day 5-year storm. Table 7 compares the four storm events.

Table 7. HUC 031401020204 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	27.58	0.21	99.2%	0.8%
1-day 100-year	27.40	0.39	98.6%	1.4%
1-day 10-year	27.63	0.16	99.4%	0.6%
1-day 5-year	27.64	0.15	99.5%	0.5%

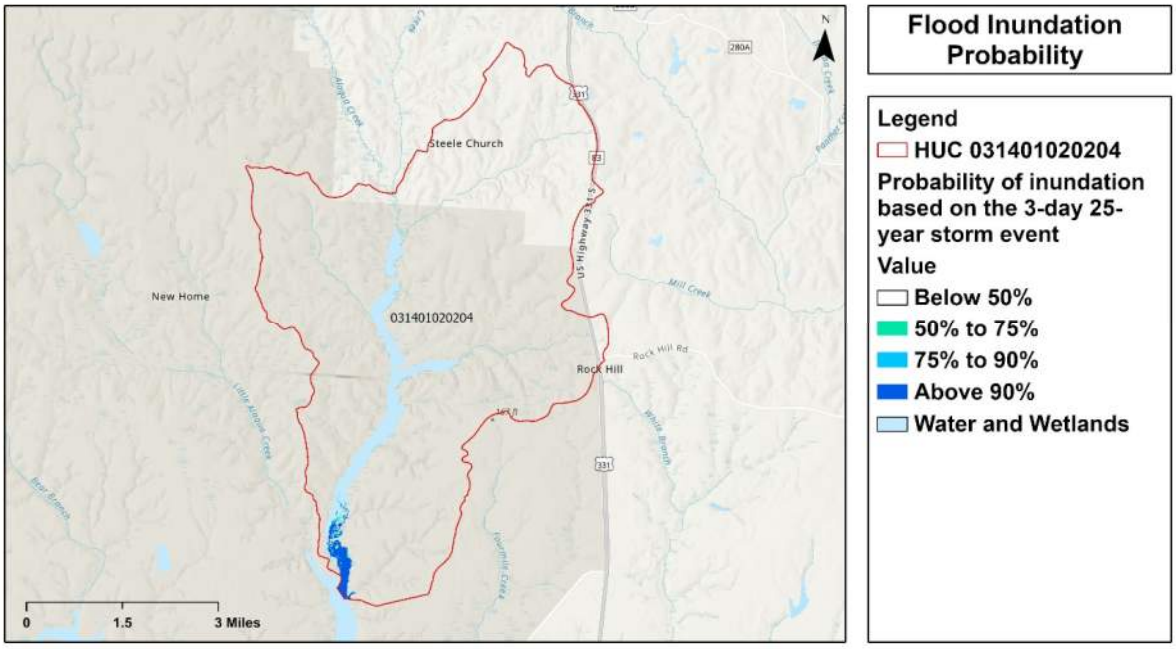

Figure 35. 3-day 25-year storm event for HUC 031401020204 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

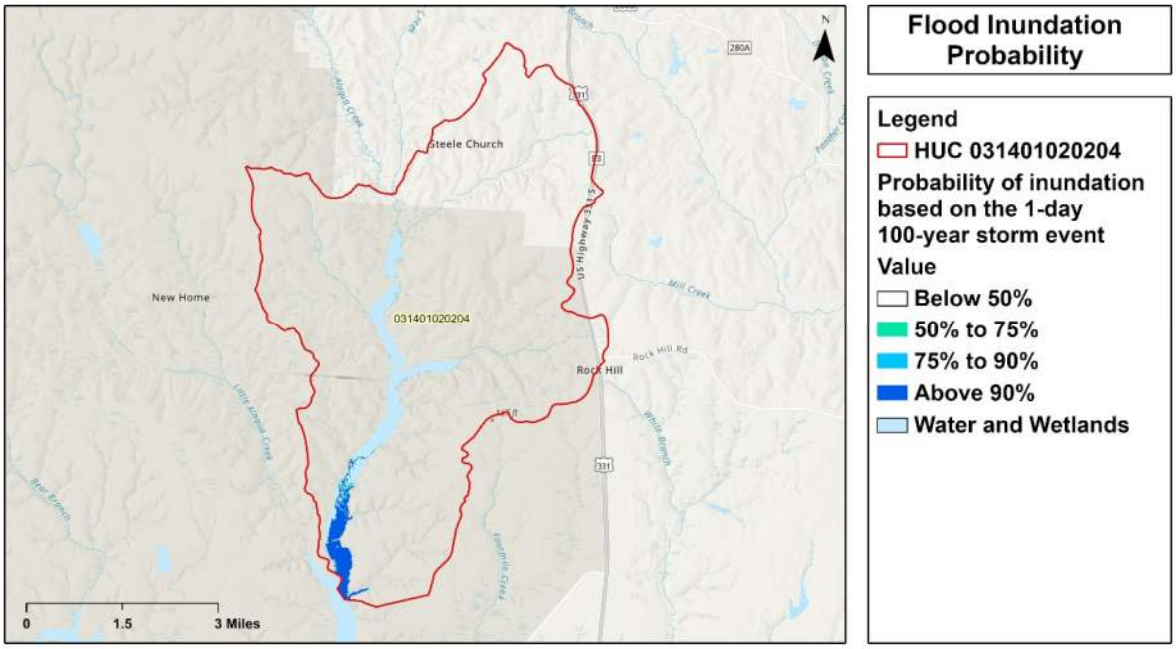

Figure 36. 1-day 100-year storm event for HUC 031401020204 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

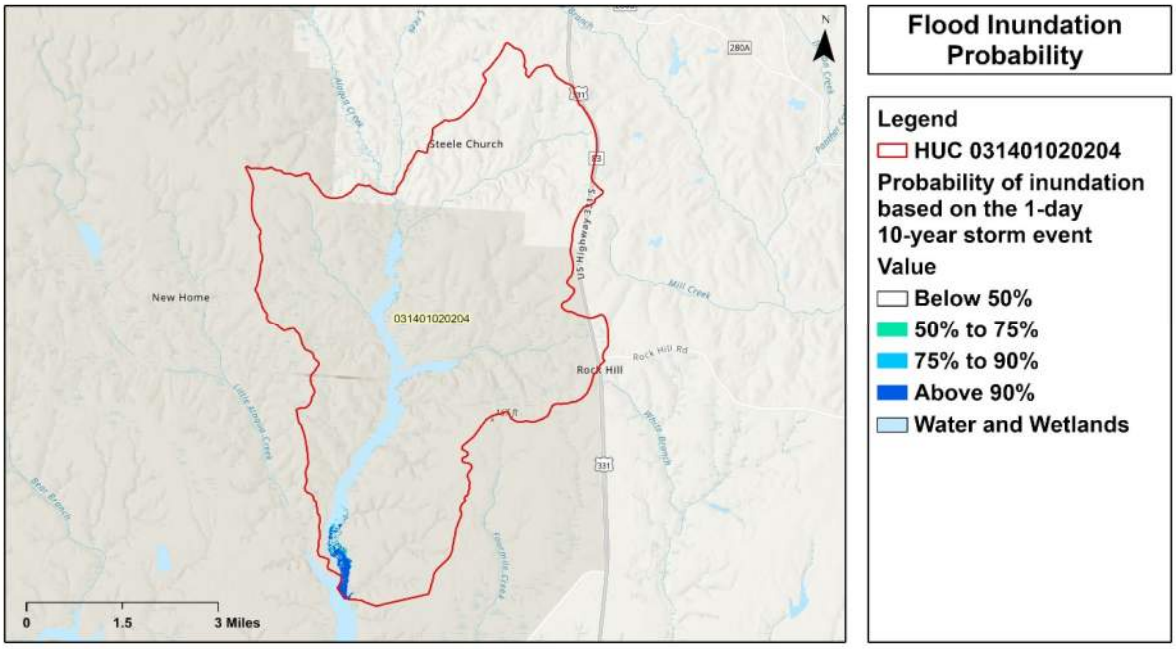

Figure 37. 1-day 10-year storm event for HUC 031401020204 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

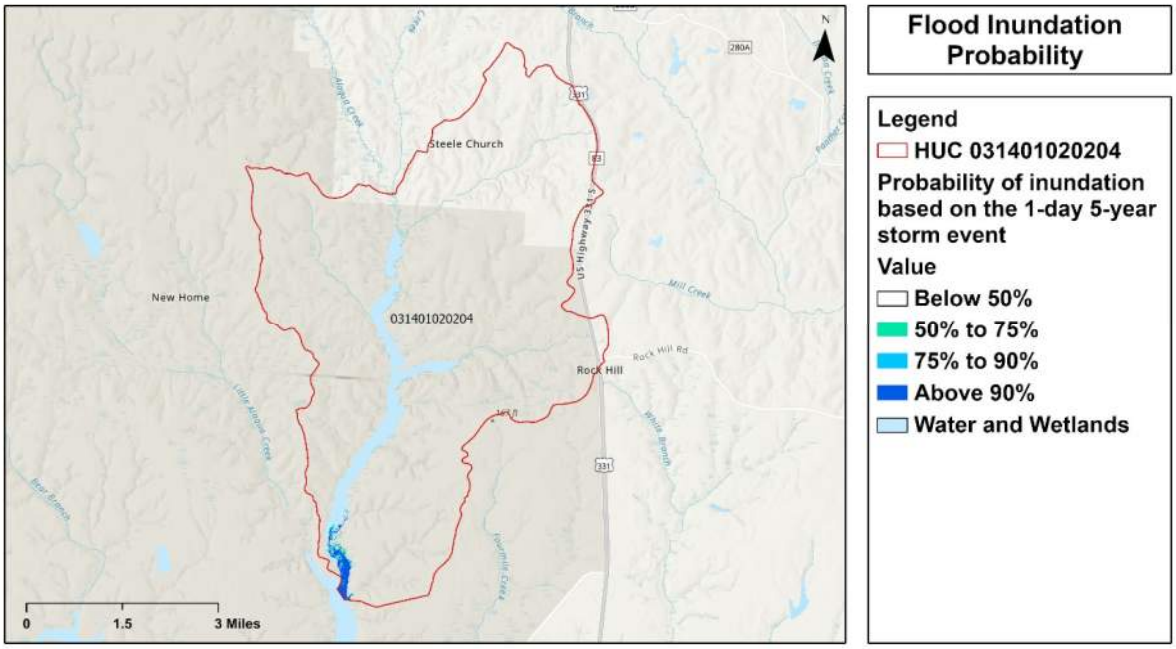

Figure 38. 1-day 5-year storm event for HUC 031401020204 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

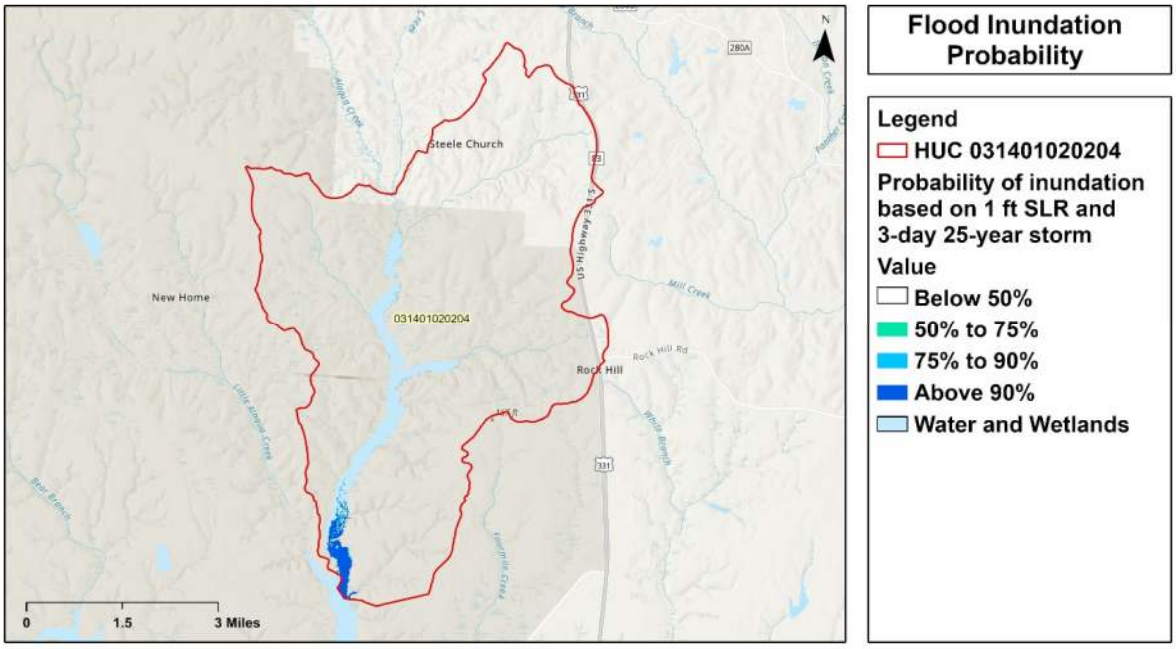

Figure 39. Sea level rise of 1 ft + 3-day25-year storm for HUC 031401020204 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

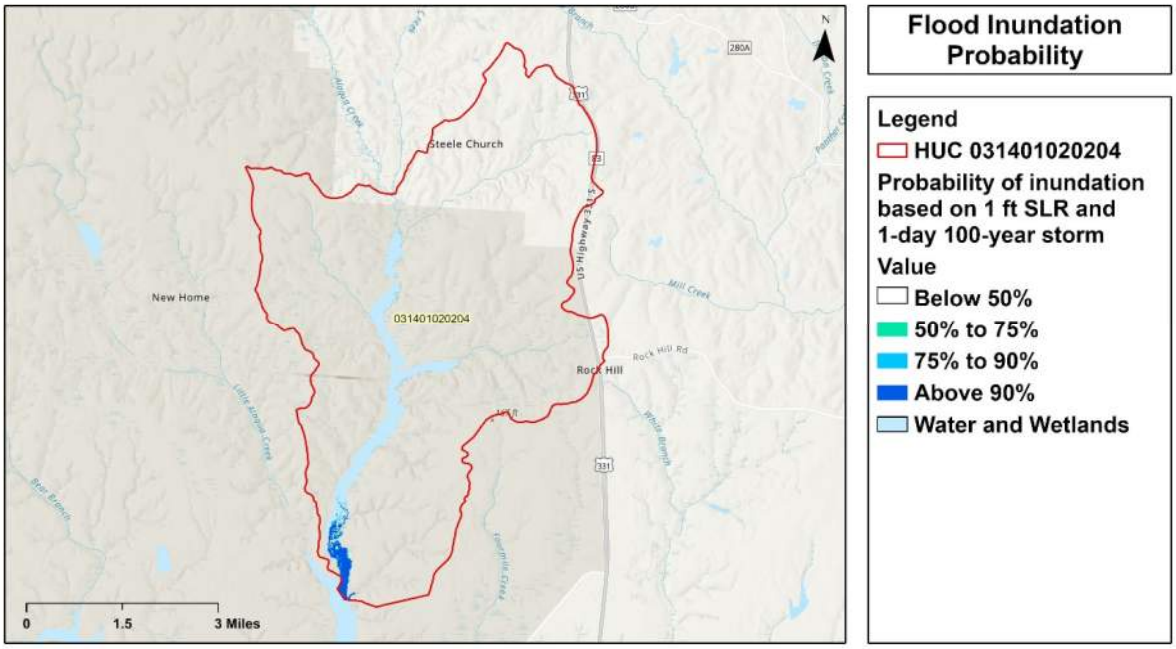

Figure 40. Sea level rise of 1 ft + 1-day 100-year storm for HUC 031401020204 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

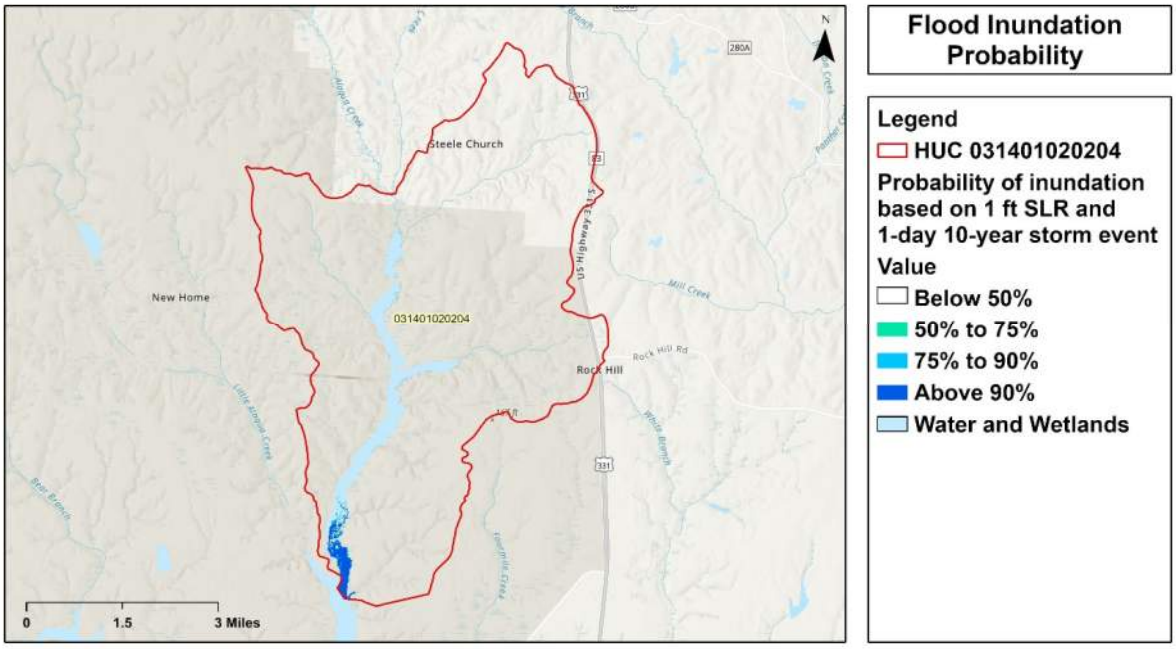

Figure 41. Sea level rise of 1 ft + 1-day 10-year storm for HUC 031401020204 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

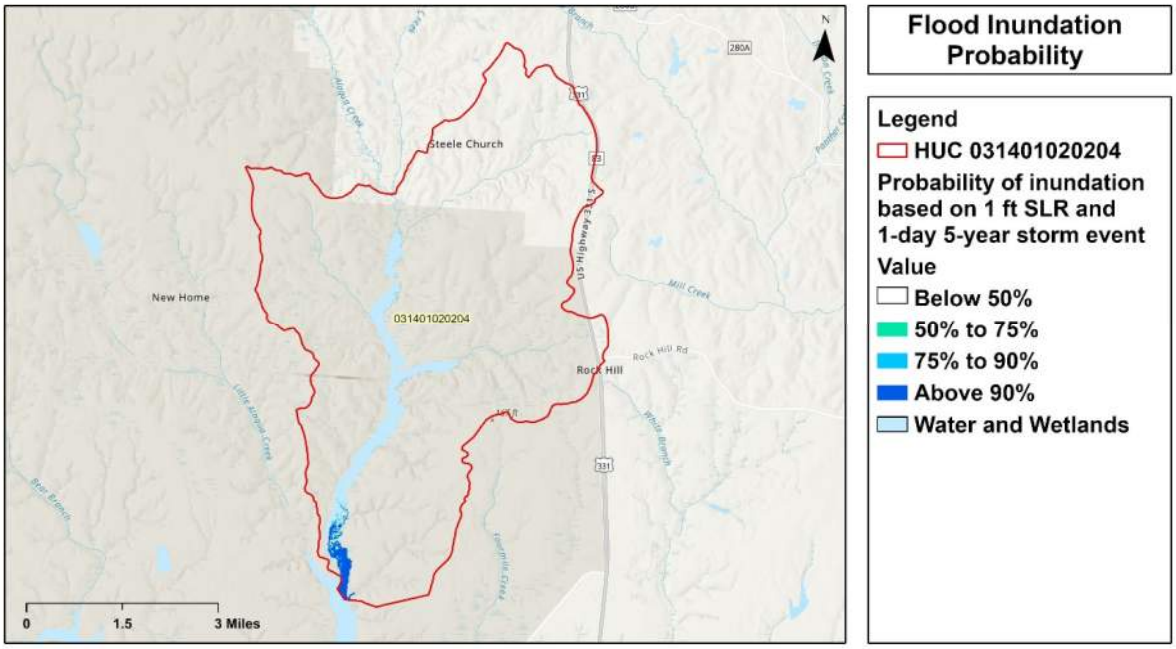

Figure 42. Sea level rise of 1 ft + 1-day 5-year storm for HUC 031401020204 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

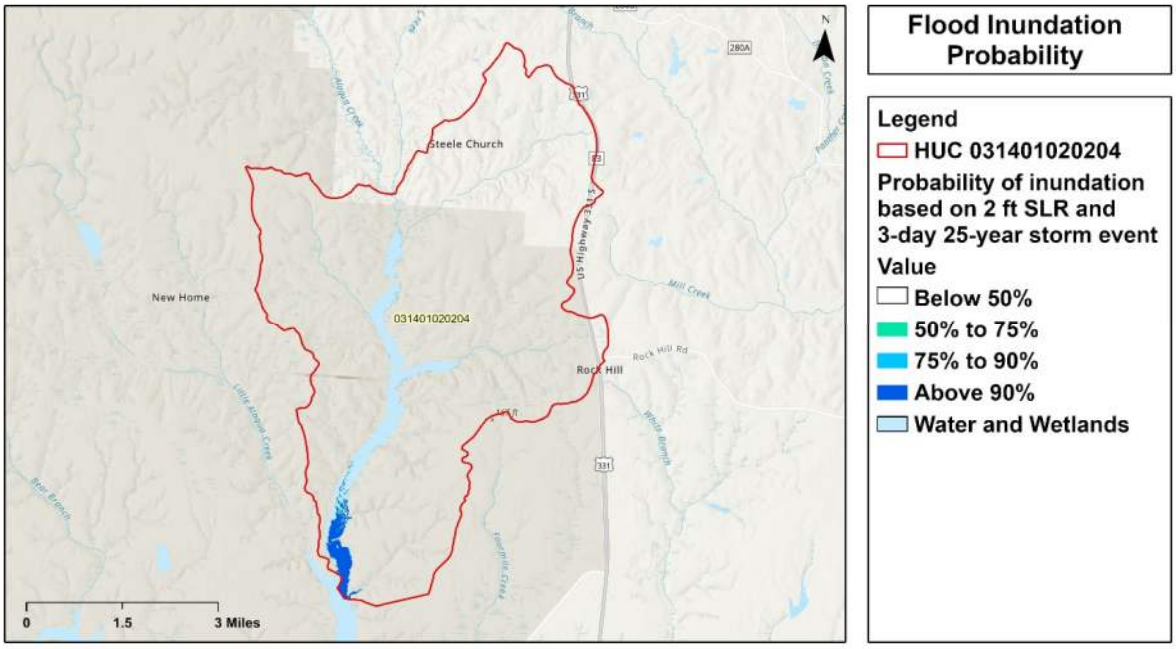

Figure 43. Sea level rise of 2 ft + 3-day 25-year storm for HUC 031401020204 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

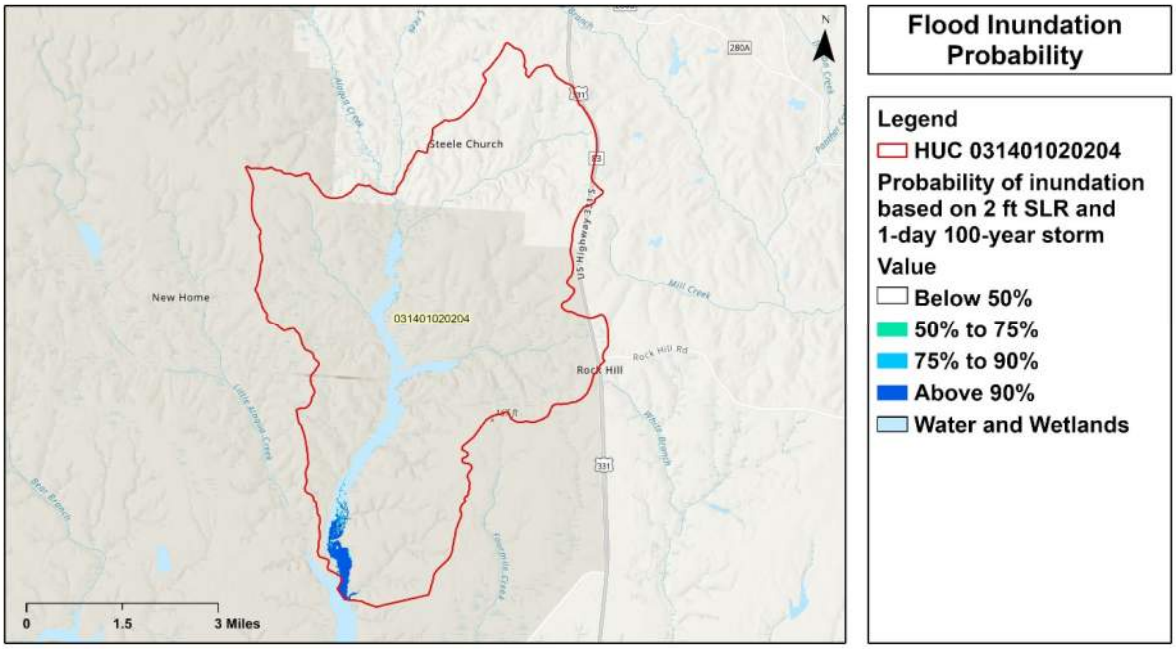

Figure 44. Sea level rise of 2 ft + 1-day 100-year storm for HUC 031401020204 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

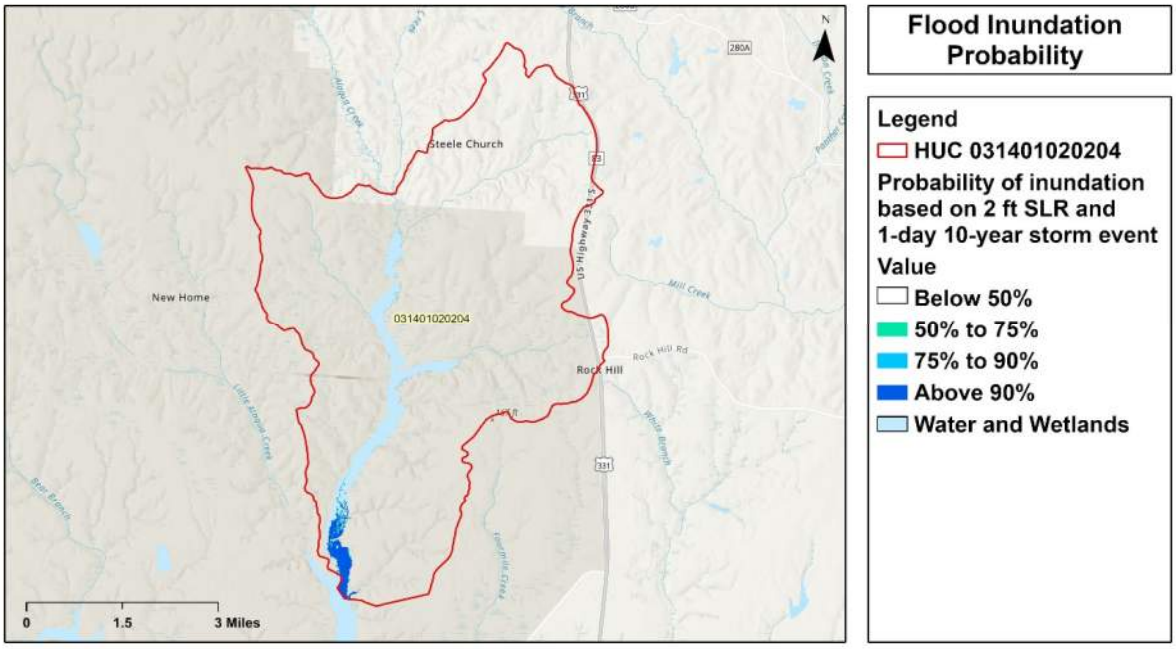

Figure 45. Sea level rise of 2 ft + 1-day 10-year storm for HUC 031401020204 sub-watershed . *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

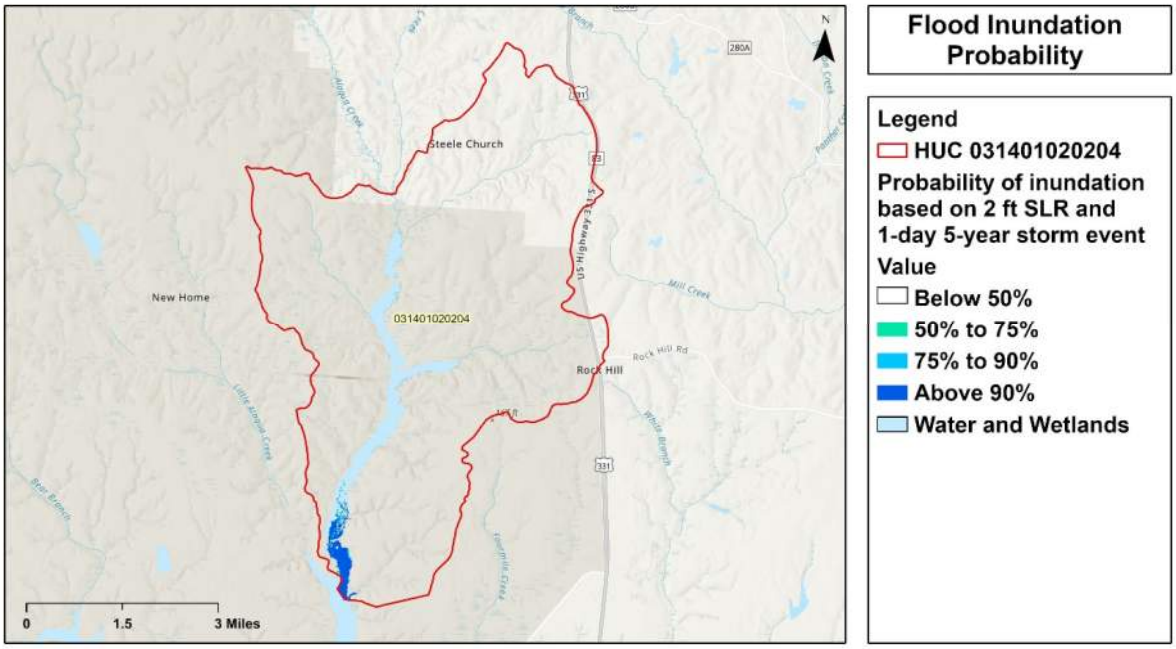

Figure 46. Sea level rise of 2 ft + 1-day 5-year storm for HUC 031401020204 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

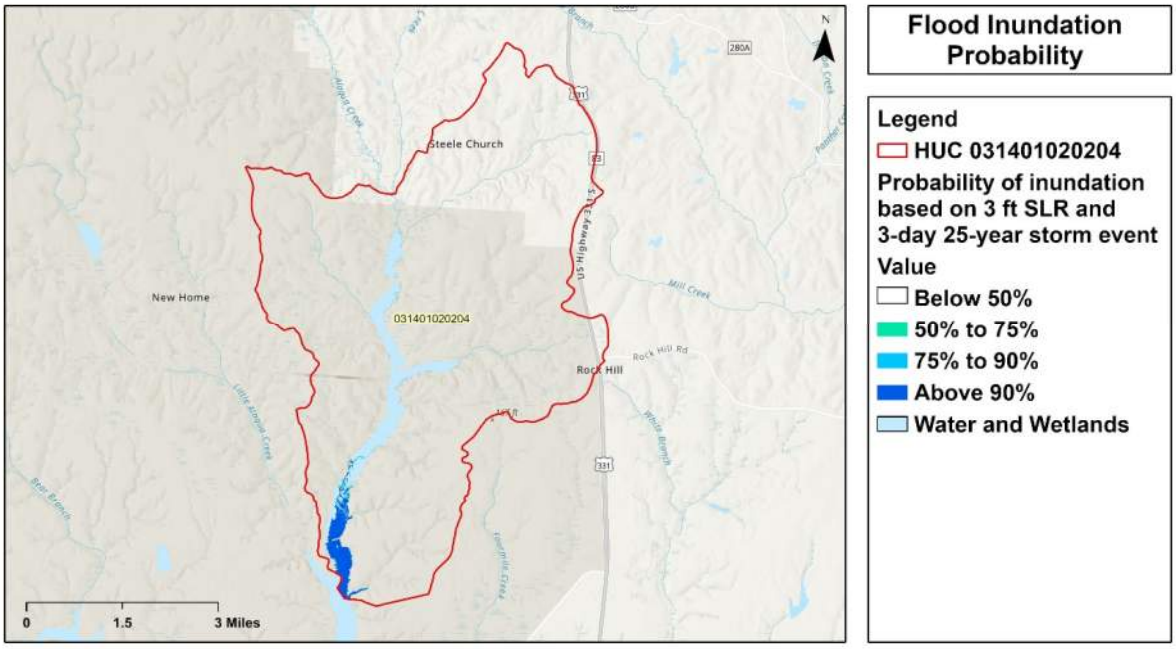

Figure 47. Sea level rise of 3 ft + 3-day 25-year storm for HUC 031401020204 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

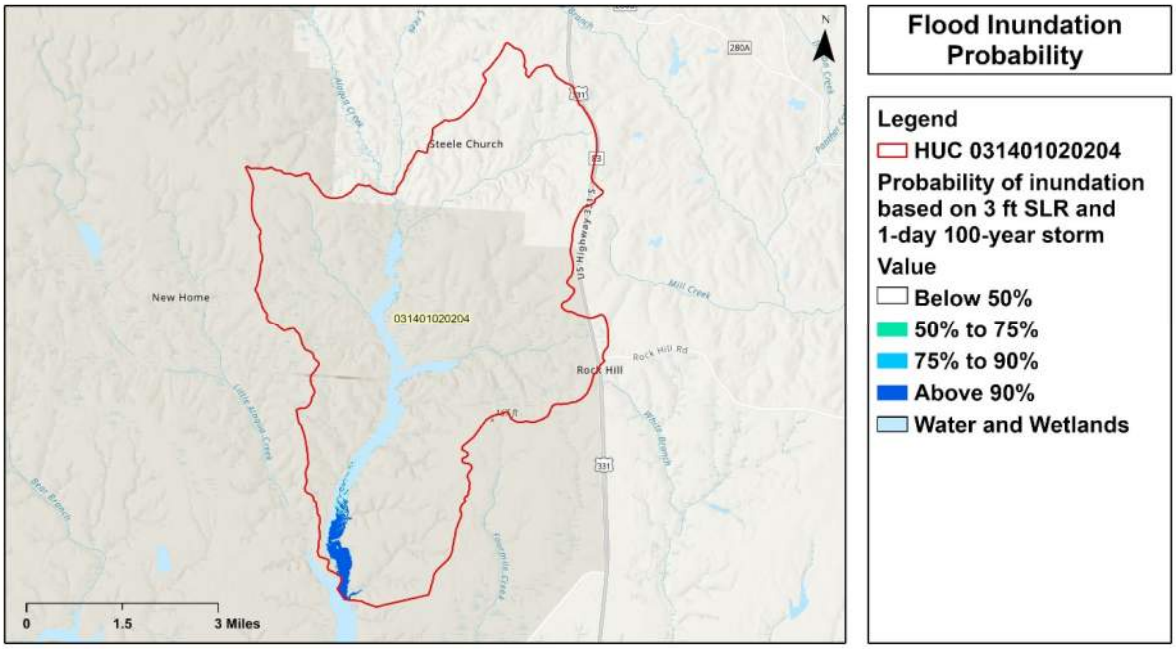

Figure 48. Sea level rise of 3 ft + 1-day 100-year storm for HUC 031401020204 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

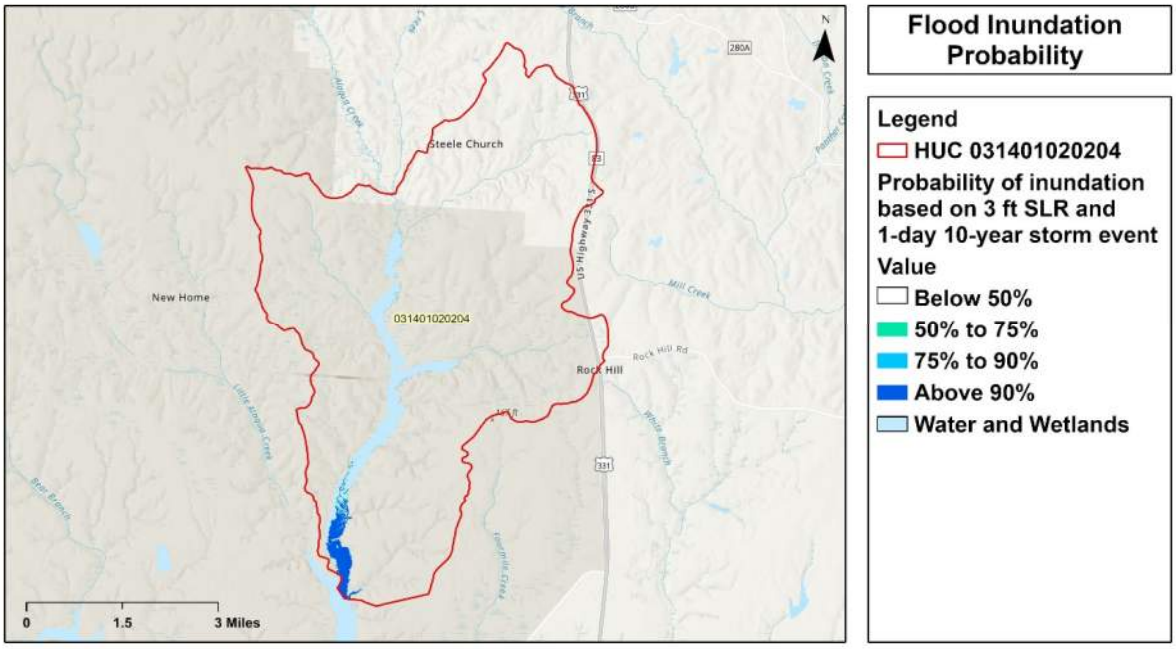

Figure 49. Sea level rise of 3 ft + 1-day 10-year storm for HUC 031401020204 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

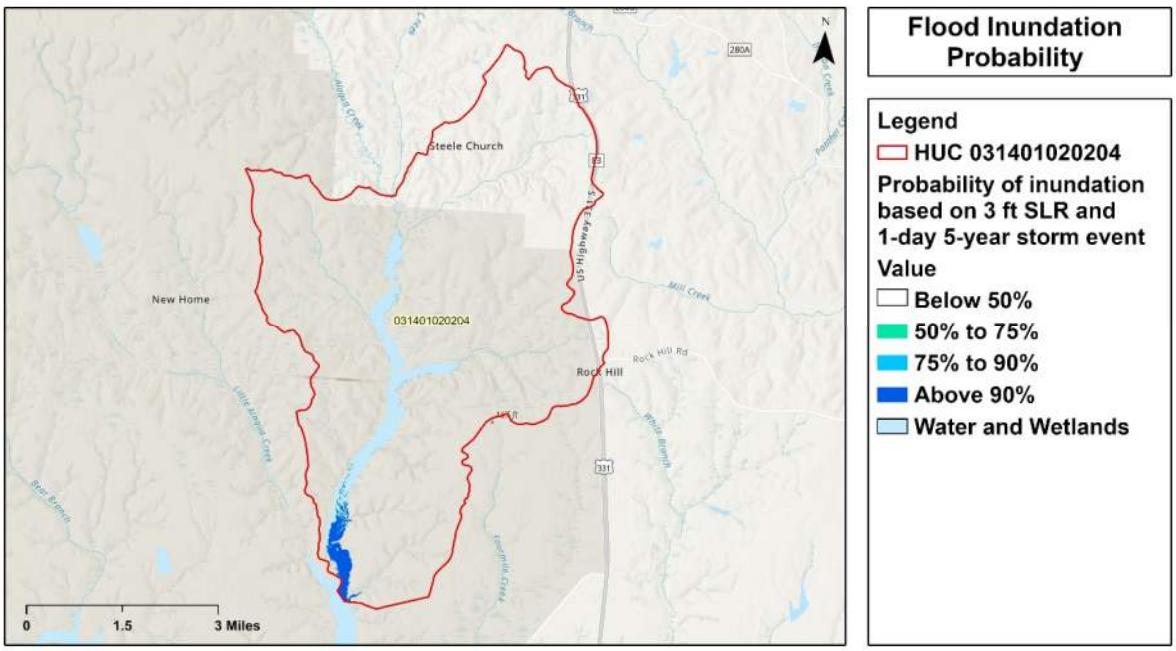

Figure 50. Sea level rise of 3 ft + 1-day 5-year storm for HUC 031401020204 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

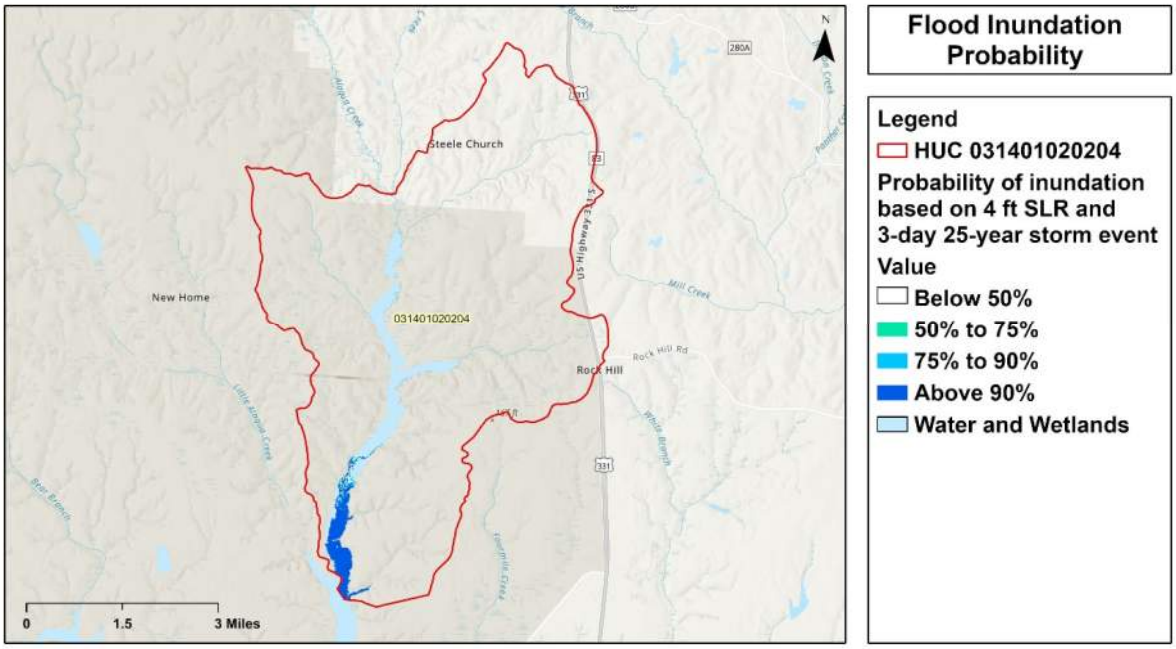

Figure 51. Sea level rise of 4 ft + 3-day 25-year storm for HUC 031401020204 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

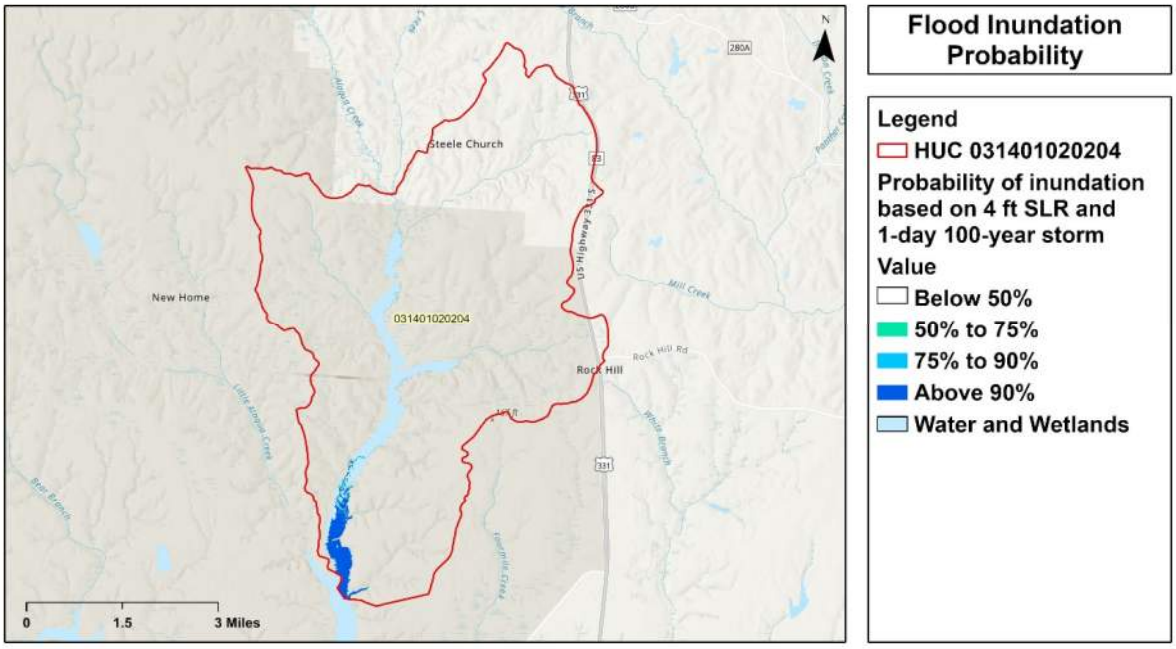

Figure 52. Sea level rise of 4 ft + 1-day 100-year storm for HUC 031401020204 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

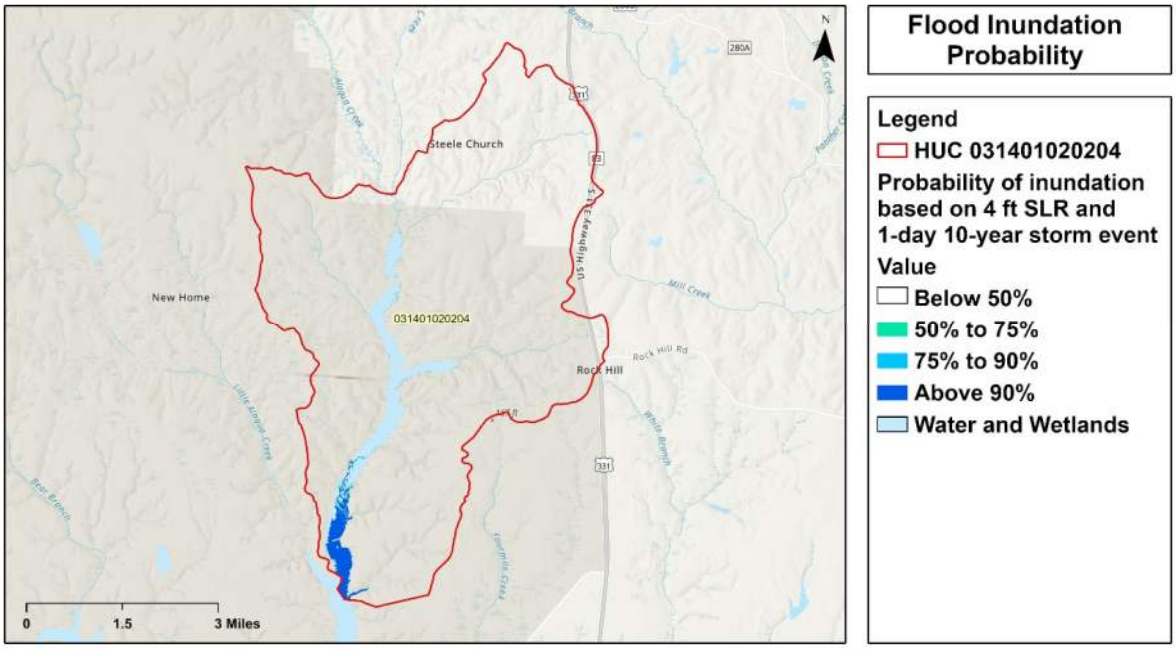

Figure 53. Sea level rise of 4 ft + 1-day 10-year storm for HUC 031401020204 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

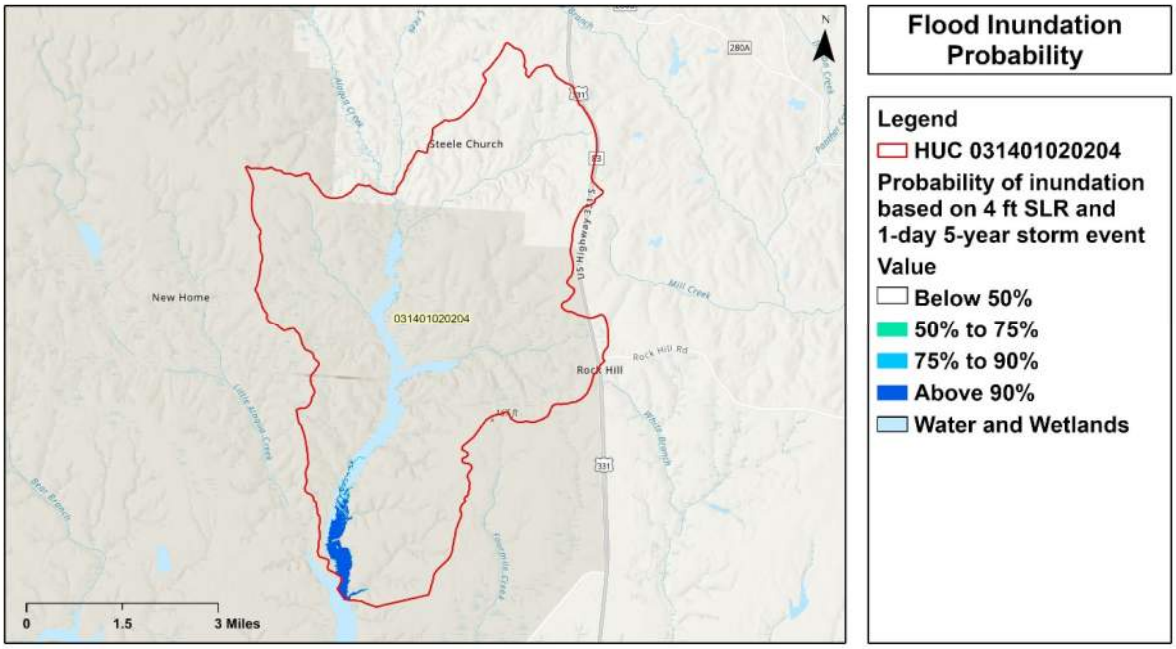

Figure 54. Sea level rise of 4 ft + 1-day 5-year storm for HUC 031401020204 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

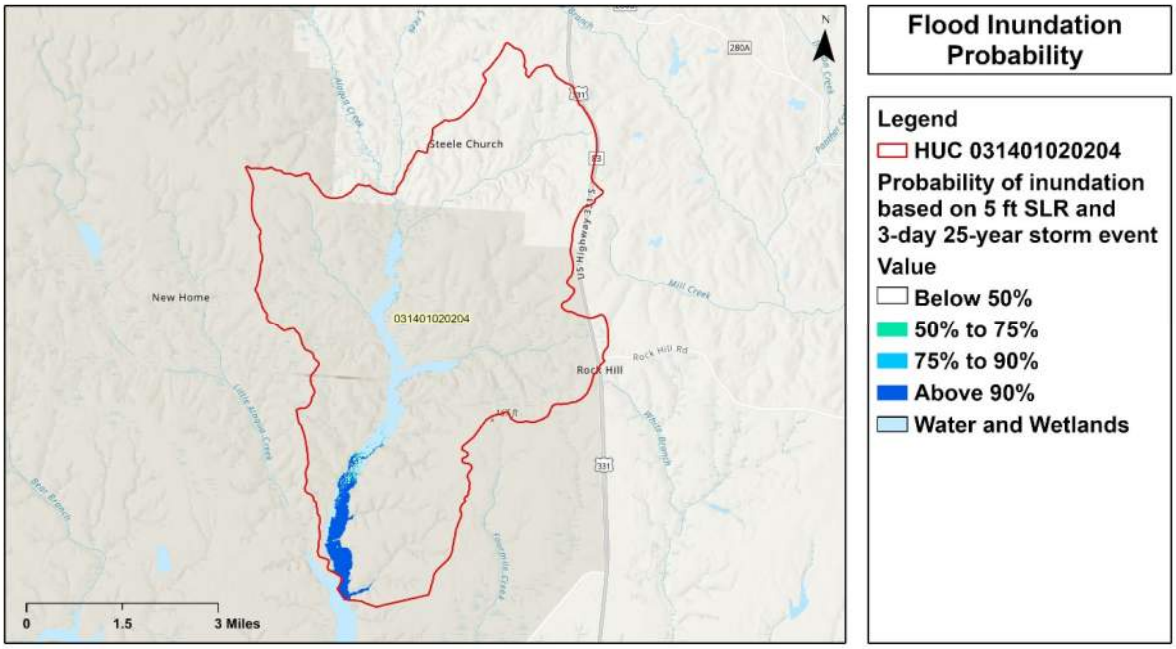

Figure 55. Sea level rise of 5 ft + 3-day 25-year storm for HUC 031401020204 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

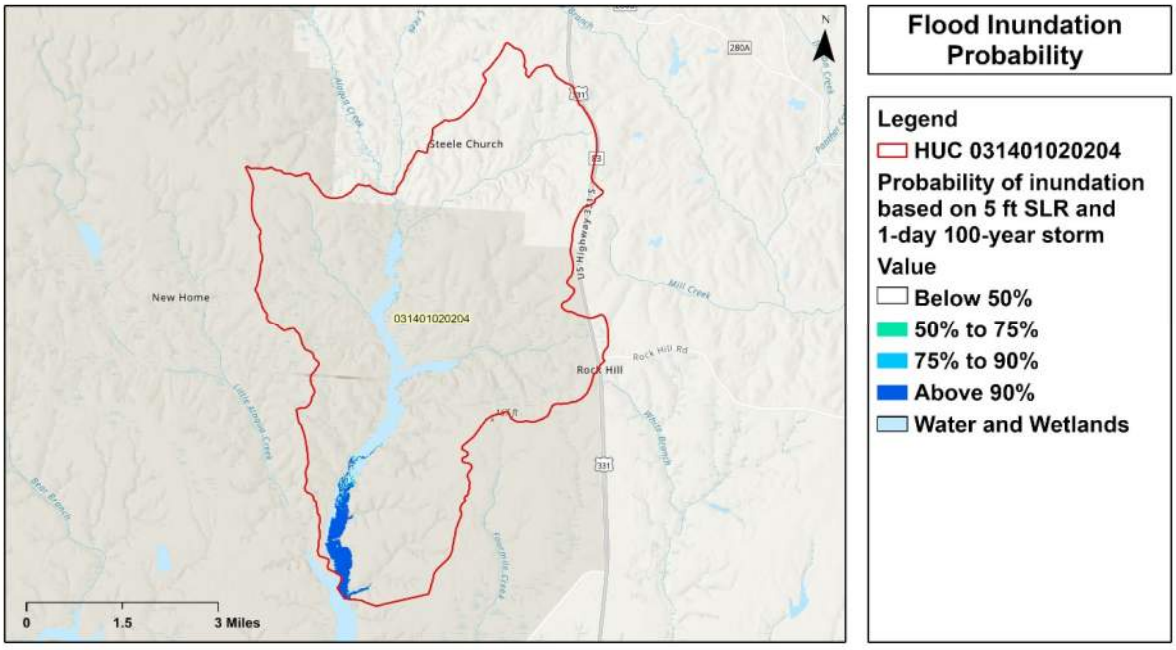

Figure 56. Sea level rise of 5 ft + 1-day 100-year storm for HUC 031401020204 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

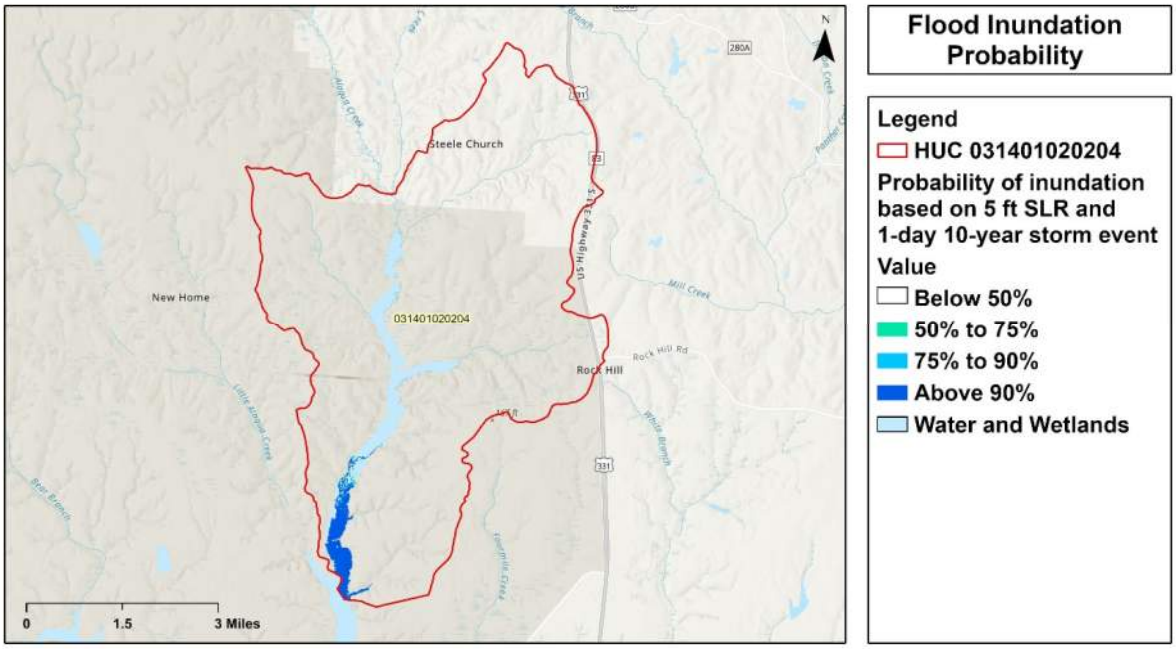

Figure 57. Sea level rise of 5 ft + 1-day 10-year storm for HUC 031401020204 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

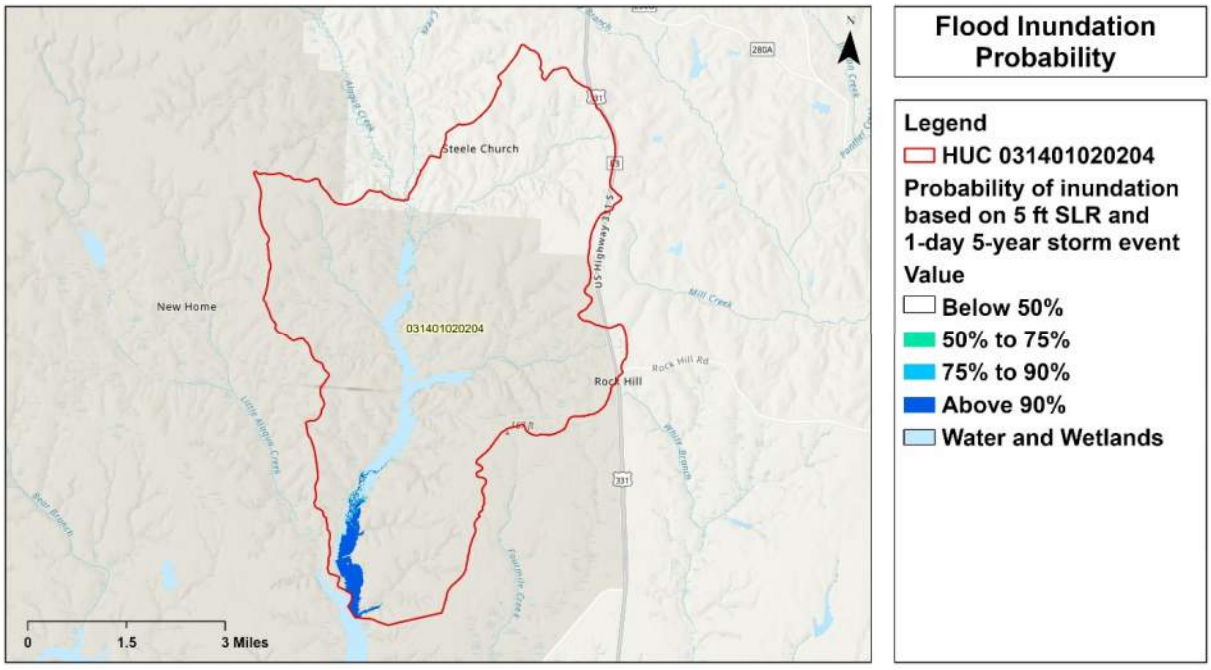

Figure 58. Sea level rise of 5 ft + 1-day 5-year storm for HUC 031401020204 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

2.5 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6

10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3

43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5

78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.5.1 Results

Error! Reference source not found. to **Error! Reference source not found.** depict the HUC 031401020204 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (Figure 59) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 60) overlays critical facilities onto the 1-day 100-year storm event scenario, while the third map (**Error! Reference source not found.**) represents the same overlay within the context of 5 feet of sea level rise (SLR) combined with the 1-day 100-year storm event. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 5 feet SLR + 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** and **Error! Reference source not found.** illustrate the composite score for the HUC, which is the result of the calculations explained above,

pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. **Error! Reference source not found.** represents the calculation for composite score based on 1-day 100-year storm event, while **Error! Reference source not found.** shows the calculation for composite score for the same storm event, but including a 5 feet of Sea Level Rise scenario. **Error! Reference source not found.** shows the same area zoomed out.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

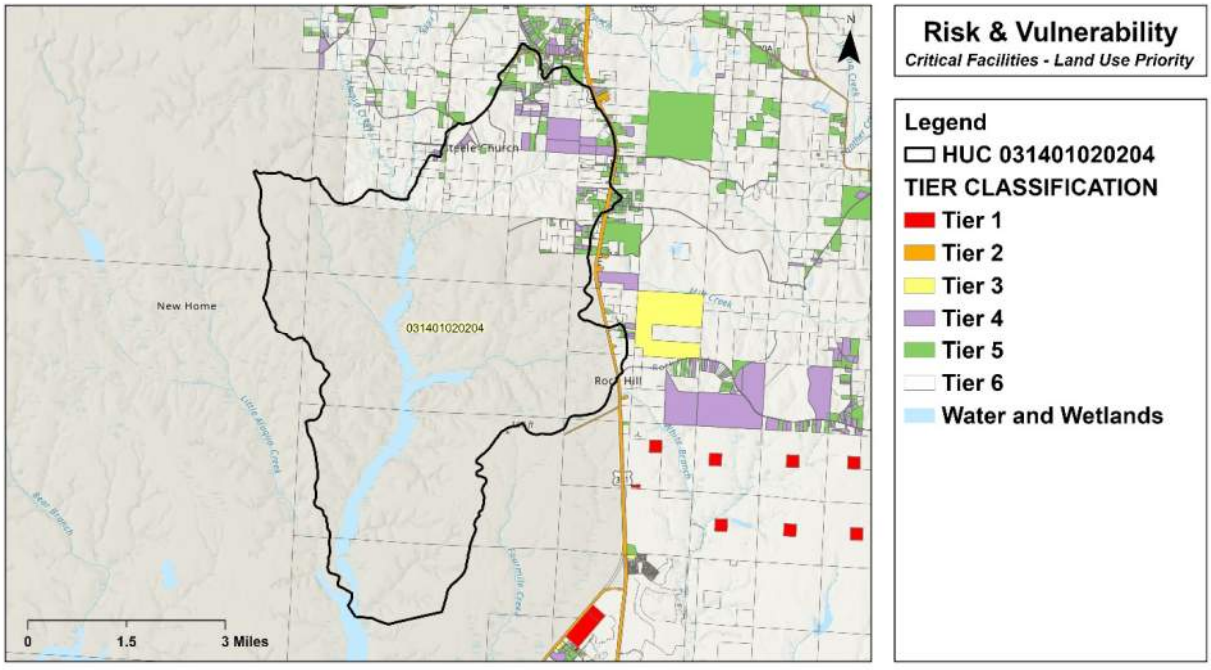

Figure 59. HUC 031401020204 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

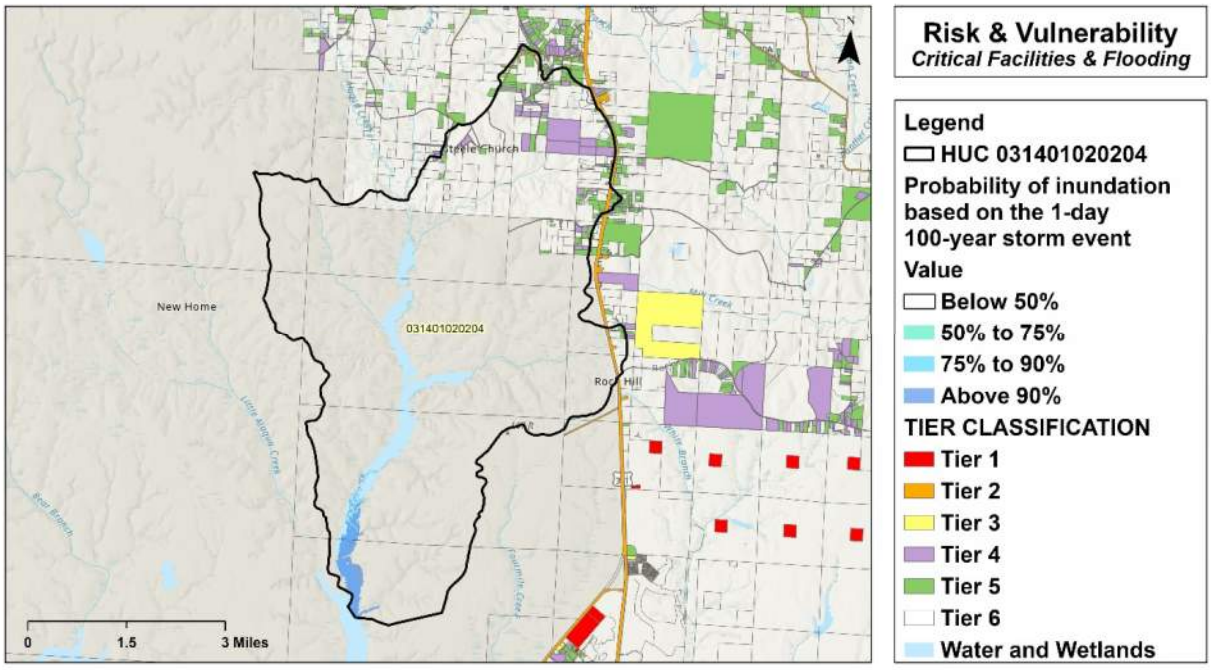

Figure 60. HUC 031401020204 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation map. Processed by FAU.

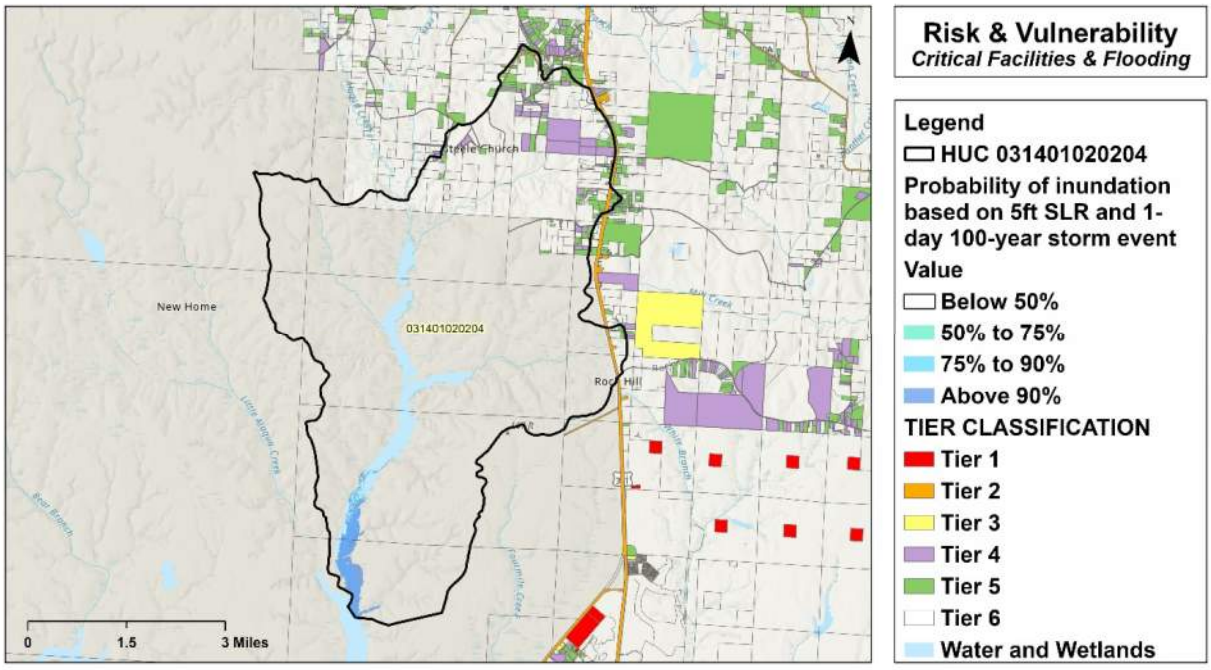

Figure 61. HUC 031401020204 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event + 5 ft SLR probability of inundation map. Processed by FAU.

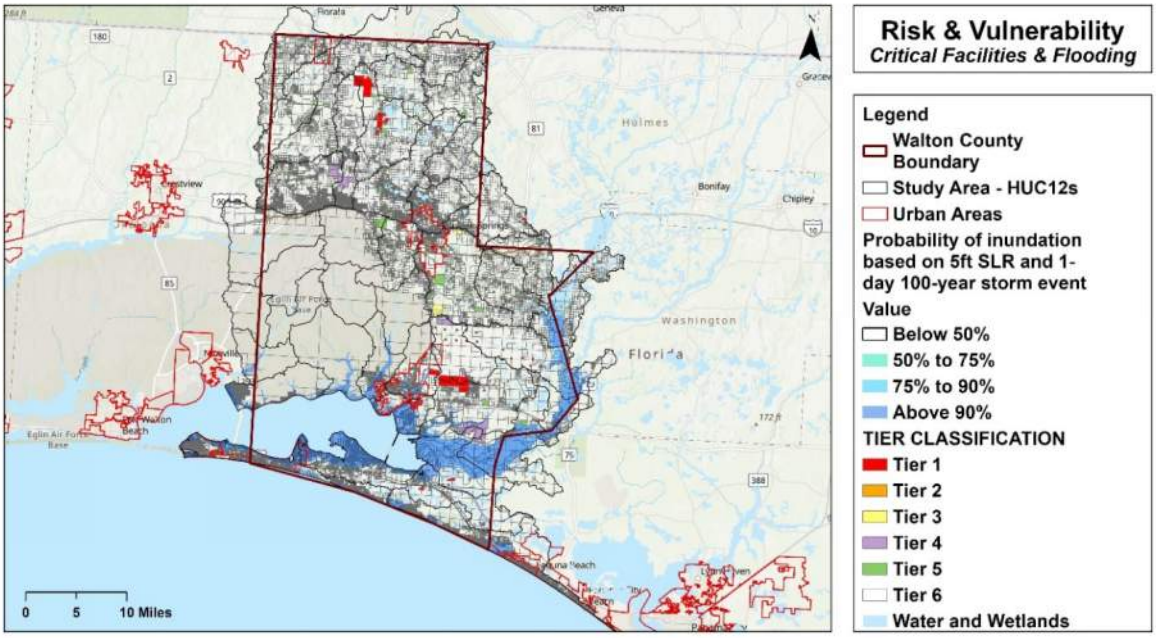

Figure 62. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event + 5 ft SLR probability of inundation map for Walton County. Processed by FAU.

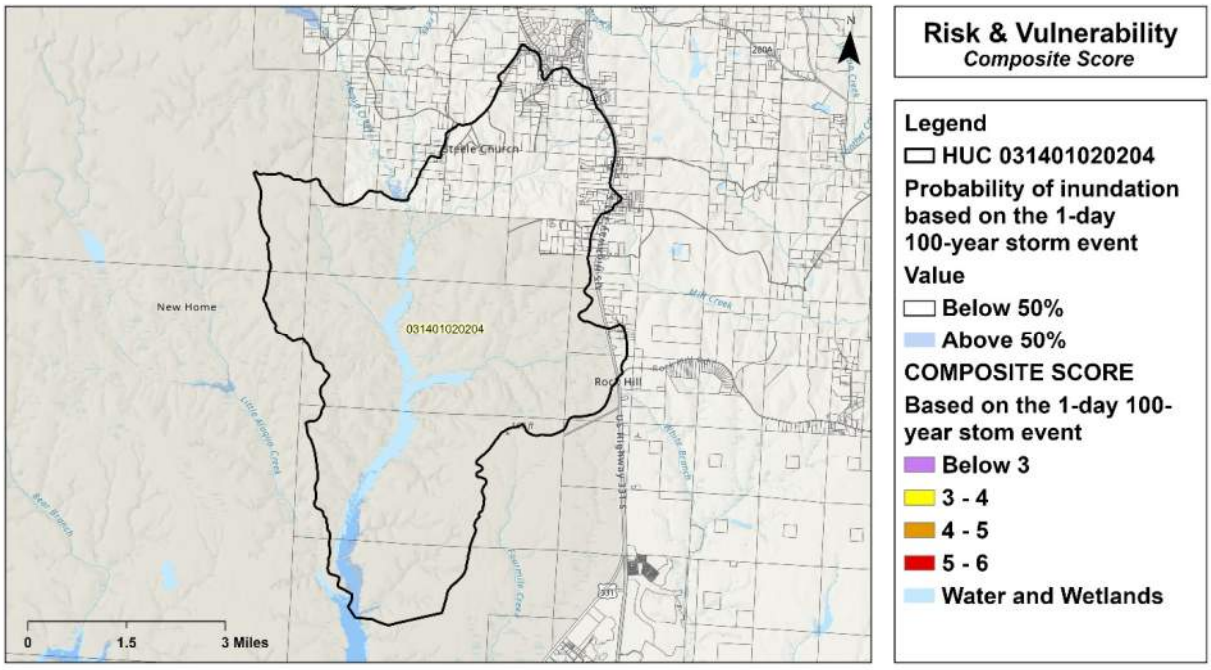

Figure 63. HUC 031401020204 sub-watershed Composite Score Risk map based on the 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation. Processed by FAU.

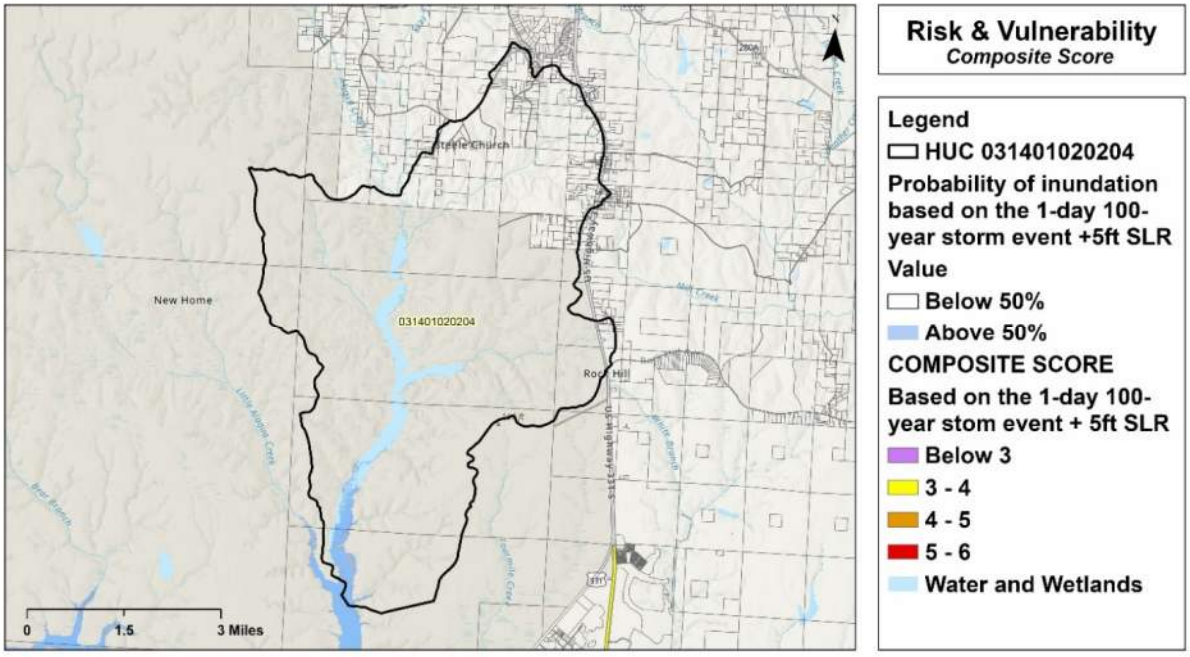

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Figure 64. HUC 031401020204 sub-watershed Composite Score Risk map based on 1-day 100-year storm event + 5 ft SRL, overlaid on the 1-day 100-year + 5 ft SLR probability of inundation. Processed by FAU.

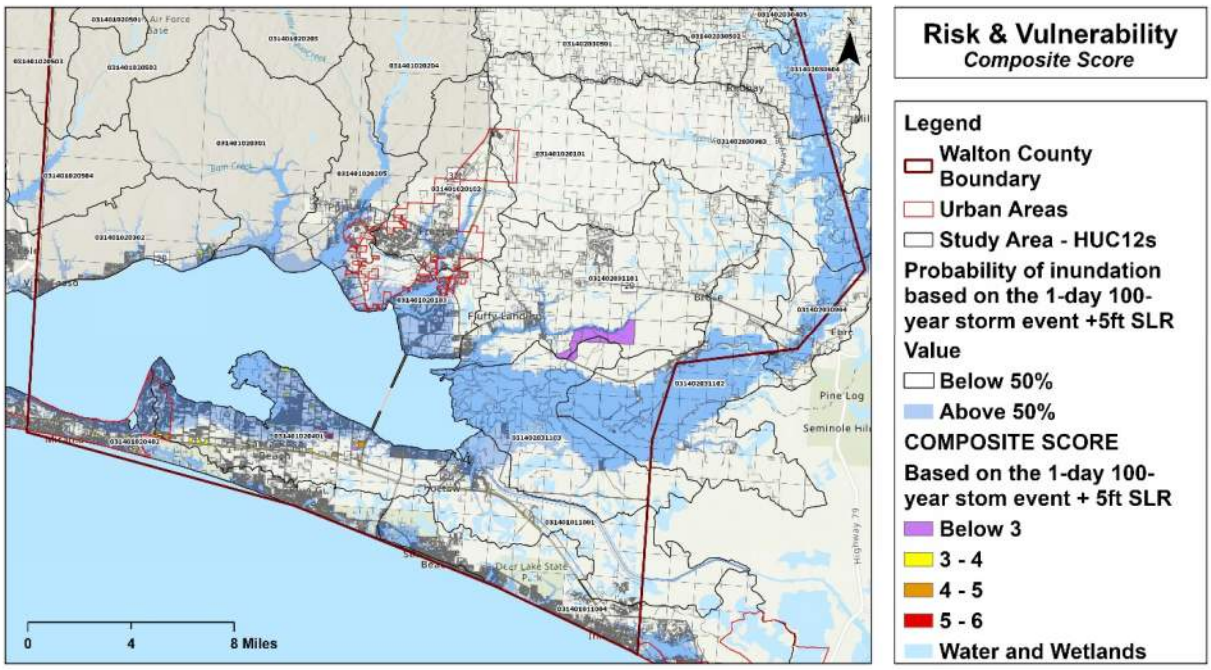

Figure 65. Coastal Area of Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year + 5 ft SLR storm event probability of inundation map. Processed by FAU.

2.5.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401020204. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.5.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401020204. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401020204	17786.48
All of the 1-day 100-year storm event inundation	**250.60**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	158.81
B. Federal Land in 1-day 100-year inundation > 10 acres	91.80
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	0.00
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	0.00

2.5.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not**

found. indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

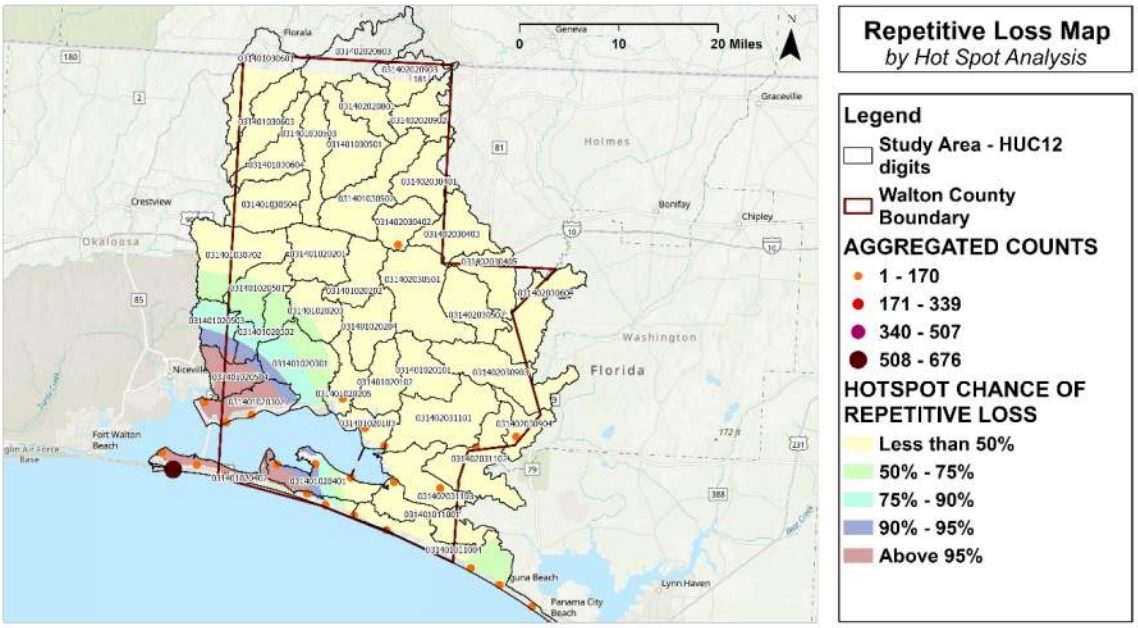

Figure 66. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.5.5 Priority Projects

The basin is mostly undeveloped, with only a portion being populated. Fortunately, this part is not affected by flooding. Considering priority of land uses, it is clear that there are some parcels falling within tiers 2 (US Highway 331), 4 and 5, which represent a low priority for intervention. However, none of them are within the flooding zone. Flooding in the area is not a major problem, consequently, when considering the composite score, it notable that the results are null, since there is no critical facilities situated within the flooding zone, indicating no necessity for priority projects intervention within the basin.

More detail about flood solutions are described in the community plan and in Section 5.5 where drilldown to specific neighborhoods is outlined.

APPENDIX K

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401020205

ALAQUA BAYOU

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 sub-watershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401020205) is highlighted among all the HUCs to help identifying its location.

The city of Freeport shares a portion of its boundary with the basin. Demographics data and other considerations of Freeport, along with other cities in Walton County, will be covered in subsequent discussions.

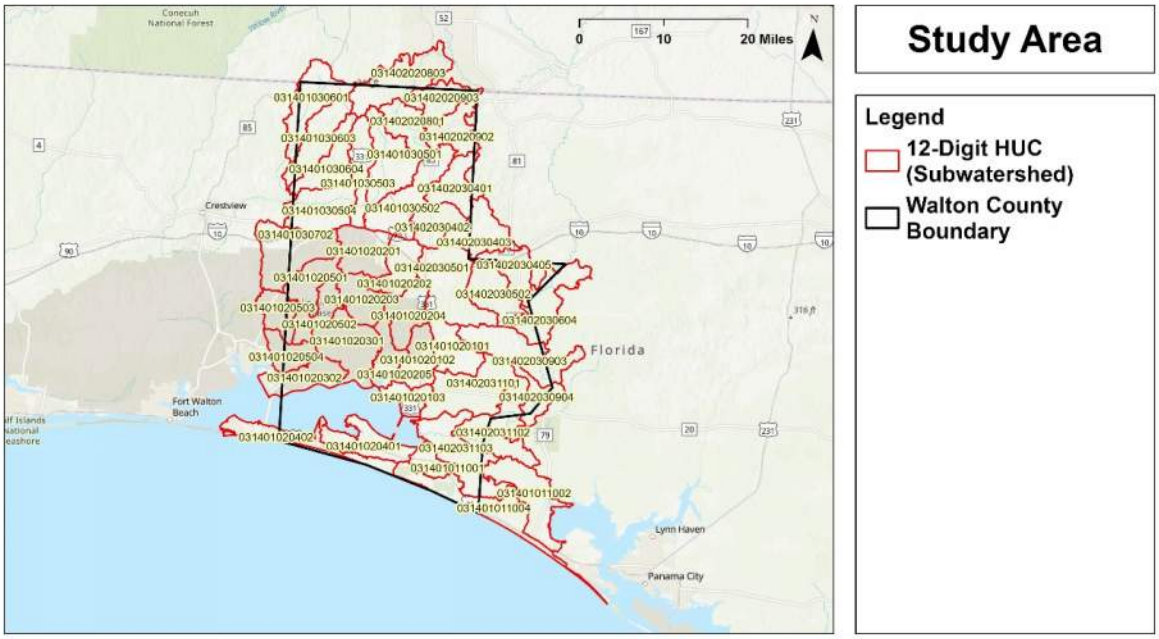

Figure 1. Walton County and all HUCs 12-digit sub-watershed, processed by FAU.

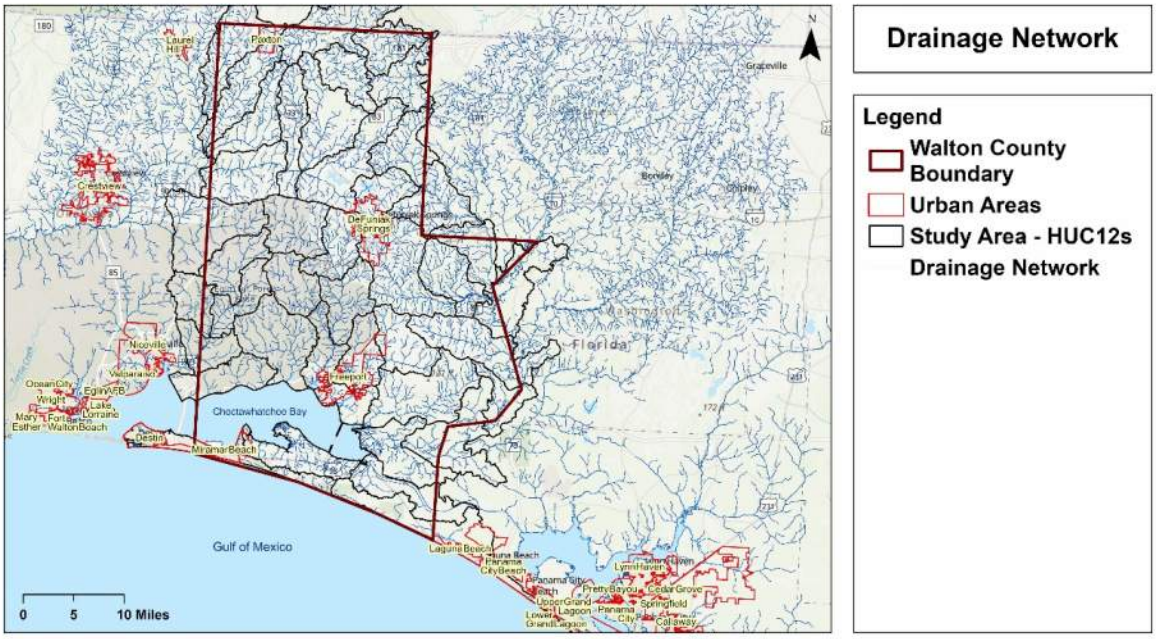

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

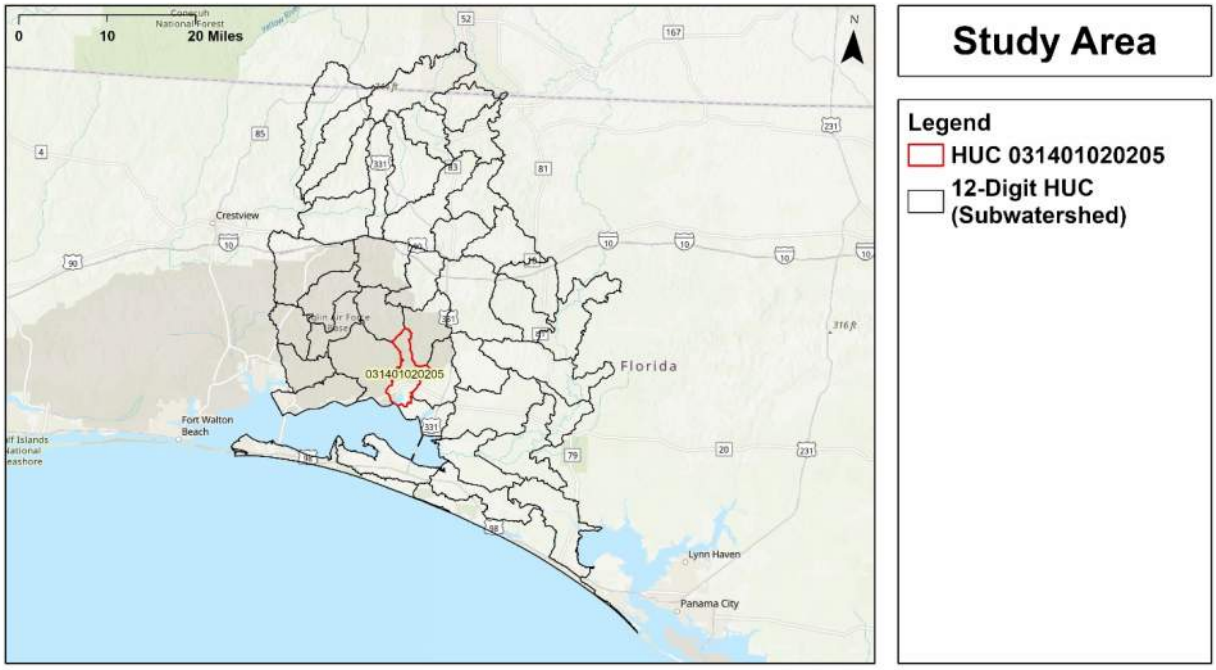

Figure 3. HUC 031401020205 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development, tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Figures 12 and 13 in the county-wide report show the current and projected land use for the County. Based on the 2017 future land use map for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL))).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water

in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

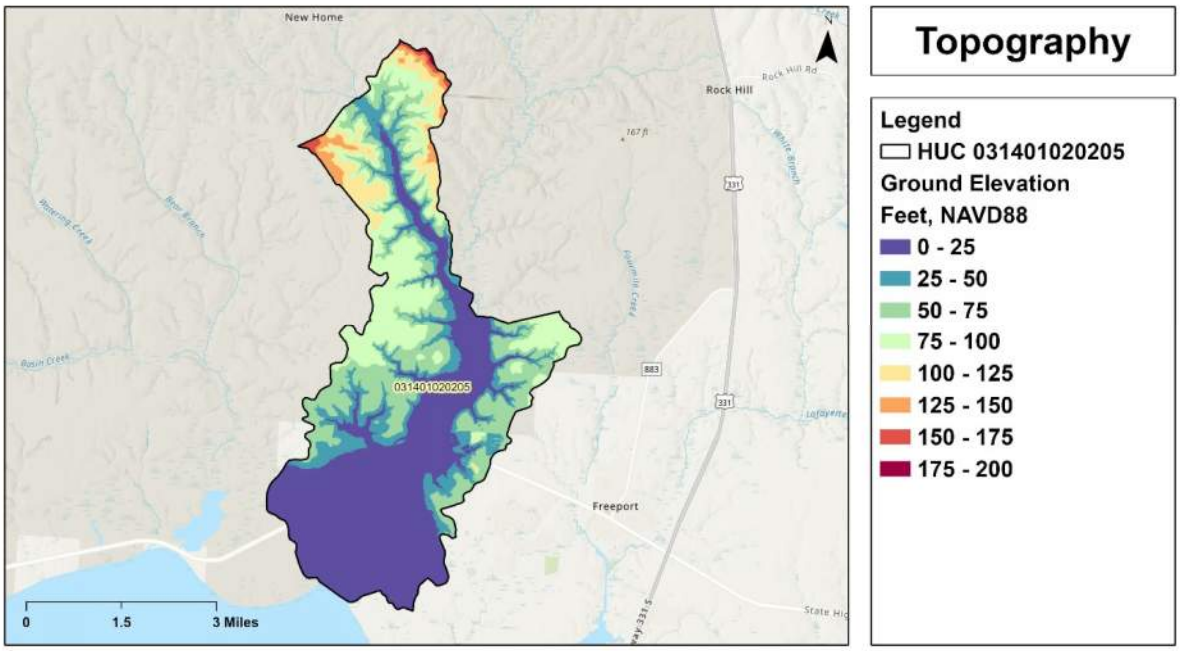

Figure 4. Topographic map of the HUC 031401020205 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401020205 sub-watershed is shown in **Error! Reference source not found.**.

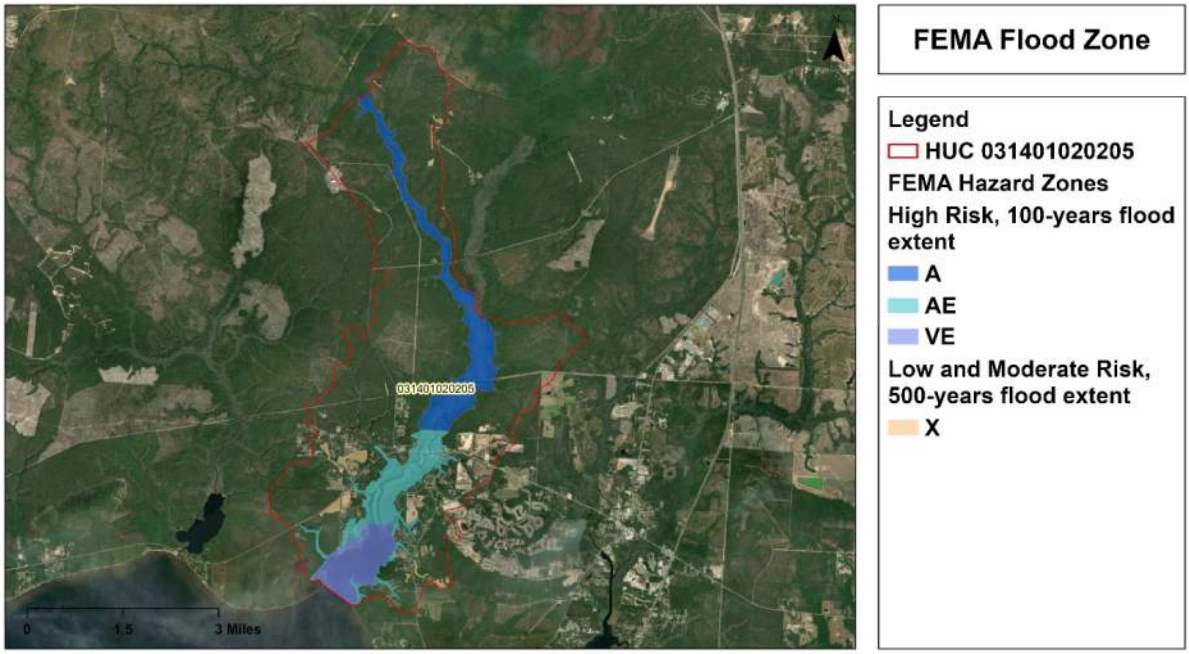

Figure 5. FEMA Flood Zone map (2020) for HUC 031401020205 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401020205 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

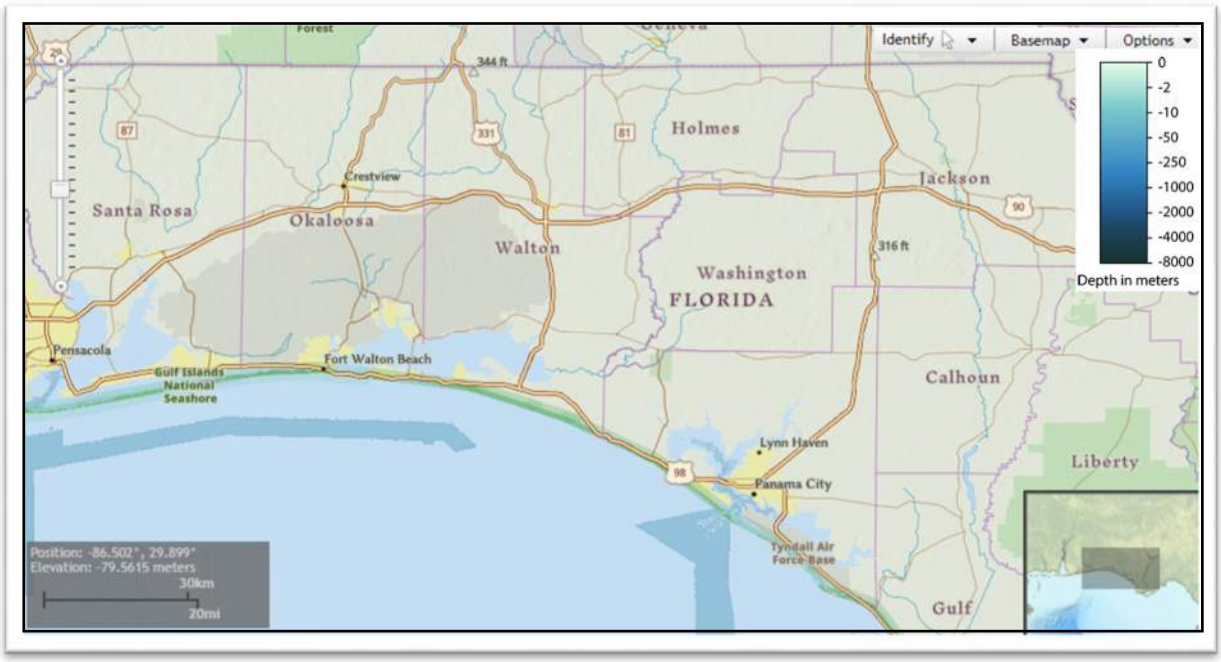

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

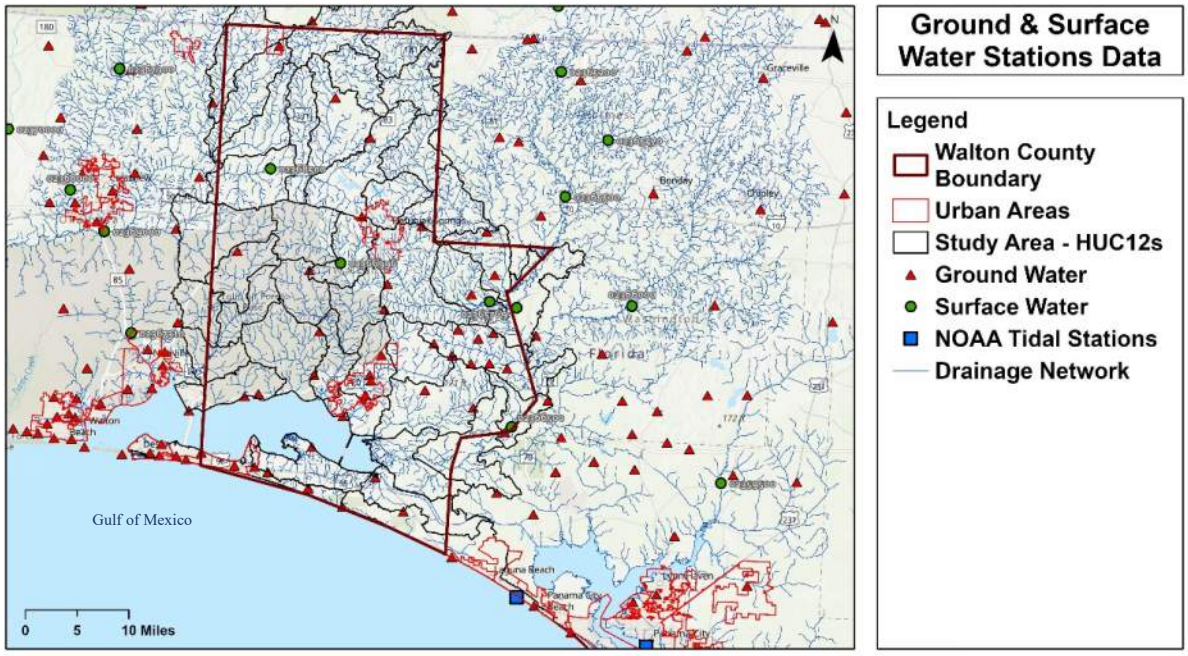

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC is connected with the Choctawhatchee Bay at its south side. The major water bodies in the HUC 031401020205 sub-watershed include:

- Alaqua Creek

- West Bayou
- Davis Mill Creek
- Flat Head
- Steep Head
- Little Alaqua Creek
- Goodwin Creek

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366996. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401020205, which is USGS 02366996 Alaqua Creek Near Pleasant Ridge, FL.

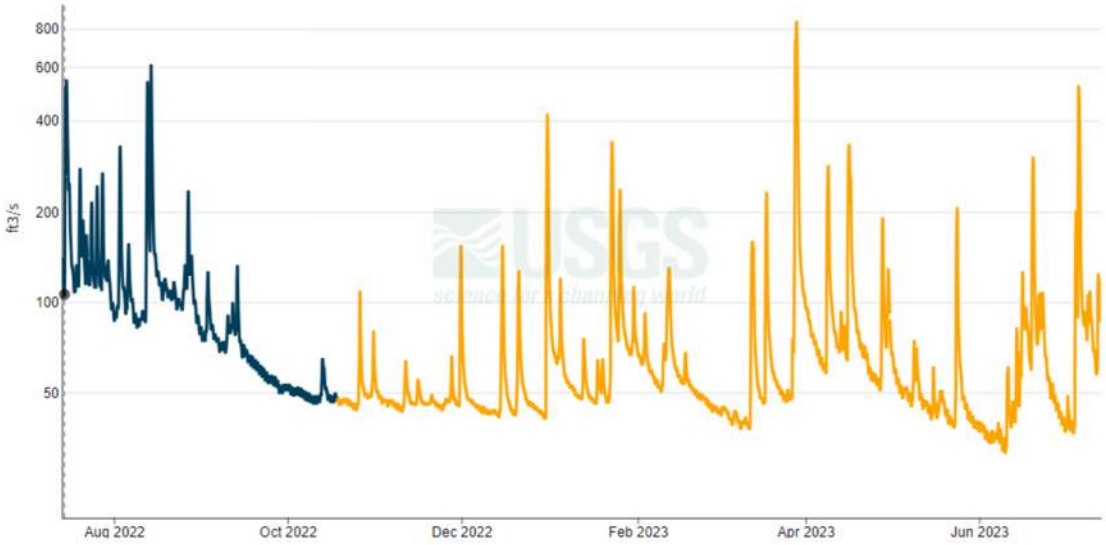

Figure 8. Average streamflow for Alaqua Creek Near Pleasant Ridge, FL (USGS 02366996 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366996/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99^{th}- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98^{th} - 100^{th} percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to

process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401020205 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031401020205 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

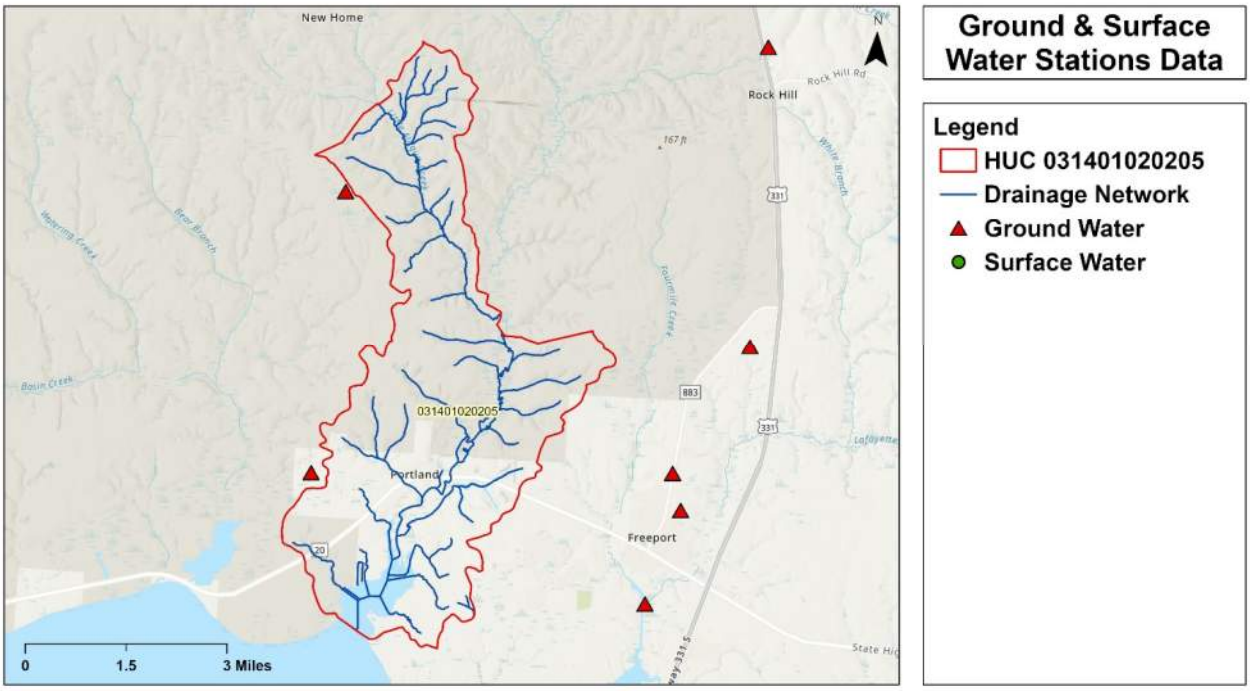

Figure 9. Ground and Surface Water Stations in the HUC 031401020205 sub-watershed, processed by FAU.

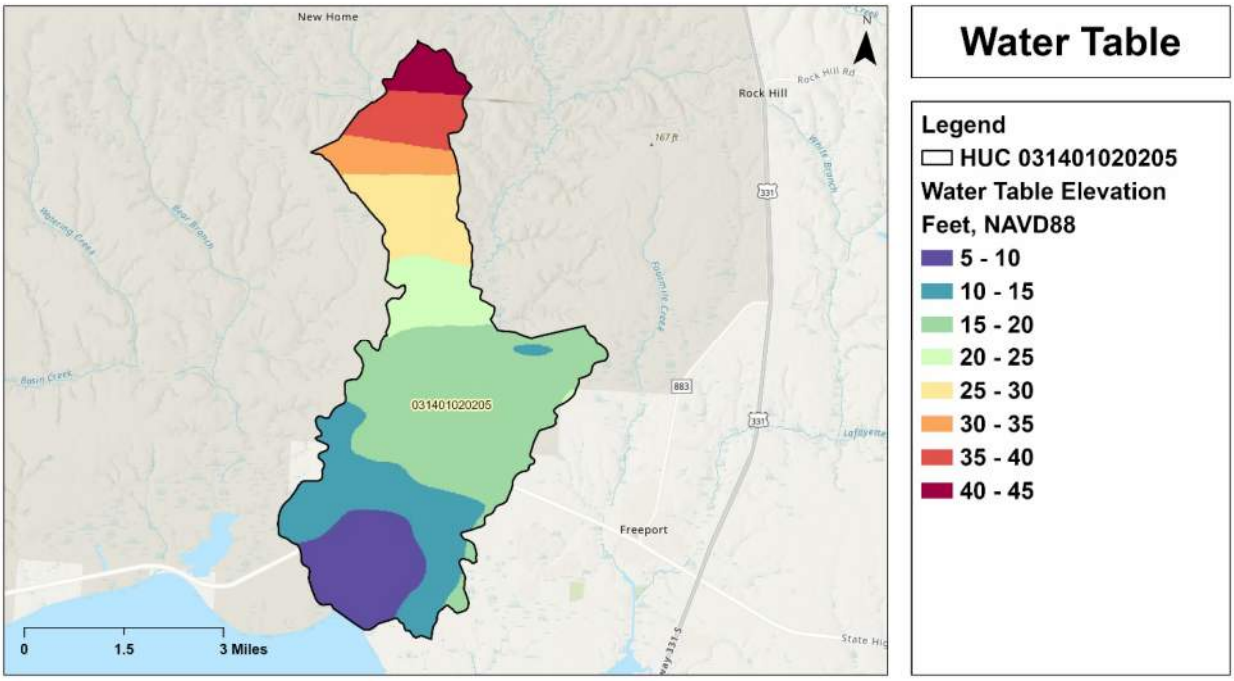

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401020205 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

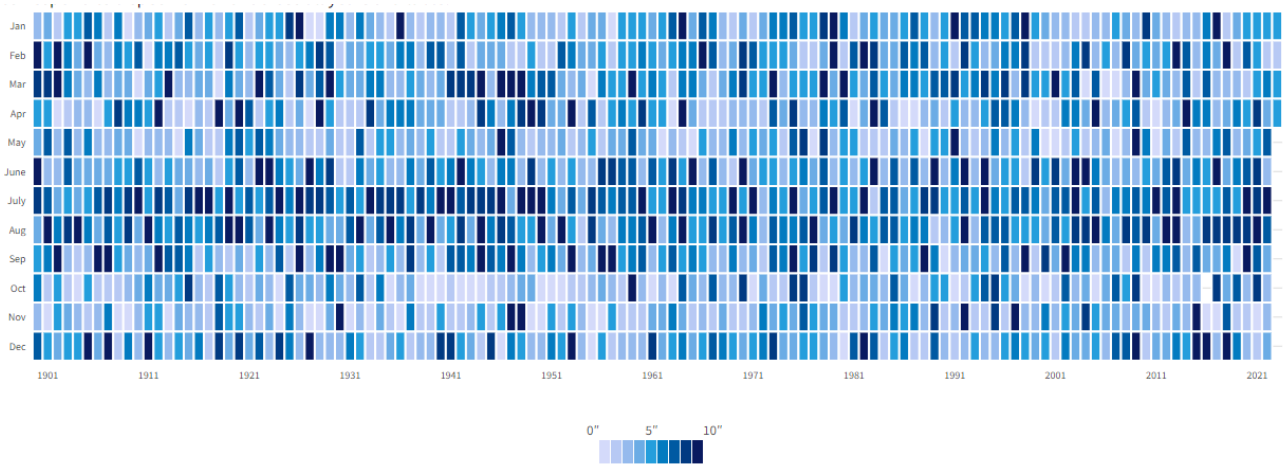

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/)

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

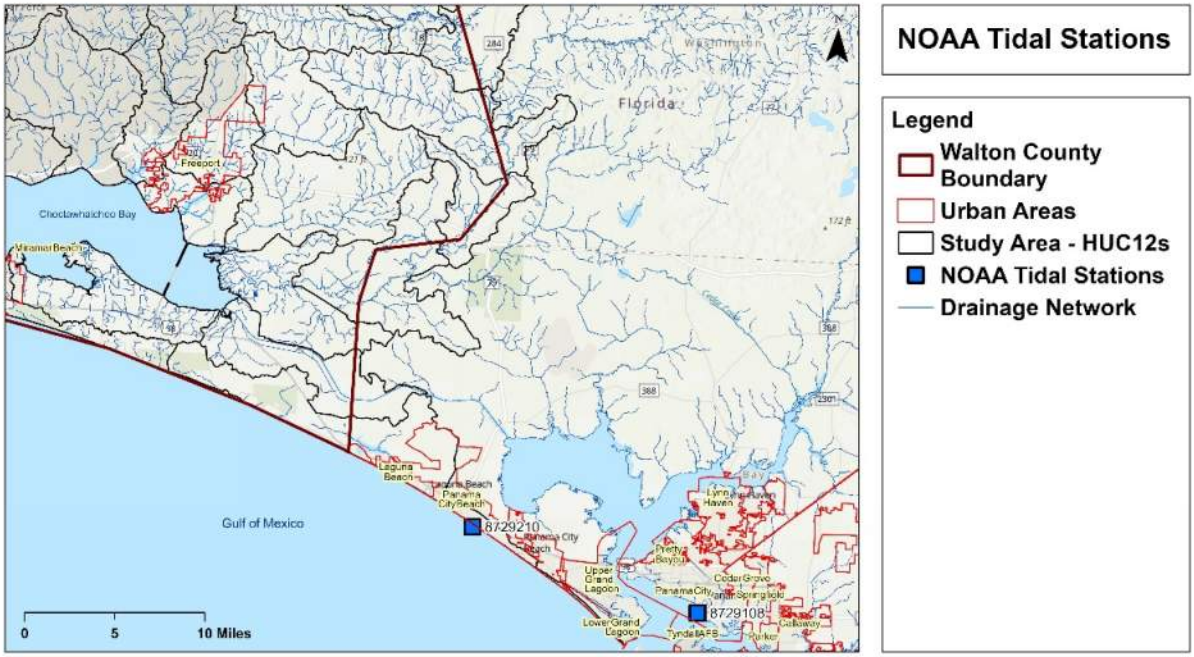

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

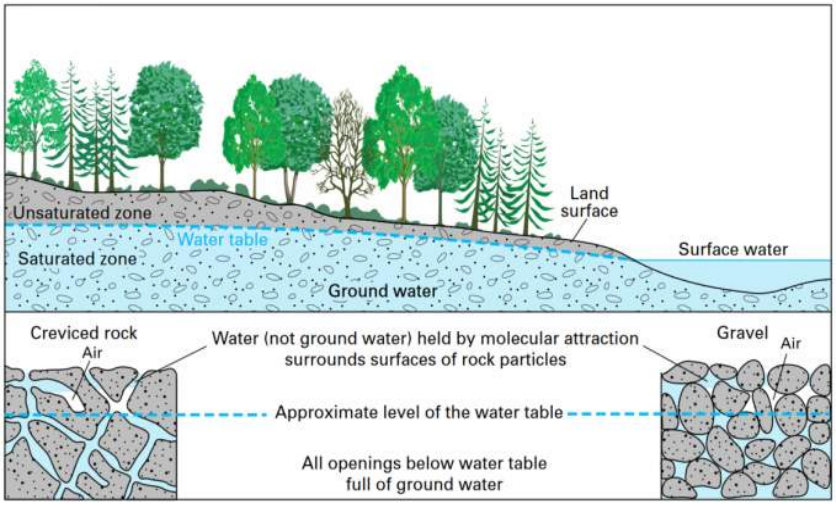

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

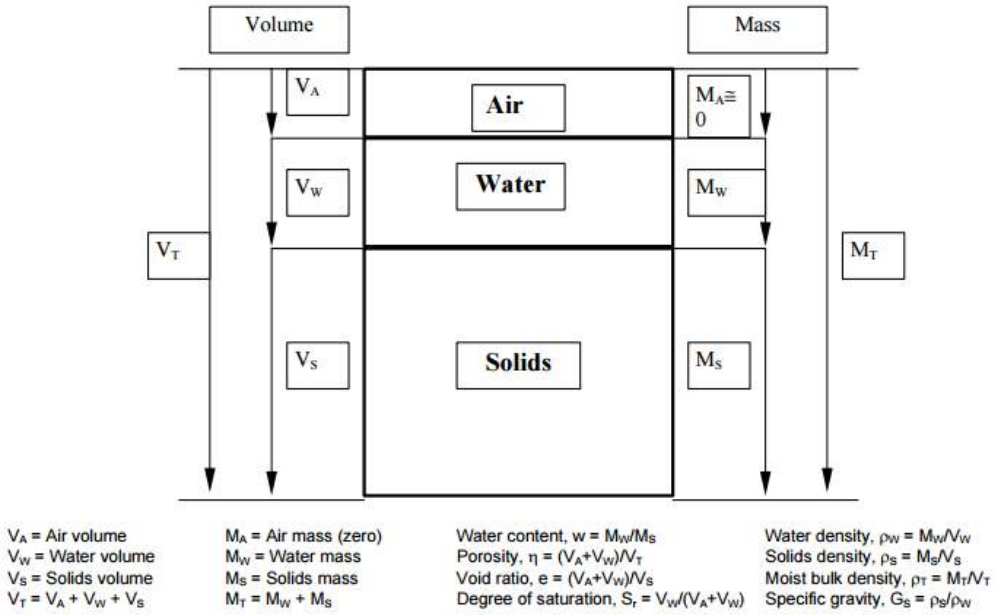

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). Figure 15 shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

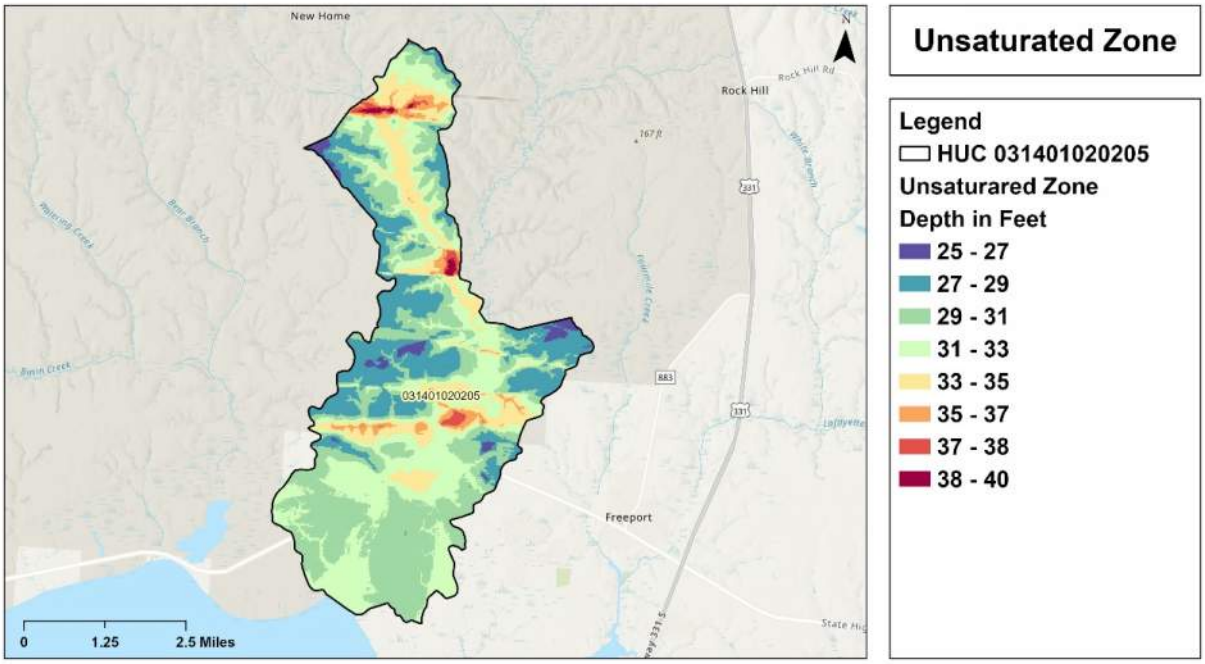

Figure 15. Unsaturated zone map for HUC 031401020205, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately favorable soil storage capacity, falling within the range of 27 to 35 feet of remaining capacity.

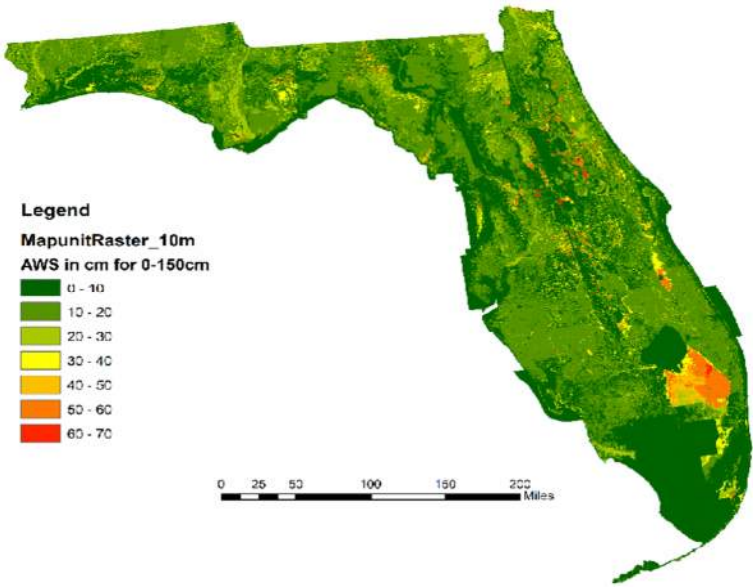

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

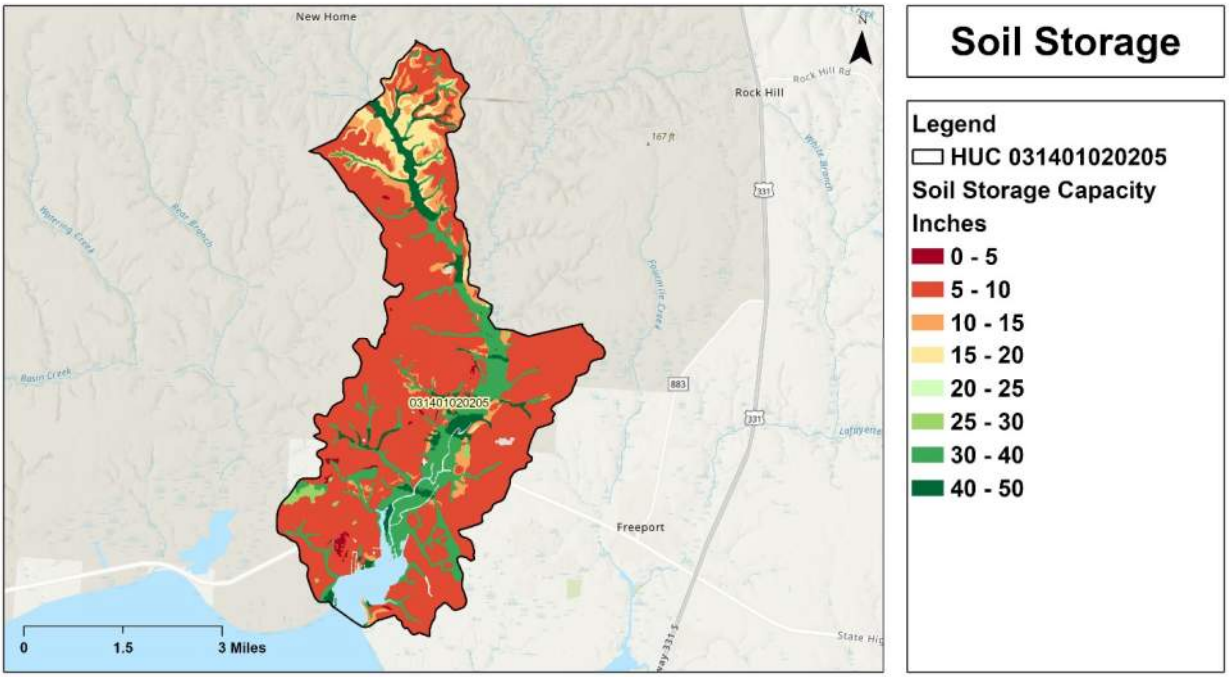

Figure 17. Water storage capacity of soil for the HUC 031401020205, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

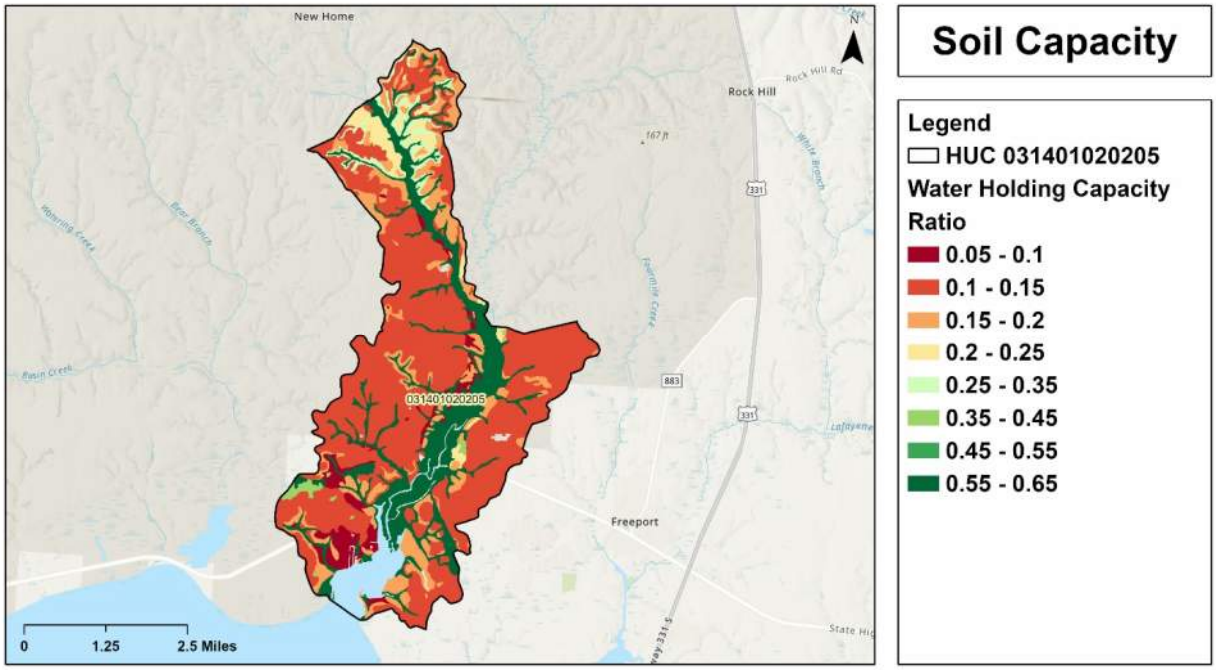

Figure 18. Water Holding Capacity (ratio) for the HUC 031401020205, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

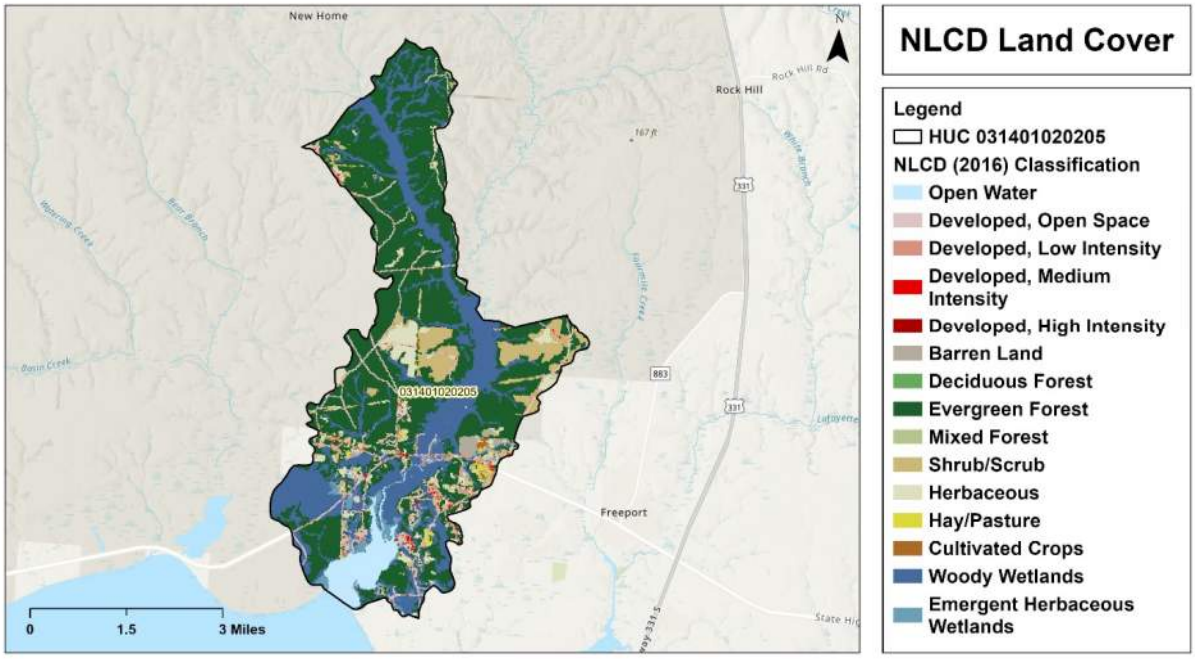

Figure 19. Land use in the HUC 031401020205 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

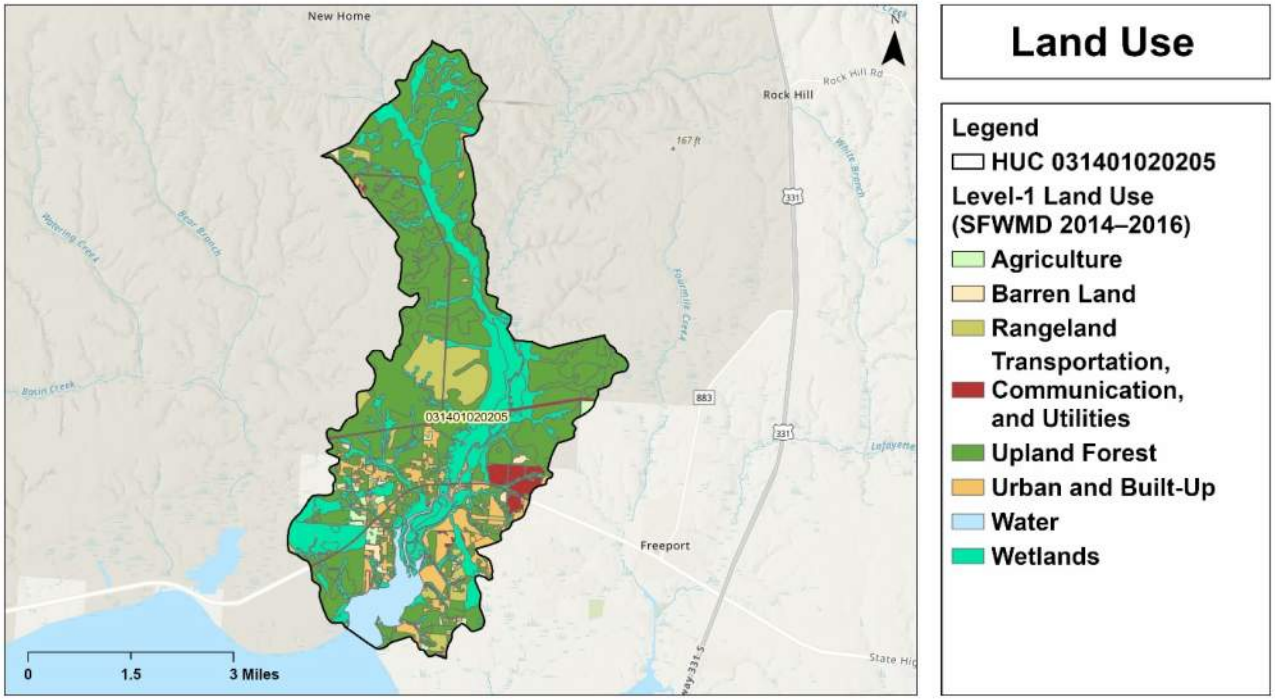

Figure 20. Land use in the HUC 031401020205 (from the 2023 Florida Geographic Data Library (FGDL))), processed by FAU.

In the HUC 031401020205 sub-watershed, the predominant land cover is upland forest, accounting for 52.63% of the area. Wetlands comes in second at 16.59%, followed by Transportation, Communication, and Utilities at 12.86%. Developed land constitutes a minor portion, with only 4.15% categorized as urban and built-up, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

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Table 3. Land use for HUC 031401020205 sub-watershed (2023 Florida Geographic Data Library (FGDL))).

Level 1 Land Use Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	290.46	1.17%
Barren Land	100.04	0.40%
Rangeland	852.53	3.45%
Transportation, Communication, and Utilities	3178.82	12.86%
Upland Forest	13011.40	52.63%
Urban and Built-Up	1026.16	4.15%
Water	2159.01	8.73%
Wetlands	4102.26	16.59%
Grand Total:	**24720.68**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

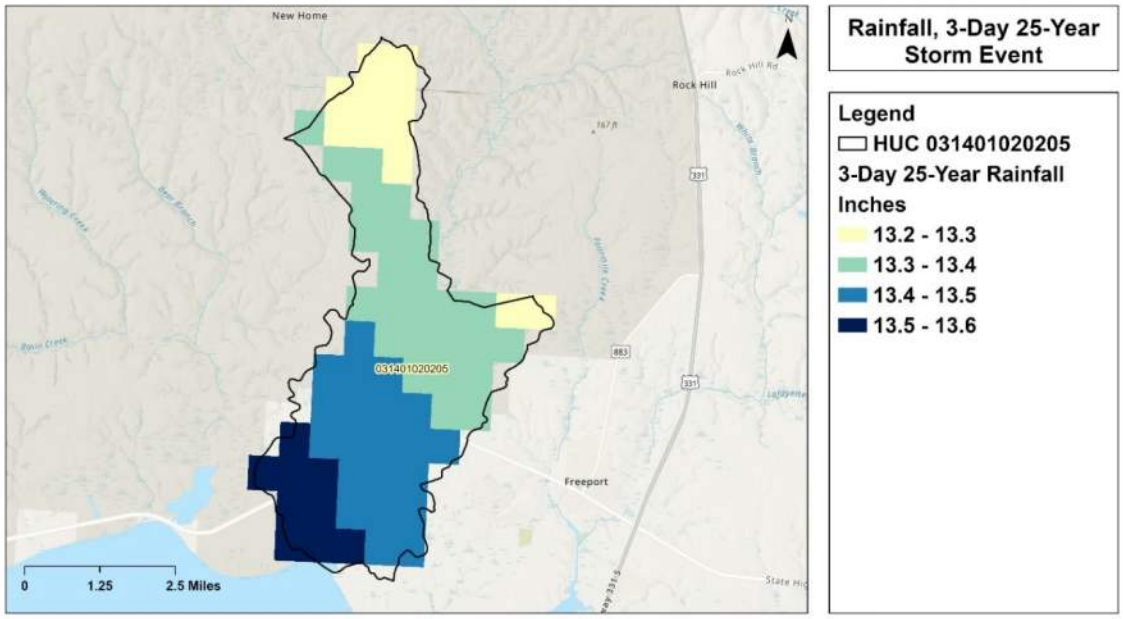

Figure 21. Rainfall distribution map across HUC 031401020205 sub-watershed, for 3-day 25-year storm event, processed by FAU.

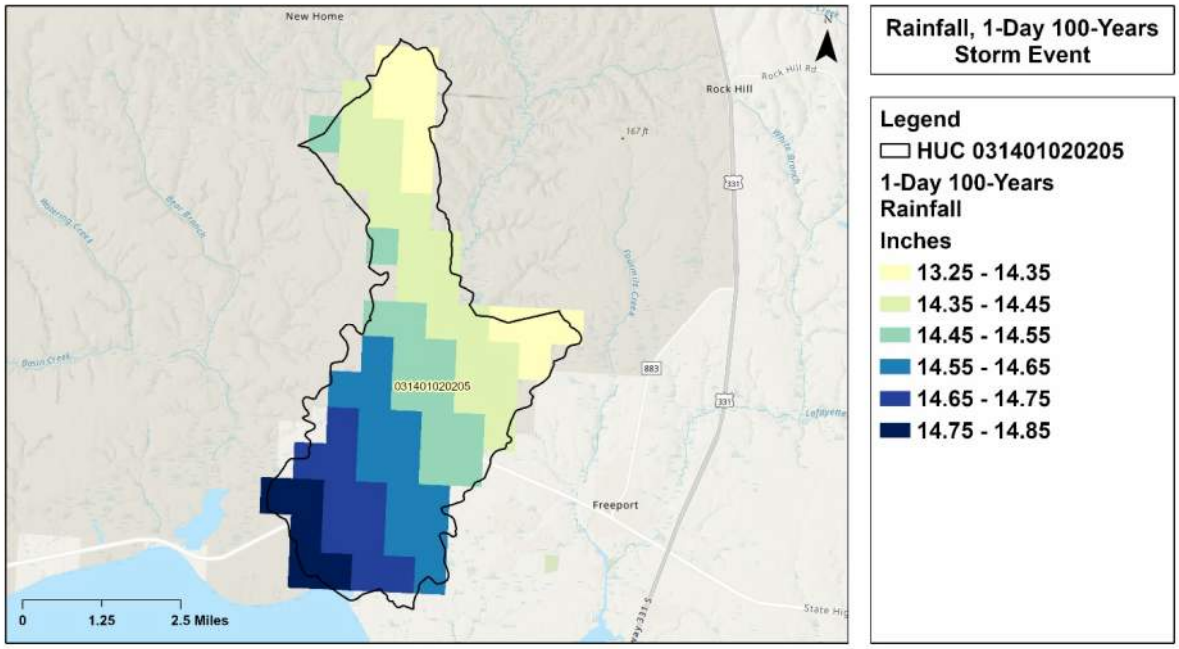

Figure 22. Rainfall distribution map across HUC 031401020205 sub-watershed, for 1-day 100-year storm event, processed by FAU.

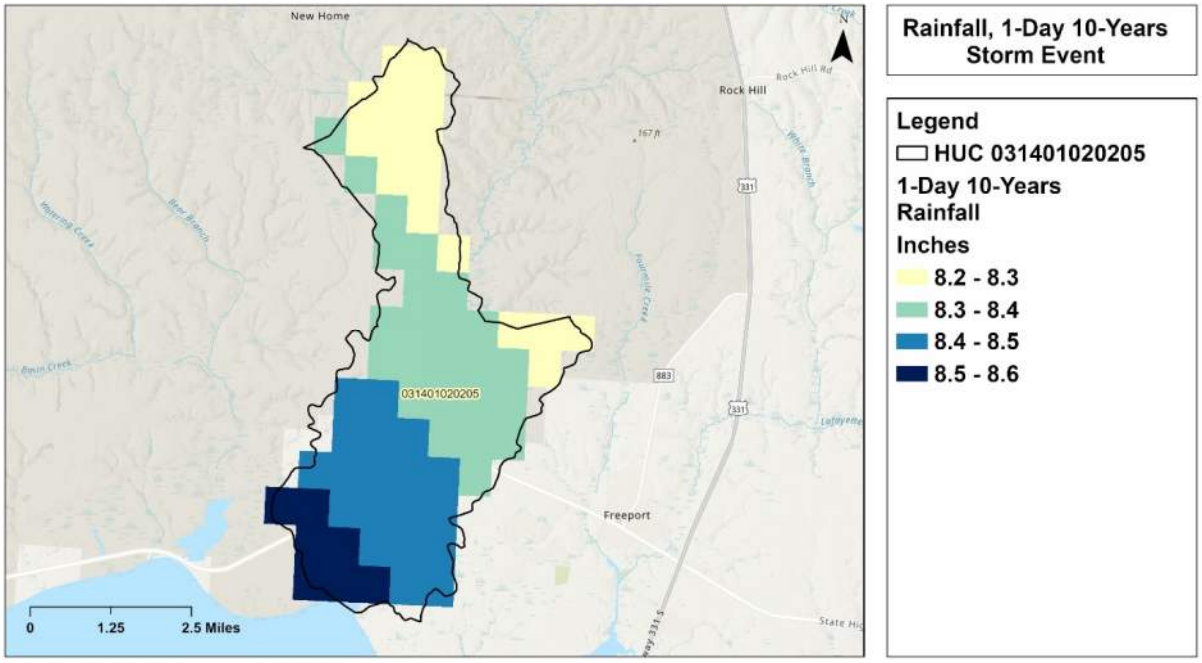

Figure 23. Rainfall distribution map across HUC 031401020205 sub-watershed, for 1-day 10-year storm event, processed by FAU.

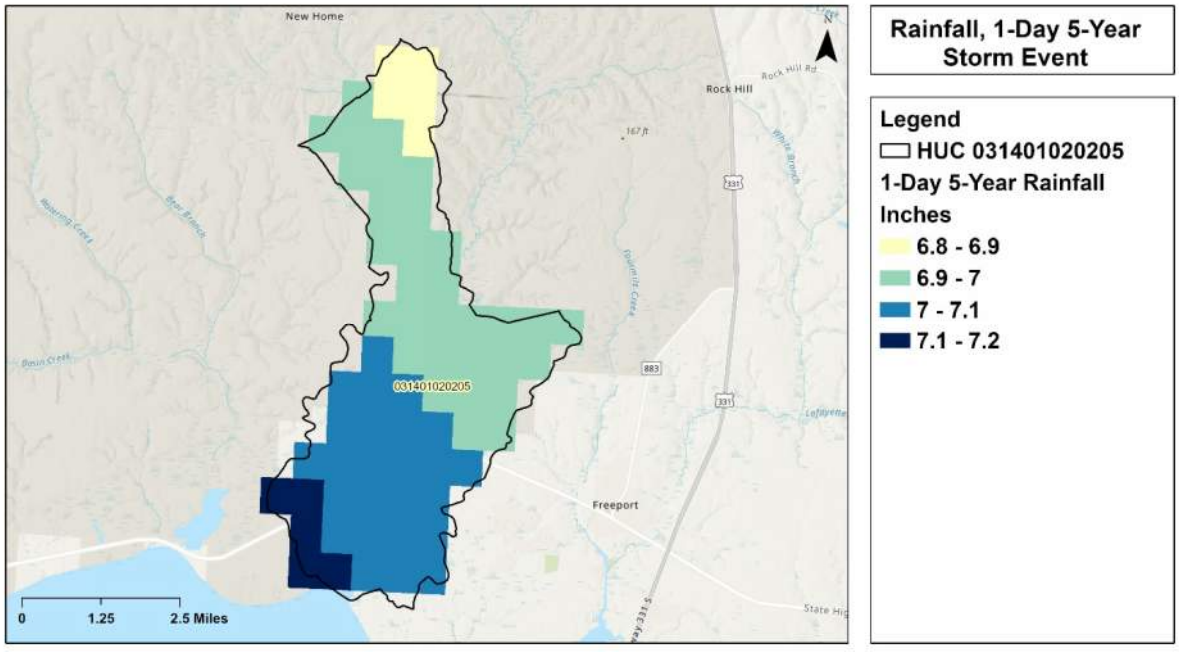

Figure 24. Rainfall distribution map across HUC 031401020205 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, whi1ch serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land

cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

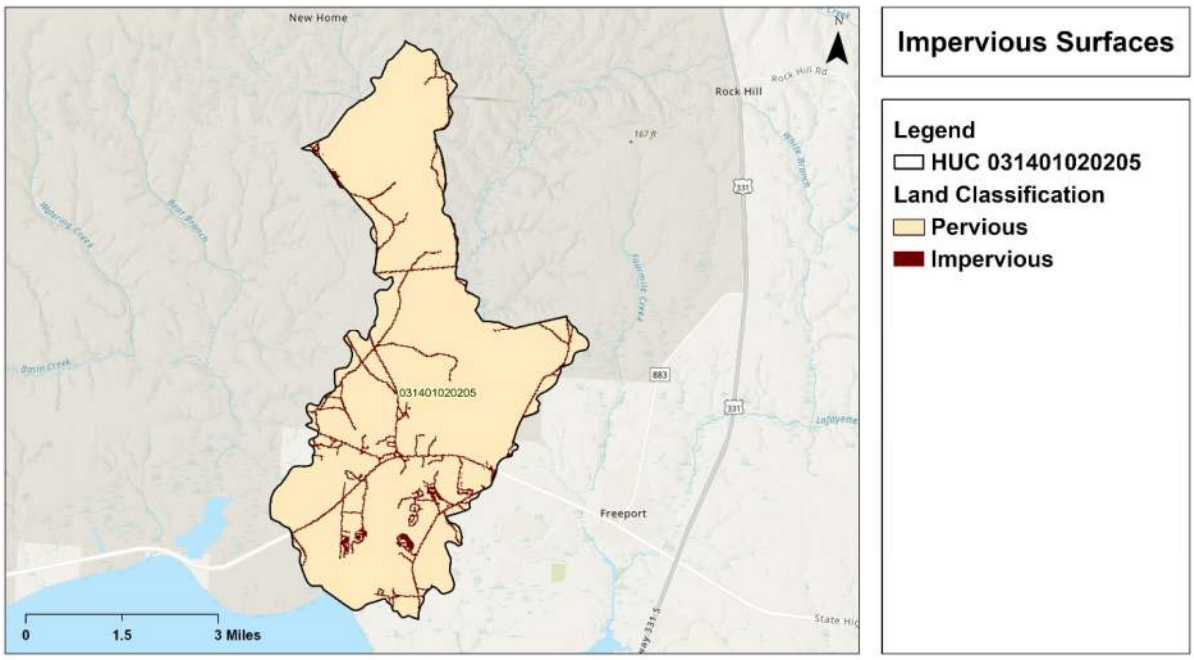

Figure 25. Impervious area map for the HUC 031401020205 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 2.4.

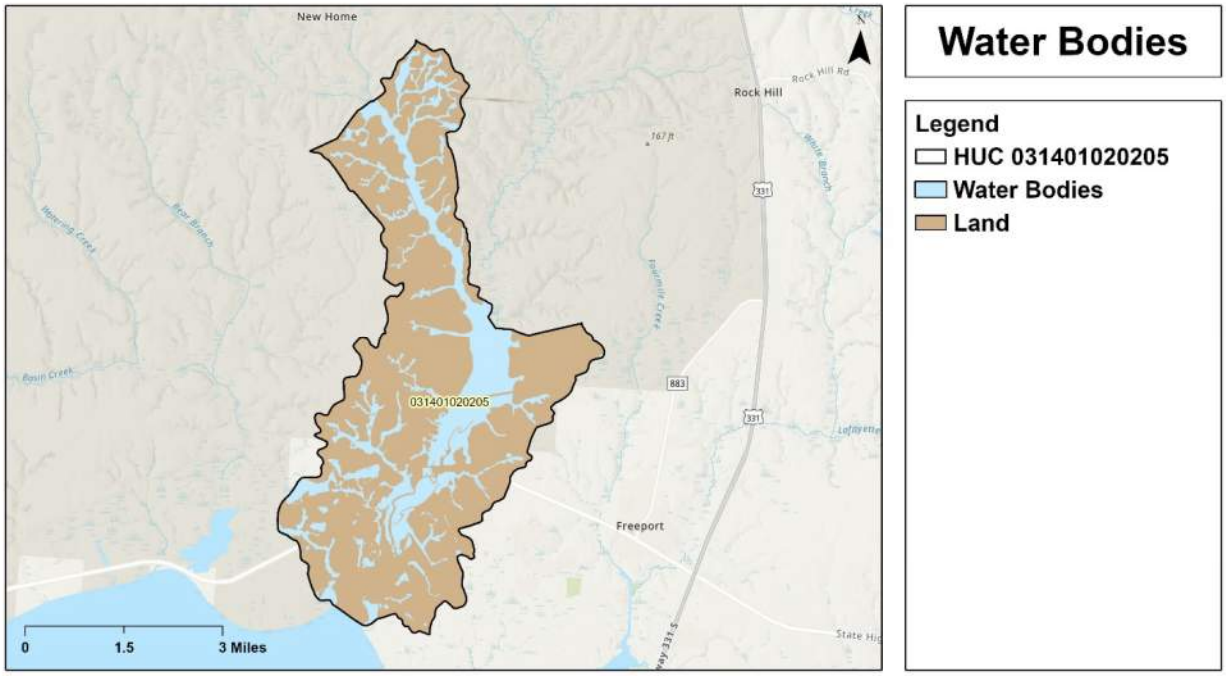

Figure 26. Water bodies map for the HUC 031401020205 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

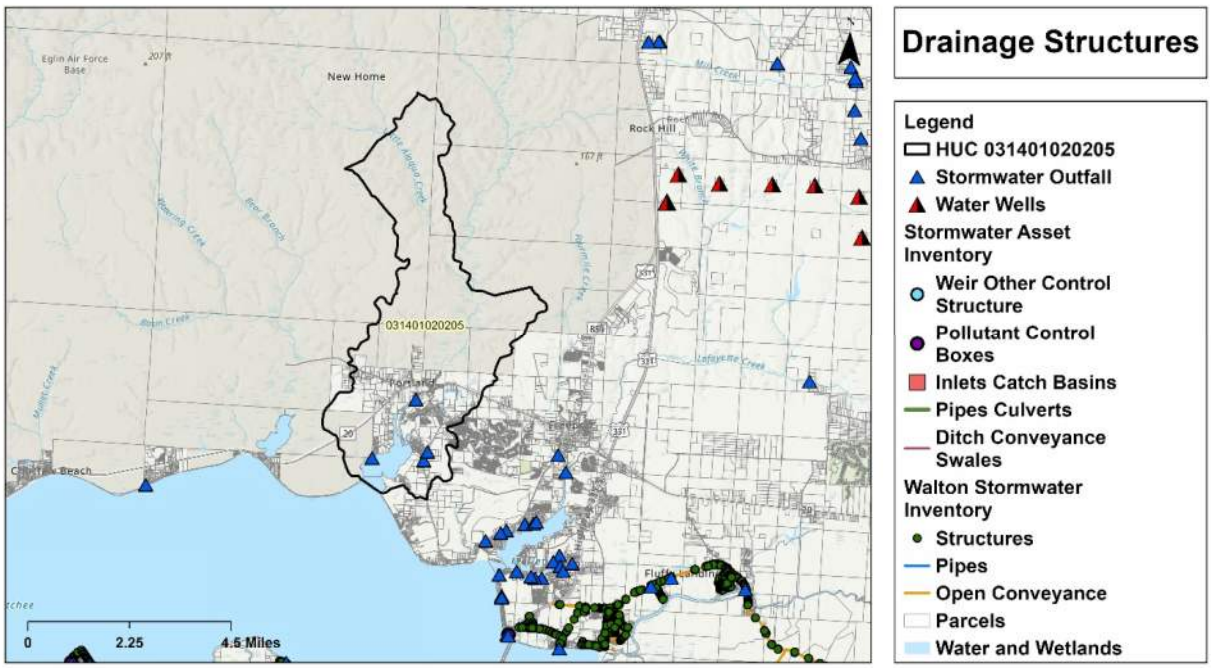

Figure 27. Stormwater Infrastructure for the HUC 031401020205. Processed by FAU.

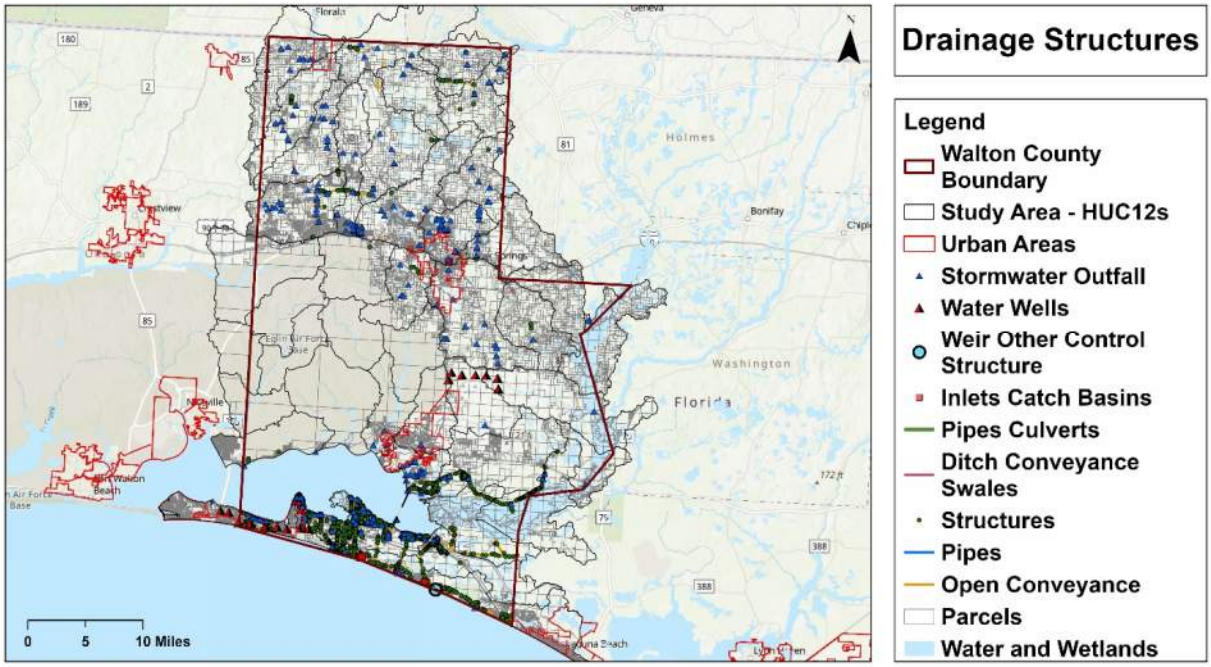

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings, as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401020204 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. Figure 29 shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

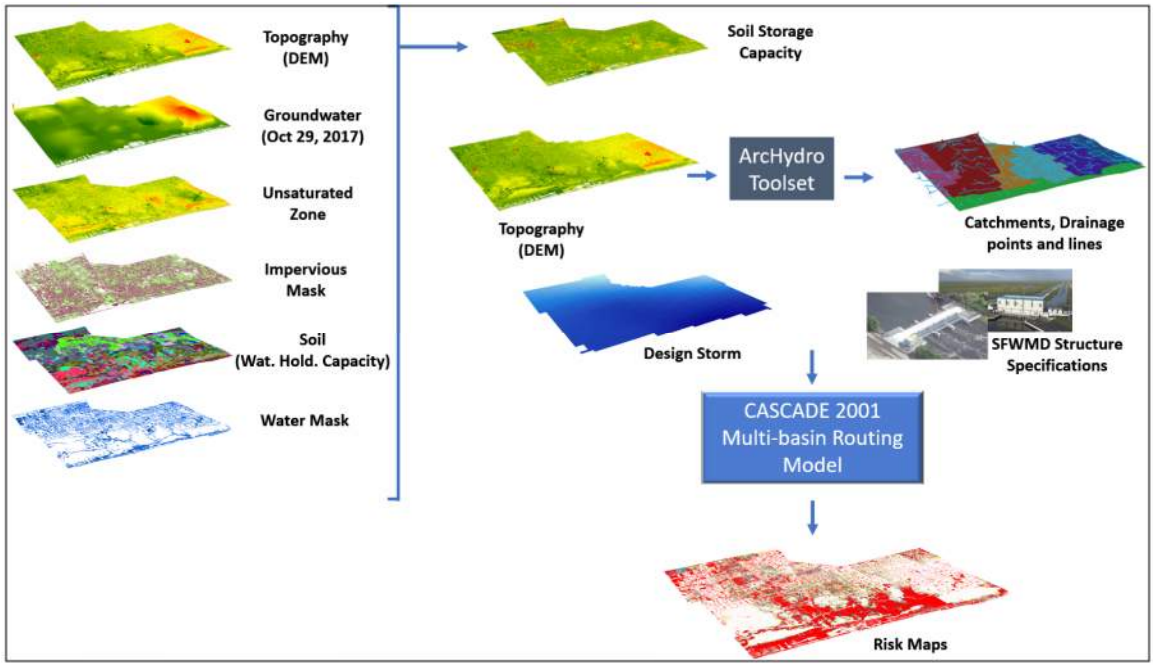

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

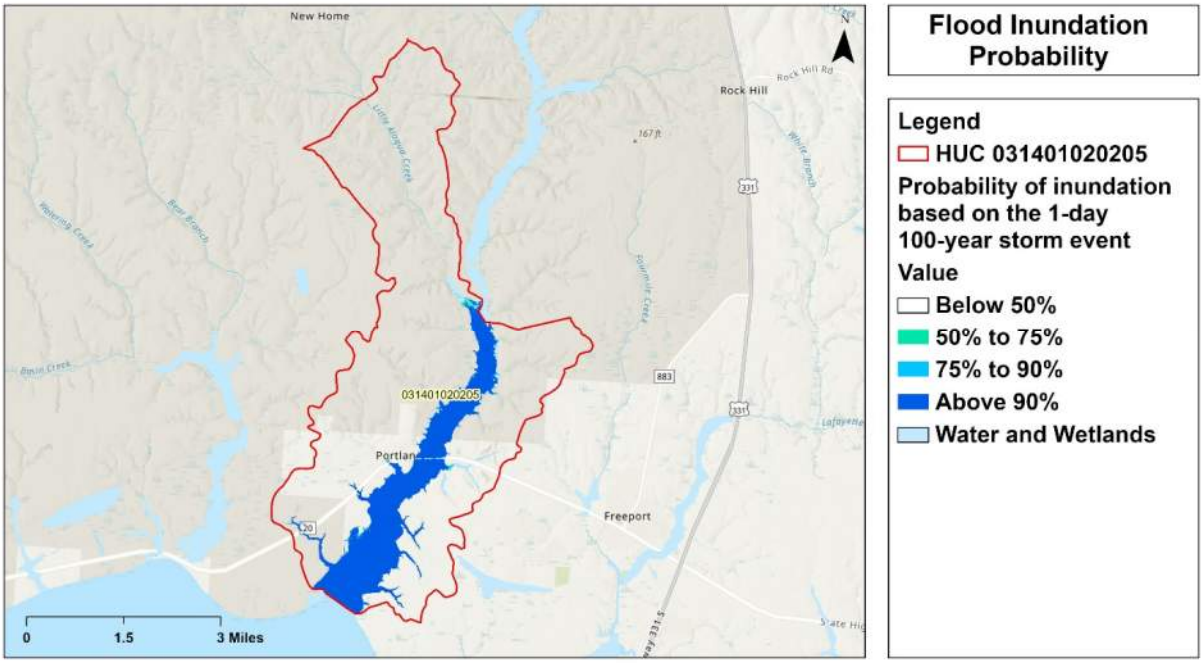

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401020205, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate

the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not

eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Future Challenges of Sea Level Rise and Climate Change

Global observations from satellites and long-term data collection have made it possible to document and analyze patterns in the Earth's climate. Scientific analysis of the impact of these changes has helped to improve the understanding of future flood hazard driving forces and long-term impacts on human activities and watershed master planning (http://www.research.noaa.gov/climate/t_observing.html). Examples of impacts are rising global average air and ocean temperatures, increased and earlier snow and ice melt, shorter subtropical rainy seasons, shifted seasons, sea level rise and greater variations in temperature and precipitation (IPCC, 2013; Freas et al., 2008; Marshall et al., 2004; Bloetscher et al., 2010). Marshall et al. (2004) specifically focused on the Florida peninsula to predict changes in rainfall and warmer temperatures but interspersed lower low temperatures due to the potential loss of wetlands.

Future changes in climate will add to the existing impacts, at a time when the population of the state is expected to nearly double by 2030. Additional research and high-resolution climate modeling for the Florida peninsula and local jurisdictions is needed to help guide long-term plans like WMPs. Rainfall appears to be decreasing and temperatures rising (see **Error! Reference source not found.**).

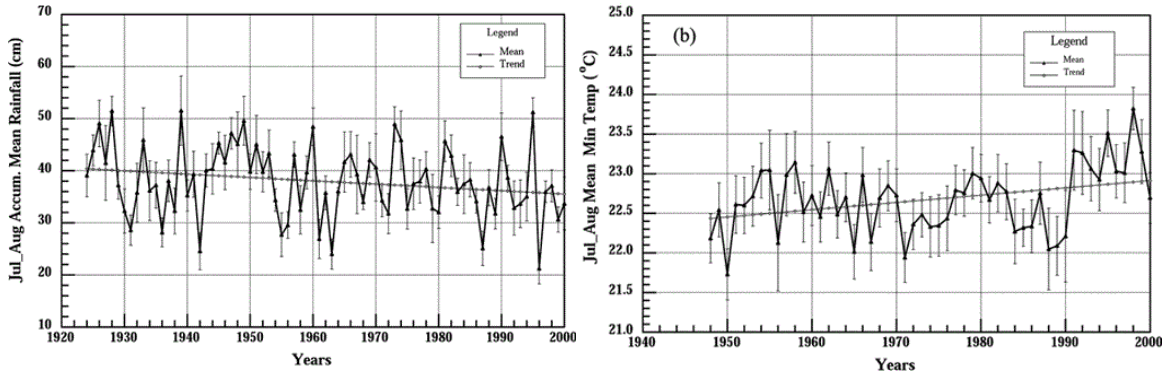

Figure 31. Change in average rainfall and change in average temp 1924 to 2000. Note the reversed trend, which means groundwater input variability is lessened. Source: Marshall et al., 2004.

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as

sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3 feet. Accompanying these drivers are potential changes in storm frequency and intensity, desertification, population migration, ocean acidification and coastal flooding (IPCC, 2007), exacerbated by the land cover and land use changes, which are substantially impacted by the fluxes, timing and quality of precipitation (Adrians et al., 2003; Scanlon et al., 2005; Marshall et al., 2004; Salmun and Molod, 2006), and leading to changes in the timing of peak flows and volumes (Richey and Costa-Cabral, 2006).

The results of these climatic changes are likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly An outcome of these climatic patterns is that during the past 140 years, an increase in sea levels has been observed (Bloetscher, 2012), a worrying pattern since sea level rise is a permanent phenomenon, that can be catastrophic to low lying areas in the long-term. The question is how much and how soon? Various studies (Bindoff et al., 2007; Domingues et al., 2008; Edwards, 2007; Gregory, 2008; Vermeer and Rahmstorf, 2009; Jevrejeva, Moore and Grinsted, 2010; Bloetscher, 2010, 2011; IPCC, 2007; Heimlich et al., 2009) indicate large uncertainty in projections of sea level rise by 2100. Gregory et al. (2012) note that during the last two decades, the global rate of sea level rise has been larger than the 20th-century time-mean, and Church et al. (2011) suggested that the cause was increased rates of thermal expansion, glacier mass loss, and ice discharge from icesheets. Gregory et al. (2012) suggested that there may also be increasing contributions to global sea level rise from the effects of groundwater depletion, reservoir impoundment, and loss of storage capacity in surface waters due to siltation. Measurements of Florida's east coast (Maul, 2008) show an average rate of sea level rise of 2.27 ± 0.04 mm per year from 1915 to 1992 based on tide gauge readings. Analyzing the tidal gauge readings for Florida shows that:

1. Florida average sea level rise is 2.10 ± 0.49 mm/yr
2. All but one location is within the 95% confidence limit range (the exception is Panama City where there is evidence of submergence and other land-based issues)

3. None of the Florida sea level rise rates differ statistically
4. Average global sea level rise for 1920-2000 was 2.0 mm/yr – within 95% confidence limit for Florida locations

From 1929 to 1992, over eight inches of sea, with another 6 inches added since 1992, which is already having significant impacts on coastal communities where population growth has increased the need for improved flood management strategies (Bloetscher, 2008; Parkinson, 2010; Zhang et al., 2011, 2011a; NFIP, 2011; Schmidt et al., 2011; Warner et al., 2012).

As a result, the SFRCCC (2015) adopted USACE's methodology to derive scenarios of sea level change intermediate to high rates of sea level rise for years 2030 (3" to 7") and 2060 (9" to 24") as the consensus projection to guide future planning. The path keeps increasing – now 14 inches since 1929 (**Error! Reference source not found.**) caused by thermal expansion of the ocean and melting ice caps (Jevrejeva et al., 2010; Vermeer and Rahmstorf, 2009). Sea level rise is a major concern in Florida, including Walton County, since the majority of the state's population live on the coast, involving most major commercial, residential, and economic enterprises. **Error! Reference source not found.** demonstrate the estimated sea level change for Panama City, considering the predictions of NOAA 2017. For NOAA high scenario SLR change scenario, the estimated level change is higher than 8 ft., while for the intermediate and low scenarios are about 3.9 feet and 1.7 feet respectively.

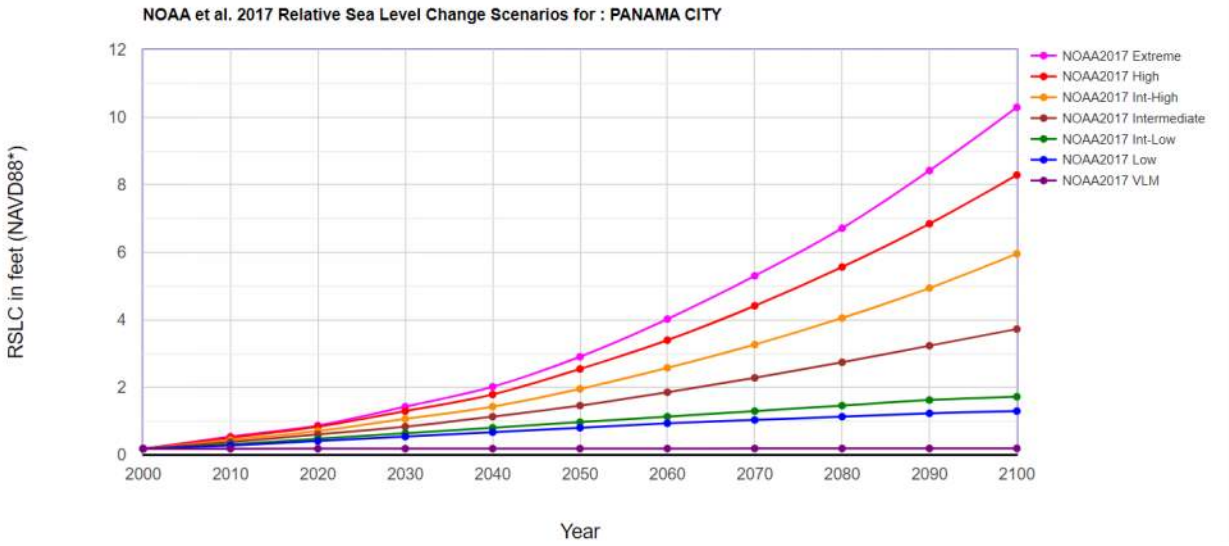

Figure 32. Relative Sea Level Change Scenarios for gauge 8729108, Panama City, FL. Source: NOAA, 2017 (https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html)

NOAA (2017) outlines five scenarios for sea level rise. The NFIP proposes the use of the intermediate high projection, which is 1.2 meters or 4 ft globally from current sea level elevations (**Error! Reference source not found.**).

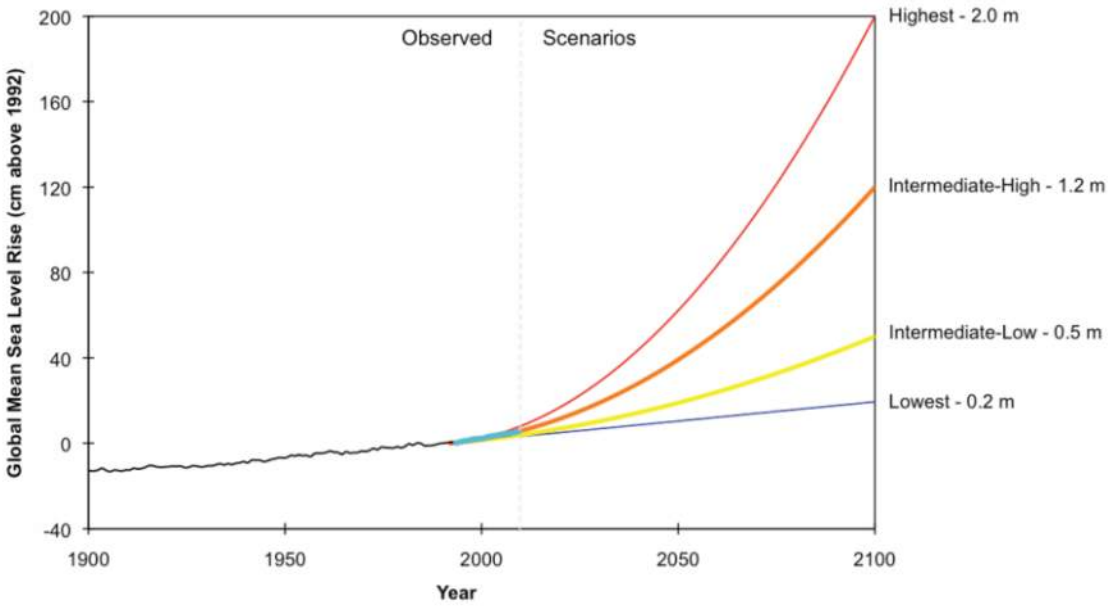

Figure 33. Graphic of global sea level rise projections from NOAA (2017). Source:https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

As sea level rises, access to roads, bridges, rail, and transit could be at risk of flooding, causing the effects of sea level rise to spread indirectly throughout the entire transportation network, affecting the overall system performance. For example, the flooding of a critical road or facility access can cause a shifting of traffic flow causing congested conditions in other roadways that are not actually flooded. Since the roadway network would be unable to carry the traffic demand, the system would experience operational failure; as a result, causing travel times and delays. Moreover, the inundation of a critical access could cause transportation connectivity problems to essential infrastructure like ports or airports. Transportation infrastructure relies on the effectiveness of flood control and stormwater drainage systems for the transportation corridors. Road integrity relies on adequate drainage. The increased risk of severe flooding in Florida's low-lying terrain can adversely affect transportation infrastructure along the coastline; roads can be inundated, and roadway beds can be damaged. Sea level rise will cause increased water table levels (FDOT, 2012), as regional water tables cannot exist naturally below mean high tide (2 feet in Florida). Adding 3 feet of sea level rise on top of groundwater would compound the risk of flooding in low-lying areas. Road bases below 5 feet NVGD would become saturated under this scenario, likely causing premature base failure. As soil storage capacity is diminished due to rising groundwater elevations associated with sea level rise, the potential for more frequently flooded roadways would likely damage pavements (FDOT, 2012). Hence sea level rise must be accounted for in WMPs in coastal areas. To allow flexibility in the analysis due to the range of increases within the different time periods, an approach that uses incremental increases of 1, 2, and 3 feet of sea level rise is suggested for modeling. The increments can work as threshold values in planning

considerations in terms of allowing planners the ability to know ahead of time where the next set of vulnerable areas will be, to allow for a proactive response approach that can be matched to the observed future rates. Sea level rise is a major concern since nearly half the US population lives within 50 miles of the coast, involving most major commercial, residential, and economic enterprises. The effects of 5 ft sea level rise, King tide, and 1-day 100-year storm event are shown in Figure 34.

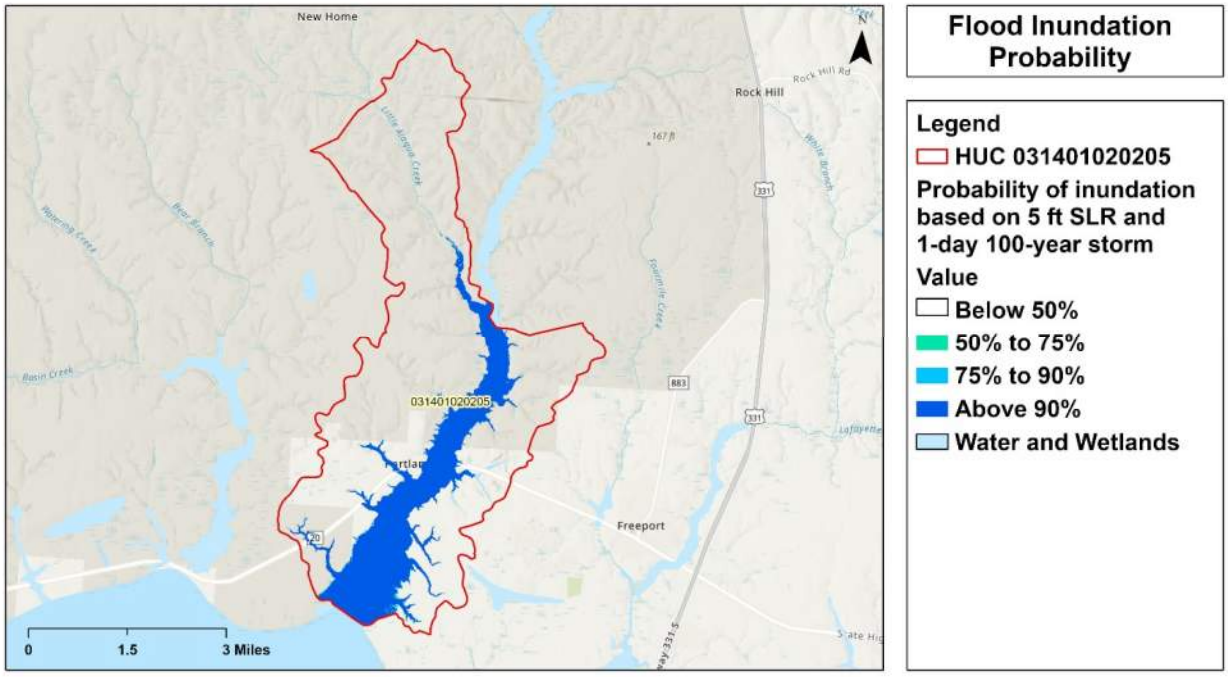

Figure 34. Flood Inundation Probability for a Sea level rise of 5 ft + 1-day 100-year storm event for HUC 031401020205 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Dark blue is area under 5 ft NAVD88 and potentially inundated at the 99th percentile tidal conditions. Processed by FAU.

2.4 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. **3-day 25-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 35)
2. **1-day 100-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 36)

3. **1-day 10-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 37)
4. **1-day 5-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 38)
5. **Sea level rise of 1 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 39)
6. **Sea level rise of 1 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations storm (Figure 40)
7. **Sea level rise of 1 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 41)
8. **Sea level rise of 1 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 42)
9. **Sea level rise of 2 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 43)
10. **Sea level rise of 2 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 44)
11. **Sea level rise of 2 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 45)
12. **Sea level rise of 2 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 46)
13. **Sea level rise of 3 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 47)
14. **Sea level rise of 3 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 48)
15. **Sea level rise of 3 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 49)
16. **Sea level rise of 3 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 50)

17. **Sea level rise of 4 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 51)
18. **Sea level rise of 4 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 52)
19. **Sea level rise of 4 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 53)
20. **Sea level rise of 4 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 54)
21. **Sea level rise of 5 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 55)
22. **Sea level rise of 5 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 56)
23. **Sea level rise of 5 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 57)
24. **Sea level rise of 5 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 58)

In all scenarios, a notable extent of flooding is observed, primarily following the path of waterbodies. As this basin connects to the ocean though Choctawhatchee River, SLR scenarios plays an important hole, implying a considered growth as the projected scenario of rising tides rises.

The design storm simulation determined that approximately 13.7% of the HUC total area or 2.63 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 14% of the HUC's total area, or 2.67 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 13.2% of the HUC's total area, or 2.53 mi^2, would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 13.2% of the HUC's total area, or 2.53 mi^2, would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401020205 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	16.50	2.63	86.3%	13.7%
1-day 100-year	16.45	2.67	86.0%	14.0%
1-day 10-year	16.60	2.53	86.8%	13.2%
1-day 5-year	16.60	2.53	86.8%	13.2%

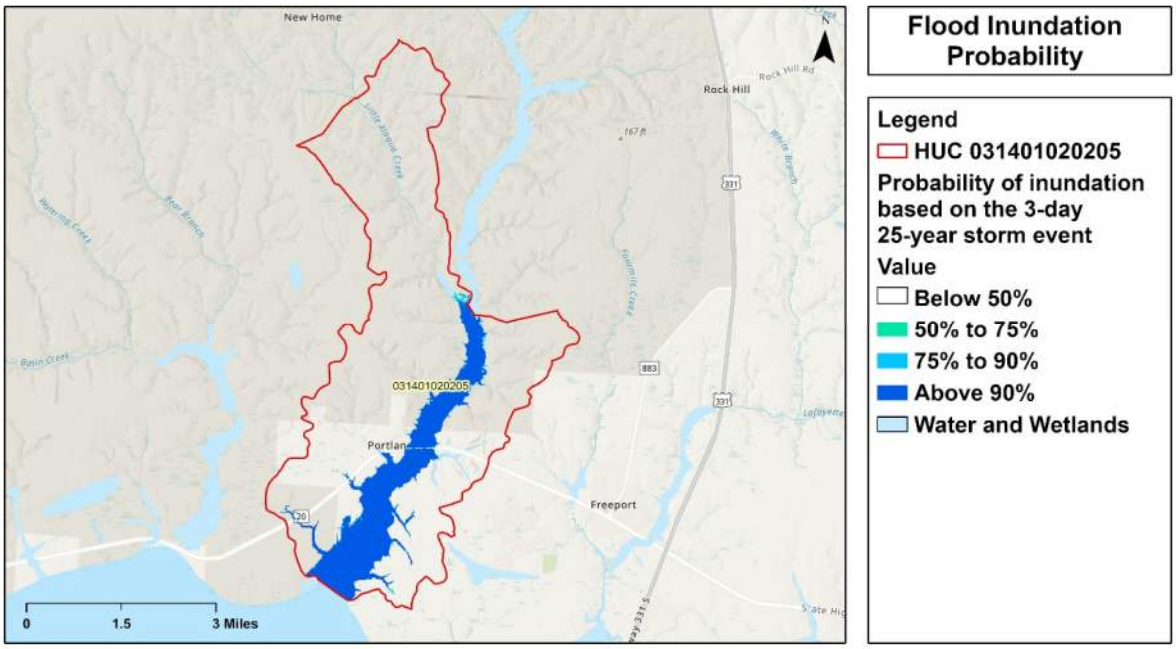

Figure 35. 3-day 25-year storm event for HUC 031401020205 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

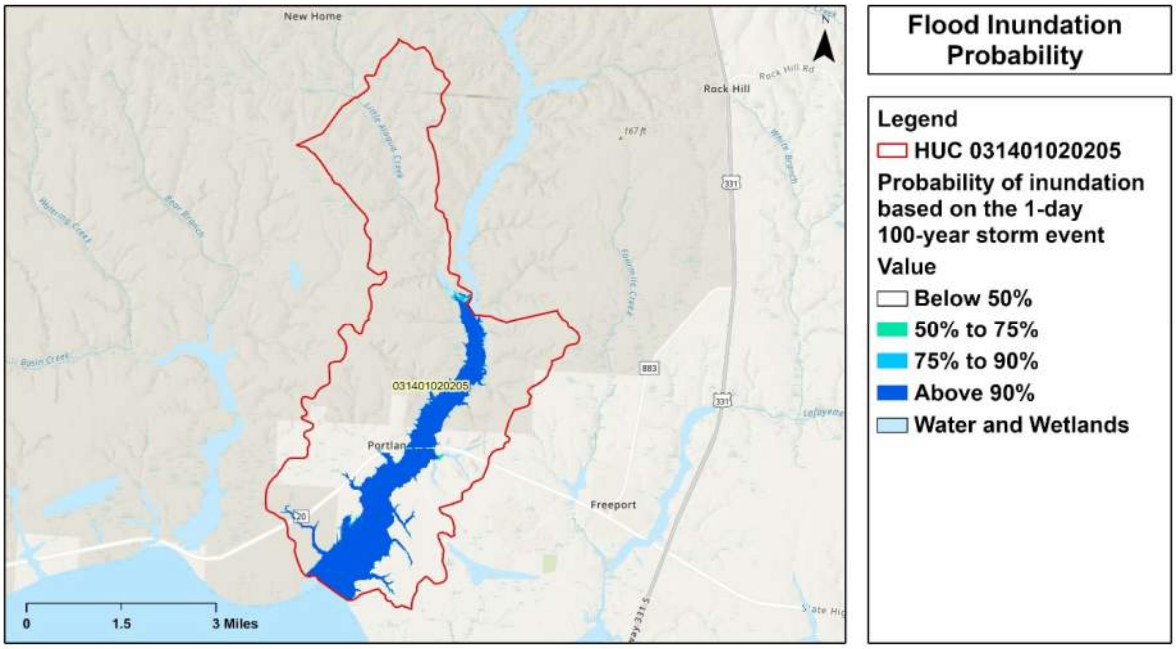

Figure 36. 1-day 100-year storm event for HUC 031401020205 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

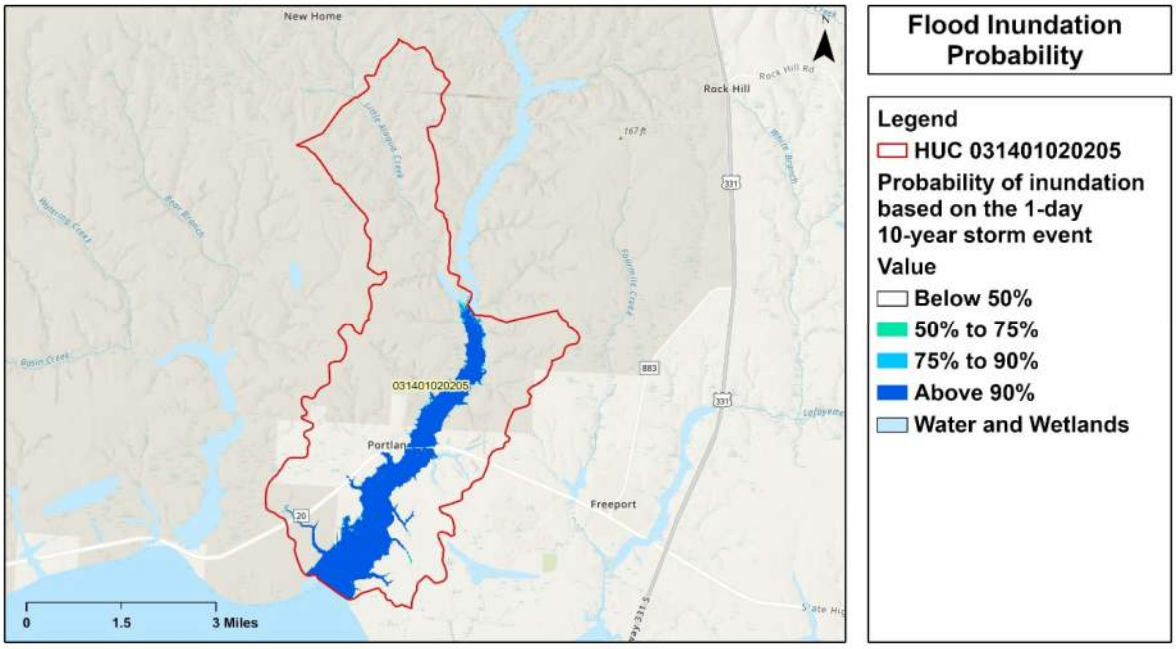

Figure 37. 1-day 10-year storm event for HUC 031401020205 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

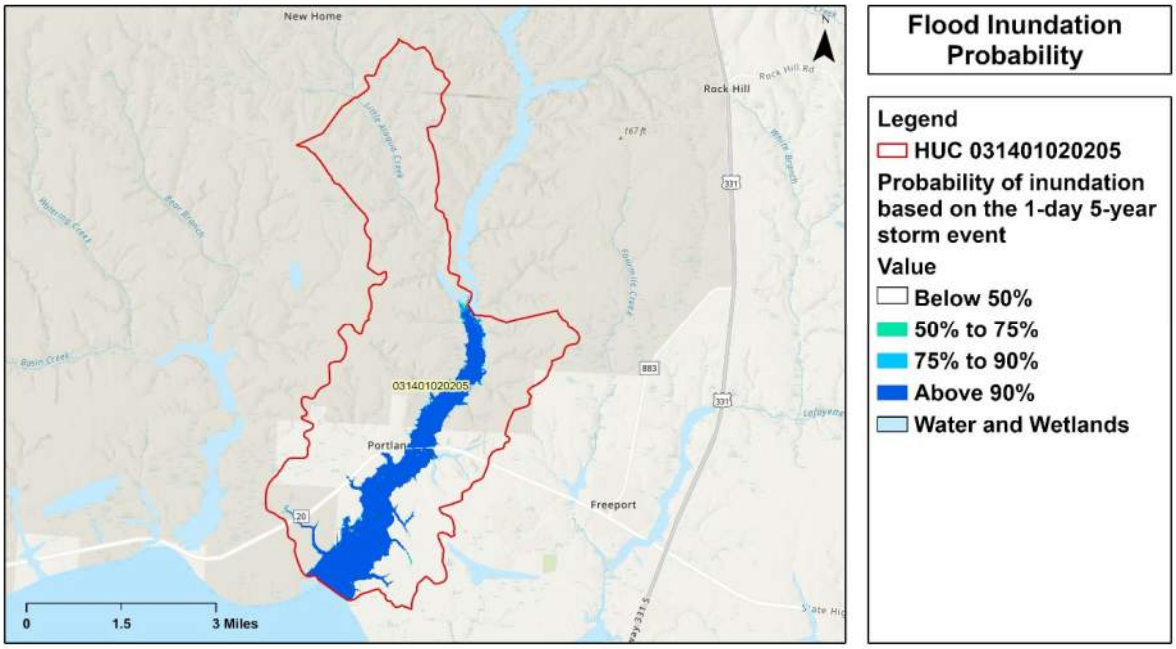

Figure 38. 1-day 5-year storm event for HUC 031401020205 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

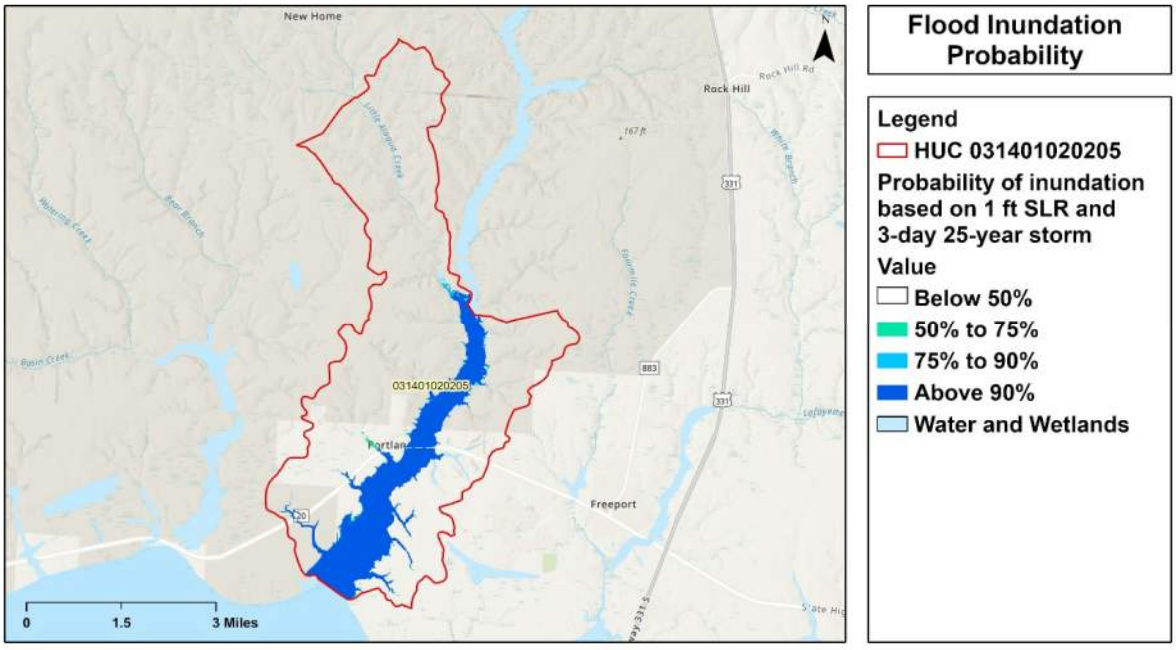

Figure 39. Sea level rise of 1 ft + 3-day 25-year storm for HUC 031401020205 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

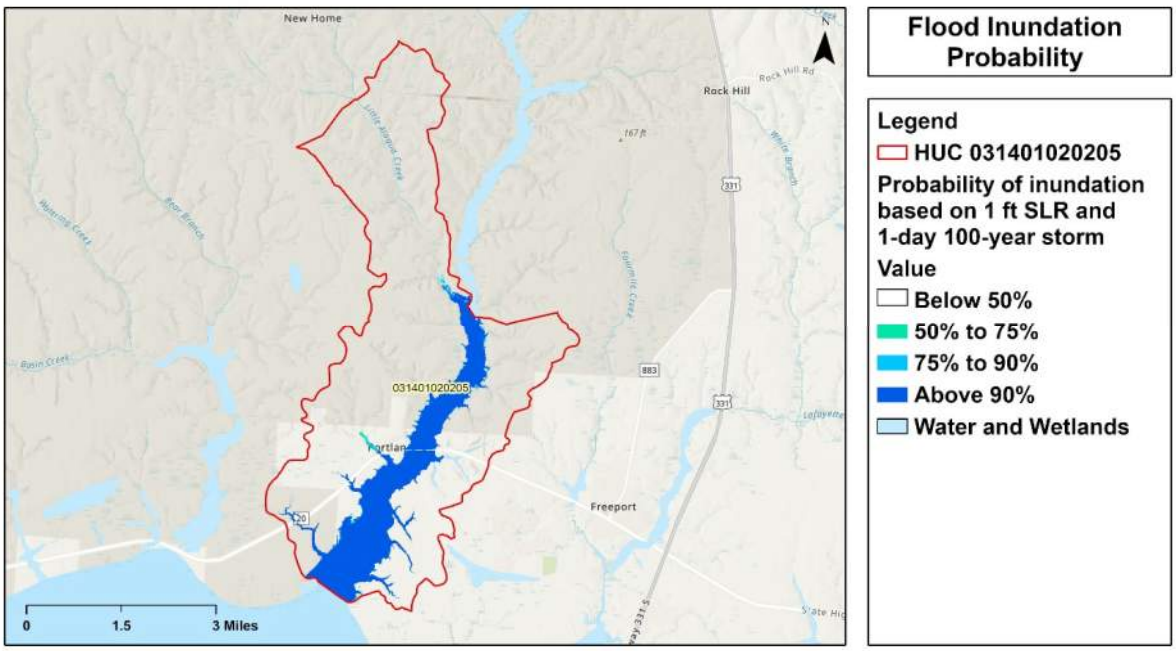

Figure 40. Sea level rise of 1 ft + 1-day 100-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

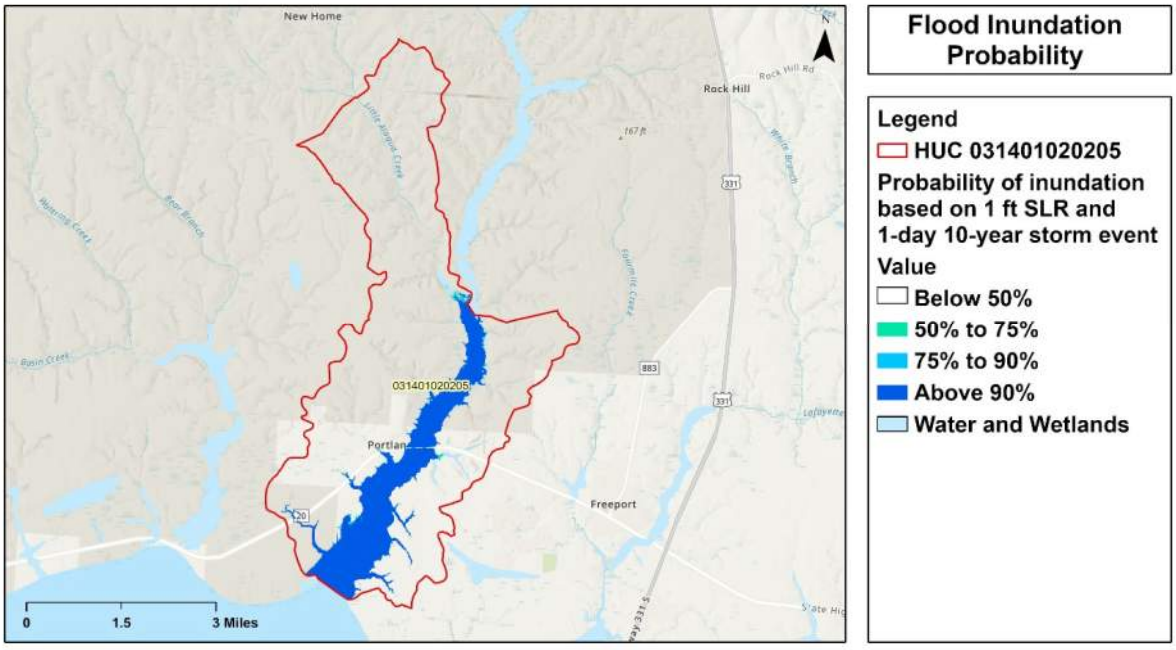

Figure 41. Sea level rise of 1 ft + 1-day 10-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

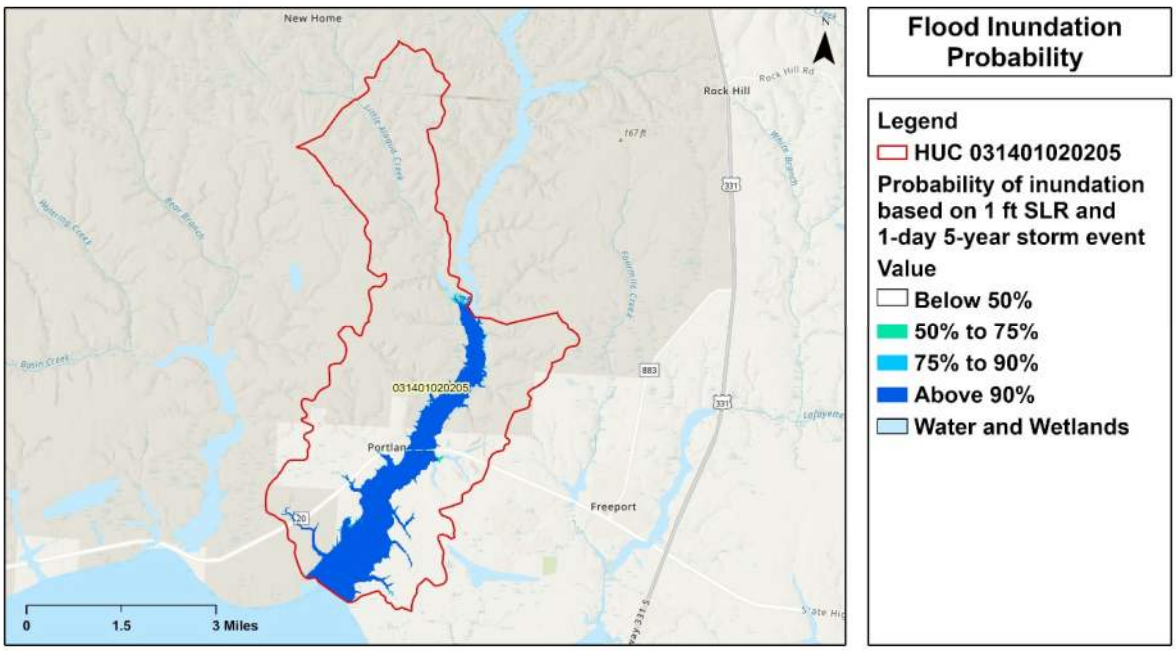

Figure 42. Sea level rise of 1 ft + 1-day 5-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

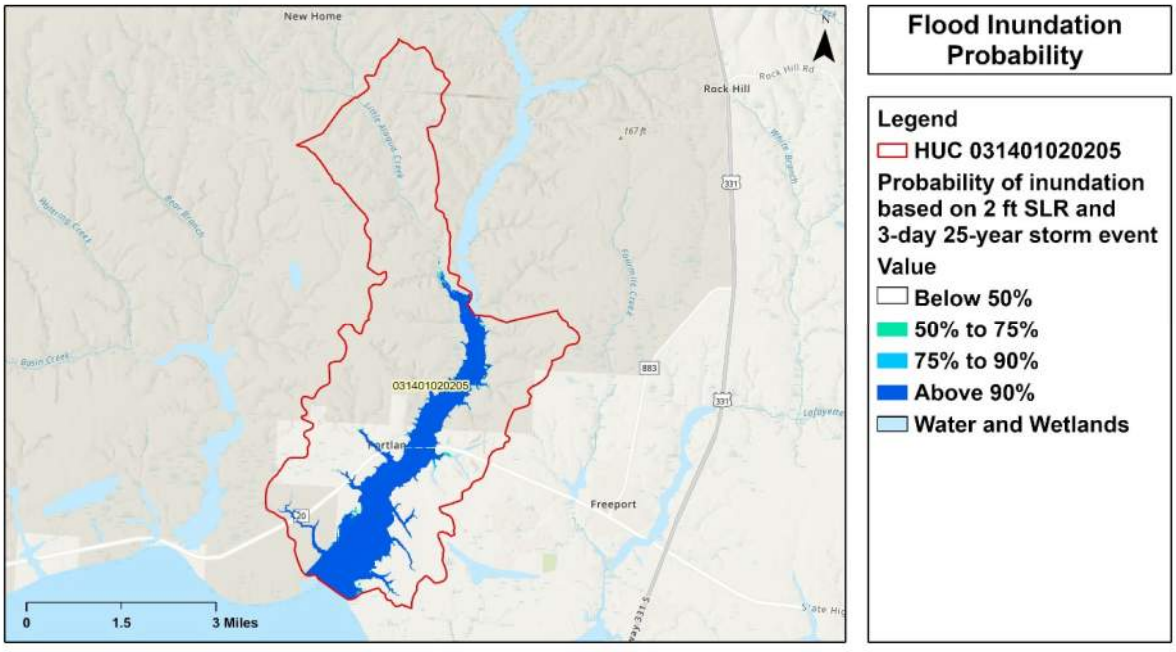

Figure 43. Sea level rise of 2 ft + 3-day 25-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

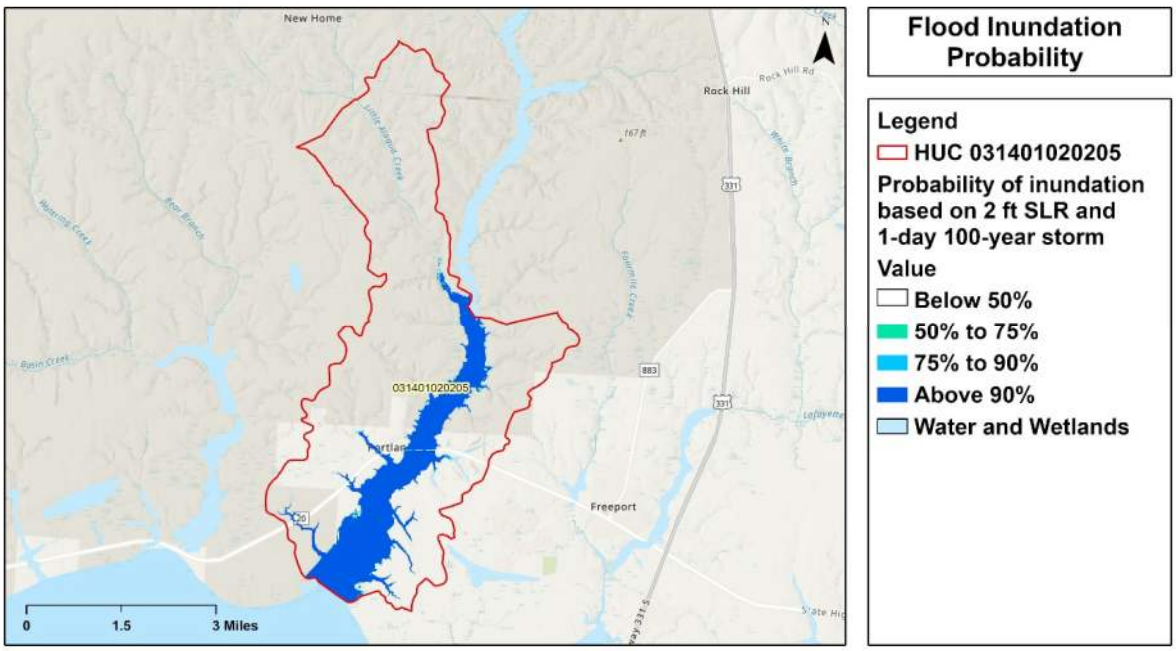

Figure 44. Sea level rise of 2 ft + 1-day 100-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

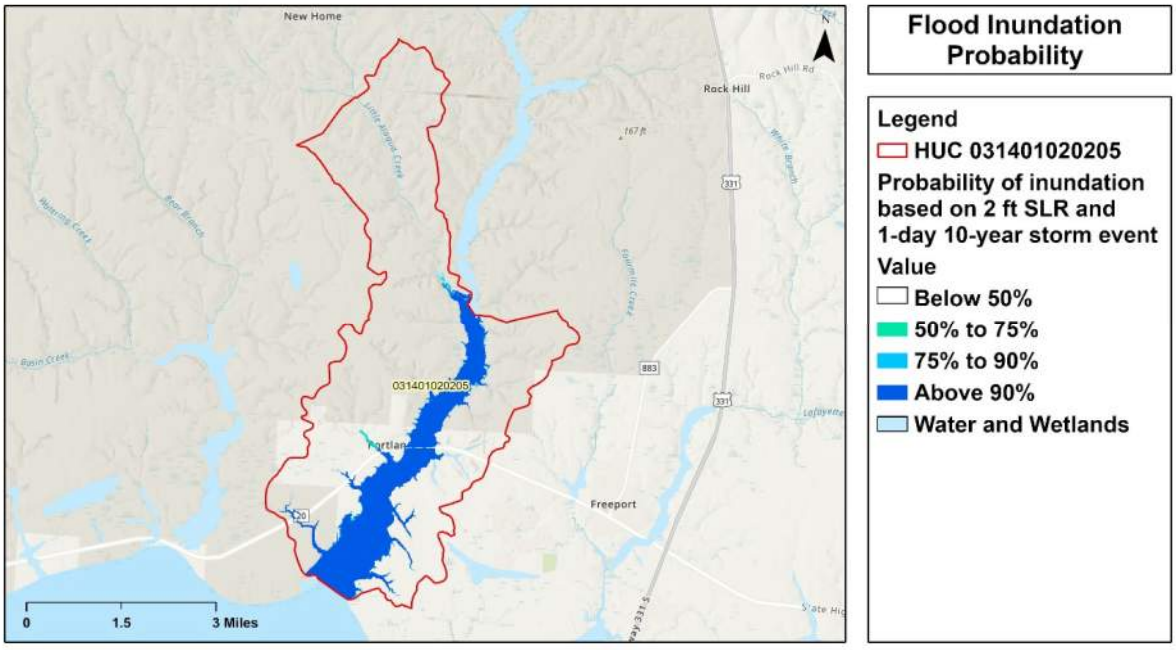

Figure 45. Sea level rise of 2 ft + 1-day 10-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

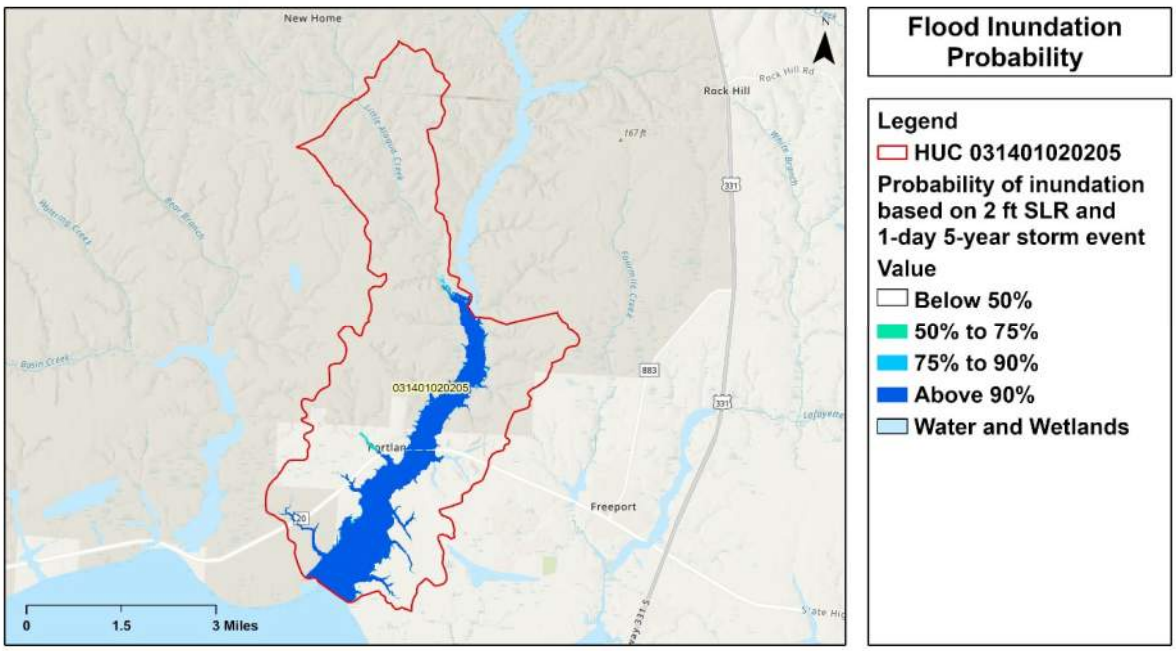

Figure 46. Sea level rise of 2 ft + 1-day 5-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

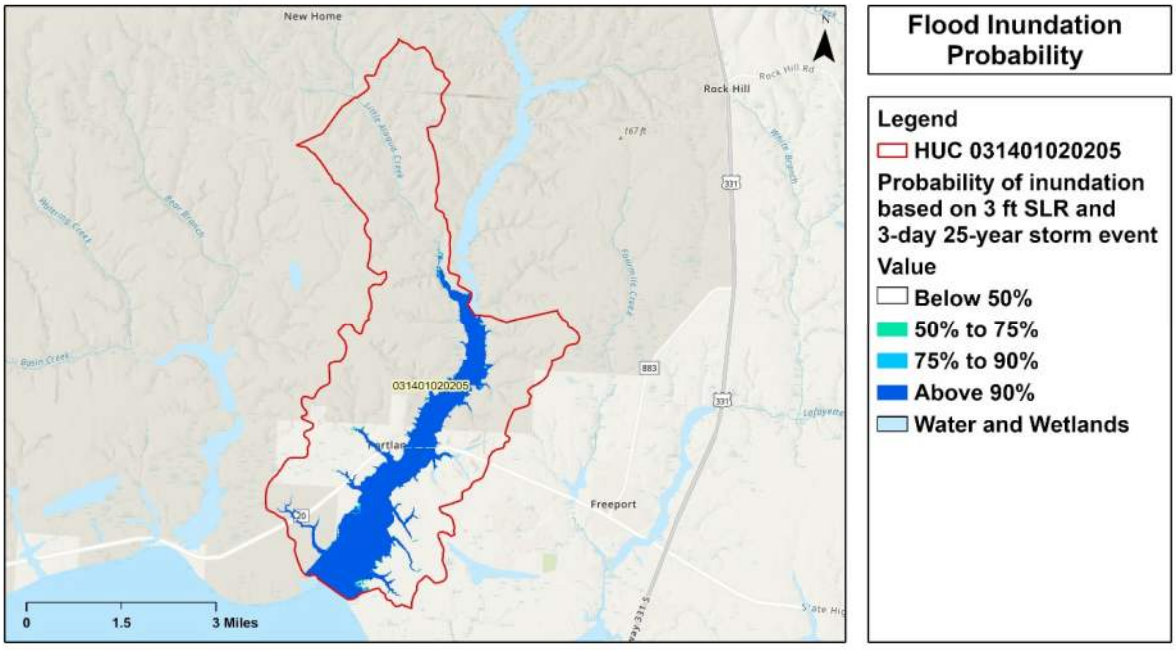

Figure 47. Sea level rise of 3 ft + 3-day 25-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

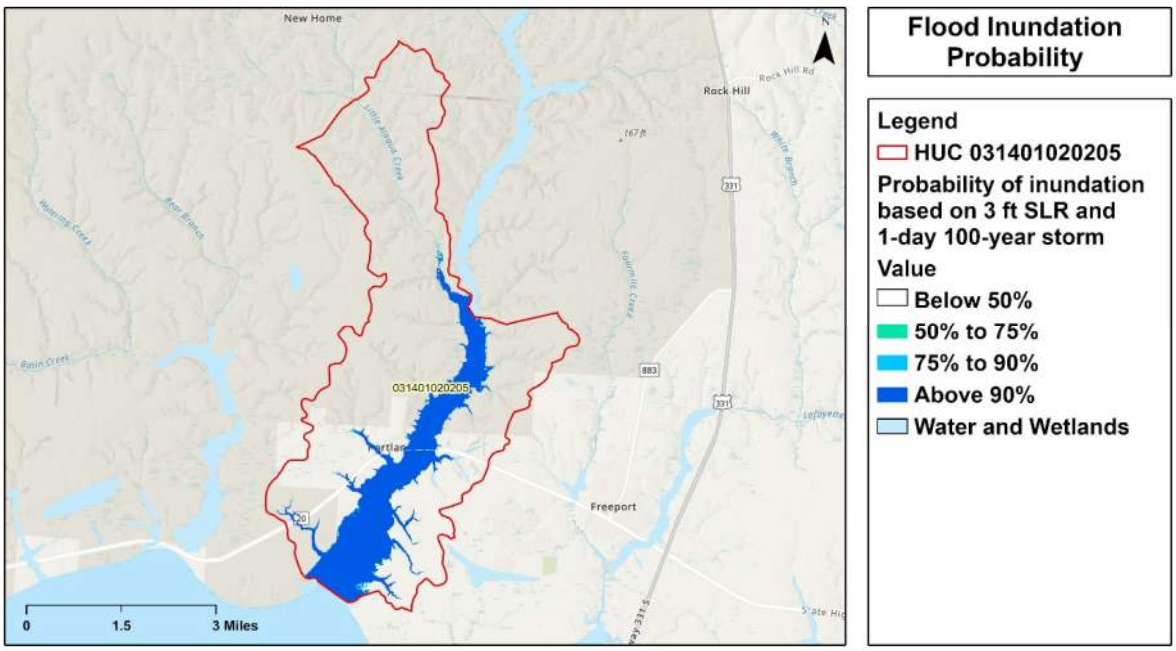

Figure 48. Sea level rise of 3 ft + 1-day 100-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

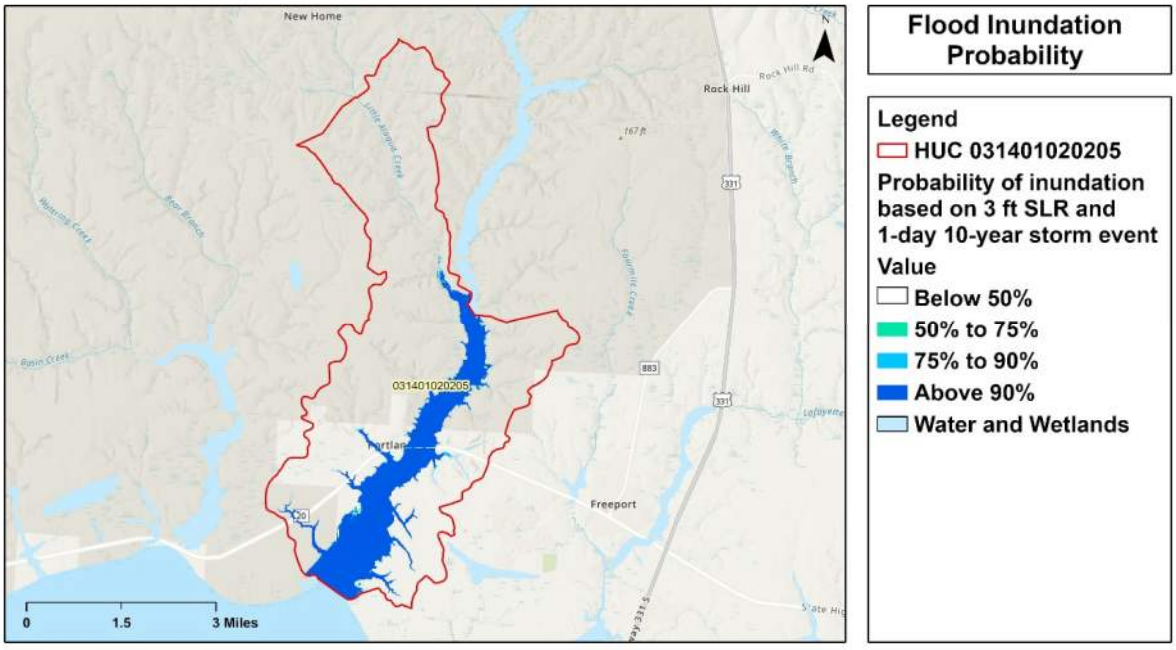

Figure 49. Sea level rise of 3 ft + 1-day 10-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

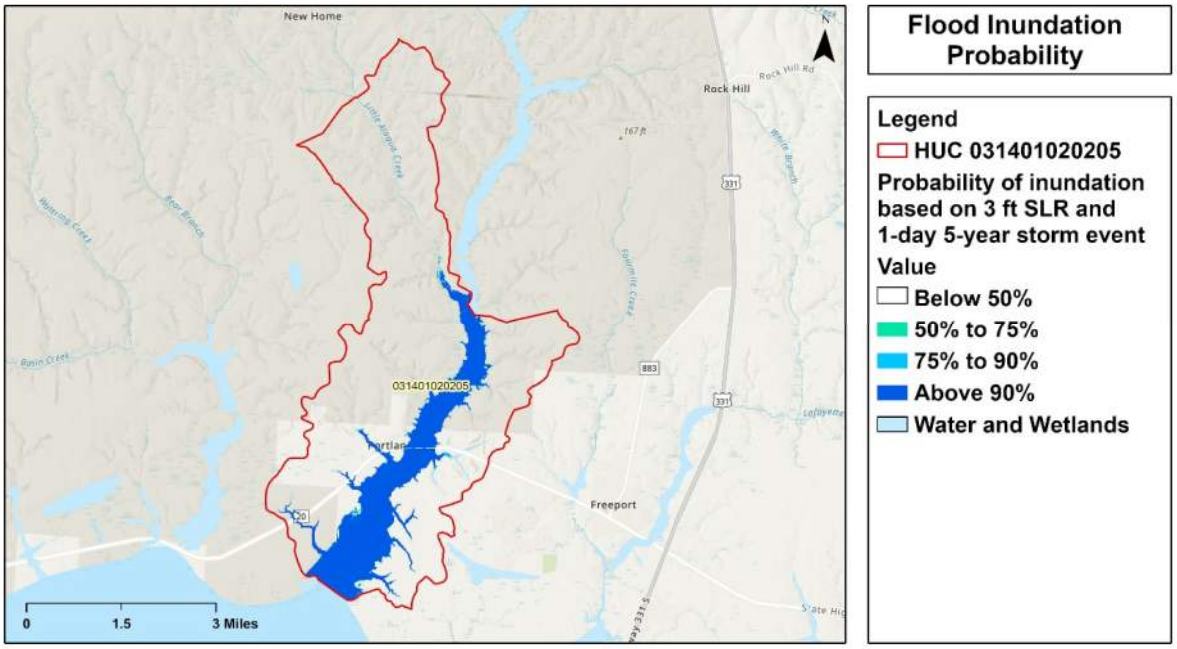

Figure 50. Sea level rise of 3 ft + 1-day 5-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

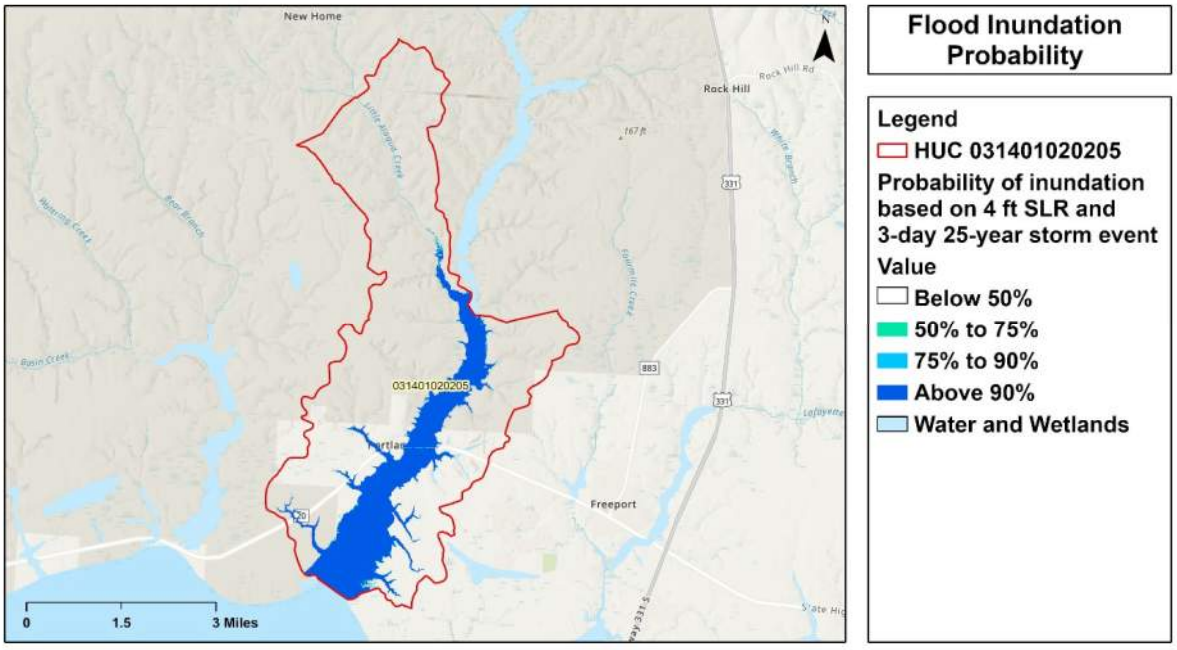

Figure 51.. Sea level rise of 4 ft + 3-day 25-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

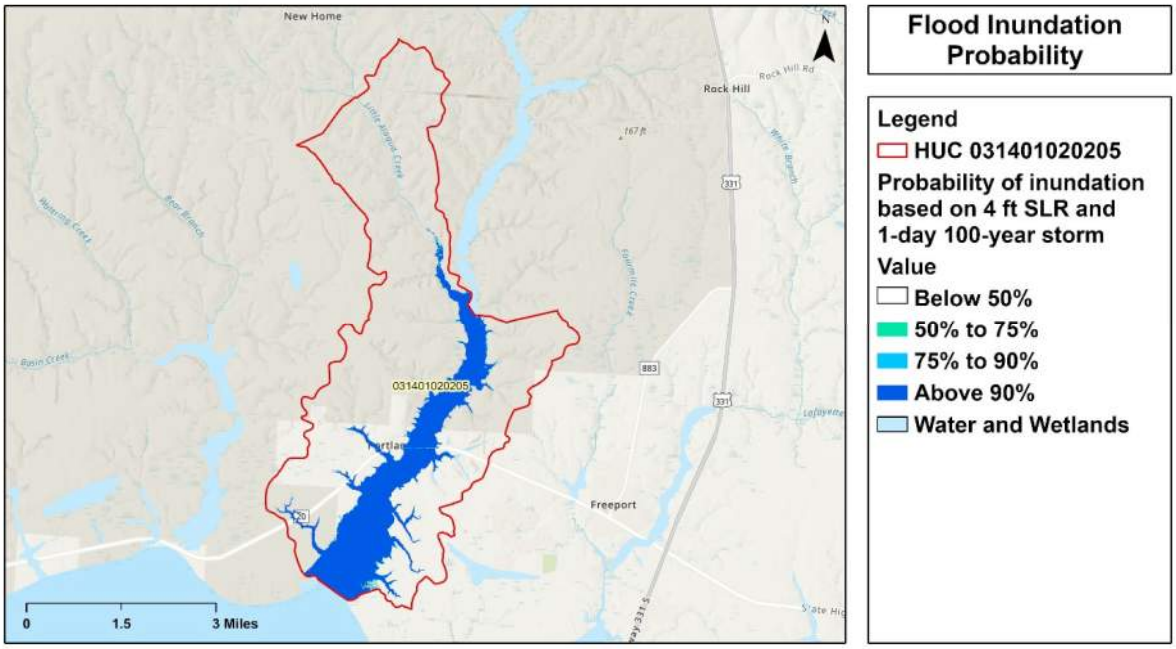

Figure 52. Sea level rise of 4 ft + 1-day 100-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

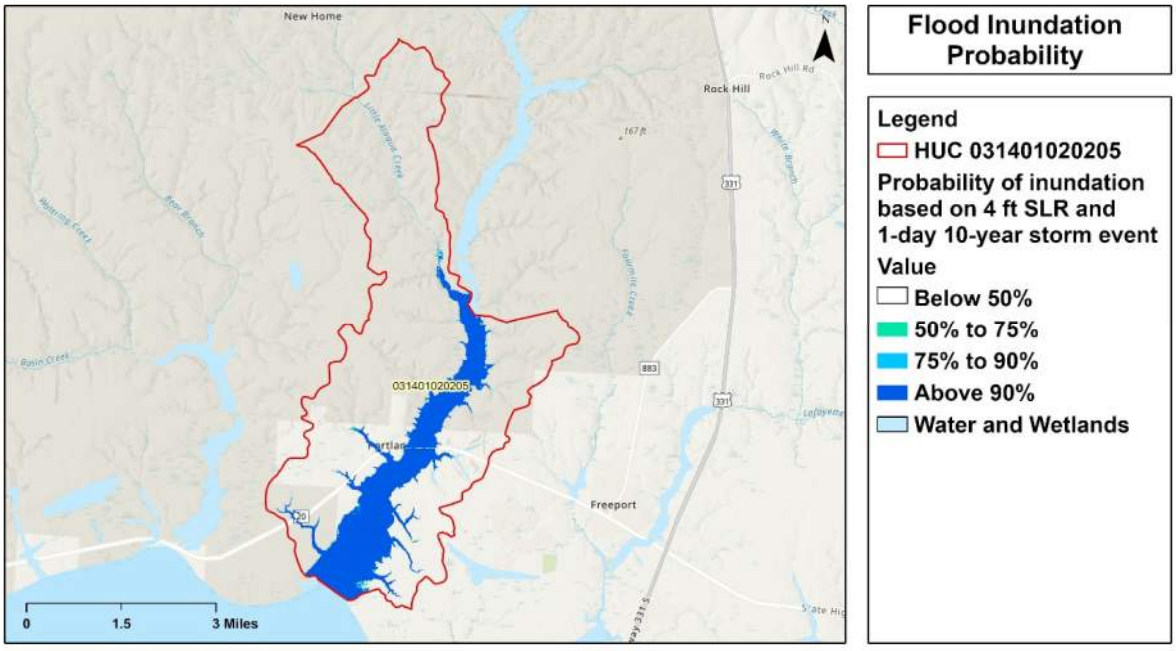

Figure 53. Sea level rise of 4 ft + 1-day 10-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

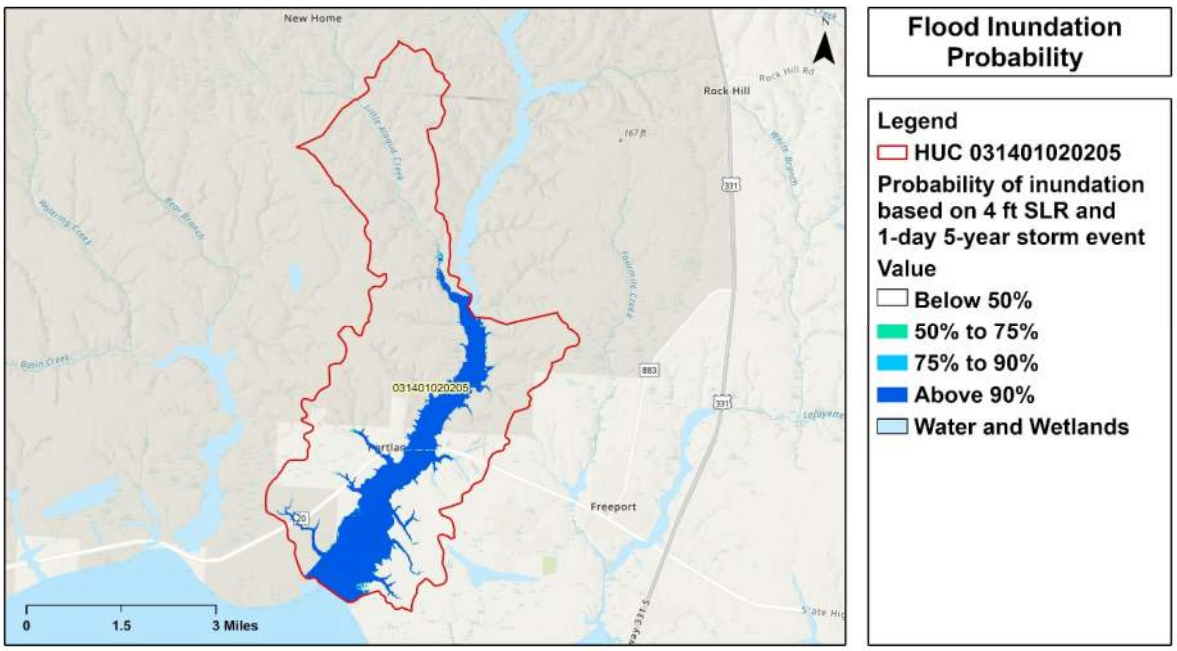

Figure 54. Sea level rise of 4 ft + 1-day 5-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

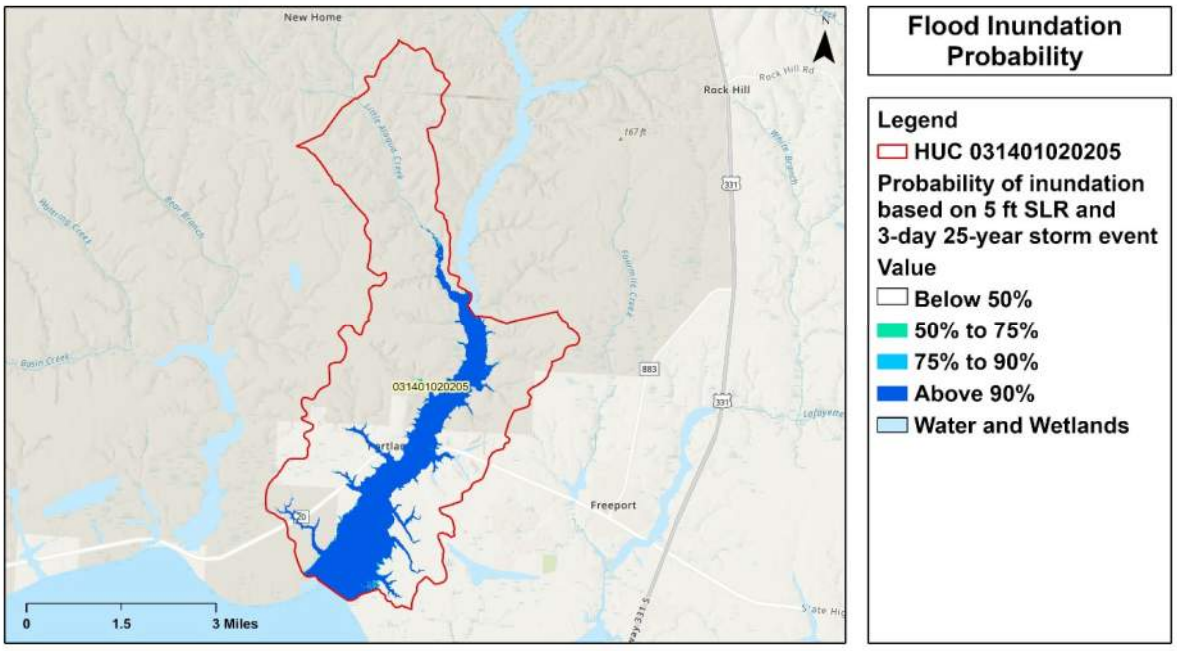

Figure 55. Sea level rise of 5 ft + 3-day 25-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

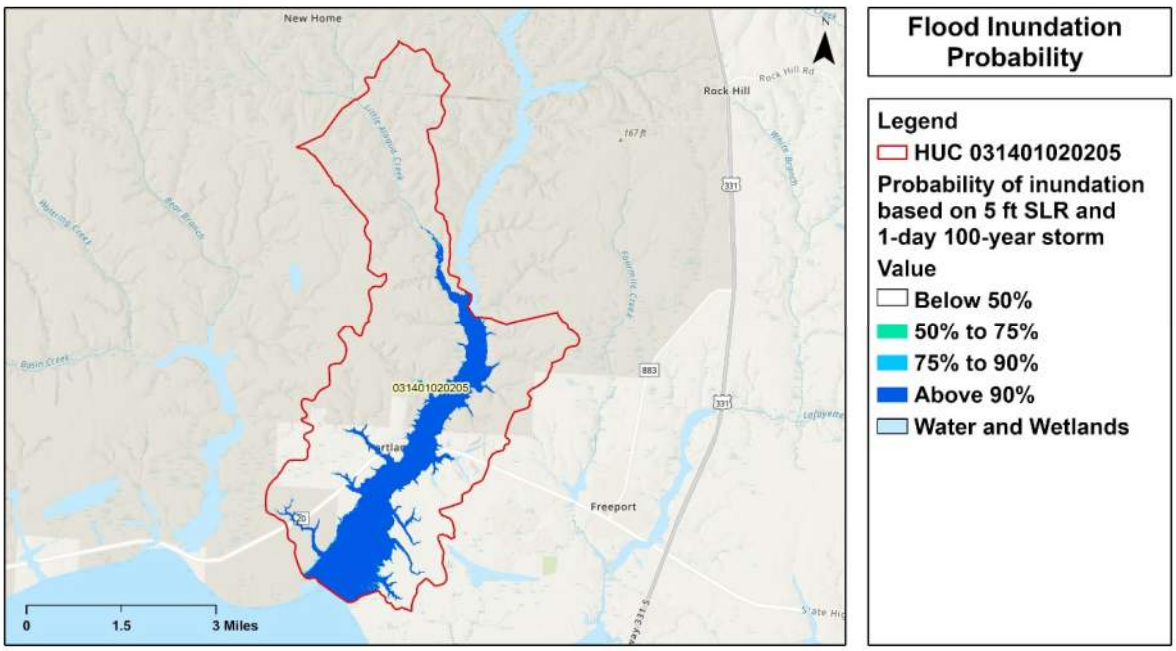

Figure 56. Sea level rise of 5 ft + 1-day 100-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

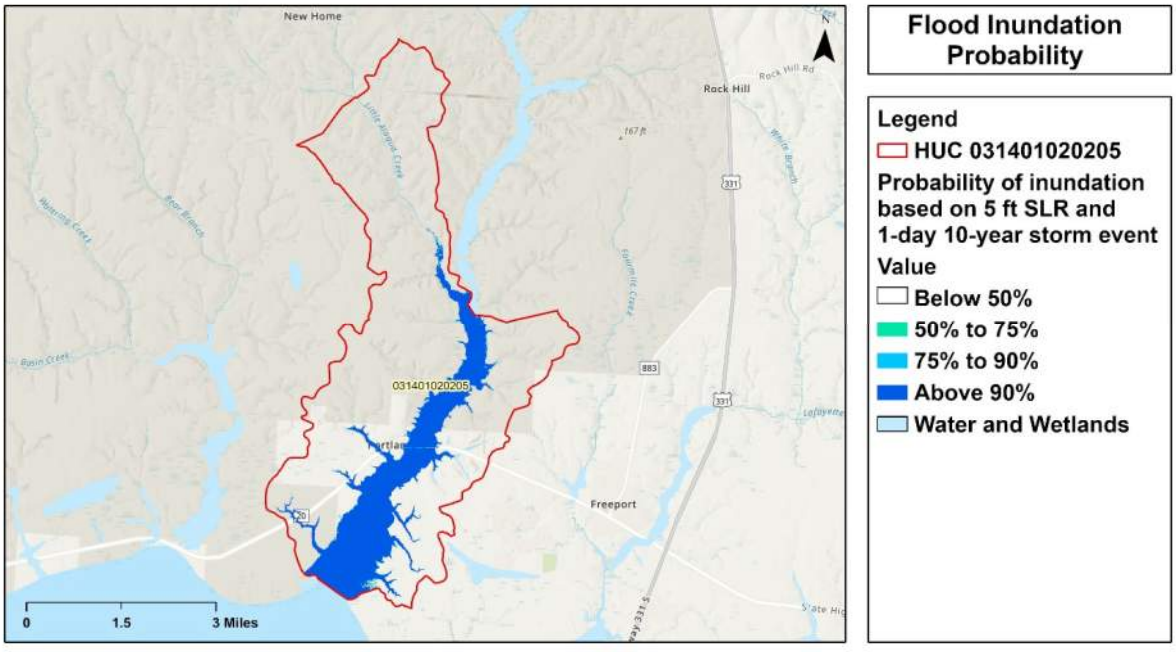

Figure 57. Sea level rise of 5 ft + 1-day 10-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

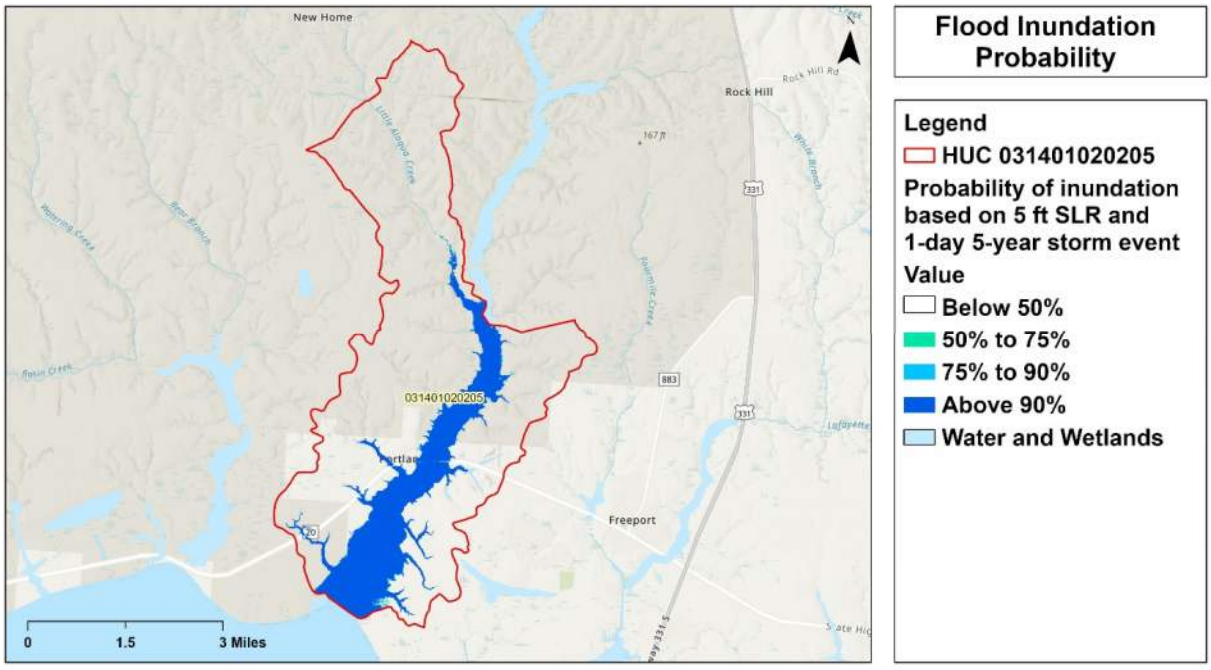

Figure 58. Sea level rise of 5 ft + 1-day 5-year storm for HUC 031401020205 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

2.5 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older,

poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5

27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6

58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6

94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.5.1 Results

Figures 59, 60, and 61 depict the HUC 031401020205 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (Figure 59) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 60) overlays critical facilities onto the 1-day 100-year storm event scenario, while the third map (**Error! Reference source not found.**) represents the same overlay within the context of 5 feet of sea level rise (SLR) combined with the 1-day 100-year storm event. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 5 feet SLR + 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** and **Error! Reference source not found.** illustrate the composite score for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. **Error! Reference source not found.** represents the calculation for composite score based on 1-day 100-year storm event, while **Error! Reference source not found.** shows the calculation for composite score for the same storm event, but including a 5 feet of Sea Level Rise scenario. **Error! Reference source not found.** shows the same area zoomed out.

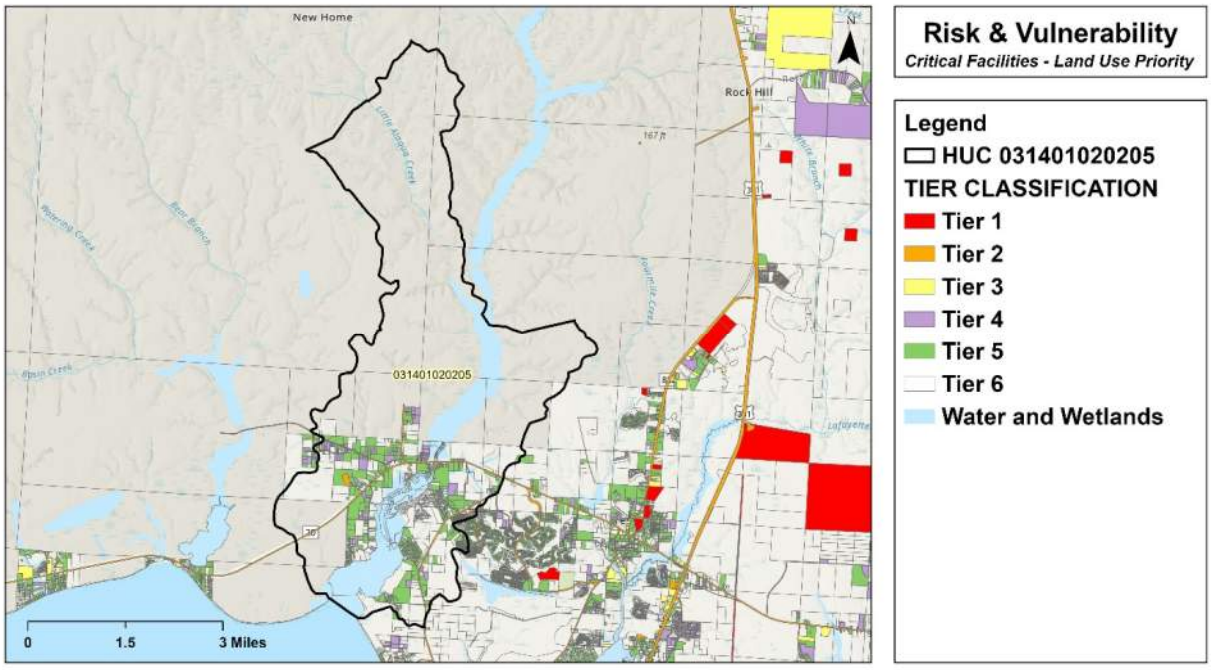

Figure 59. HUC 031401020205 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

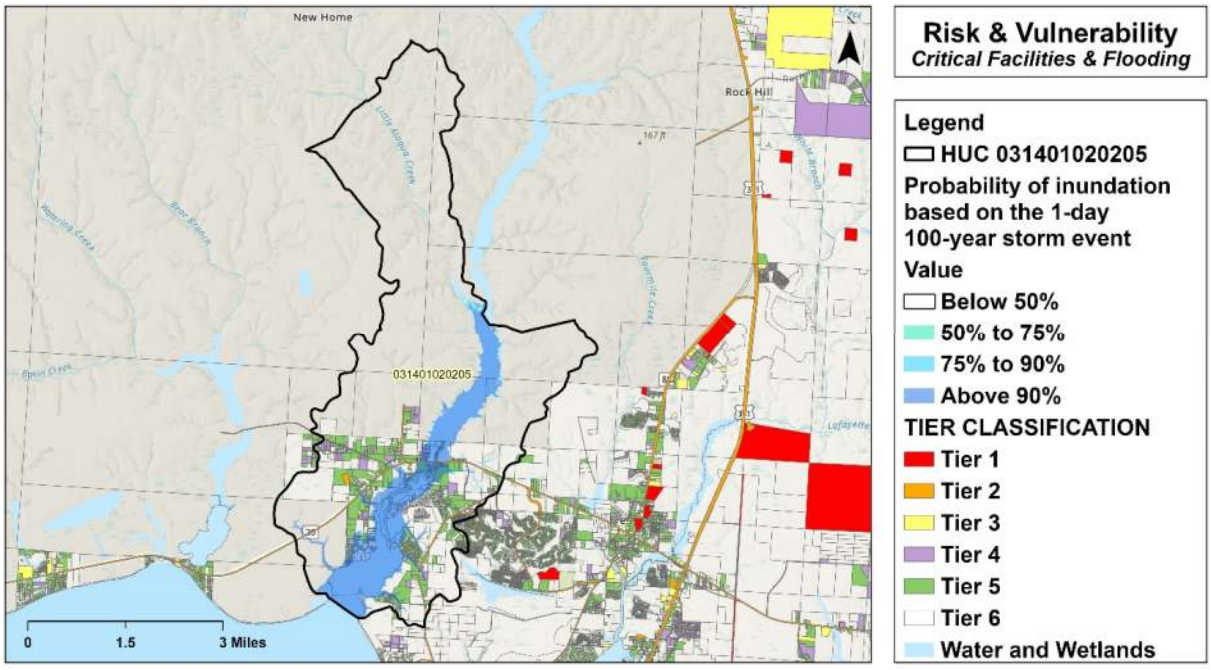

Figure 60. HUC 031401020205 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation map. Processed by FAU.

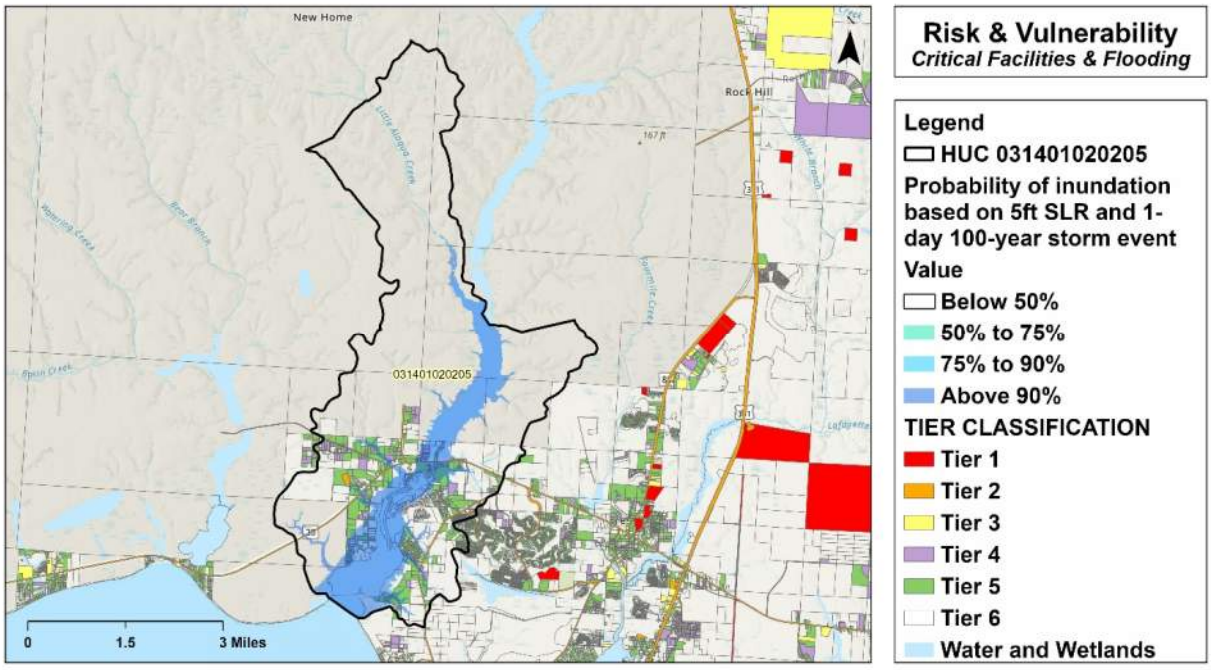

Figure 61. HUC 031401020205 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event + 5 ft SLR probability of inundation map. Processed by FAU.

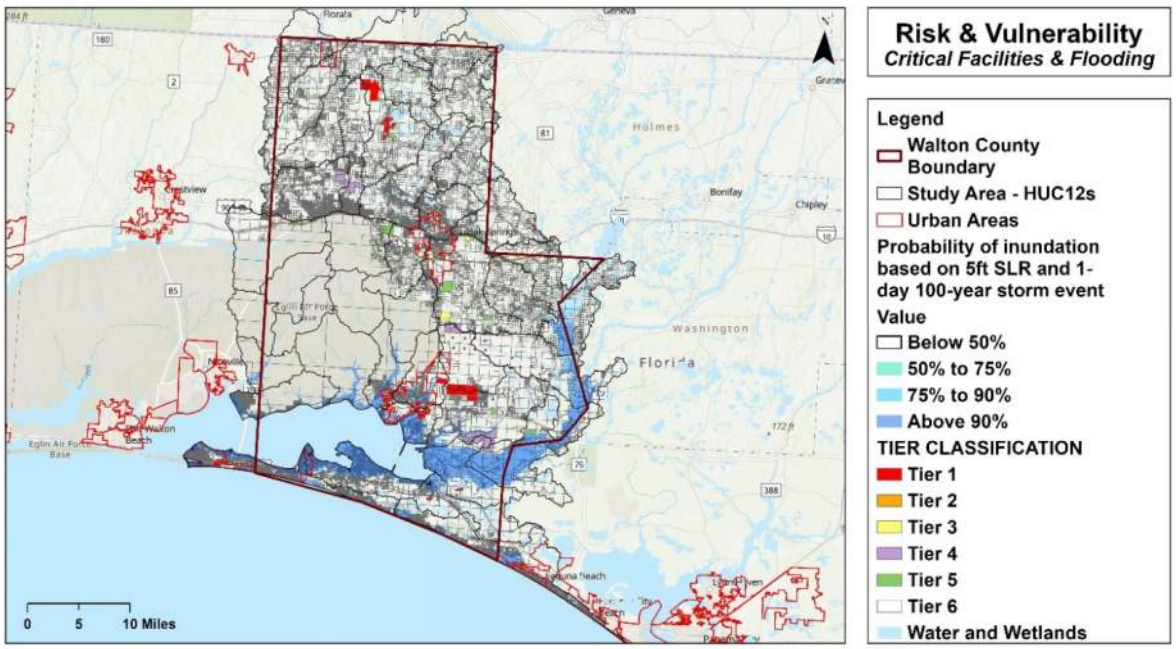

Figure 62. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event + 5 ft SLR probability of inundation map for Walton County. Processed by FAU.

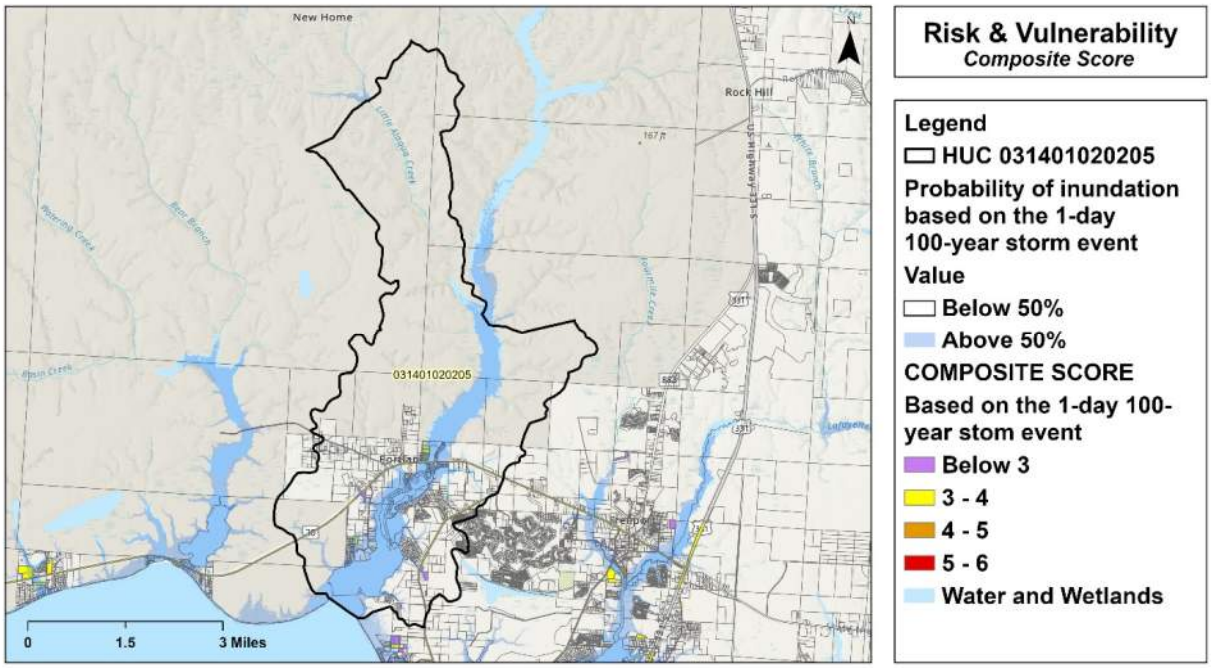

Figure 63. HUC 031401020205 sub-watershed Composite Score Risk map based on the 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation. Processed by FAU.

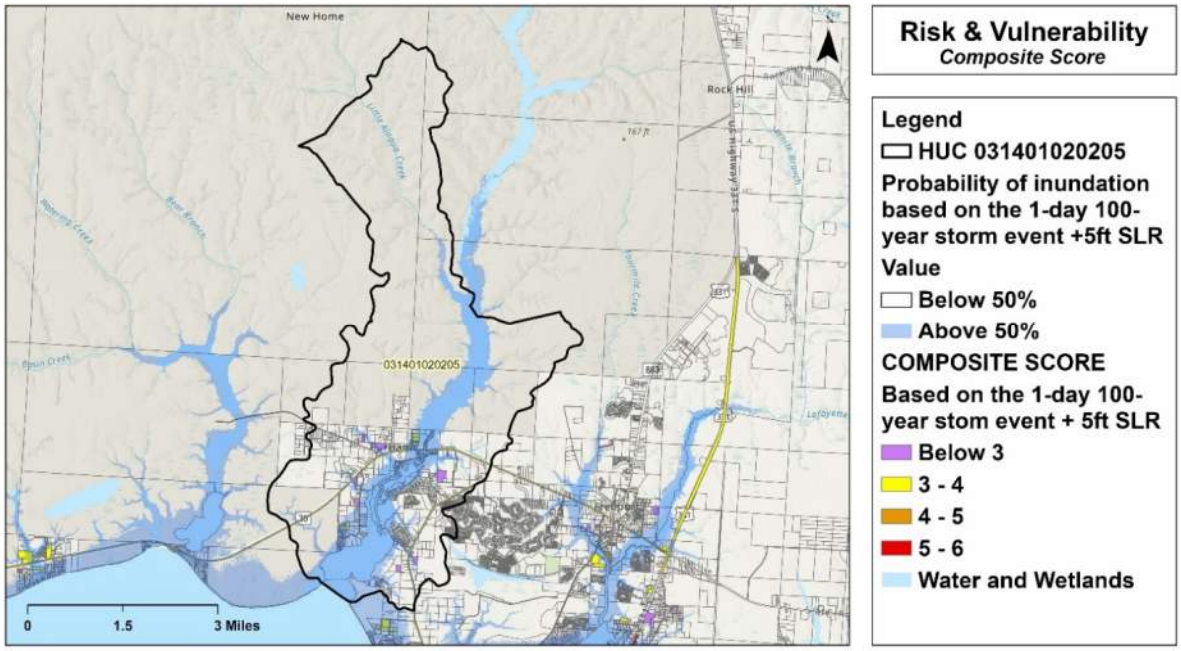

Figure 64. HUC 031401020205 sub-watershed Composite Score Risk map based on 1-day 100-year storm event + 5 ft. SRL, overlaid on the 1-day 100-year + 5 ft. SLR probability of inundation. Processed by FAU.

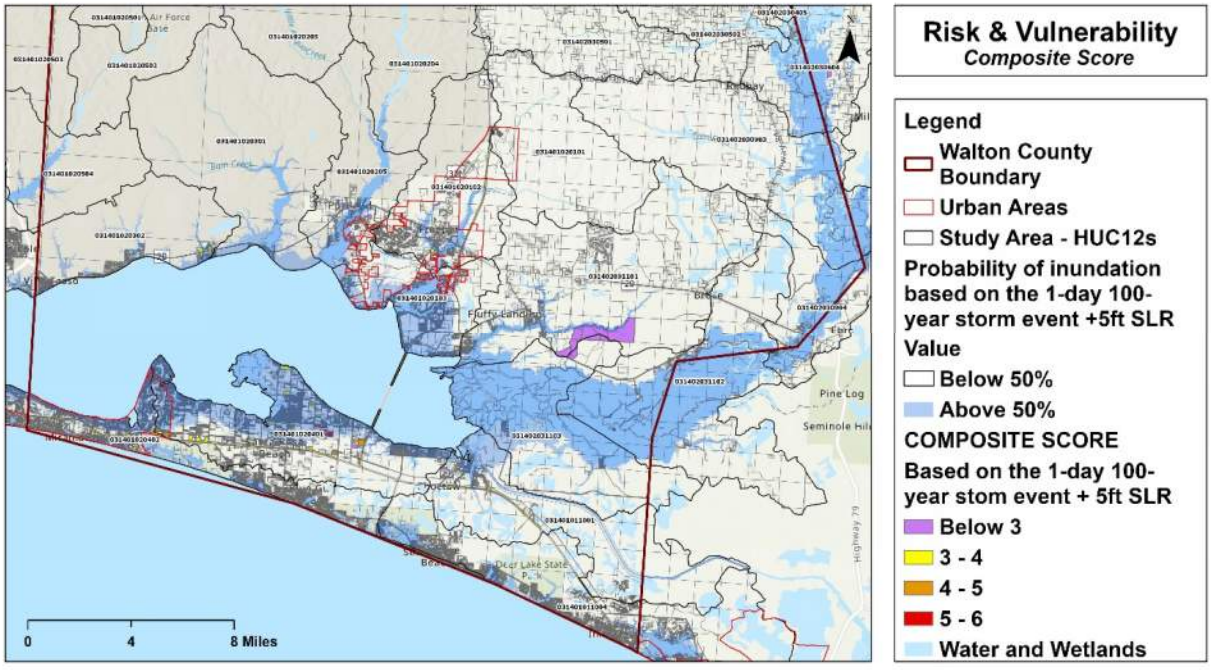

Figure 65. Coastal Area of Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event + 5 ft SLR probability of inundation map. Processed by FAU.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

2.5.2 Drill-down – Freeport

For enhanced visualization of the urban areas within this HUC 031401020205, Figure 66 to Figure 75 illustrate the same results for critical facilities (land use priorities) and composite scores, but on a reduced scale, which better facilitates the examination of finer details within the urban area (Freeport). These maps cover both the 1-day 100-year scenario and the 1-day 100-year + 5 feet SLR scenario.

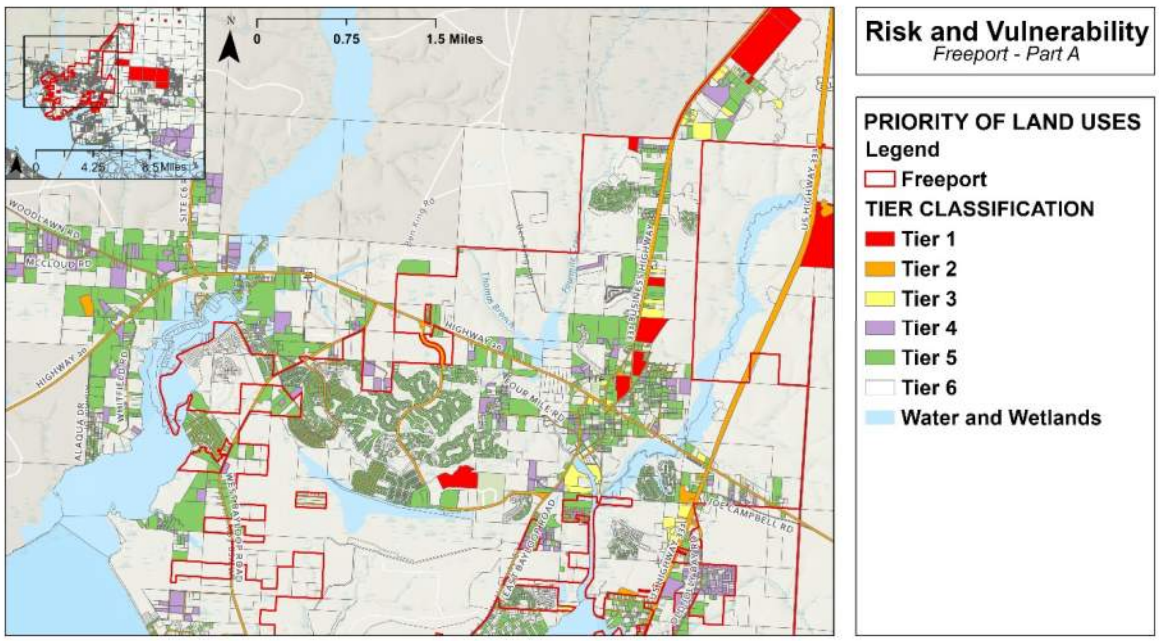

Figure 66. Critical Facilities (priority of land uses) map for Freeport (part A). Processed by FAU.

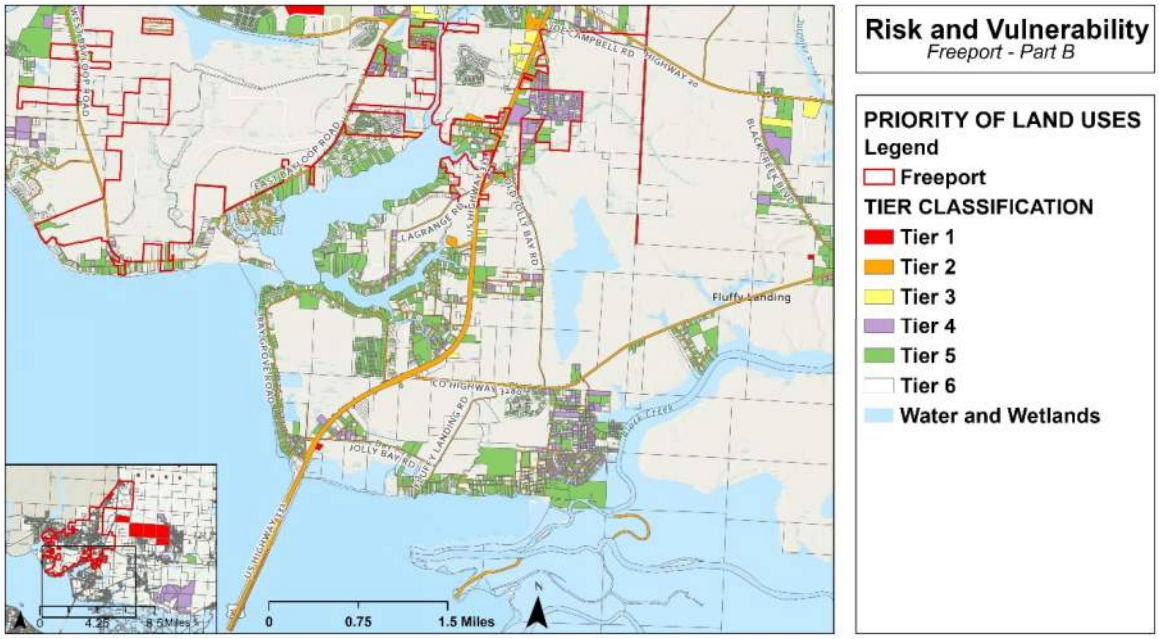

Figure 67. Critical Facilities (priority of land uses) map for Freeport (part B). Processed by FAU.

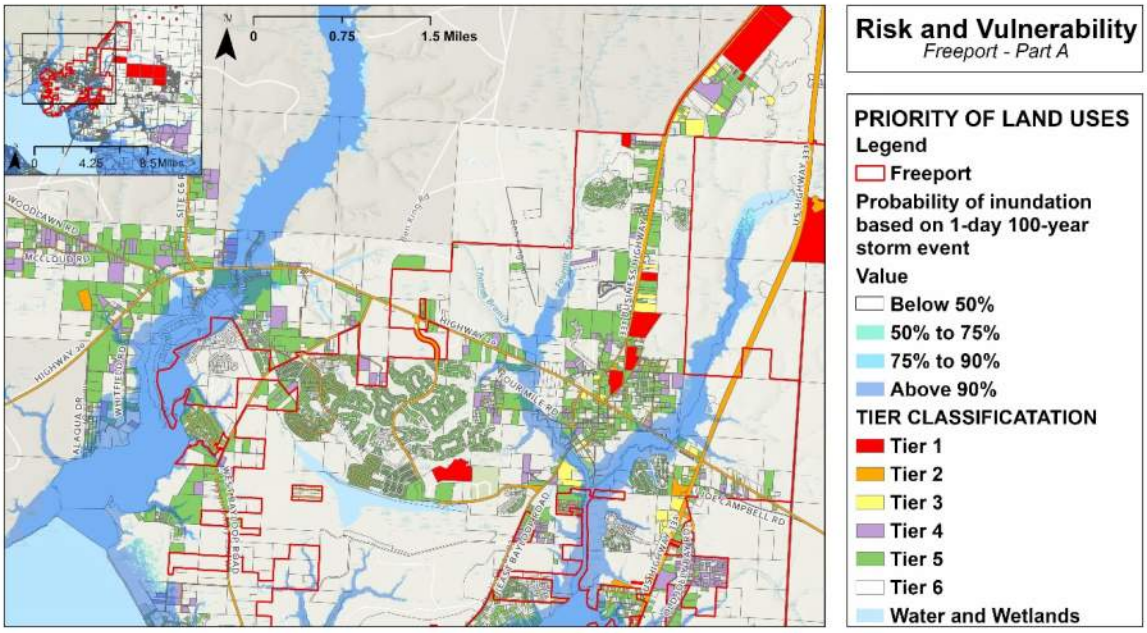

Figure 68. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event for Freeport (part A). Processed by FAU.

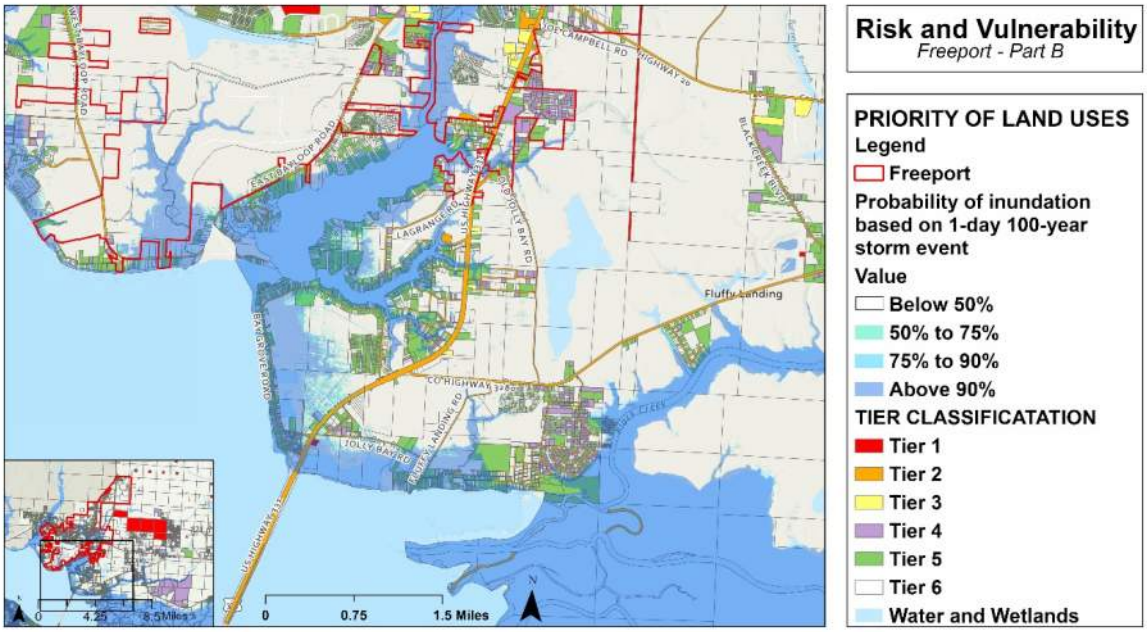

Figure 69. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event for Freeport (part B). Processed by FAU.

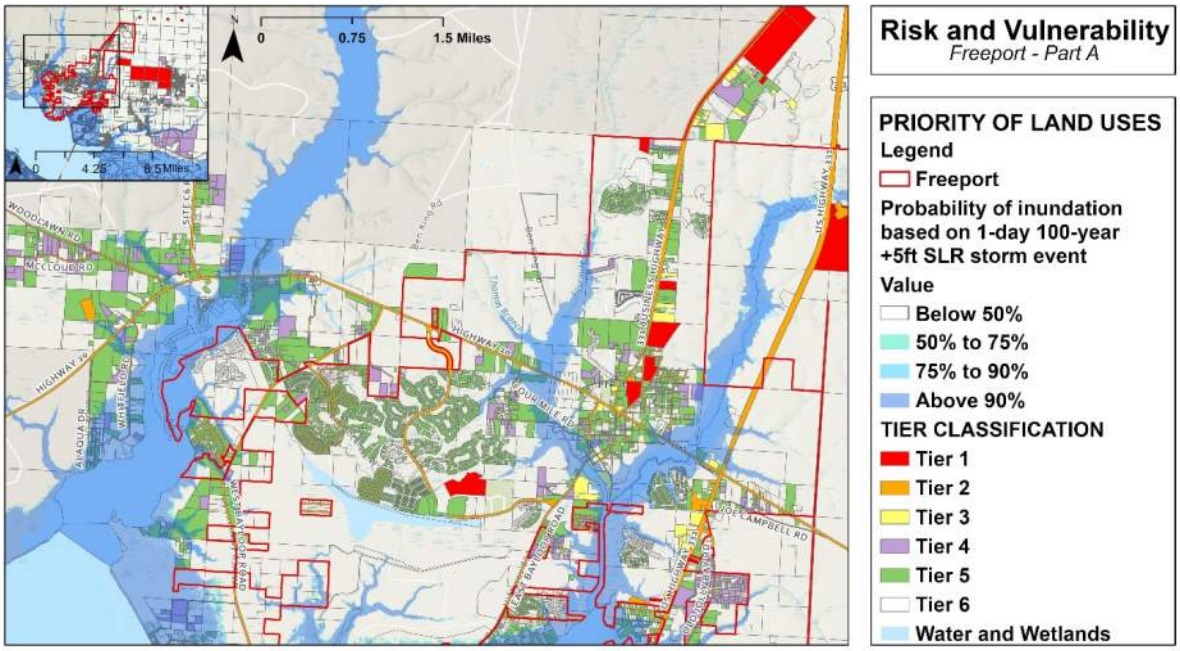

Figure 70. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event + 5 feet SLR for Freeport (part A). Processed by FAU.

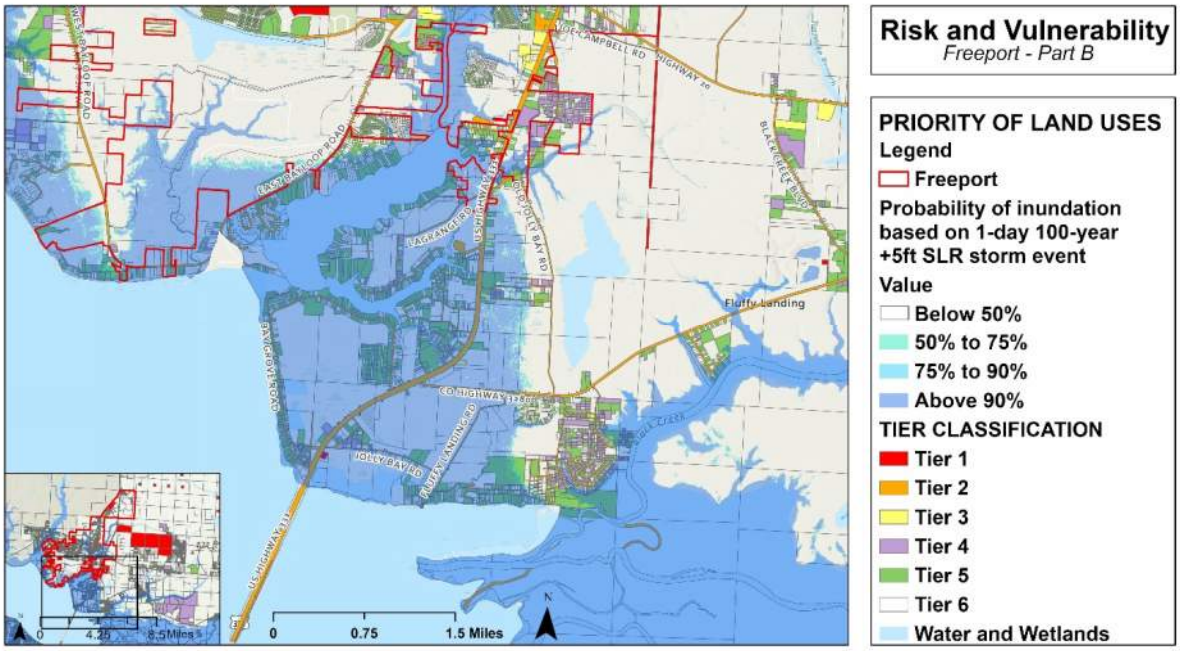

Figure 71. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event + 5 feet SLR for Freeport (part B). Processed by FAU.

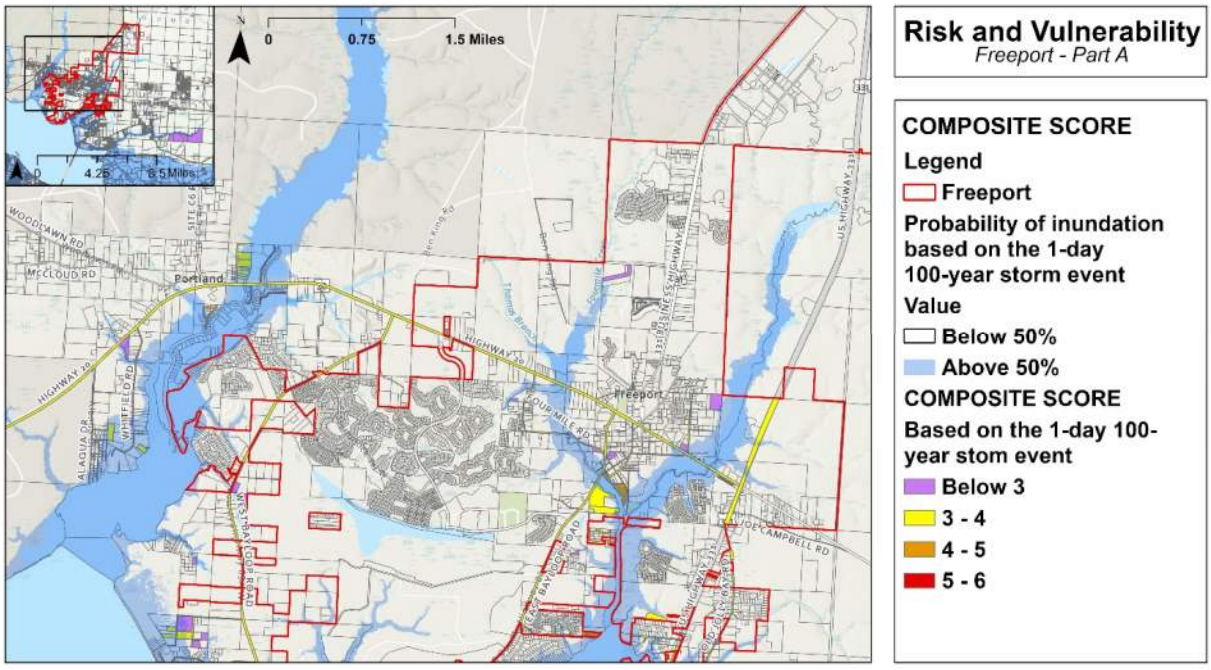

Figure 72. Composite Score map based on 1-day 100-year storm event, overlaid in flooding layer for Freeport (part A). Processed by FAU.

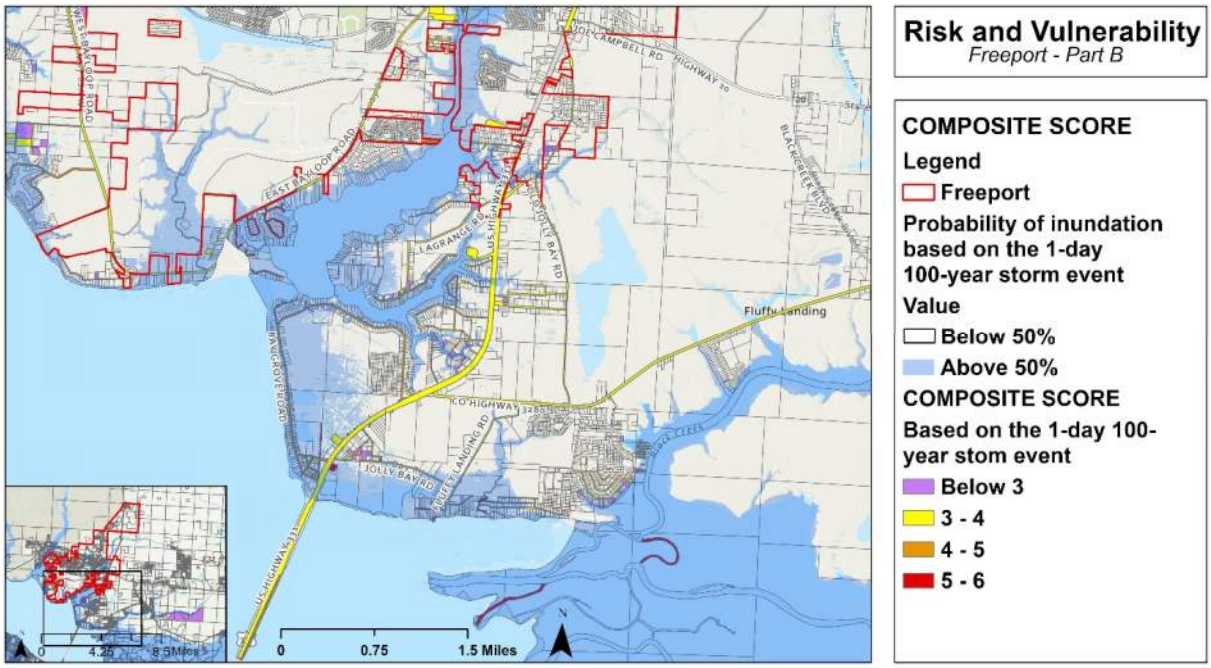

Figure 73. Composite Score map based on 1-day 100-year storm event, overlaid in flooding layer for Freeport (part B). Processed by FAU.

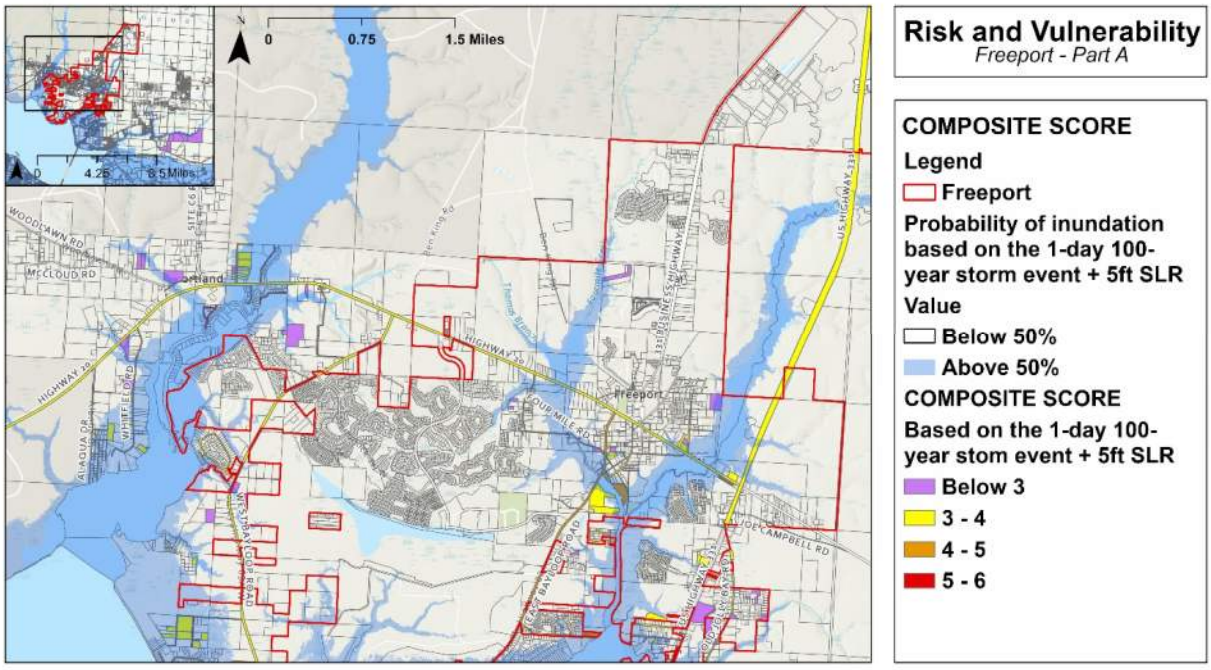

Figure 74. Composite Score map based on 1-day 100-year storm event + 5 feet SLR, overlaid in flooding layer for Freeport (part A). Processed by FAU.

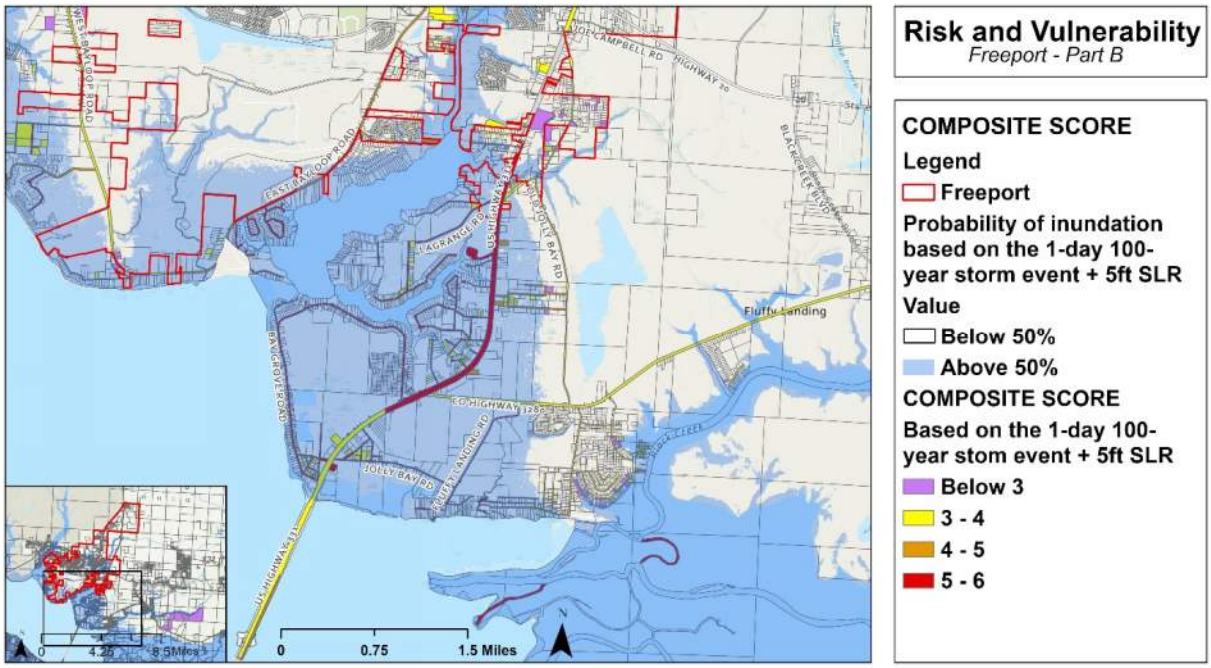

Figure 75. Composite Score map based on 1-day 100-year storm event + 5 feet SLR, overlaid in flooding layer for Freeport (part B). Processed by FAU.

2.5.3 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401020205. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.5.4 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It is important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401020205. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401020205	12240.06
All of the 1-day 100-year storm event inundation	**1711.29**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	1248.10
B. Federal Land in 1-day 100-year inundation > 10 acres	80.48
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	382.71
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	382.71

2.5.5 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that

have a higher concentration of properties prone to repetitive losses. Figure 76 indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

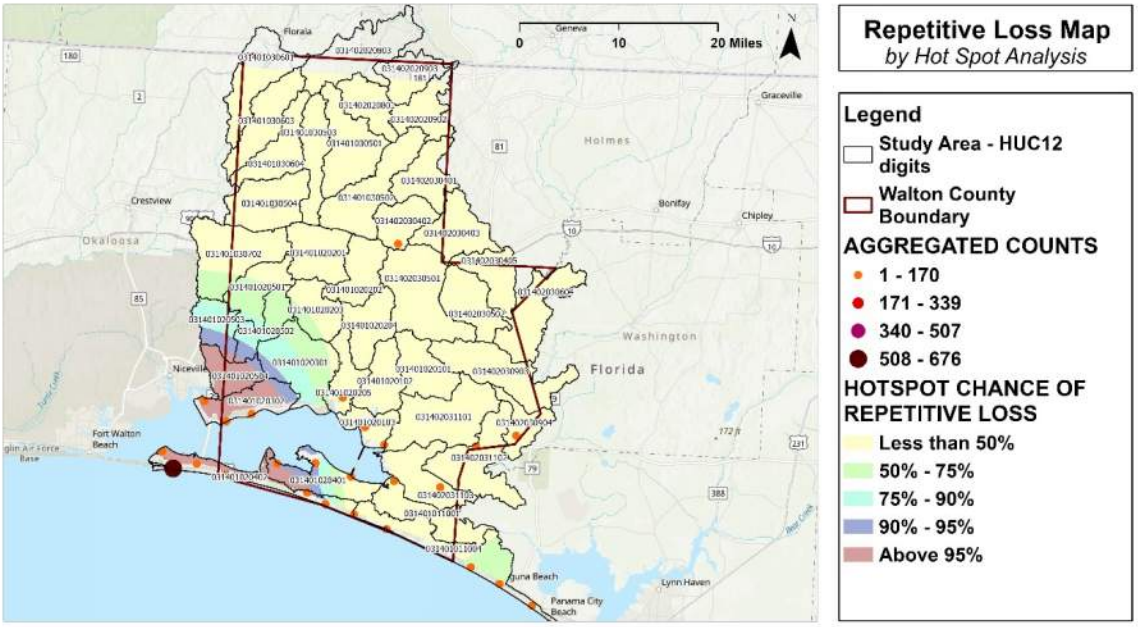

Figure 76. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.5.6 Priority Projects

The basin features a significant amount of developed land, with a large number of parcels falling within the flood zone. In terms of priority for land use, there are parcels in tier 2, including one private school and 40 road segments, which require attention. Additionally, there is a substantial number of parcels falling within tiers 4 and 5, signifying a lower priority for intervention. Notably, no critical facilities (tier 1) were identified within the basin.

Examining the composite score, eight parcels fall within the score range of 5-6, and all of them are roads (Alaqua Cove Rd, South Street, Ruth Rd, Thelma Rd, Don Blizzard Rd, John's Lane, Alaqua Acres Rd, and Portland Park Road), representing the highest priority for intervention. Furthermore, there are nine parcels within the score range of 4-5, all of which are also roads (Alaqua Dr, Church St, West Bayloop Road, Waterview Cove Drive, Waterview Place, Highway 20, Hatcher Cemetery Rd, Alaqua Terrace Road, and Whitfield Rd). In the score range of 3-4, there are 25 parcels, all classified as mobile homes, and below a score of 3, there are 14 parcels, all of which are also mobile homes.

APPENDIX L

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401020301

BASIN BAYOU

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 sub-watershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401020301) is highlighted among all the HUCs to help identifying its location. (Figure 3).

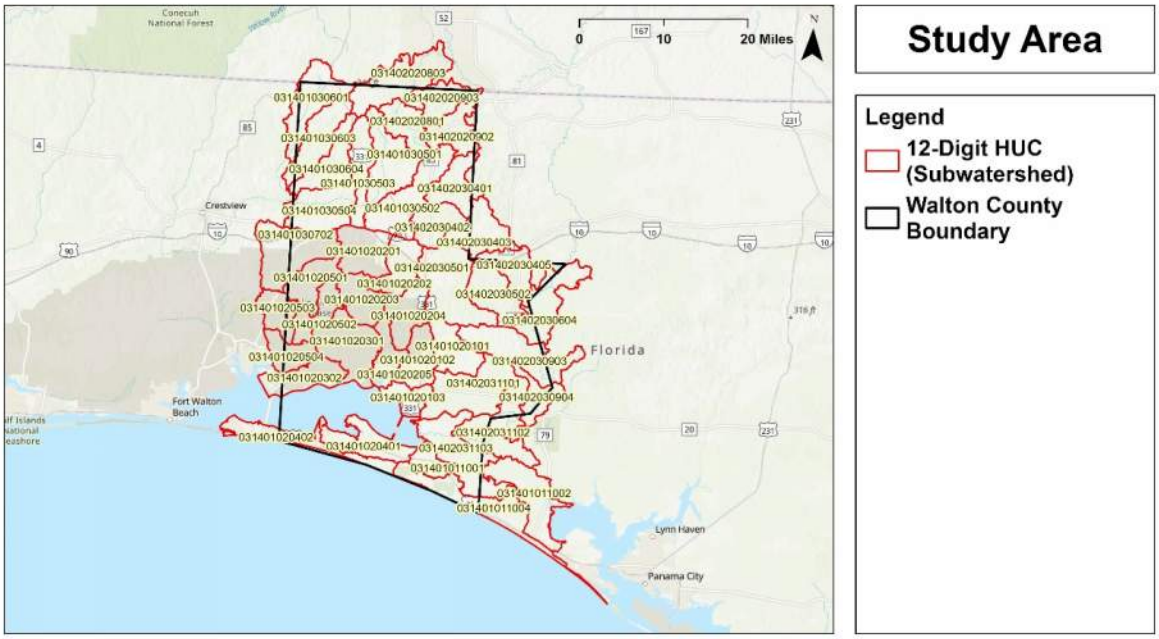

Figure 1. FigurWalton County and all HUCs 12-digit sub-watershed, processed by FAU.

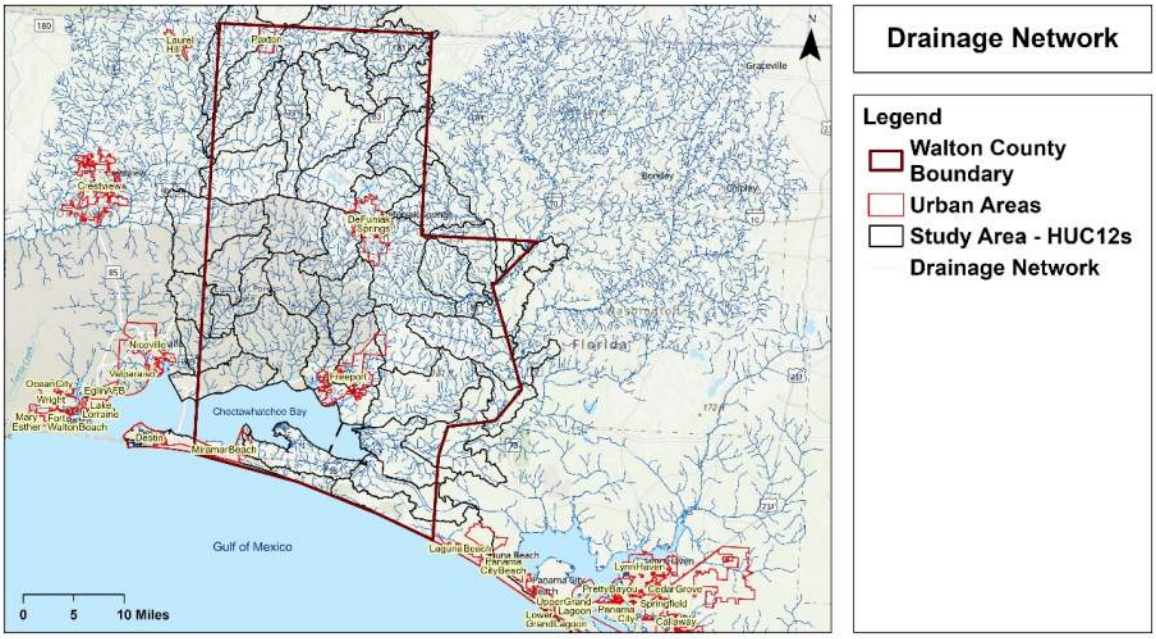

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

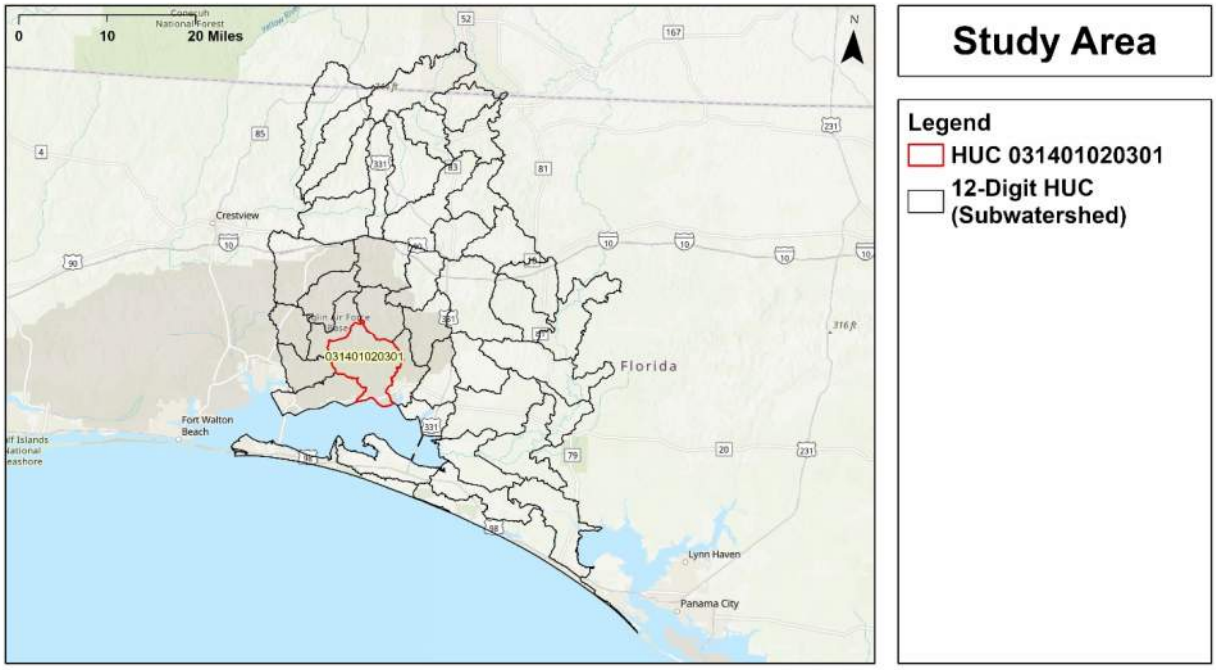

Figure 3. HUC 031401020301 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development, tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Figures 12 and 13 in the county-wide report show the current and projected land use for the County. Based on the 2017 future land use map for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**..

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL))

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 1.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water

in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

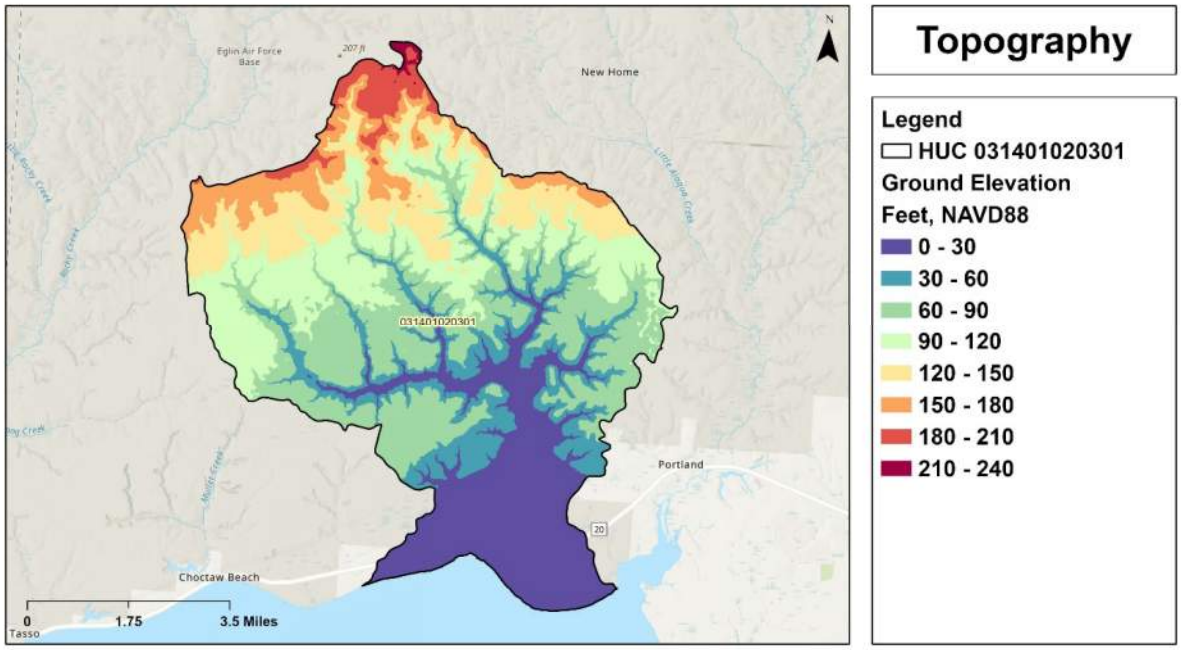

Figure 4. Topographic map of the HUC 031401020301 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401020301 sub-watershed is shown in **Error! Reference source not found.**.

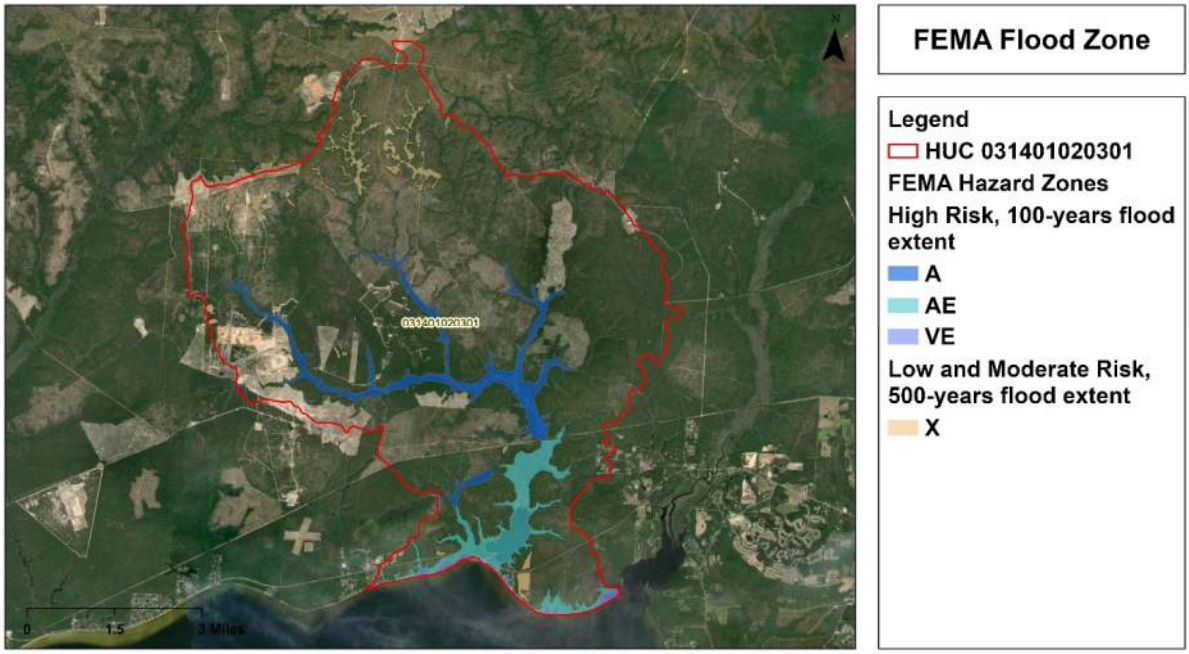

Figure 5. FEMA Flood Zone map (2020) for HUC 031401020301 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself

characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401020301 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing.

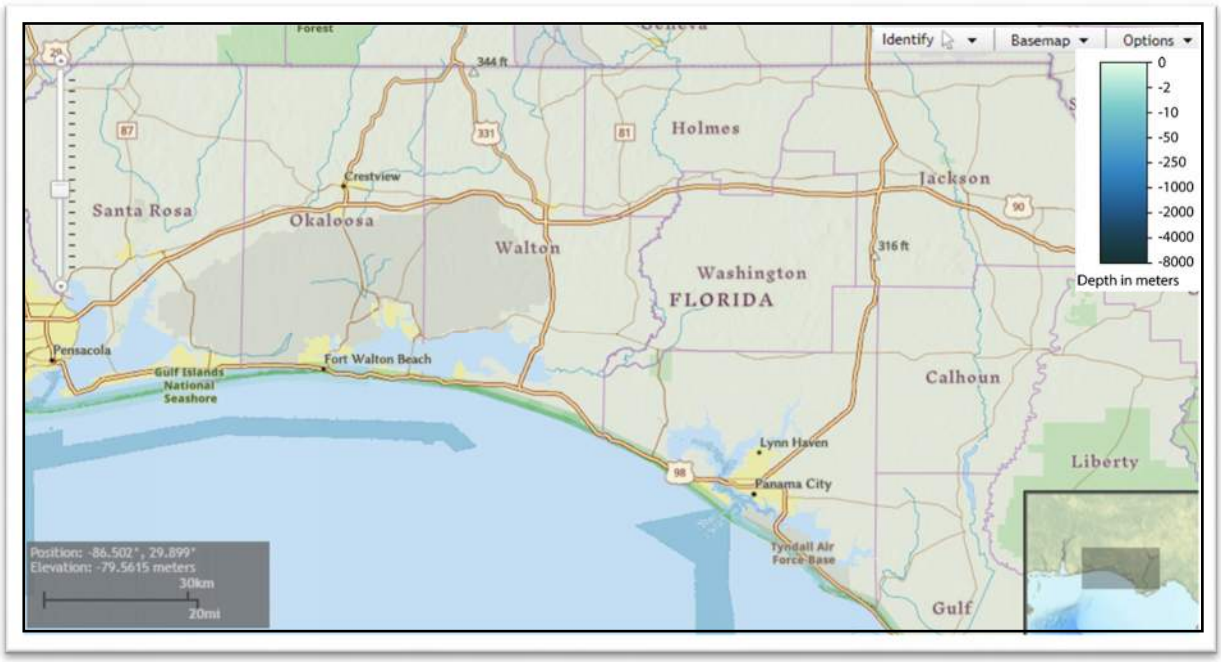

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

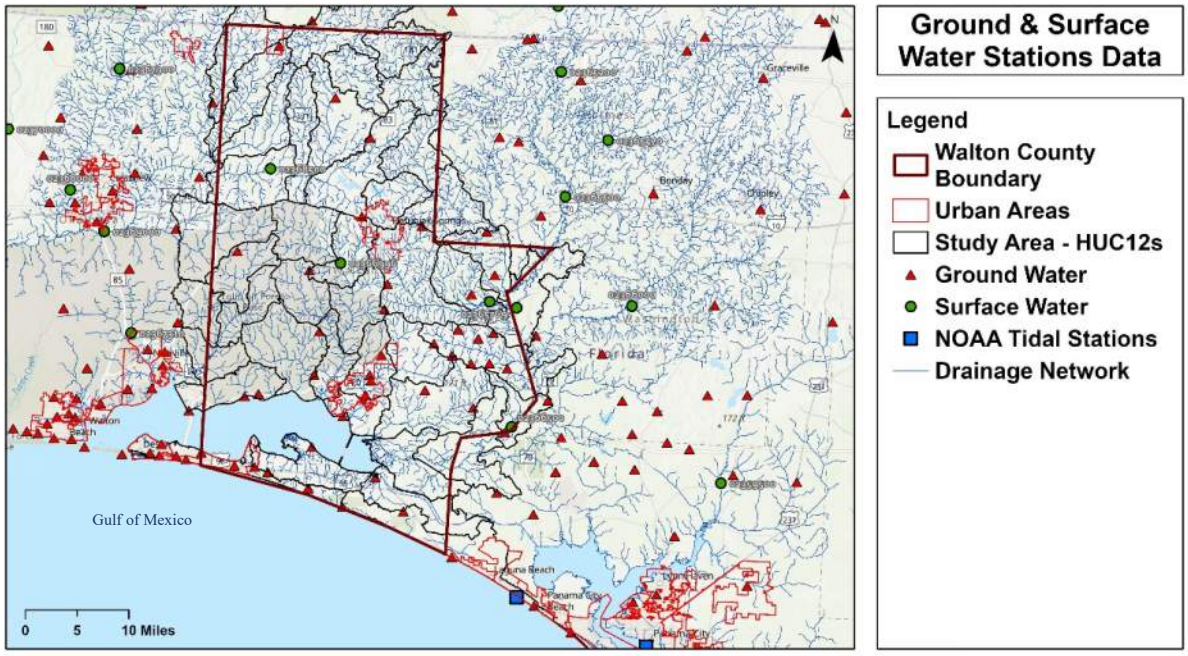

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The basin is connected to the Choctawhatchee Bay at its south side. The major water bodies in the HUC 031401020301 sub-watershed are listed below:

- Basin Creek
- Coon Head Branch

- Middle Creek
- Watering Creek
- Bear Branch
- Little Basin Creek
- Linton Spring Branch
- Steep Head Branch
- Watering Creek
- Little Basin Creek

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366996. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401020301, which is USGS 02366996 Alaqua Creek Near Pleasant Ridge, FL.

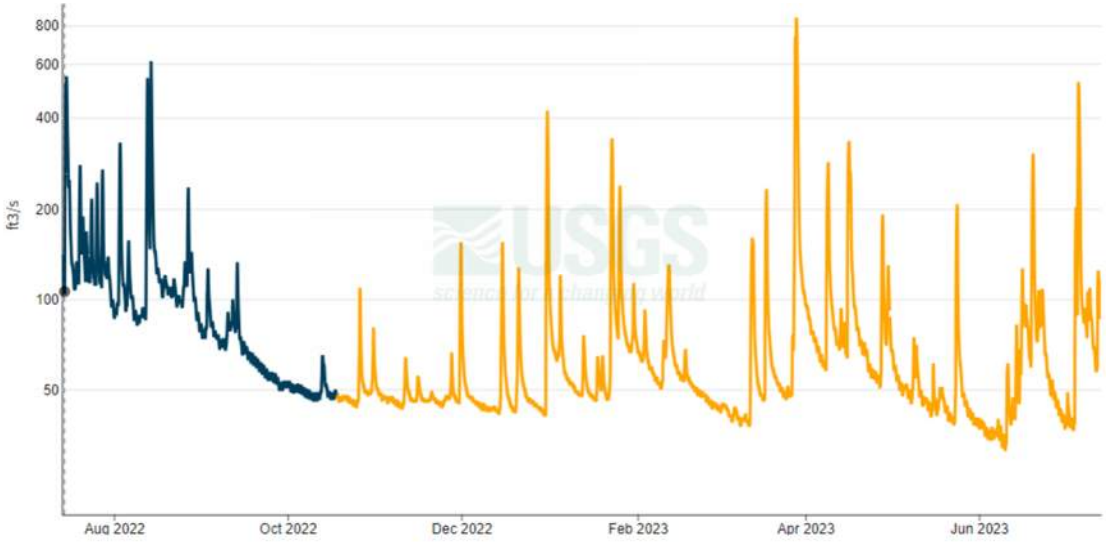

Figure 8. Average streamflow for Alaqua Creek Near Pleasant Ridge, FL (USGS 02366996 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366996/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure

detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401020301 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031401020301 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

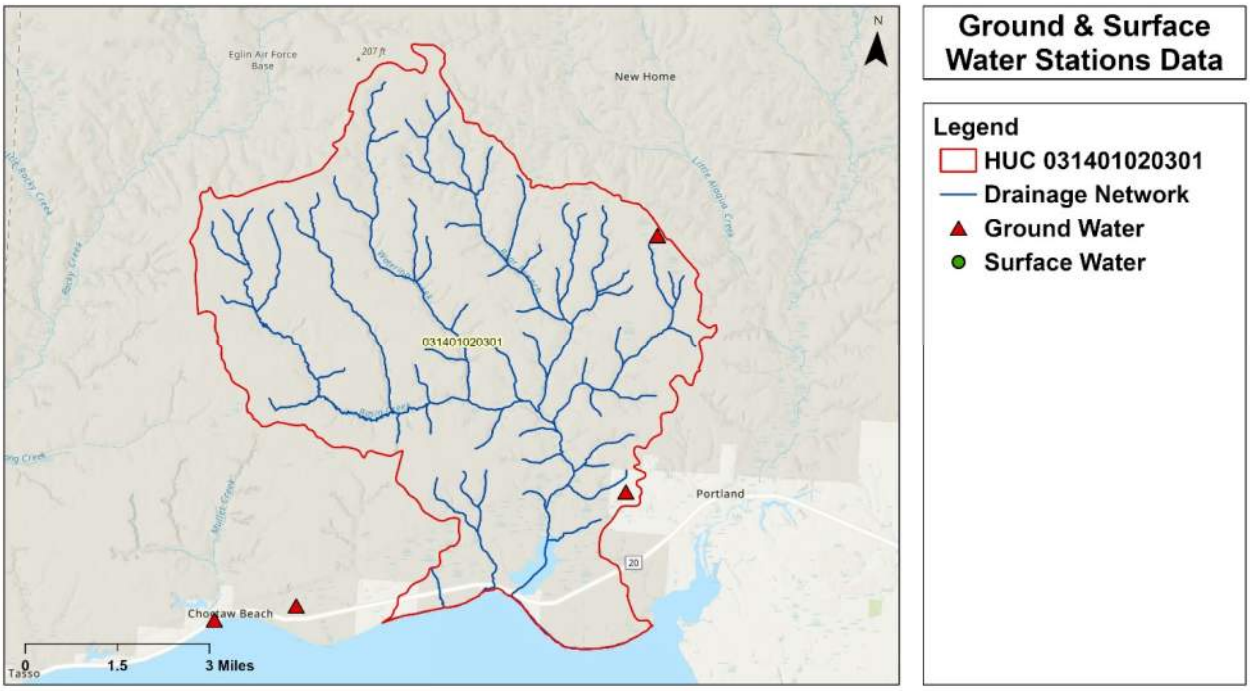

Figure 9. Ground and Surface Water Stations in the HUC 031401020301 sub-watershed, processed by FAU.

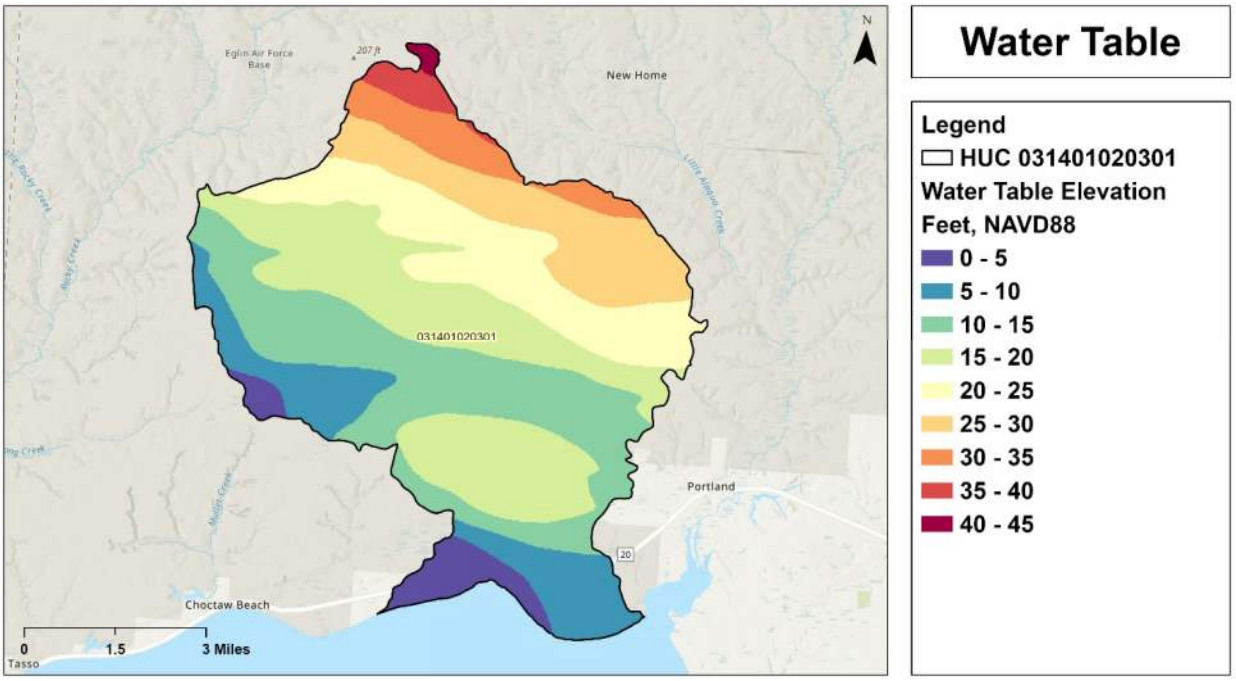

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401020301 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

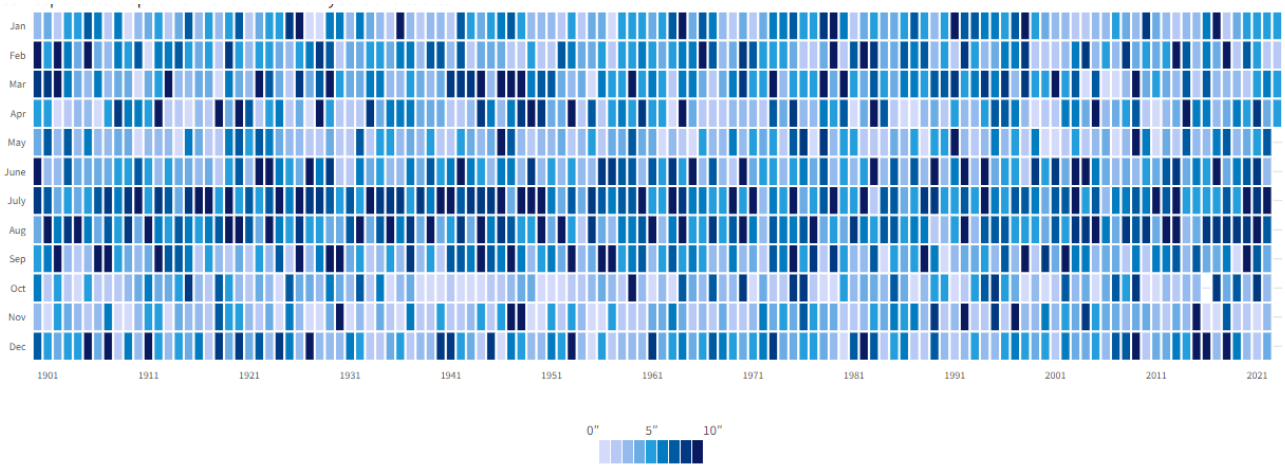

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/)

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

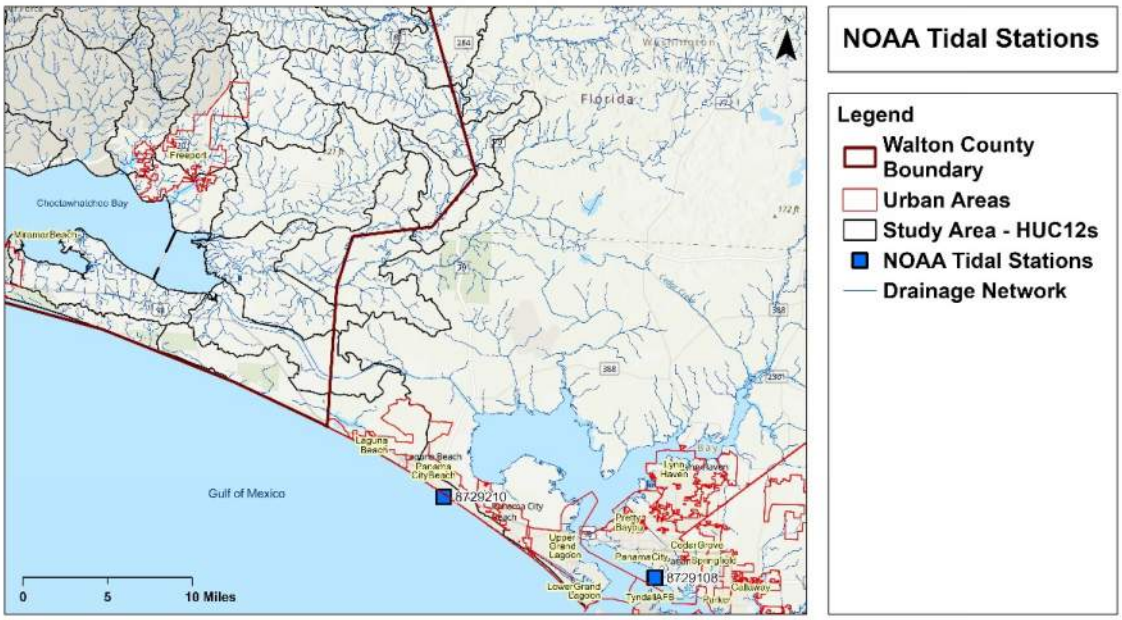

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

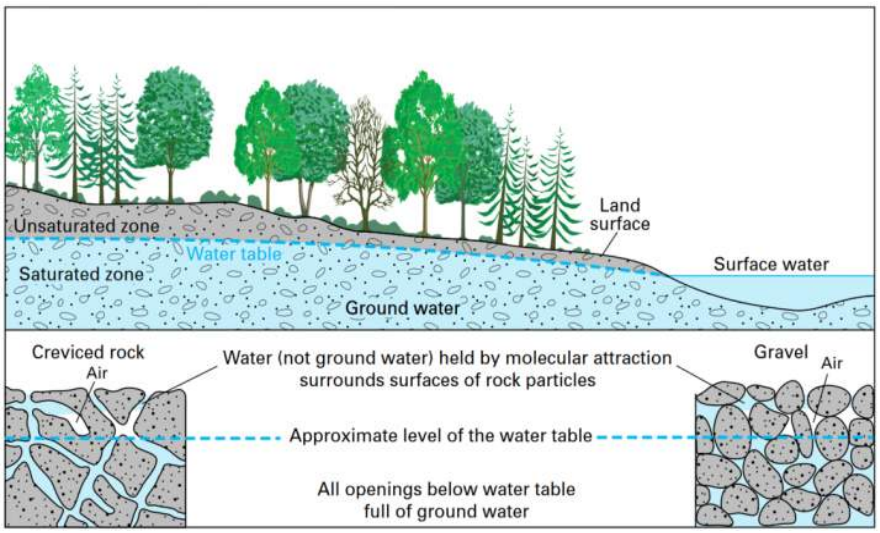

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

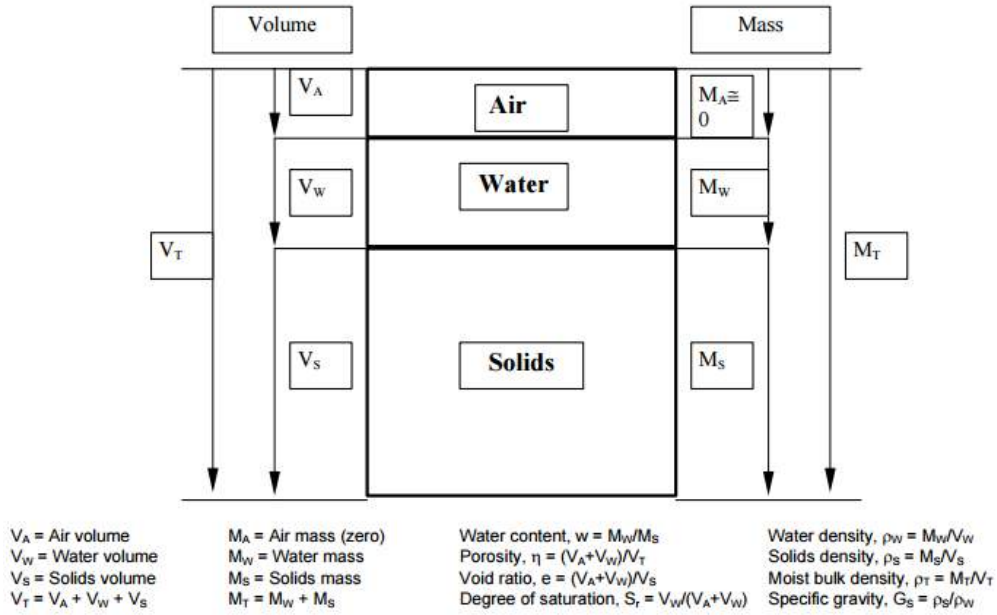

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

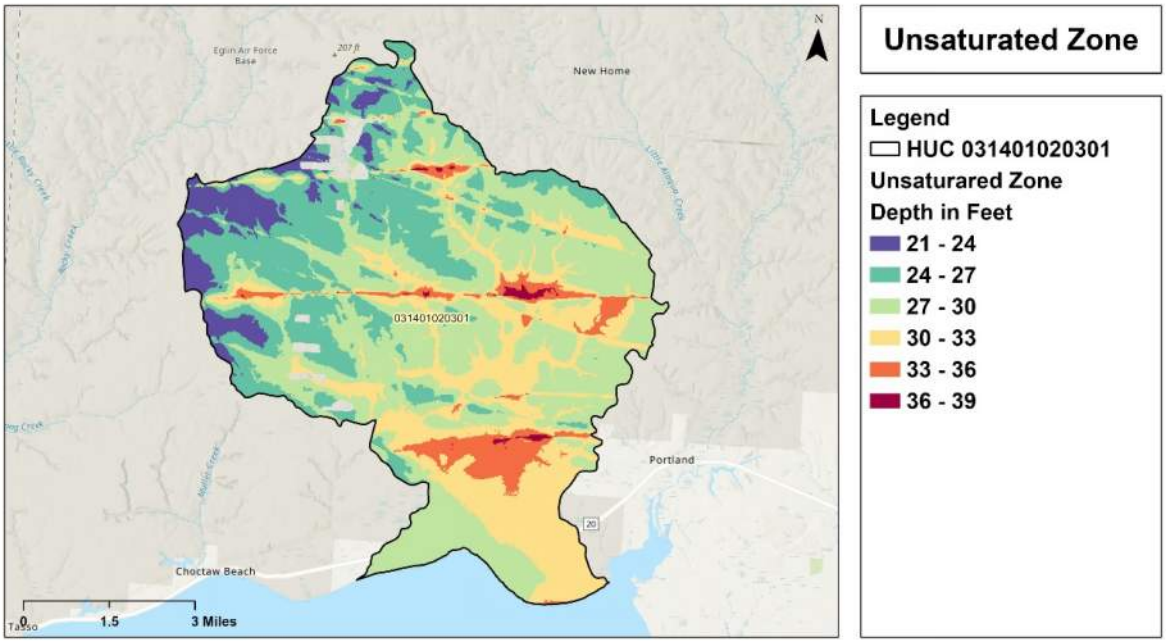

Figure 15. Unsaturated zone map for HUC 031401020301, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately favorable soil storage capacity, falling within the range of 24 to 36 feet of remaining capacity.

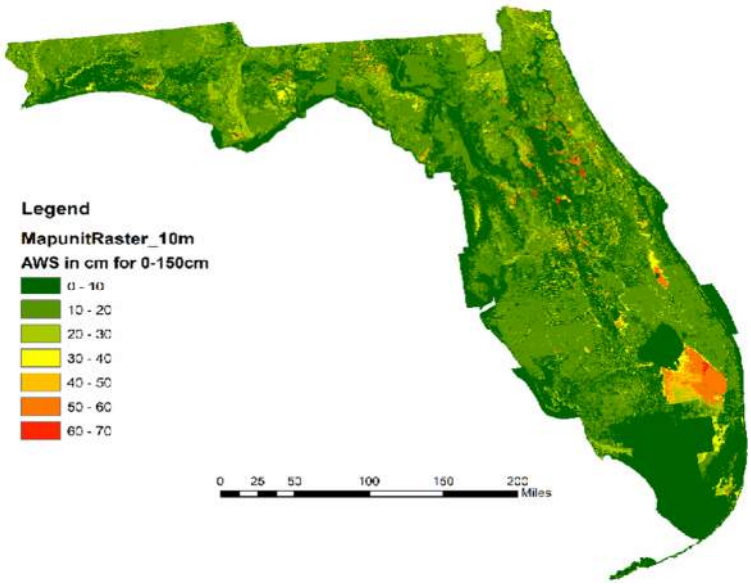

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

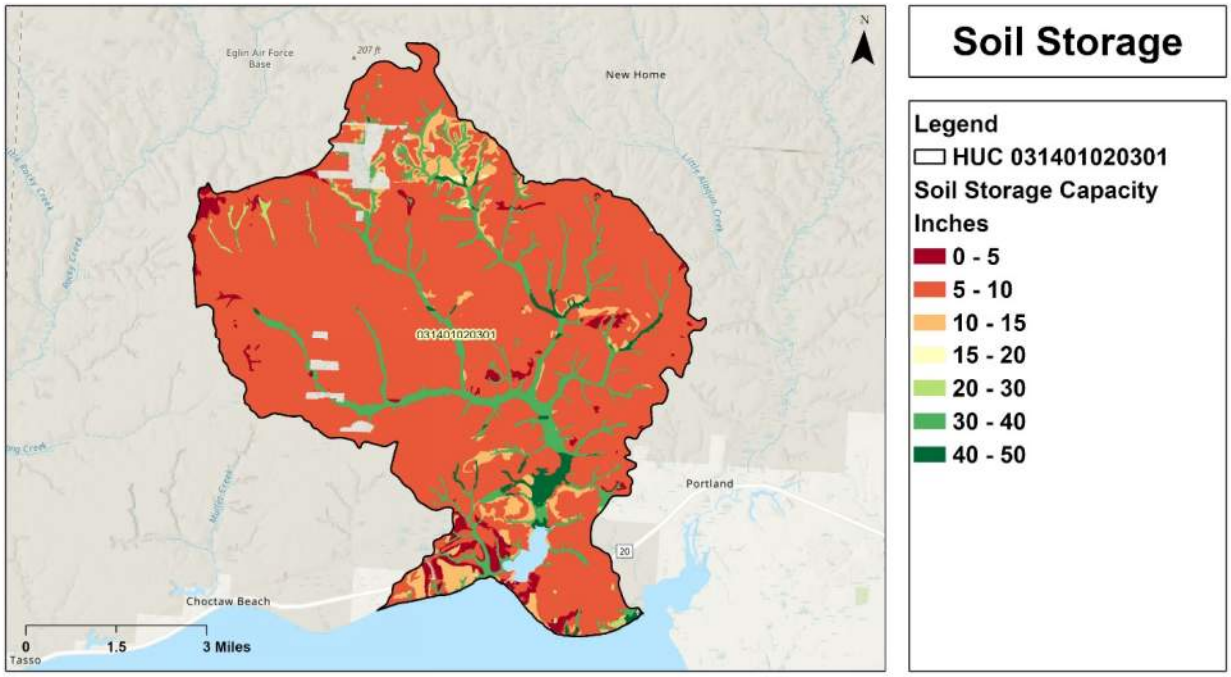

Figure 17. Water storage capacity of soil for the HUC 031401020301 (inches), processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

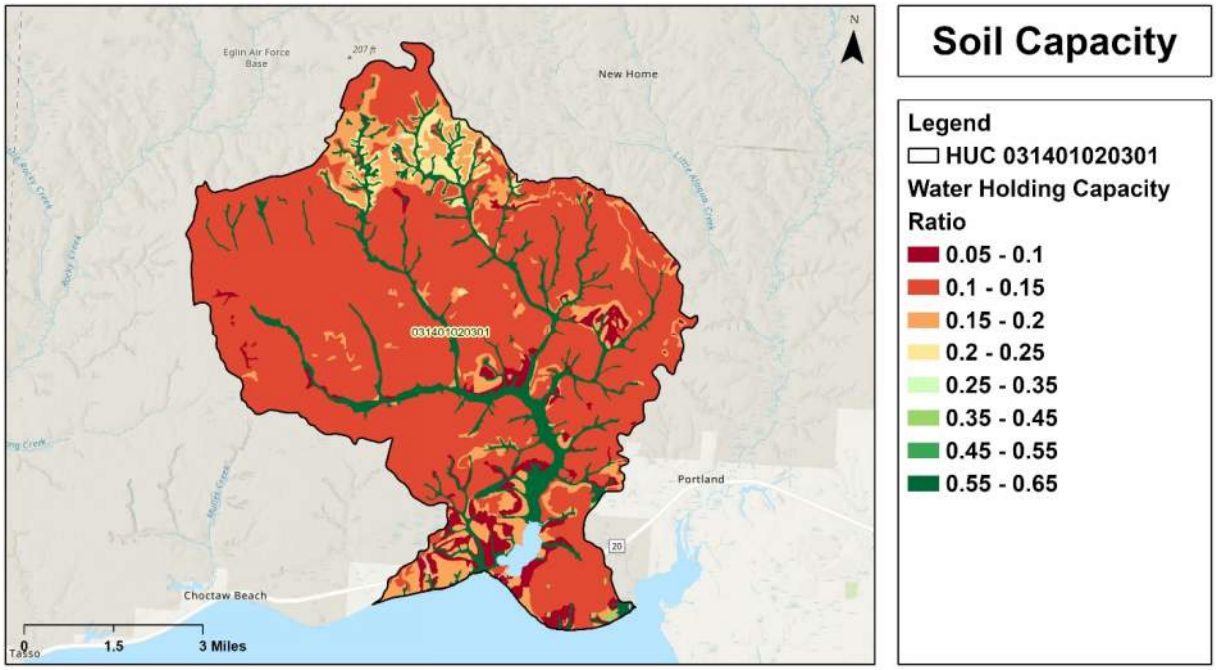

Figure 18. Water Holding Capacity (ratio) for the HUC 031401020301, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

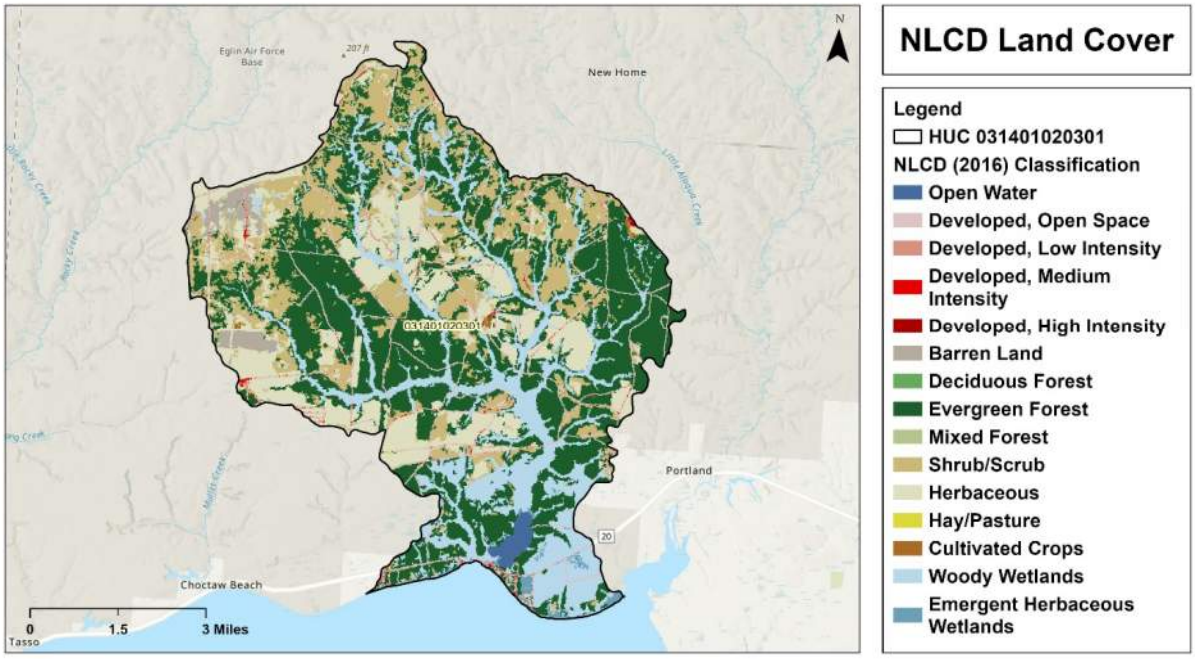

Figure 19. Land use in the HUC 031401020301 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

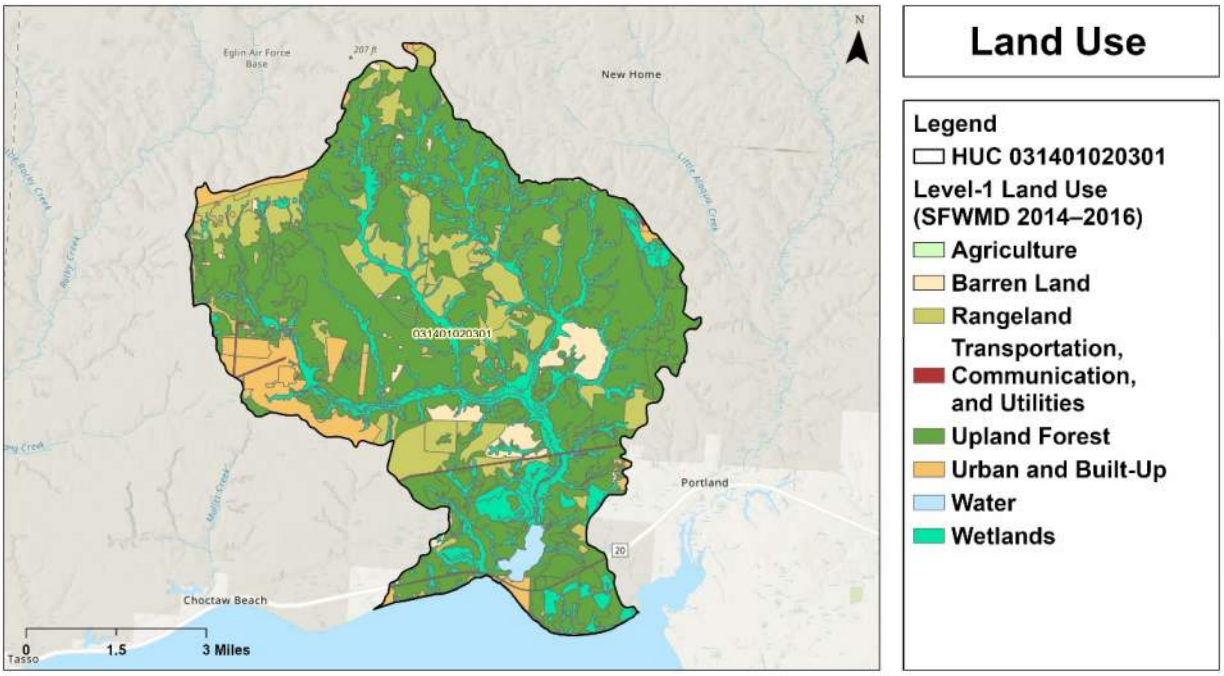

Figure 20. Land use in the HUC 031401020301 (from the (2023 Florida Geographic Data Library (FGDL))database), processed by FAU.

In the HUC sub-watershed, the predominant land cover is upland forest, accounting for 60.35% of the area. Wetlands comes in second at 11.63%, followed by urban and built-up at 10.83%, and rangeland at 9.58%, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031401020301 sub-watershed (2023 Florida Geographic Data Library (FGDL))

Level 1 Land Use Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	10.91	0.02%
Barren Land	966.41	1.99%
Rangeland	4651.72	9.58%
Transportation, Communication, and Utilities	515.69	1.06%
Upland Forest	29303.69	60.35%
Urban and Built-Up	5256.64	10.83%
Water	2205.63	4.54%
Wetlands	5646.34	11.63%
Grand Total:	**48557.03**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

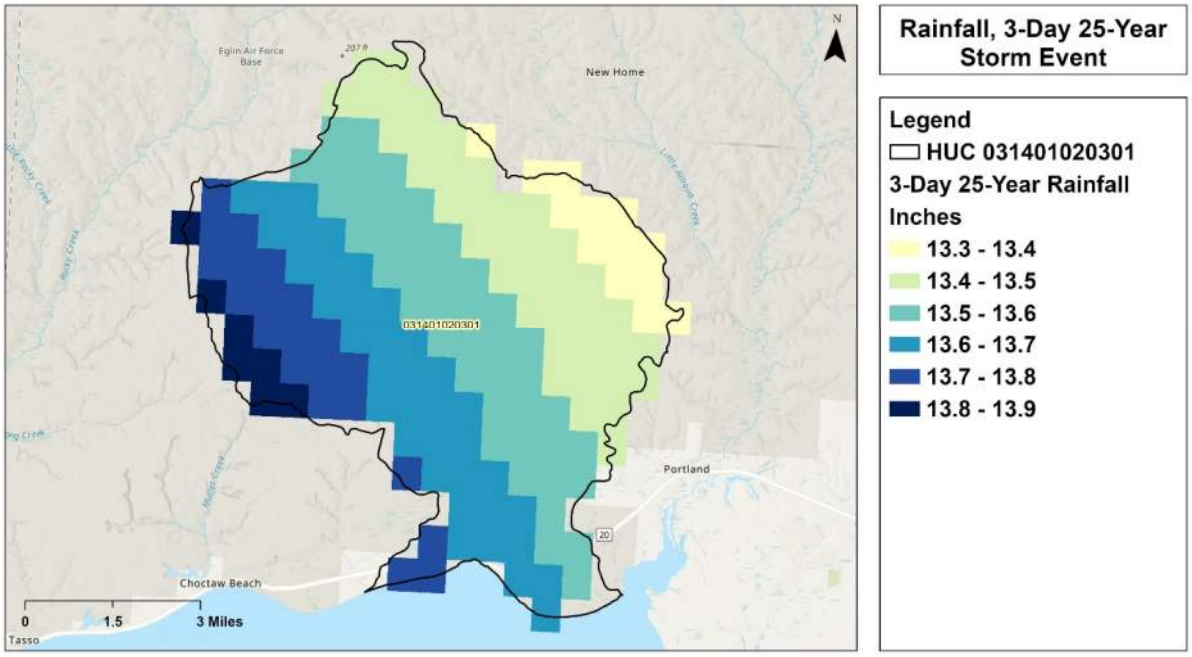

Figure 21. Rainfall distribution map across HUC 031401020301 sub-watershed, for 3-day 25-year storm event, processed by FAU.

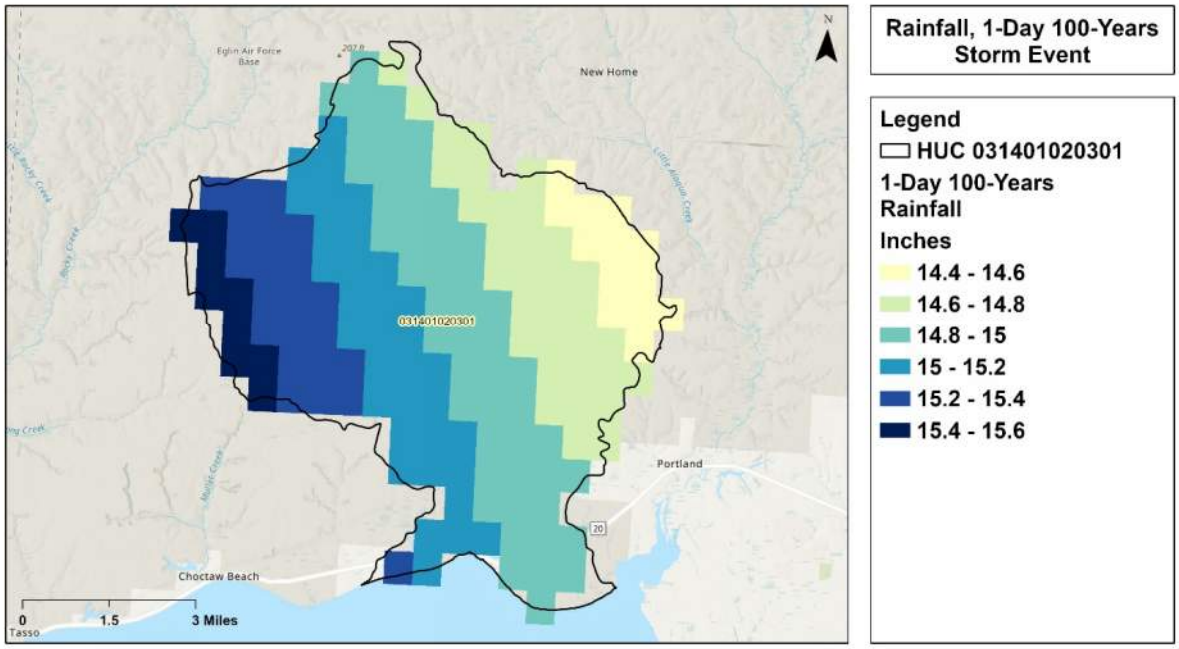

Figure 22. Rainfall distribution map across HUC 031401020301 sub-watershed, for 1-day 100-year storm event, processed by FAU.

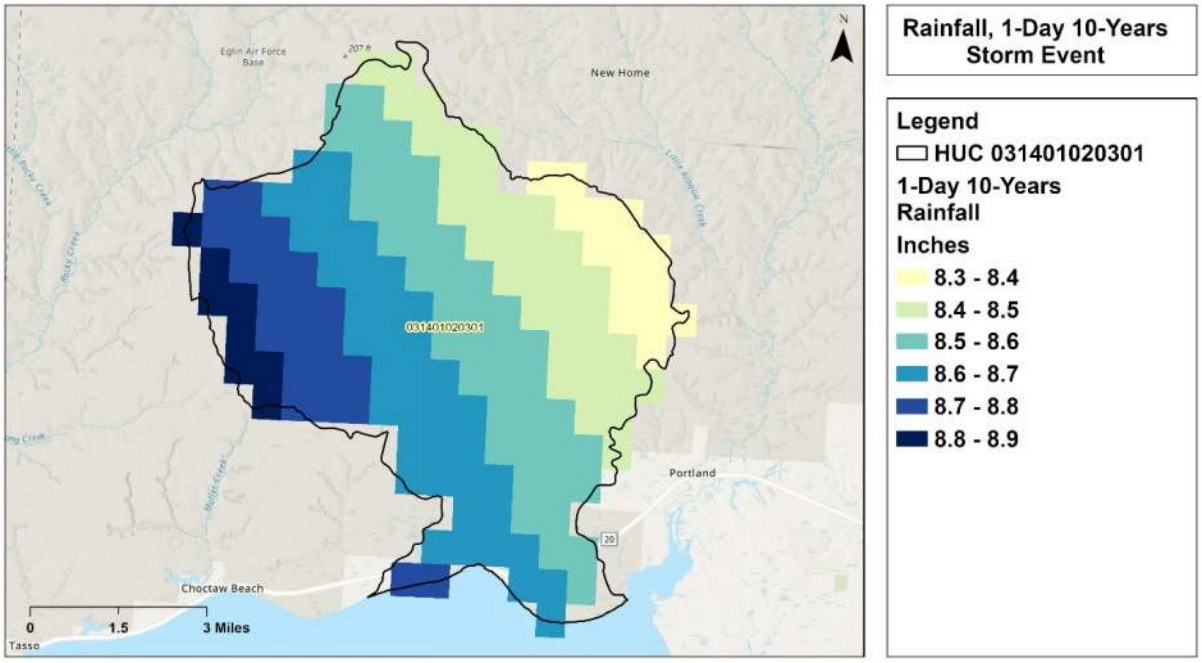

Figure 23. Rainfall distribution map across HUC 031401020301 sub-watershed, for 1-day 10-year storm event, processed by FAU.

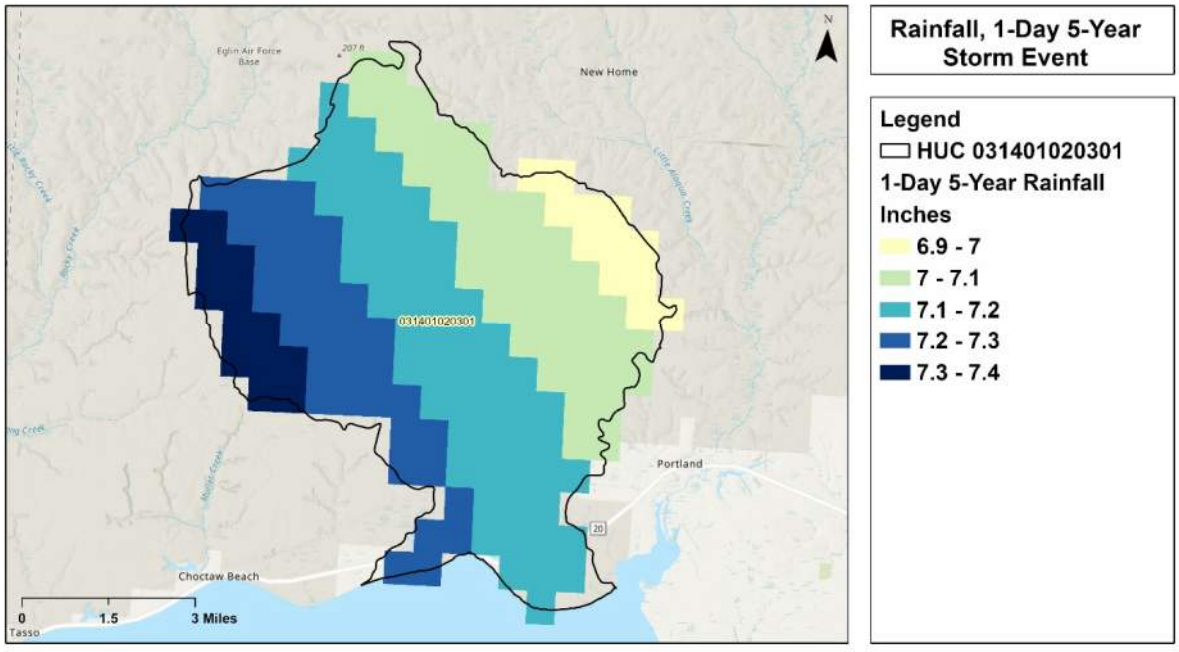

Figure 24. Rainfall distribution map across HUC 031401020301 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land

cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

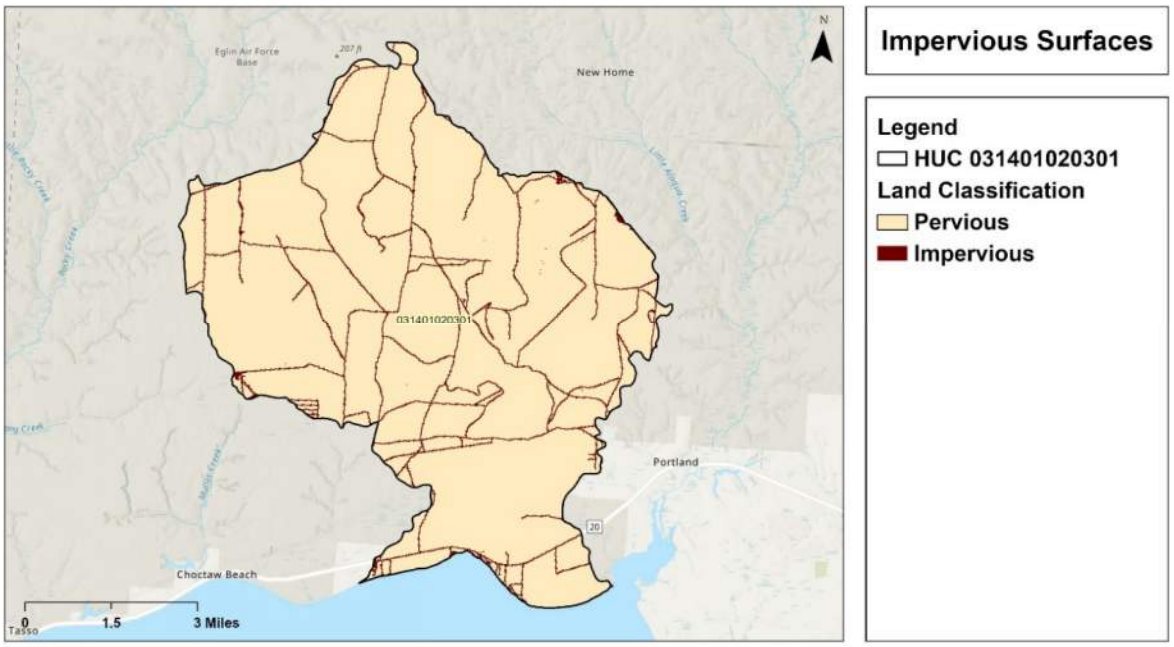

Figure 25. Impervious area map for the HUC 031401020301 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

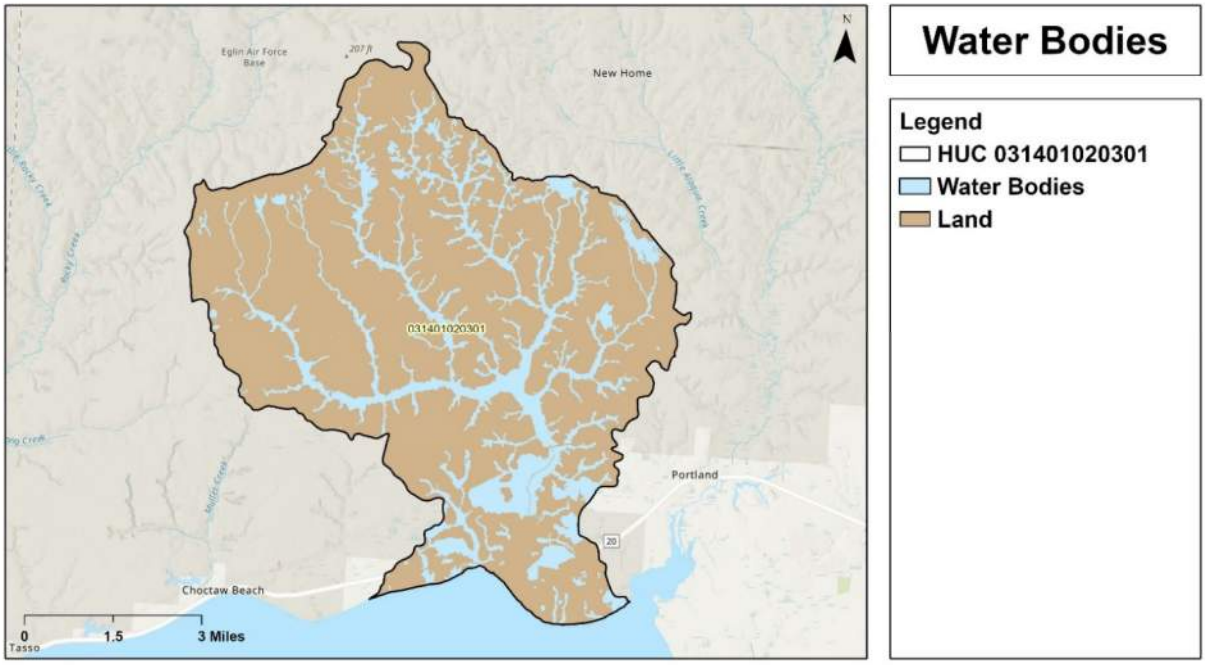

Figure 26. Water bodies map for the HUC 031401020301 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs,

property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

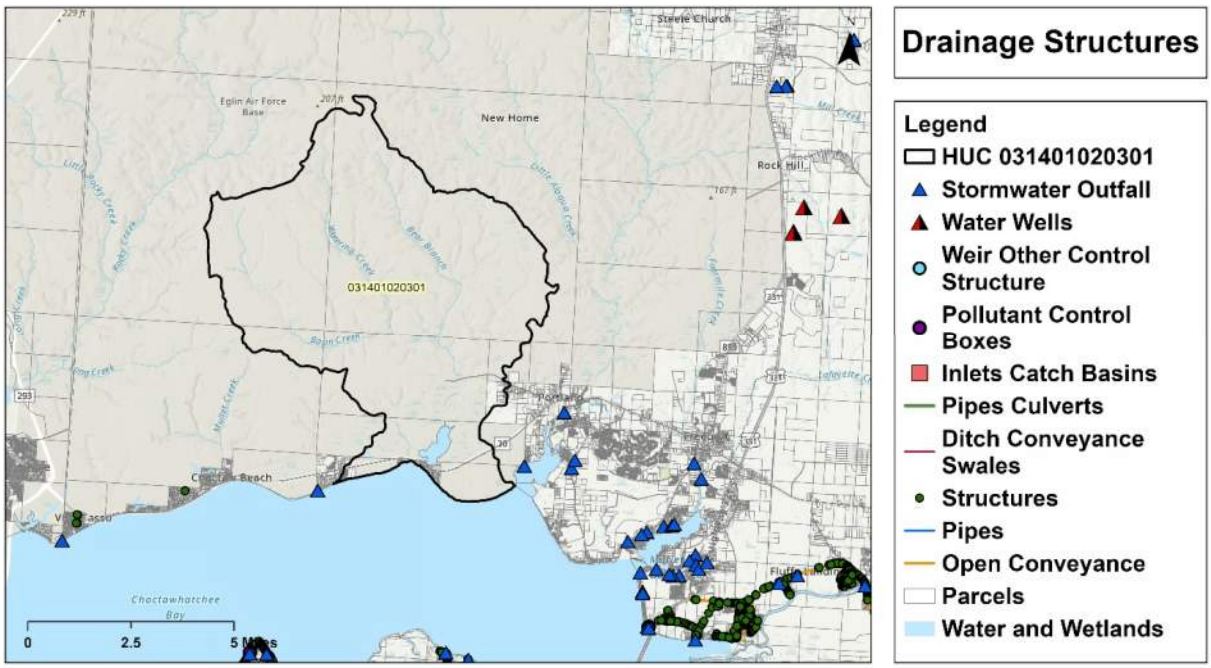

Figure 27. Stormwater Infrastructure for the HUC 031401020301. Processed by FAU.

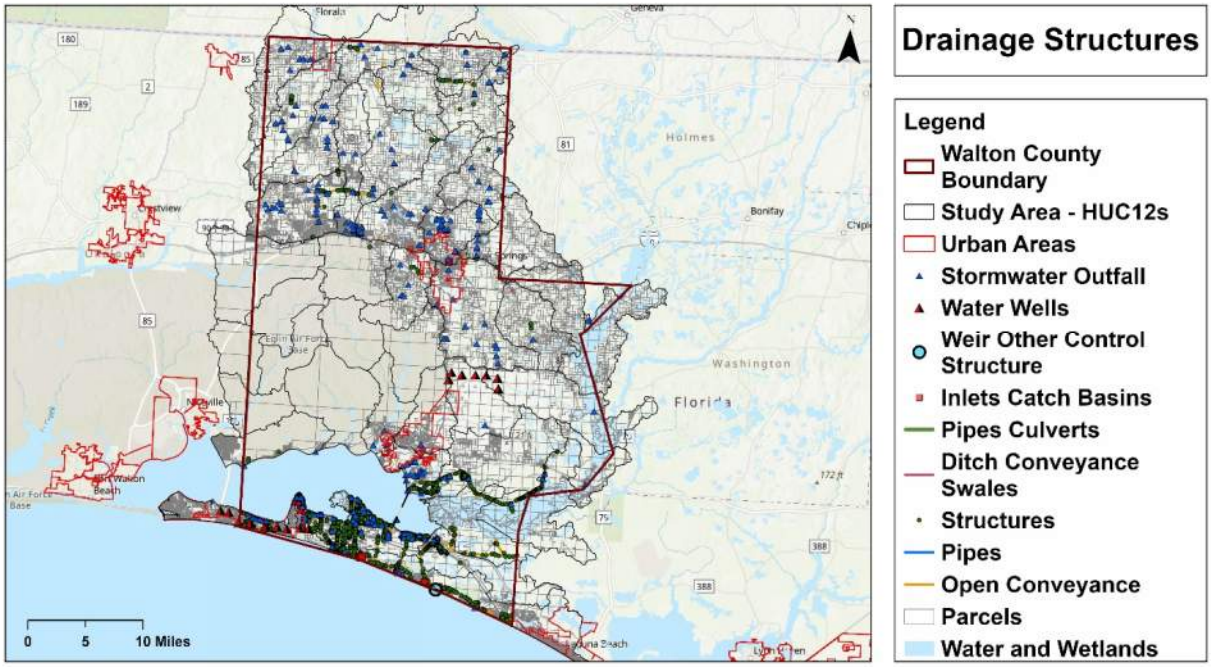

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

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1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401020301 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species

while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

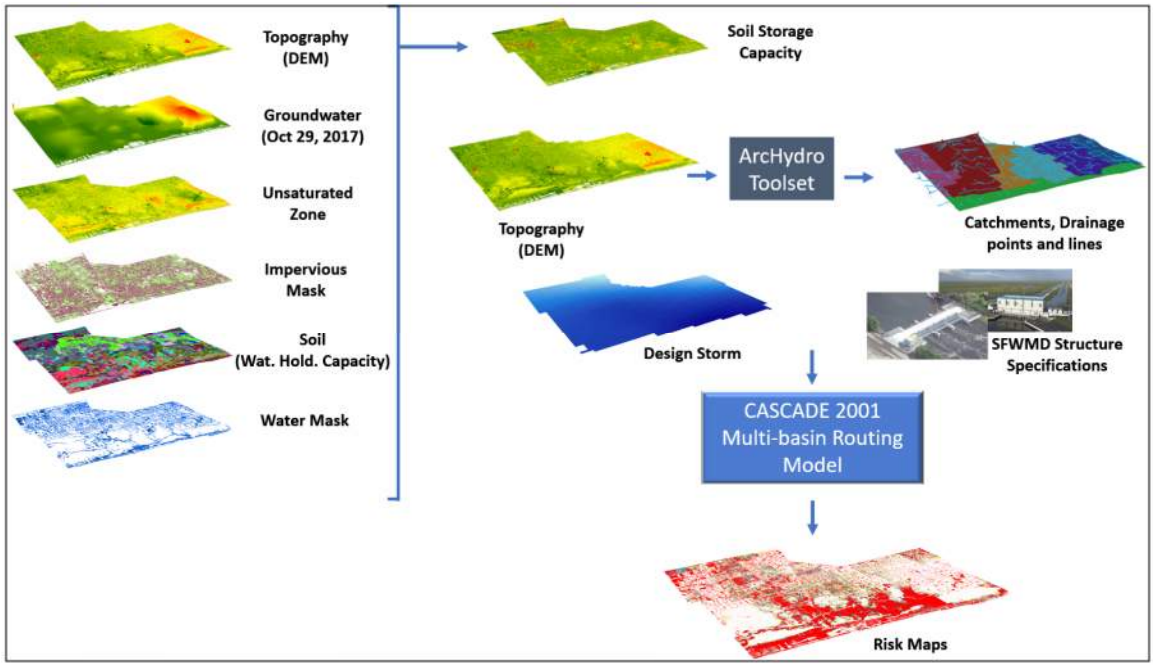

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are

critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

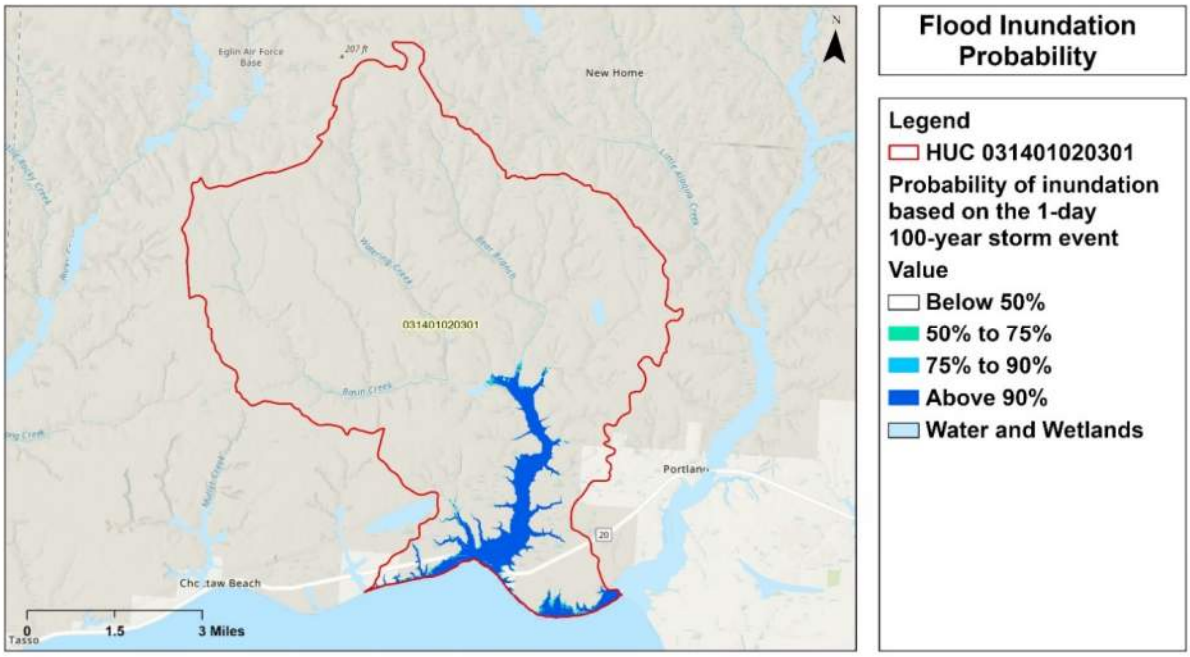

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401020301, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate

the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not

eligible for rehabilitation assistance under Public Law 84-99. here are no levees/dams listed in the sub-watershed study area.

2.3 Future Challenges of Sea Level Rise and Climate Change

Global observations from satellites and long-term data collection have made it possible to document and analyze patterns in the Earth's climate. Scientific analysis of the impact of these changes has helped to improve the understanding of future flood hazard driving forces and long-term impacts on human activities and watershed master planning (http://www.research.noaa.gov/climate/t_observing.html). Examples of impacts are rising global average air and ocean temperatures, increased and earlier snow and ice melt, shorter subtropical rainy seasons, shifted seasons, sea level rise and greater variations in temperature and precipitation (IPCC, 2013; Freas et al., 2008; Marshall et al., 2004; Bloetscher et al., 2010). Marshall et al. (2004) specifically focused on the Florida peninsula to predict changes in rainfall and warmer temperatures but interspersed lower low temperatures due to the potential loss of wetlands.

Future changes in climate will add to the existing impacts, at a time when the population of the state is expected to nearly double by 2030. Additional research and high-resolution climate modeling for the Florida peninsula and local jurisdictions is needed to help guide long-term plans like WMPs. Rainfall appears to be decreasing and temperatures rising (see **Error! Reference source not found.**).

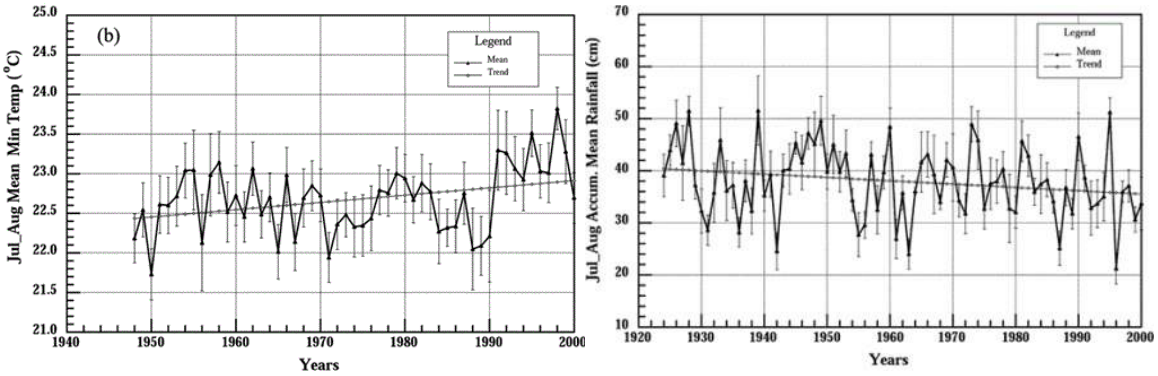

Figure 31. Change in average rainfall and change in average temp 1924 to 2000. Note the reversed trend, which means groundwater input variability is lessened. Source: Marshall et al., 2004.

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as

sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3 feet. Accompanying these drivers are potential changes in storm frequency and intensity, desertification, population migration, ocean acidification and coastal flooding (IPCC, 2007), exacerbated by the land cover and land use changes, which are substantially impacted by the fluxes, timing and quality of precipitation (Adrians et al., 2003; Scanlon et al., 2005; Marshall et al., 2004; Salmun and Molod, 2006), and leading to changes in the timing of peak flows and volumes (Richey and Costa-Cabral, 2006).

The results of these climatic changes are likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly An outcome of these climatic patterns is that during the past 140 years, an increase in sea levels has been observed (Bloetscher, 2012), a worrying pattern since sea level rise is a permanent phenomenon, that can be catastrophic to low lying areas in the long-term. The question is how much and how soon? Various studies (Bindoff et al., 2007; Domingues et al., 2008; Edwards, 2007; Gregory, 2008; Vermeer and Rahmstorf, 2009; Jevrejeva, Moore and Grinsted, 2010; Bloetscher, 2010, 2011; IPCC, 2007; Heimlich et al., 2009) indicate large uncertainty in projections of sea level rise by 2100. Gregory et al. (2012) note that during the last two decades, the global rate of sea level rise has been larger than the 20th-century time-mean, and Church et al. (2011) suggested that the cause was increased rates of thermal expansion, glacier mass loss, and ice discharge from icesheets. Gregory et al. (2012) suggested that there may also be increasing contributions to global sea level rise from the effects of groundwater depletion, reservoir impoundment, and loss of storage capacity in surface waters due to siltation. Measurements of Florida's east coast (Maul, 2008) show an average rate of sea level rise of 2.27 ± 0.04 mm per year from 1915 to 1992 based on tide gauge readings. Analyzing the tidal gauge readings for Florida shows that:

1. Florida average sea level rise is 2.10 ± 0.49 mm/yr
2. All but one location is within the 95% confidence limit range (the exception is Panama City where there is evidence of submergence and other land-based issues)

3. None of the Florida sea level rise rates differ statistically
4. Average global sea level rise for 1920-2000 was 2.0 mm/yr – within 95% confidence limit for Florida locations

From 1929 to 1992, over eight inches of sea, with another 6 inches added since 1992, which is already having significant impacts on coastal communities where population growth has increased the need for improved flood management strategies (Bloetscher, 2008; Parkinson, 2010; Zhang et al., 2011, 2011a; NFIP, 2011; Schmidt et al., 2011; Warner et al., 2012).

As a result, the SFRCCC (2015) adopted USACE's methodology to derive scenarios of sea level change intermediate to high rates of sea level rise for years 2030 (3" to 7") and 2060 (9" to 24") as the consensus projection to guide future planning. The path keeps increasing – now 14 inches since 1929 (**Error! Reference source not found.**) caused by thermal expansion of the ocean and melting ice caps (Jevrejeva et al., 2010; Vermeer and Rahmstorf, 2009). Sea level rise is a major concern in Florida, including Walton County, since the majority of the state's population live on the coast, involving most major commercial, residential, and economic enterprises. **Error! Reference source not found.** demonstrate the estimated sea level change for Panama City, considering the predictions of NOAA 2017. For NOAA high scenario SLR change scenario, the estimated level change is higher than 8 ft., while for the intermediate and low scenarios are about 3.9 feet and 1.7 feet respectively.

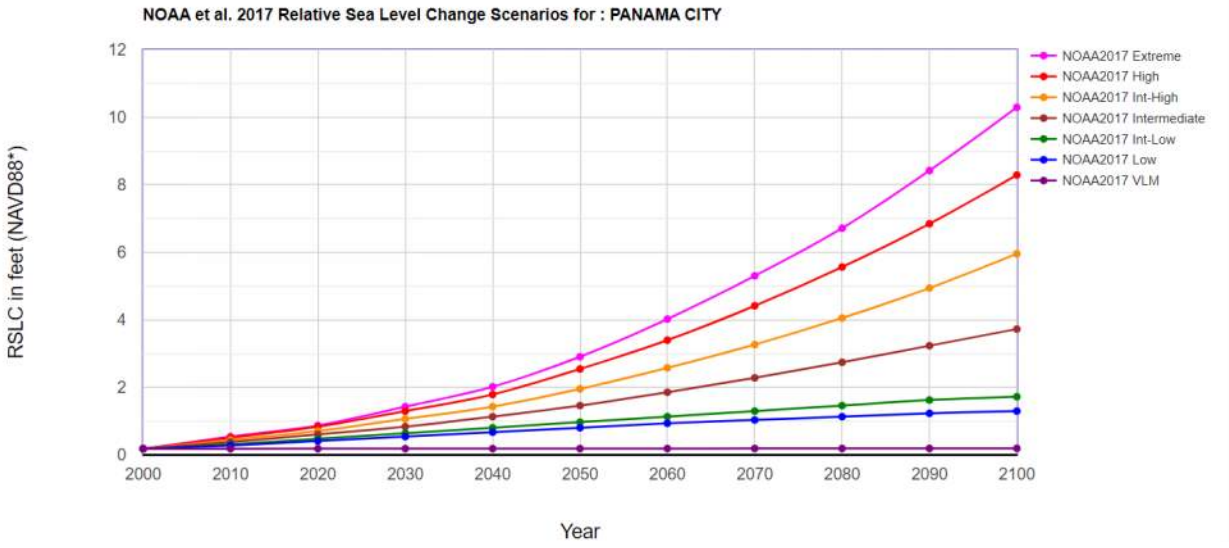

Figure 32. Relative Sea Level Change Scenarios for gauge 8729108, Panama City, FL. Source: NOAA 2017 (https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html).

NOAA (2017) outlines five scenarios for sea level rise. The NFIP proposes the use of the intermediate high projection, which is 1.2 meters or 4 ft globally from current sea level elevations (**Error! Reference source not found.**).

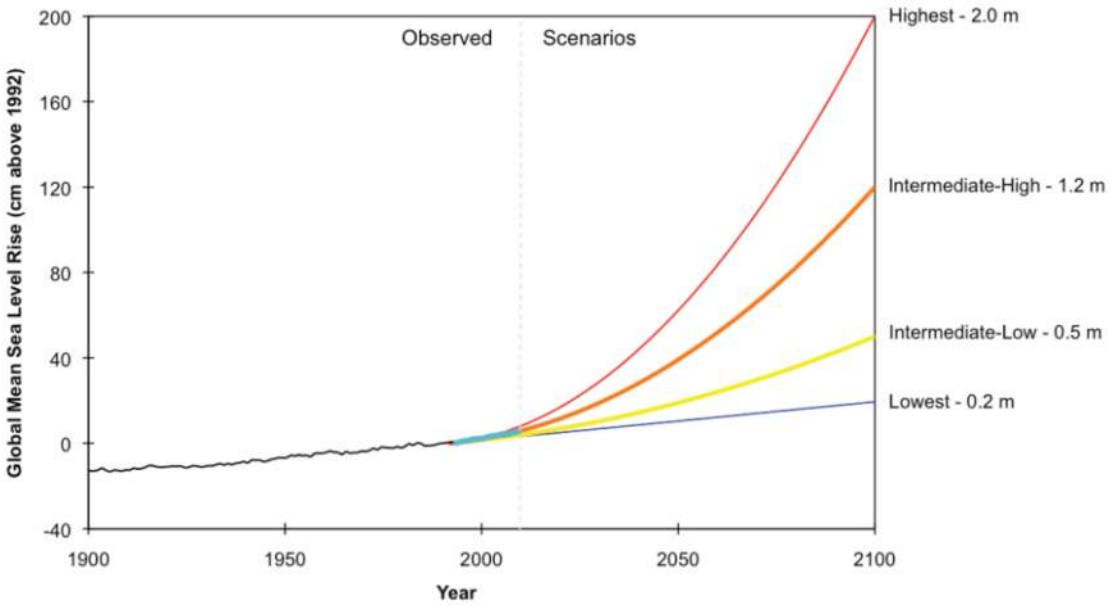

Figure 33. Graphic of global sea level rise projections from NOAA (2017). Source:https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

As sea level rises, access to roads, bridges, rail, and transit could be at risk of flooding, causing the effects of sea level rise to spread indirectly throughout the entire transportation network, affecting the overall system performance. For example, the flooding of a critical road or facility access can cause a shifting of traffic flow causing congested conditions in other roadways that are not actually flooded. Since the roadway network would be unable to carry the traffic demand, the system would experience operational failure; as a result, causing travel times and delays. Moreover, the inundation of a critical access could cause transportation connectivity problems to essential infrastructure like ports or airports. Transportation infrastructure relies on the effectiveness of flood control and stormwater drainage systems for the transportation corridors. Road integrity relies on adequate drainage. The increased risk of severe flooding in Florida's low-lying terrain can adversely affect transportation infrastructure along the coastline; roads can be inundated, and roadway beds can be damaged. Sea level rise will cause increased water table levels (FDOT, 2012), as regional water tables cannot exist naturally below mean high tide (2 feet in Florida). Adding 3 feet of sea level rise on top of groundwater would compound the risk of flooding in low-lying areas. Road bases below 5 feet NVGD would become saturated under this scenario, likely causing premature base failure. As soil storage capacity is diminished due to rising groundwater elevations associated with sea level rise, the potential for more frequently flooded roadways would likely damage pavements (FDOT, 2012). Hence sea level rise must be accounted for in WMPs in coastal areas. To allow flexibility in the analysis due to the range of increases within the different time periods, an approach that uses incremental increases of 1, 2, and 3 feet of sea level rise is suggested for modeling. The increments can work as threshold values in planning

considerations in terms of allowing planners the ability to know ahead of time where the next set of vulnerable areas will be, to allow for a proactive response approach that can be matched to the observed future rates. Sea level rise is a major concern since nearly half the US population lives within 50 miles of the coast, involving most major commercial, residential, and economic enterprises. The effects of 5 ft sea level rise, King tide, and 1-day 100-year storm event are shown in **Error! Reference source not found.**.

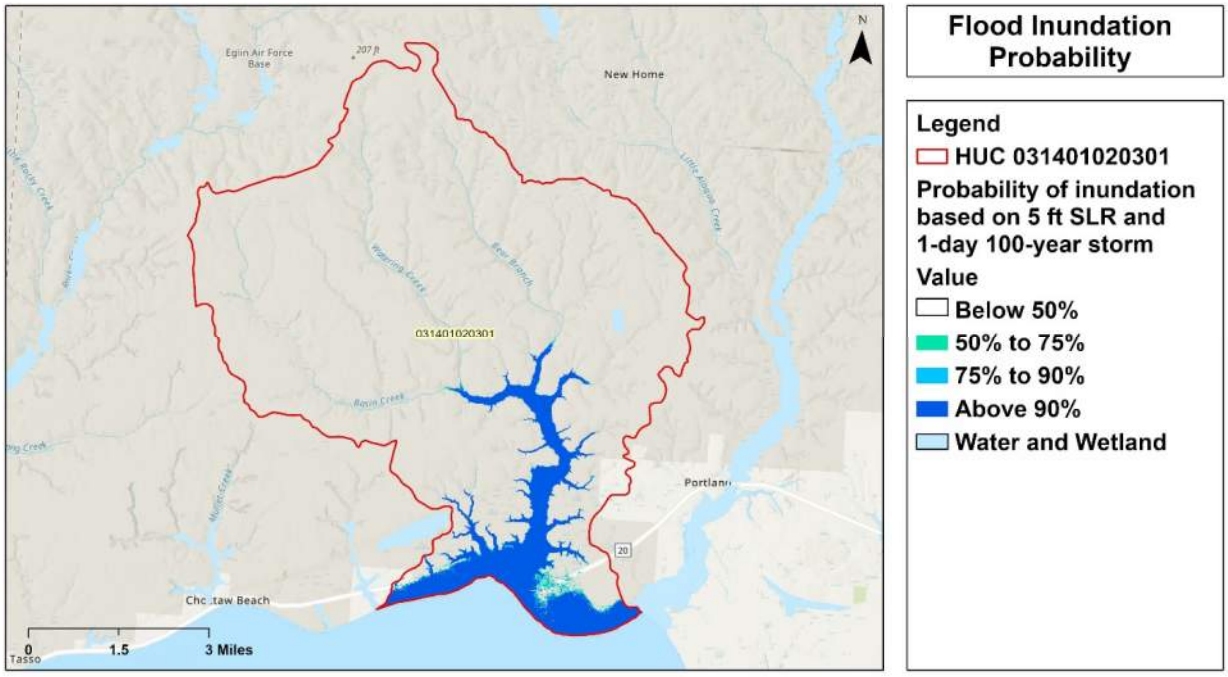

Figure 34. Flood Inundation Probability for a Sea level rise of 5 ft + 1-day 100-year storm event for HUC 031401020301 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Dark blue is area under 5 ft NAVD88 and potentially inundated at the 99th percentile tidal conditions. Processed by FAU.

2.4 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. **3-day 25-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 35)
2. **1-day 100-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 36)

3. **1-day 10-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 37)
4. **1-day 5-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 38)
5. **Sea level rise of 1 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 39)
6. **Sea level rise of 1 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations storm (Figure 40)
7. **Sea level rise of 1 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 41)
8. **Sea level rise of 1 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 42)
9. **Sea level rise of 2 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 43)
10. **Sea level rise of 2 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 44)
11. **Sea level rise of 2 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 45)
12. **Sea level rise of 2 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 46)
13. **Sea level rise of 3 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 47)
14. **Sea level rise of 3 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 48)
15. **Sea level rise of 3 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 49)
16. **Sea level rise of 3 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 50)

17. **Sea level rise of 4 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 51)
18. **Sea level rise of 4 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 52)
19. **Sea level rise of 4 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 53)
20. **Sea level rise of 4 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 54)
21. **Sea level rise of 5 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 55)
22. **Sea level rise of 5 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 56)
23. **Sea level rise of 5 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 57)
24. **Sea level rise of 5 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 58)

In all scenarios, a considerable amount of flooding is noted along the coast and following the waterbodies flow path. As this basin connects to the ocean though Choctawhatchee Bay, SLR scenarios plays an important hole, implying a considered growth as the projected scenario of rising tides rises.

The design storm simulation determined that approximately 4.5% of the HUC total area or 2.04 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 4.8% of the HUC's total area, or 2.16 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 4.2% of the HUC's total area, or 1.90 mi^2, would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 4.1% of the HUC's total area, or 1.85 mi^2, would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401020301 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	43.34	2.04	95.5%	4.5%
1-day 100-year	43.22	2.16	95.2%	4.8%
1-day 10-year	43.47	1.90	95.8%	4.2%
1-day 5-year	43.53	1.85	95.9%	4.1%

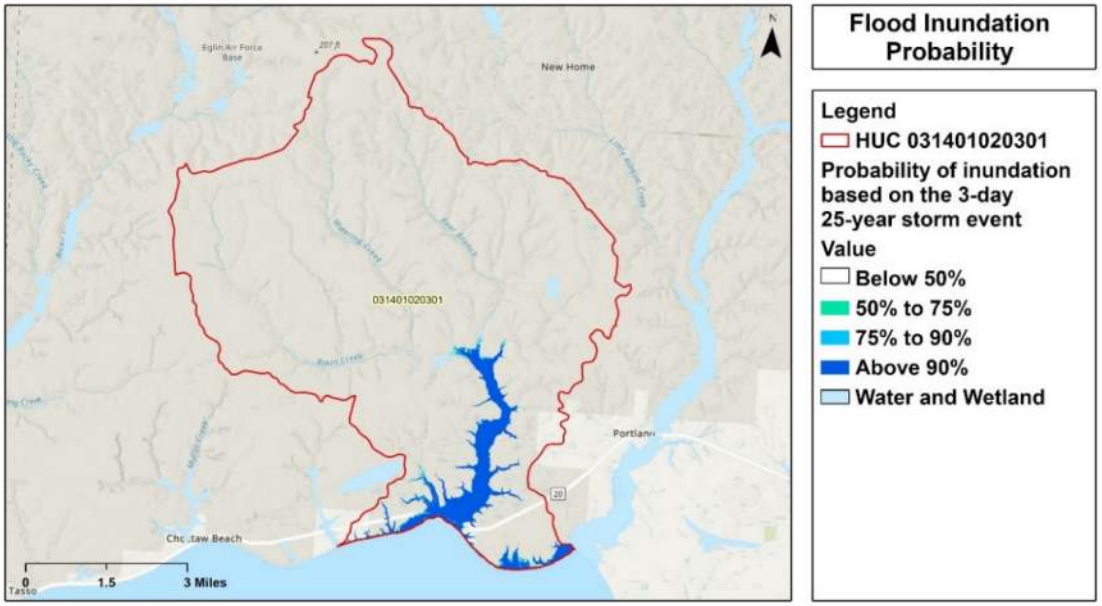

Figure 35. 3-day 25-year storm event for HUC 031401020301 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

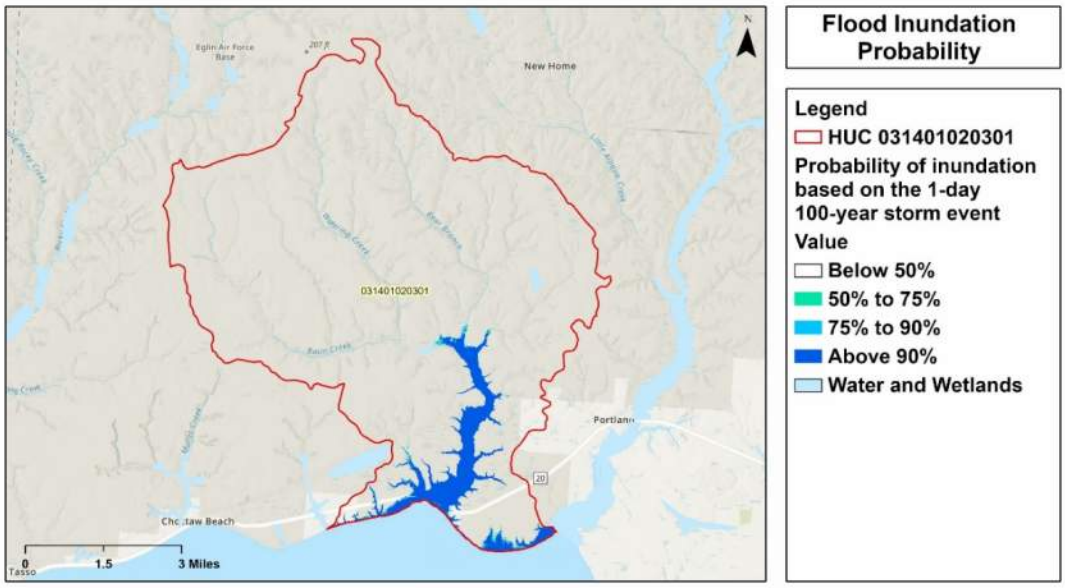

Figure 36. 1-day 100-year storm event for HUC 031401020301 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

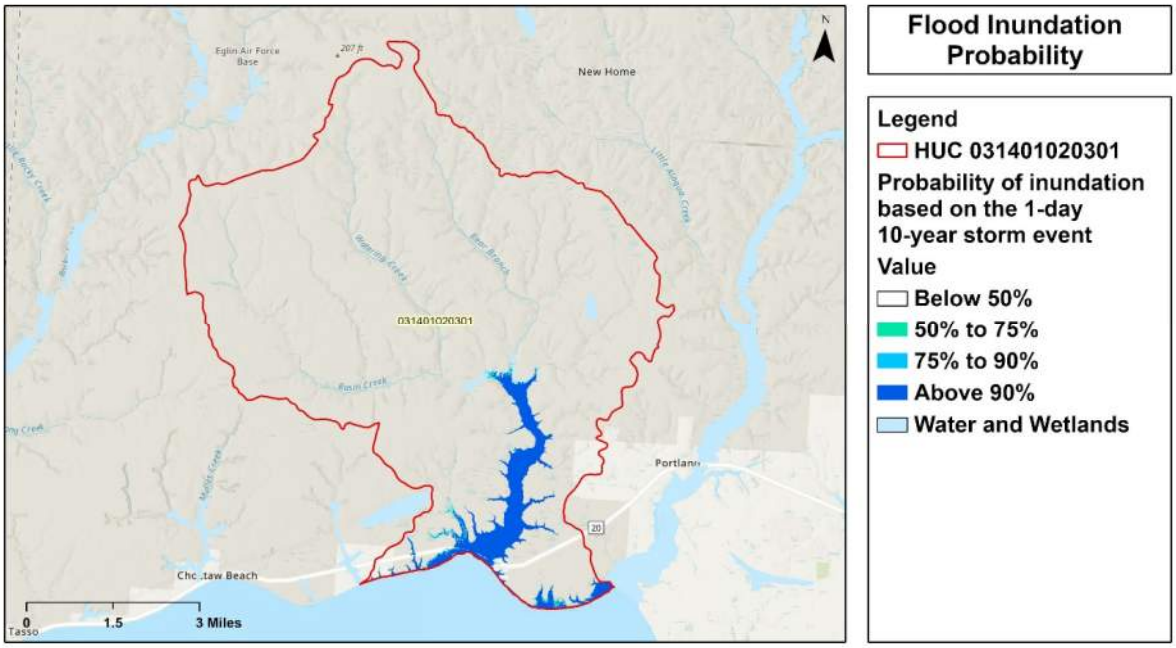

Figure 37. 1-day 10-year storm event for HUC 031401020301 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

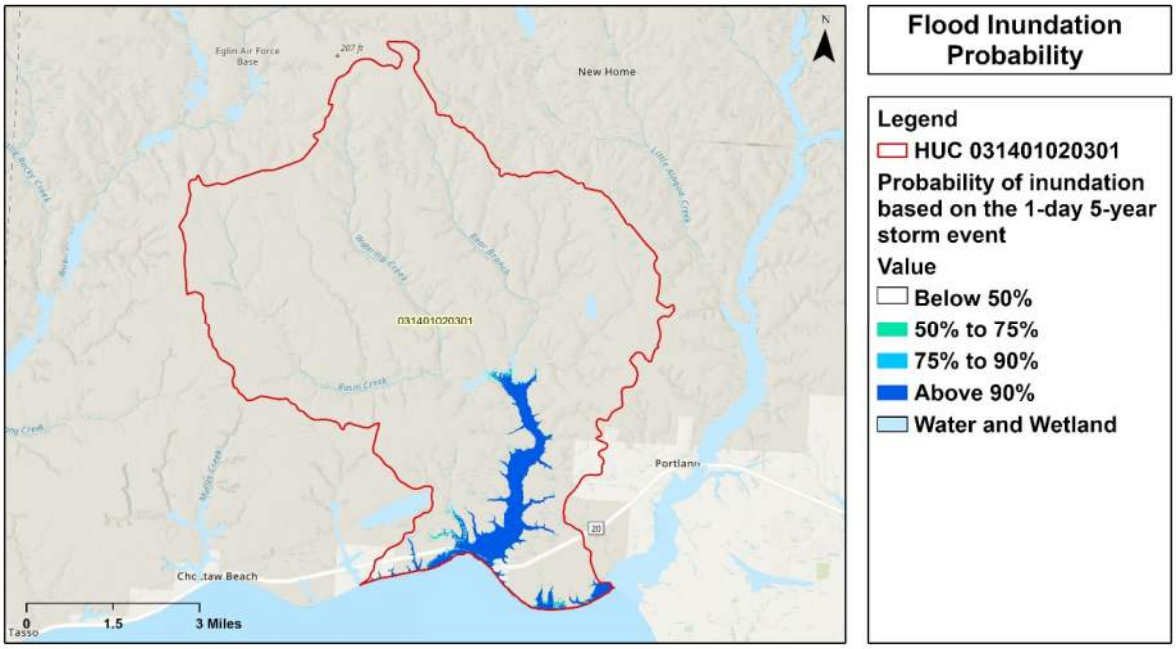

Figure 38. 1-day 5-year storm event for HUC 031401020301 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

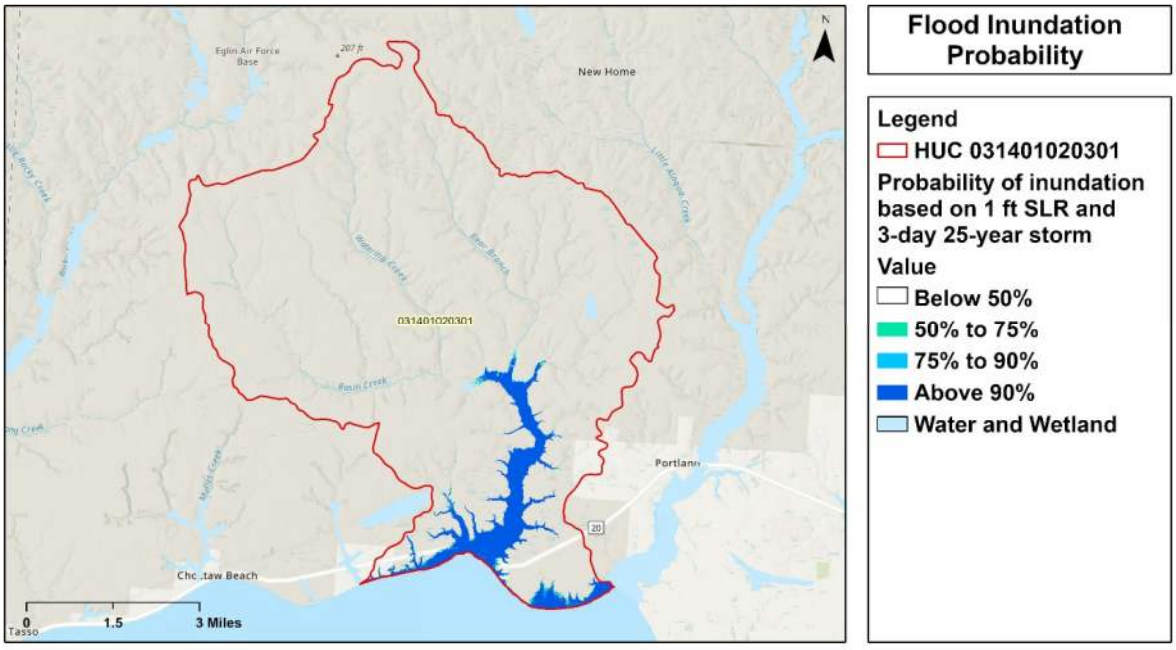

Figure 39. Sea level rise of 1 ft + 3-day 25-year storm for HUC 031401020301 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

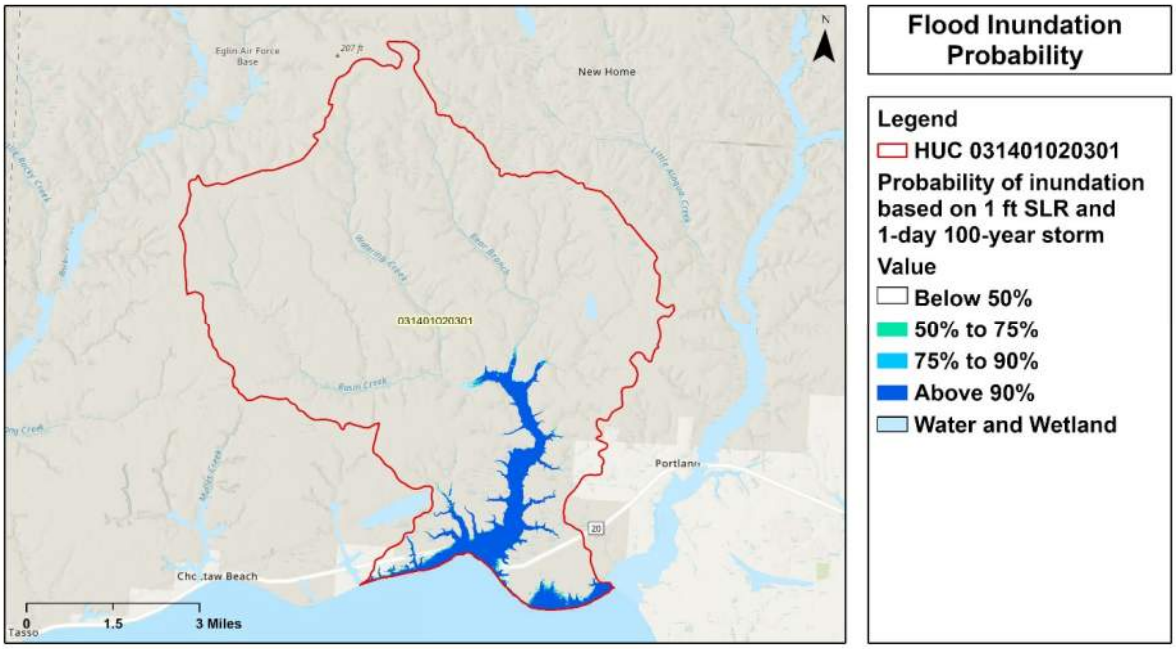

Figure 40. Sea level rise of 1 ft + 1-day 100-year storm for HUC 031401020301 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

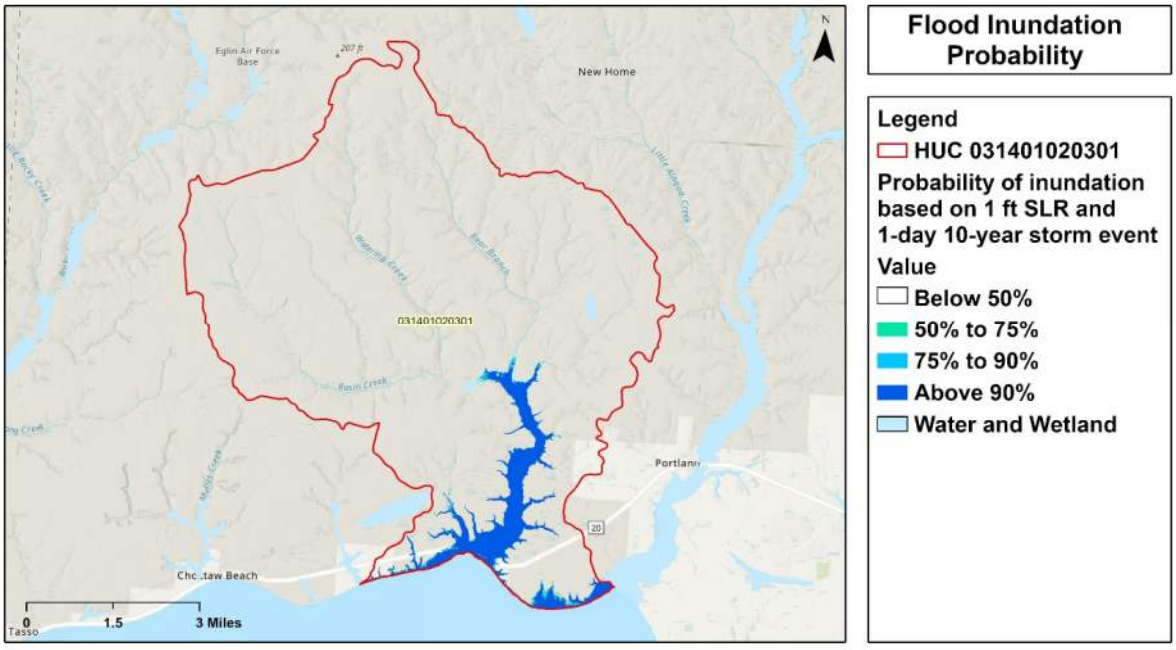

Figure 41. Sea level rise of 1 ft + 1-day 10-year storm for HUC 031401020301 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

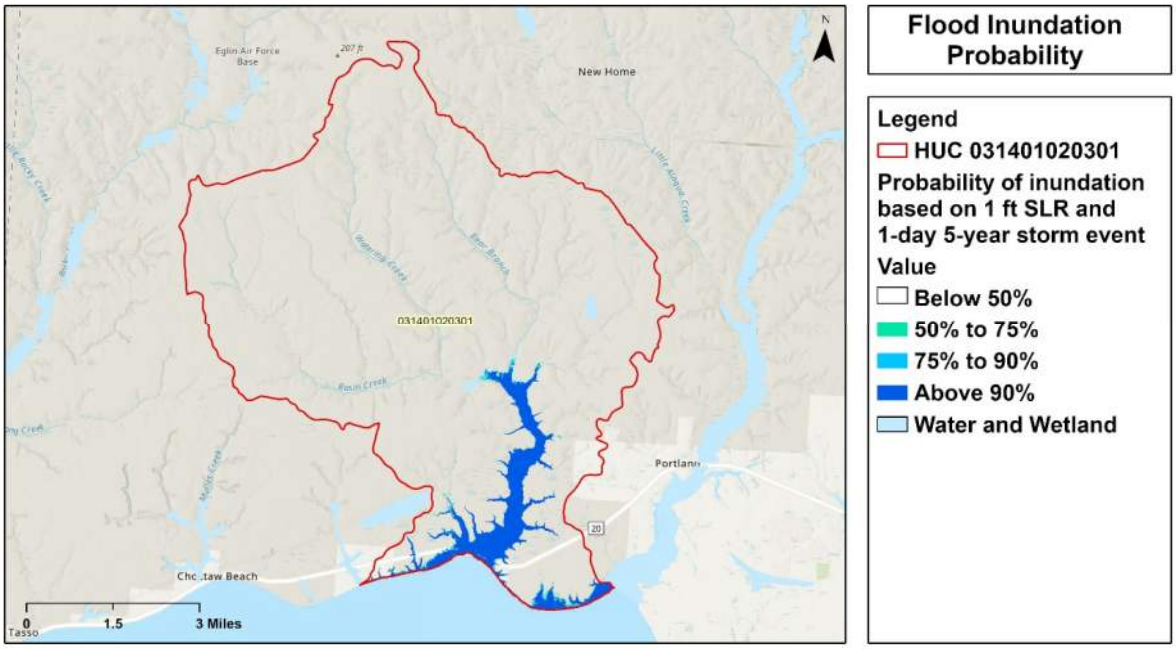

Figure 42. Sea level rise of 1 ft + 1-day 5-year storm for HUC 031401020301 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

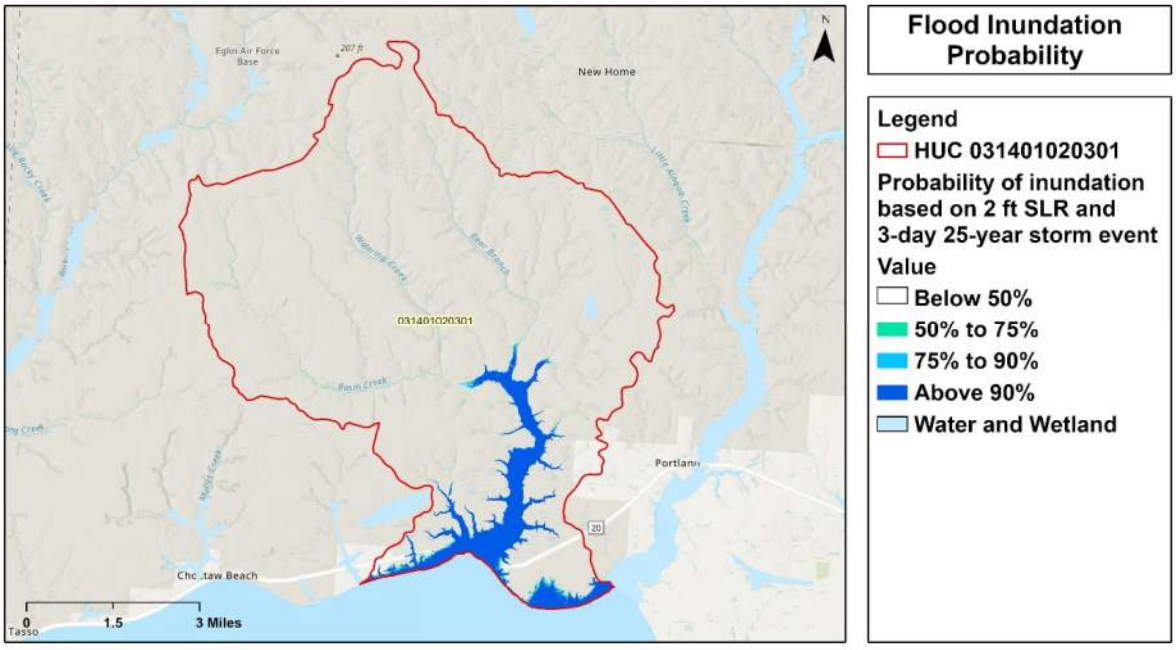

Figure 43. Sea level rise of 2 ft + 3-day 25-year storm for HUC 031401020301 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

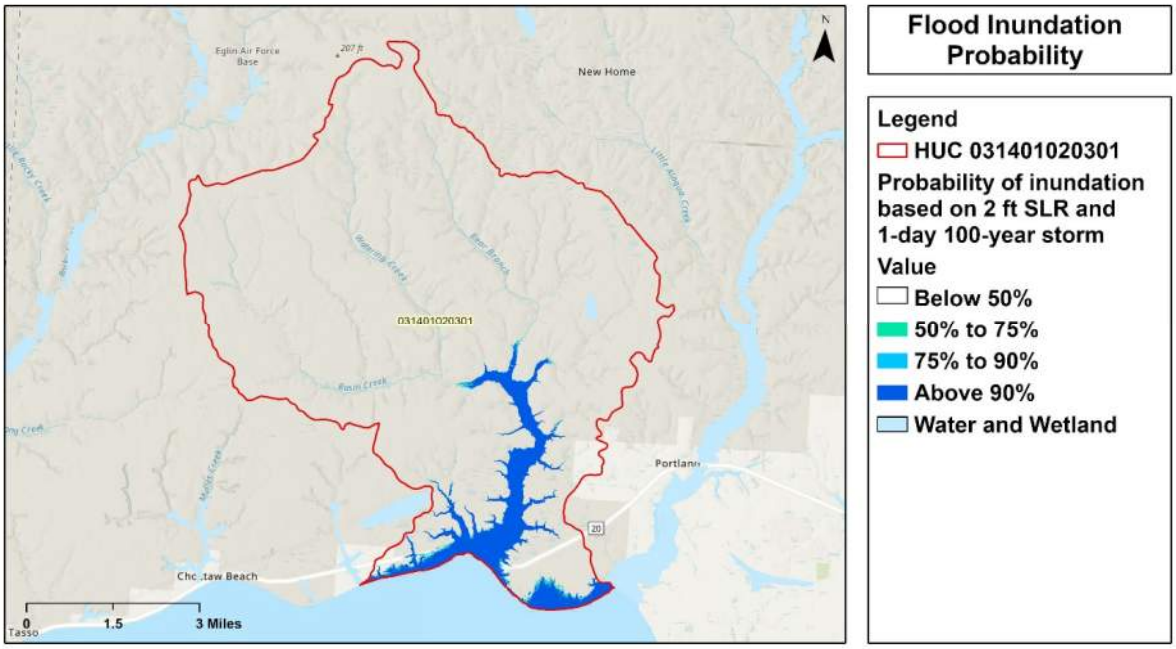

Figure 44. Sea level rise of 2 ft + 1-day 100-year storm for HUC 031401020301 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

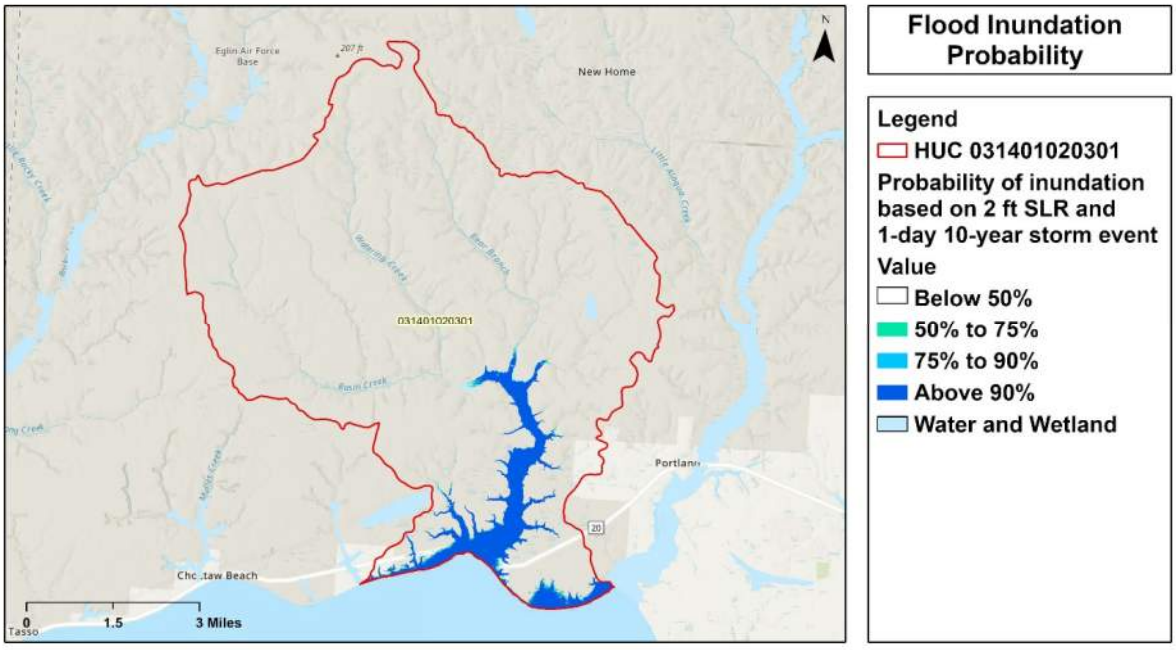

Figure 45. Sea level rise of 2 ft + 1-day 10-year storm for HUC 031401020301 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

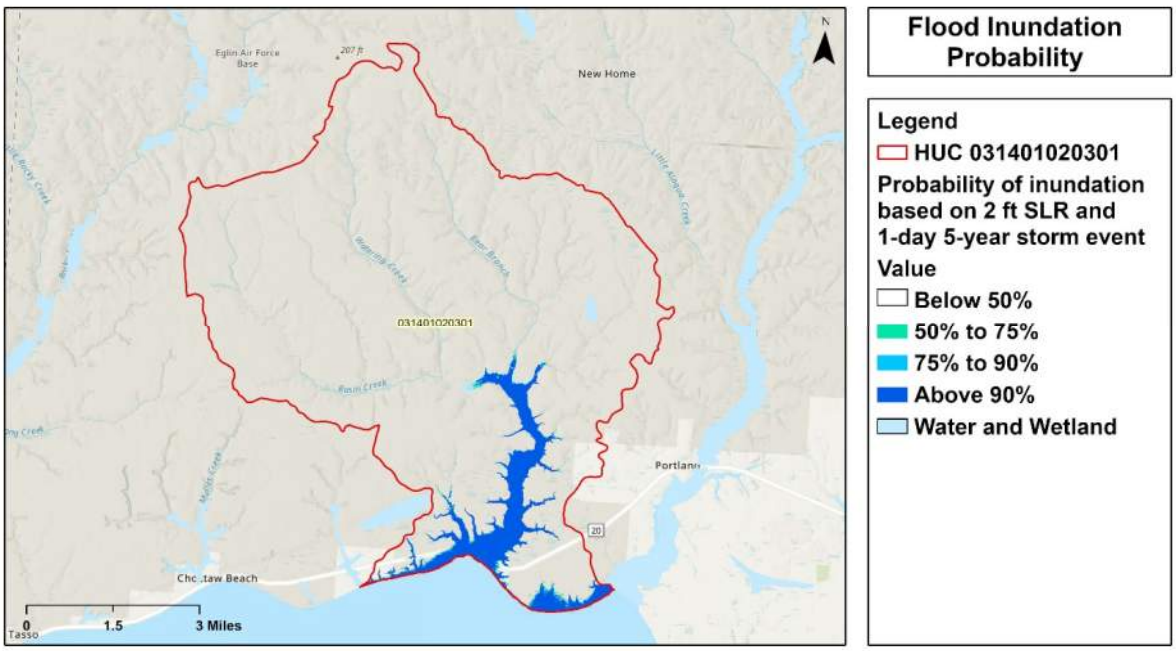

Figure 46. Sea level rise of 2 ft + 1-day 5-year storm for HUC 031401020301 sub-watershed . Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

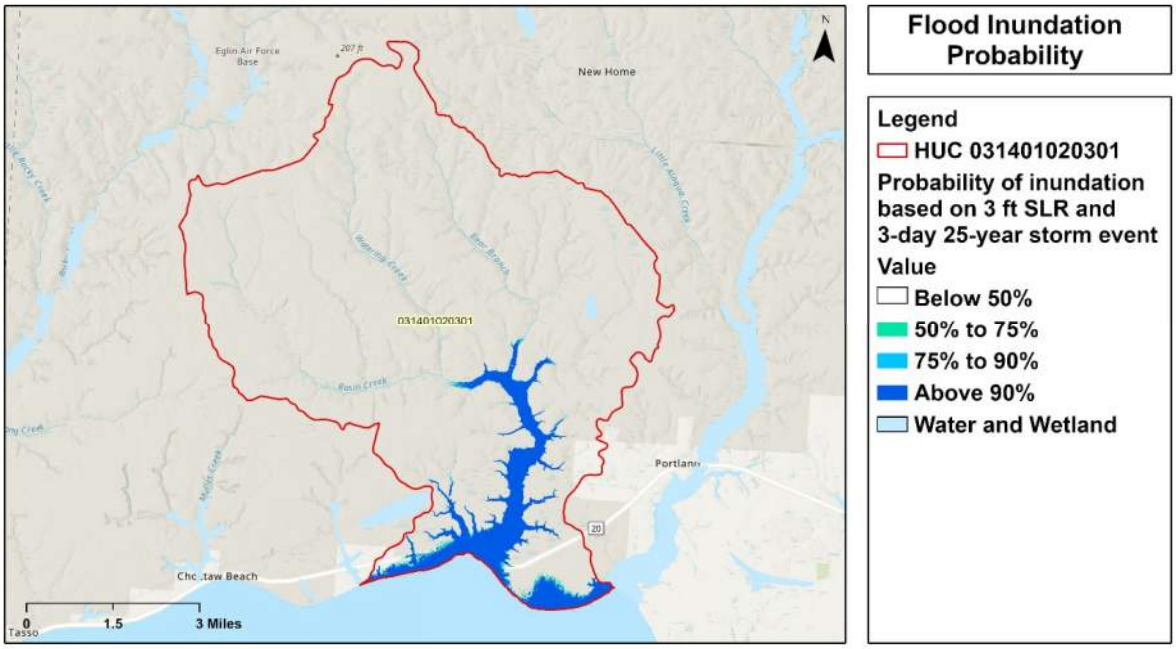

Figure 47. Sea level rise of 3 ft + 3-day 25-year storm for HUC 031401020301 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

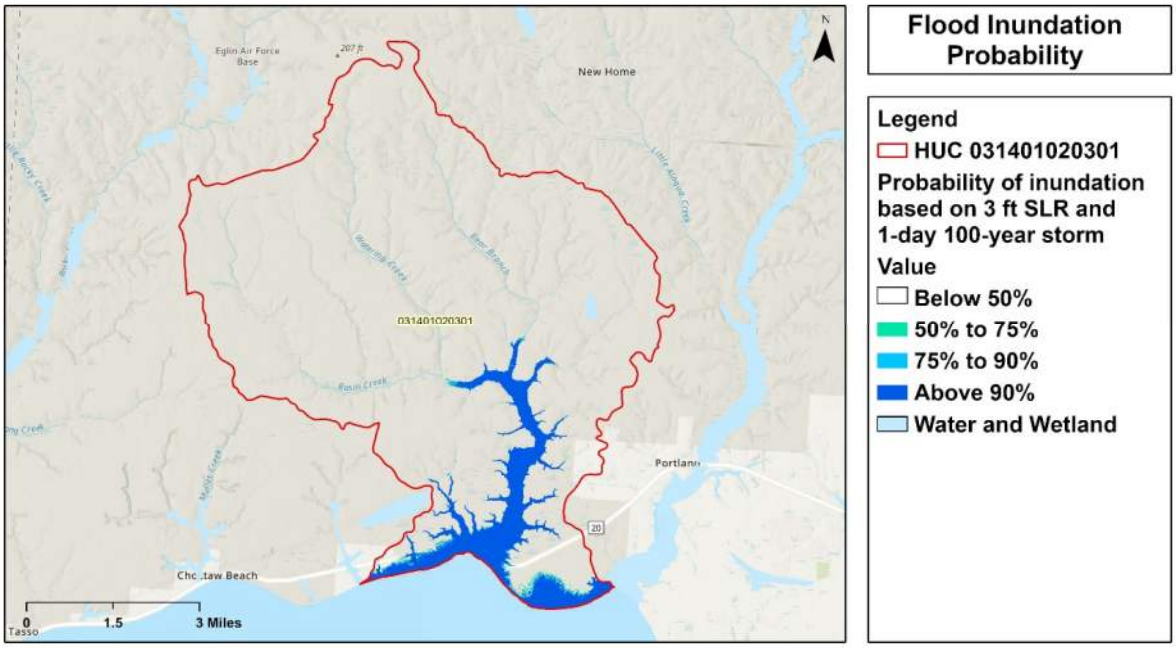

Figure 48. Sea level rise of 3 ft + 1-day 100-year storm for HUC 031401020301 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

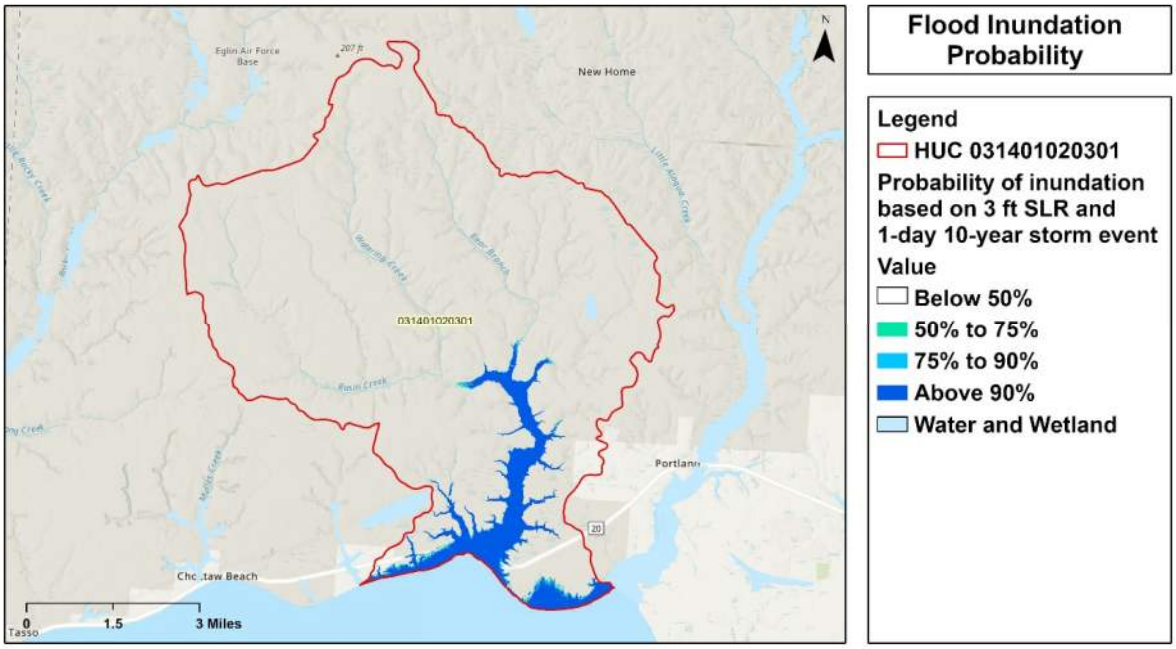

Figure 49. Sea level rise of 3 ft + 1-day 10-year storm for HUC 031401020301 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

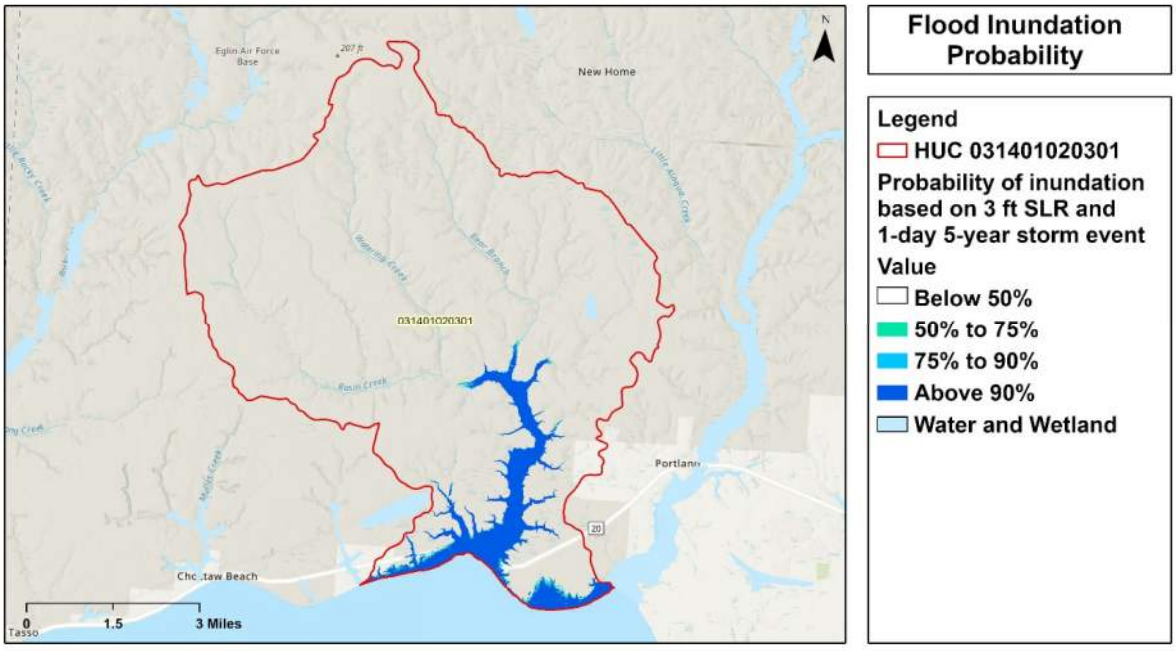

Figure 50. Sea level rise of 3 ft + 1-day 5-year storm for HUC 031401020301 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

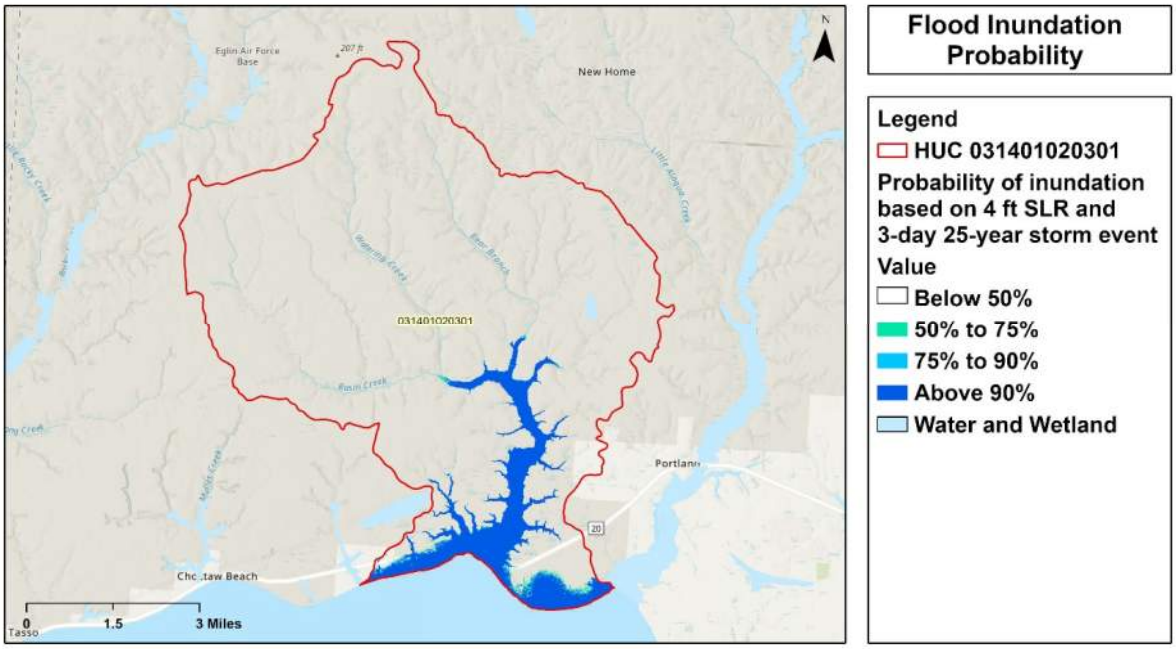

Figure 51. Sea level rise of 4 ft + 3-day 25-year storm for HUC 031401020301 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

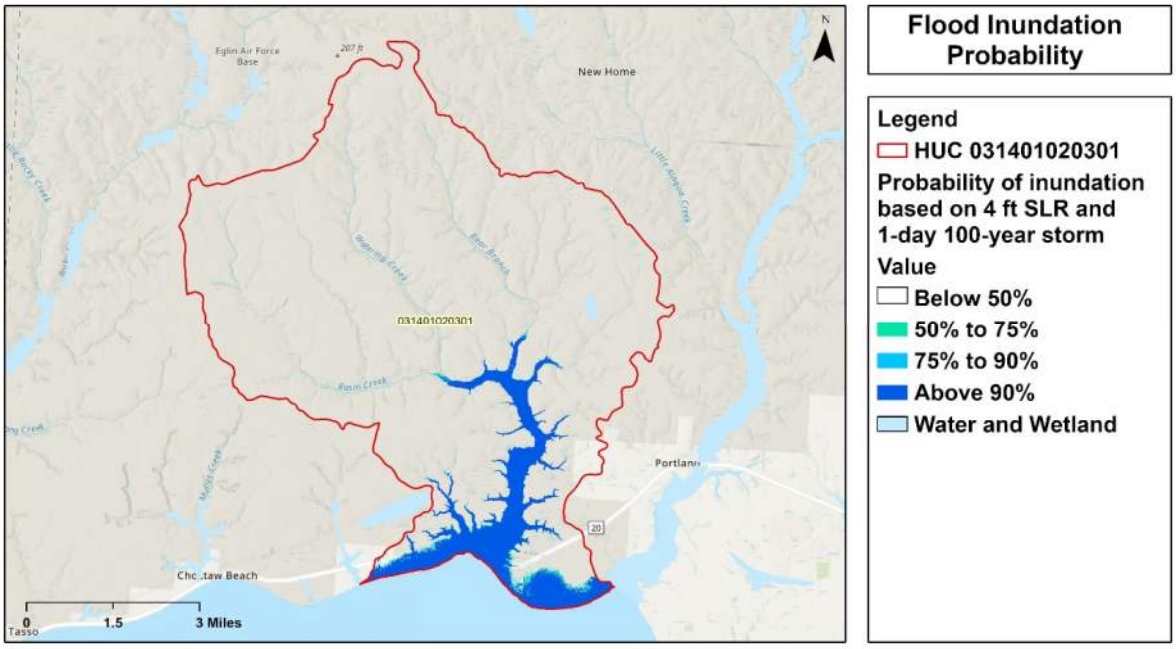

Figure 52. Sea level rise of 4 ft + 1-day 100-year storm for HUC 031401020301 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

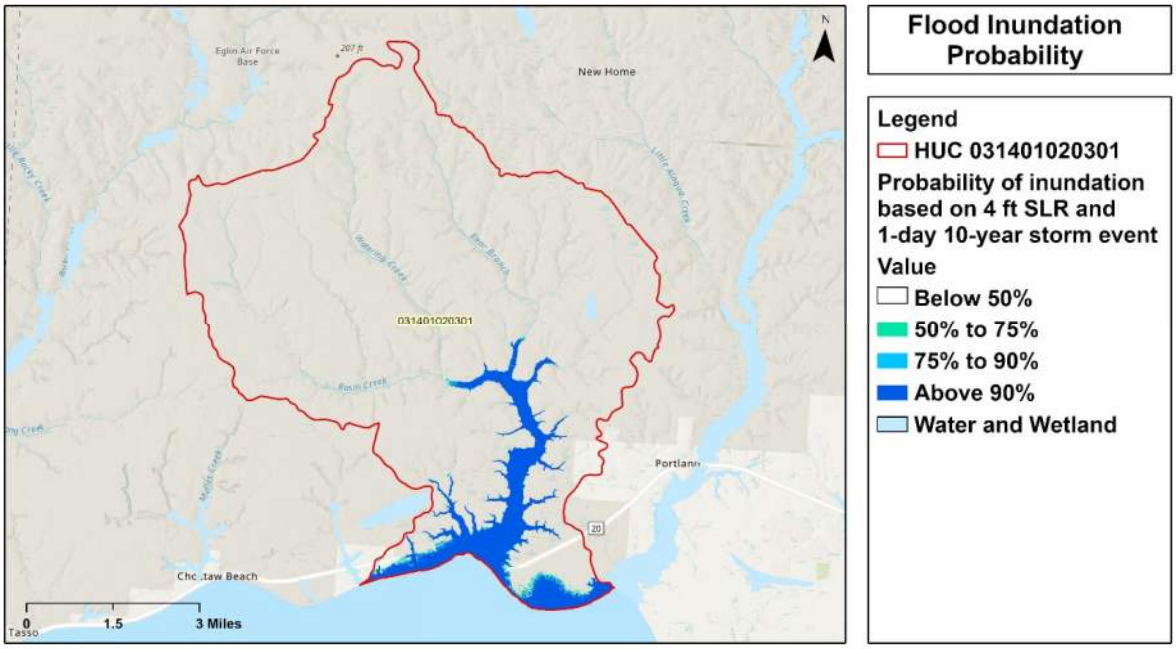

Figure 53. Sea level rise of 4 ft + 1-day 10-year storm for HUC 031401020301 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

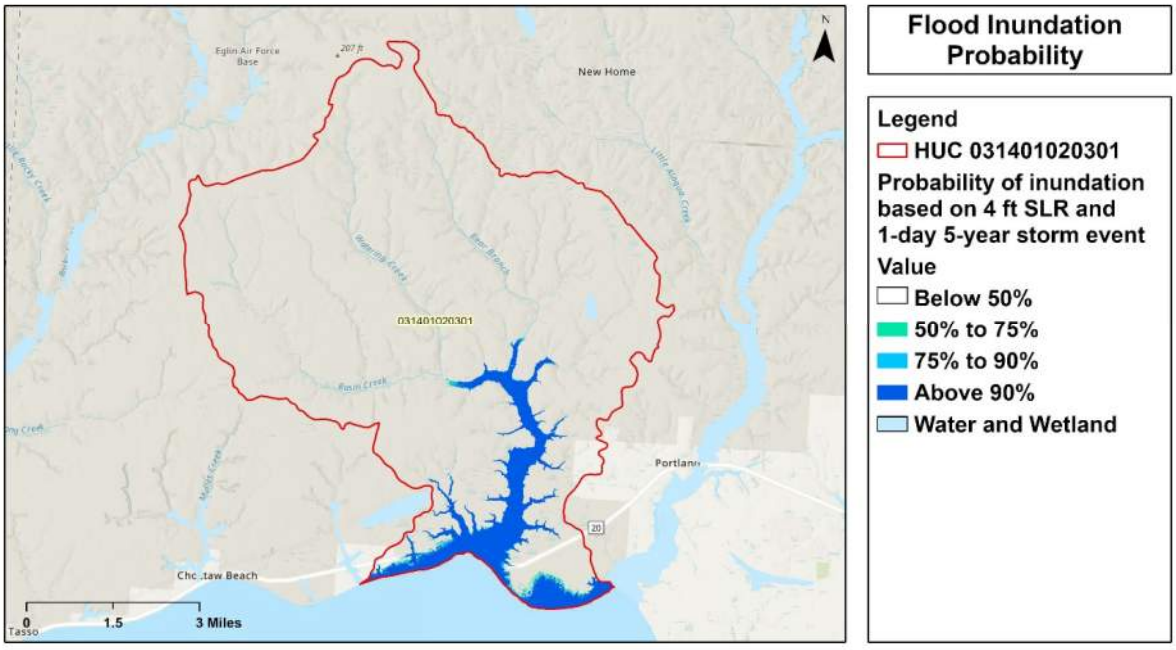

Figure 54. Sea level rise of 4 ft + 1-day 5-year storm for HUC 031401020301 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

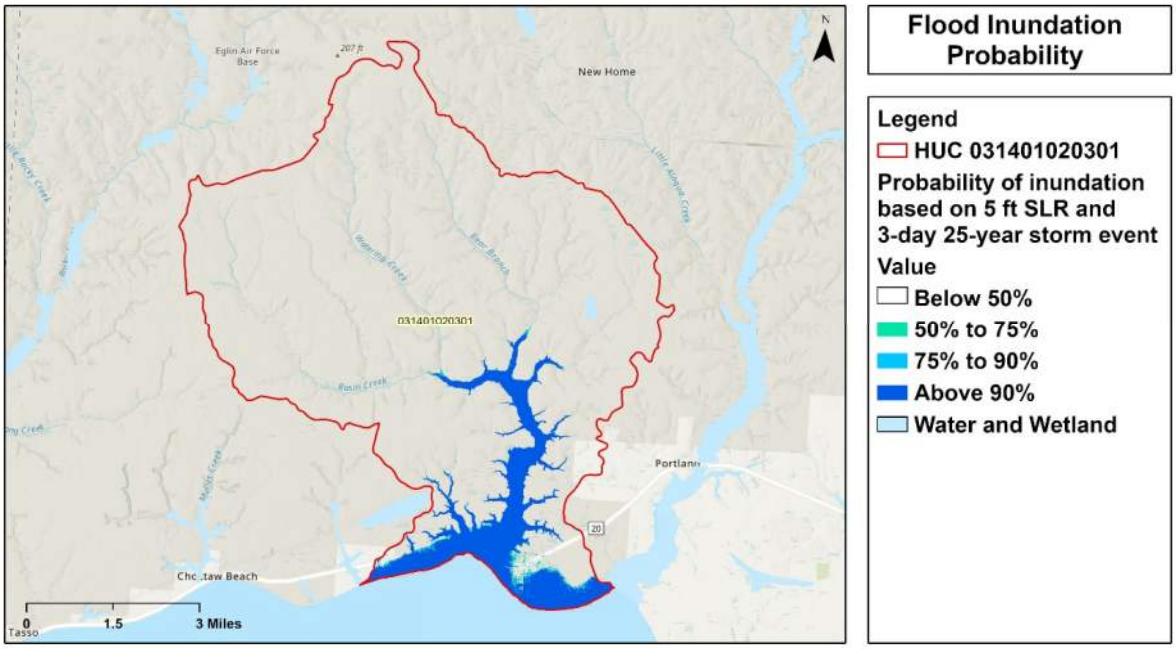

Figure 55. Sea level rise of 5 ft + 3-day 25-year storm for HUC 031401020301 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

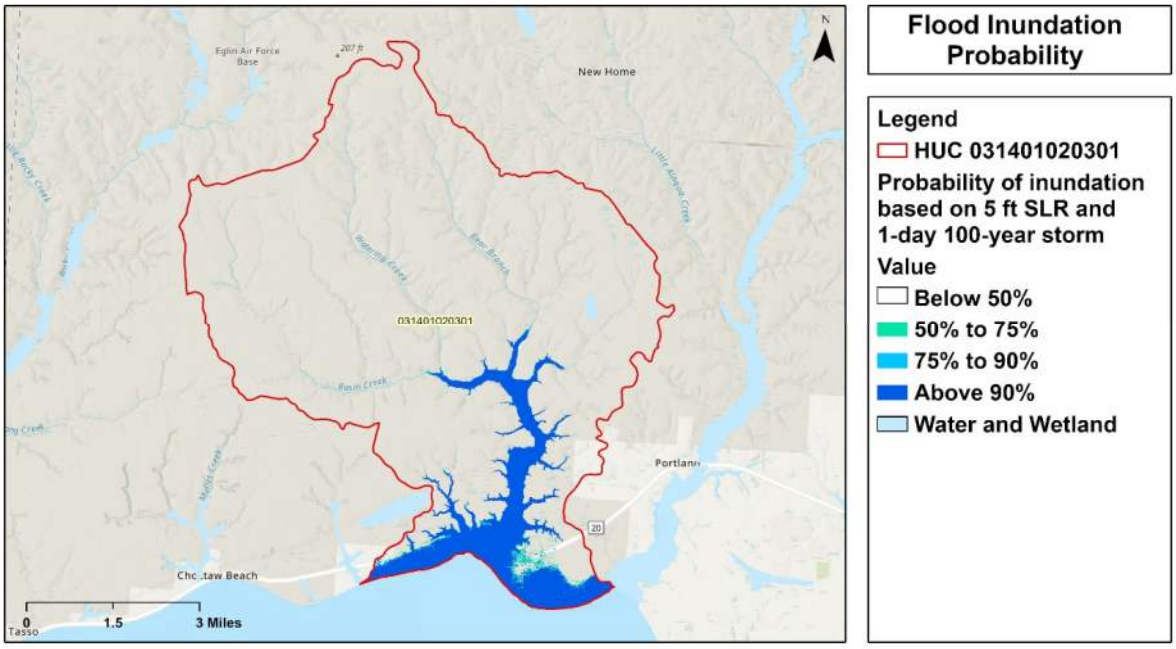

Figure 56. Sea level rise of 5 ft + 1-day 100-year storm for HUC 031401020301 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

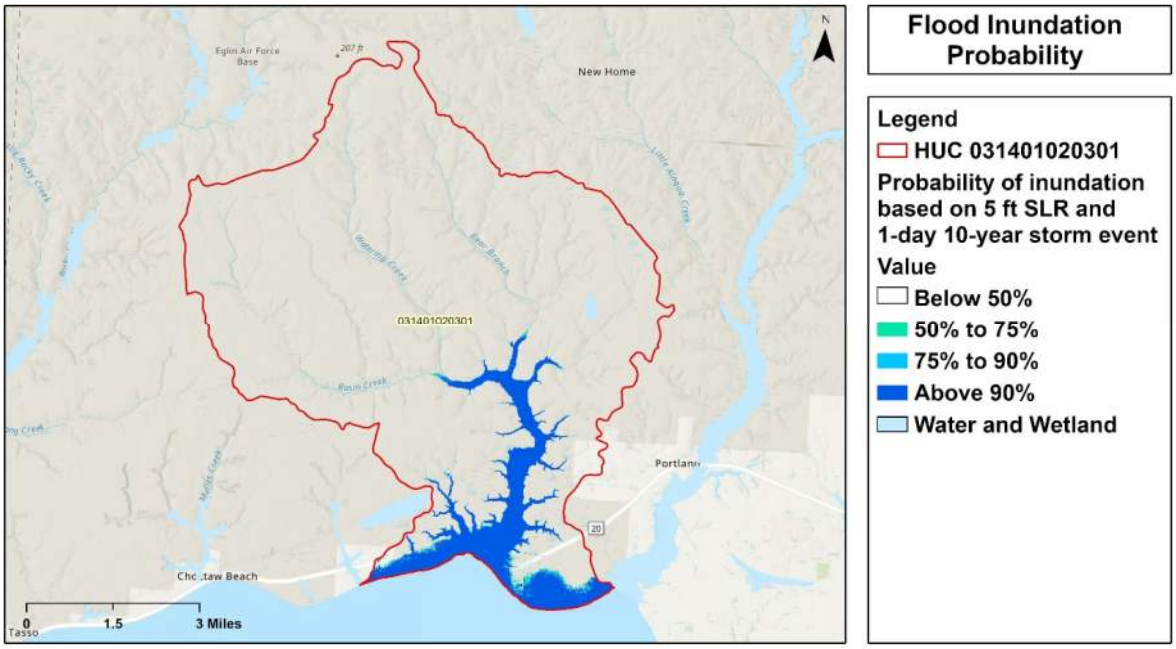

Figure 57. Sea level rise of 5 ft + 1-day 10-year storm for HUC 031401020301 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

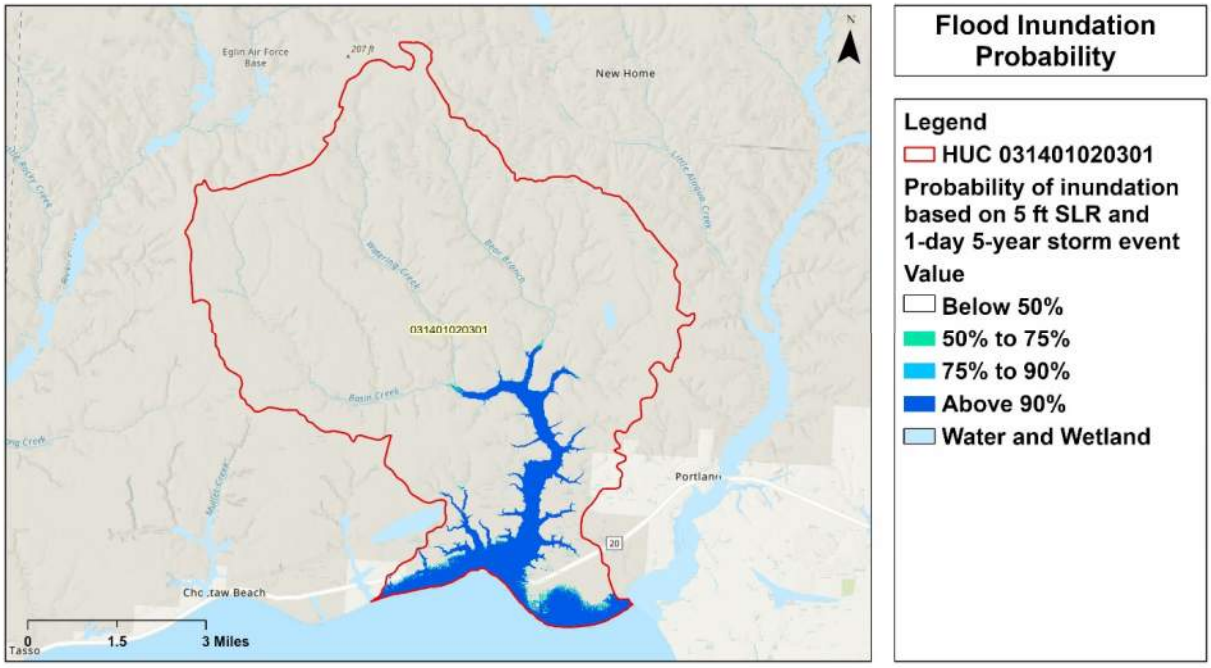

Figure 58. Sea level rise of 5 ft + 1-day 5-year storm for HUC 031401020301 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.5 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6

11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3

43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5

78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, as shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.5.1 Results

Error! Reference source not found. to **Error! Reference source not found.** depict the HUC 031401020301 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 60) overlays critical facilities onto the 1-day 100-year storm event scenario, while the third map (**Error! Reference source not found.**) represents the same overlay within the context of 5 feet of sea level rise (SLR) combined with the 1-day 100-year storm event. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 5 feet SLR + 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** and **Error! Reference source not found.** illustrate the composite score for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. **Error! Reference source not found.** represents the calculation for composite score based on 1-day 100-year storm event, while **Error! Reference source not found.** shows the calculation for composite score for the same storm event, but including a 5 feet of Sea Level Rise scenario. **Error! Reference source not found.** shows the same area zoomed out.

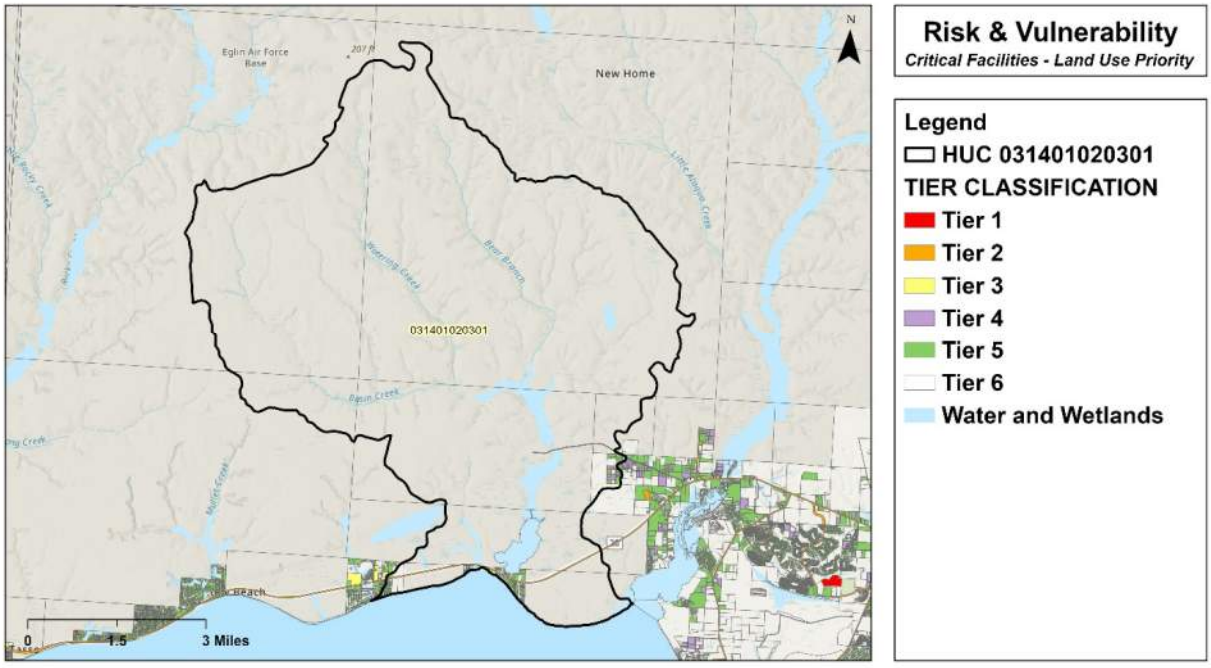

Figure 59. HUC 031401020301 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

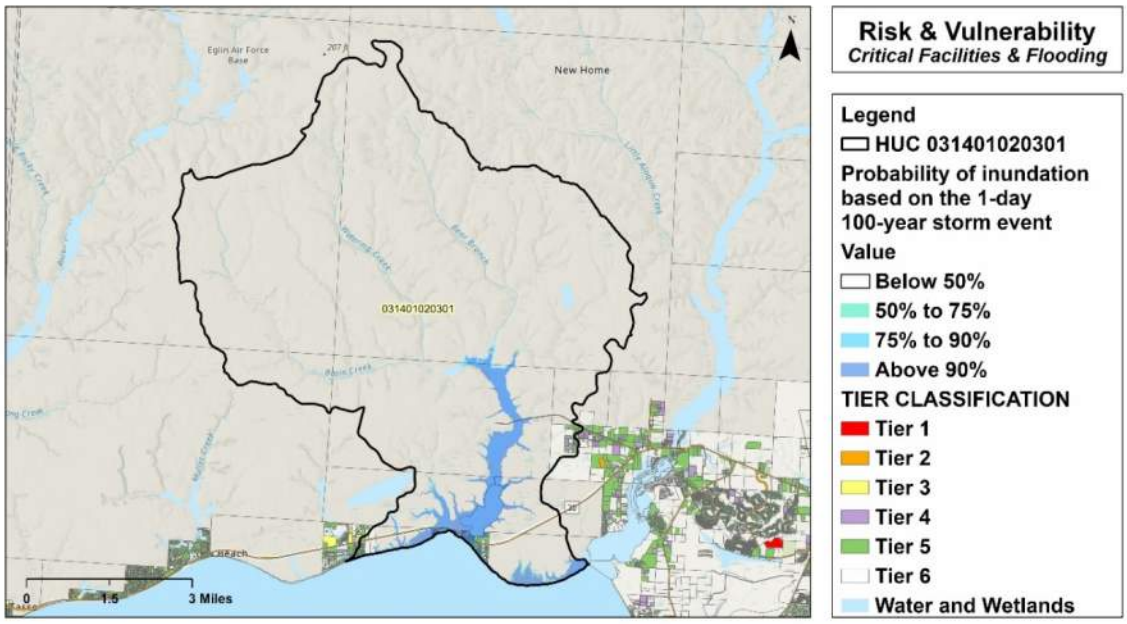

Figure 60. HUC 031401020301 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation map. Processed by FAU.

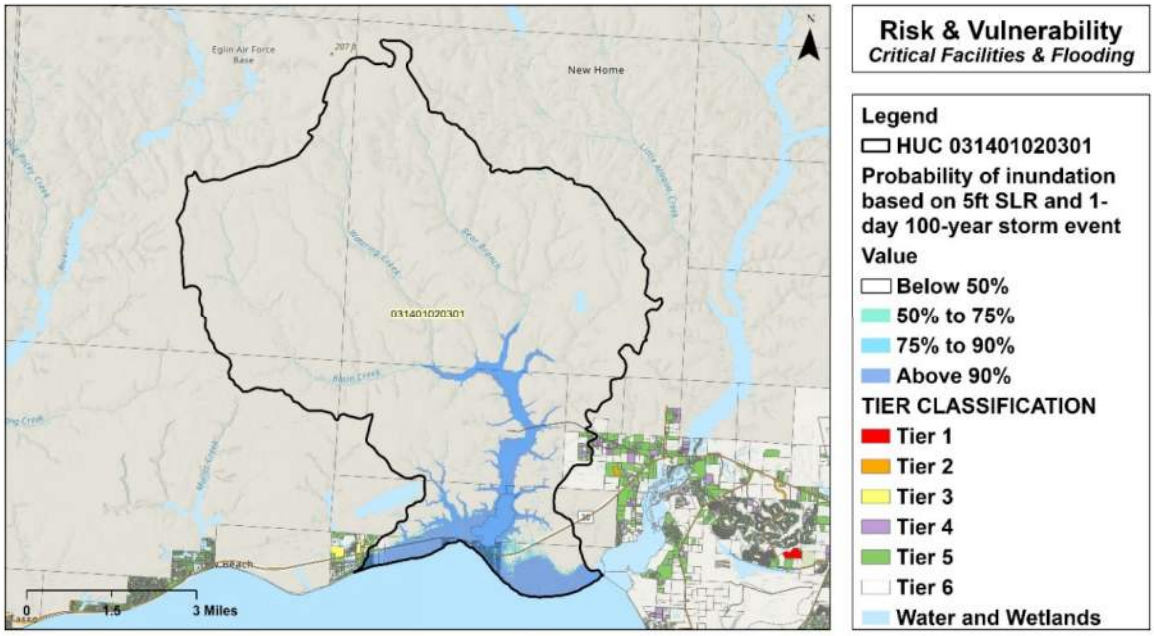

Figure 61. HUC 031401020301 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event + 5 ft. SLR probability of inundation map. Processed by FAU.

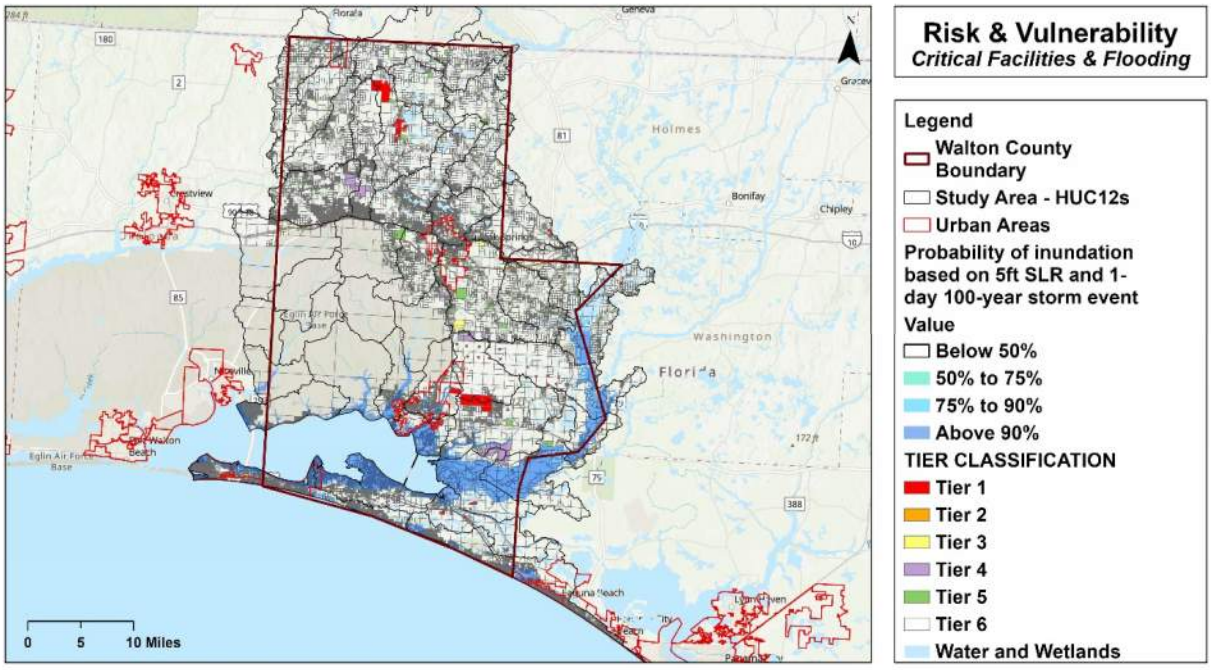

Figure 62. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event + 5 ft. SLR probability of inundation map for Walton County. Processed by FAU.

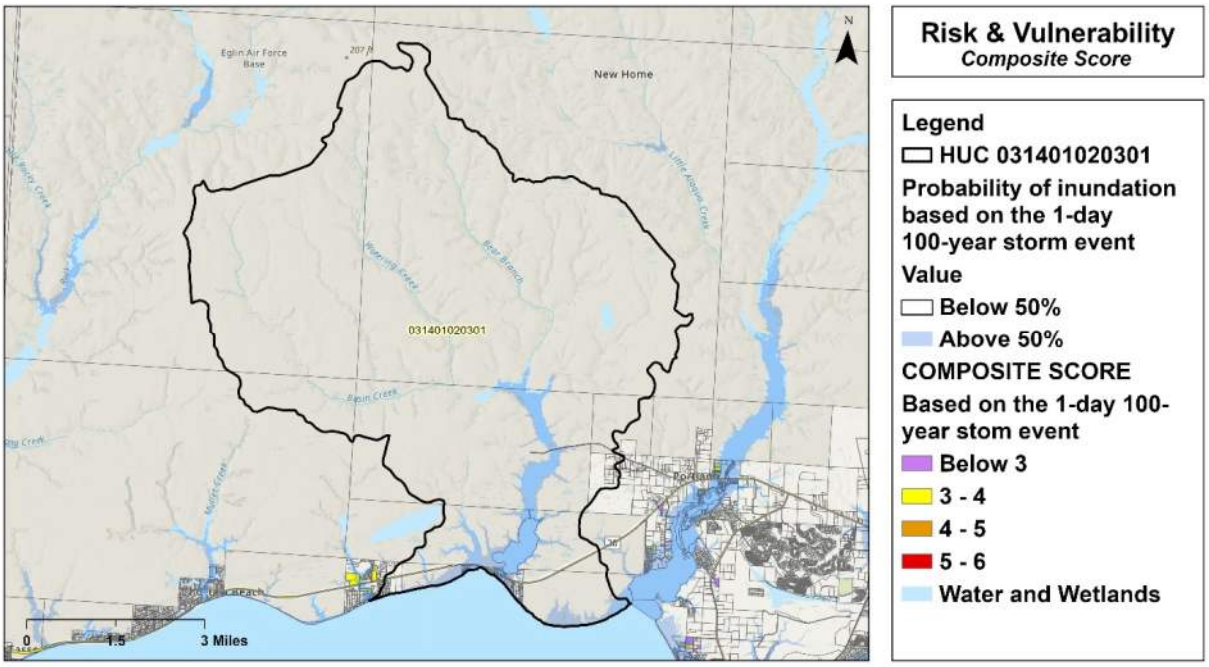

Figure 63. HUC 031401020301 sub-watershed Composite Score Risk map based on the 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation. Processed by FAU.

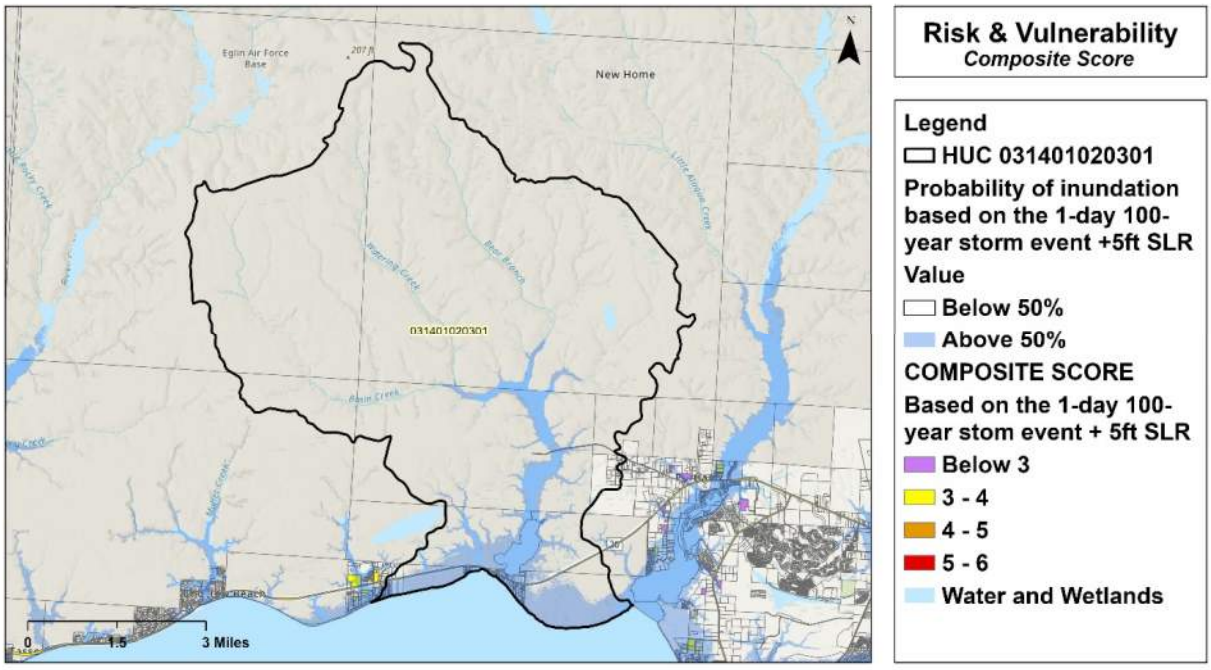

Figure 64. HUC 031401020301 sub-watershed Composite Score Risk map based on 1-day 100-year storm event + 5 ft SRL, overlaid on the 1-day 100-year + 5 ft SLR probability of inundation. Processed by FAU.

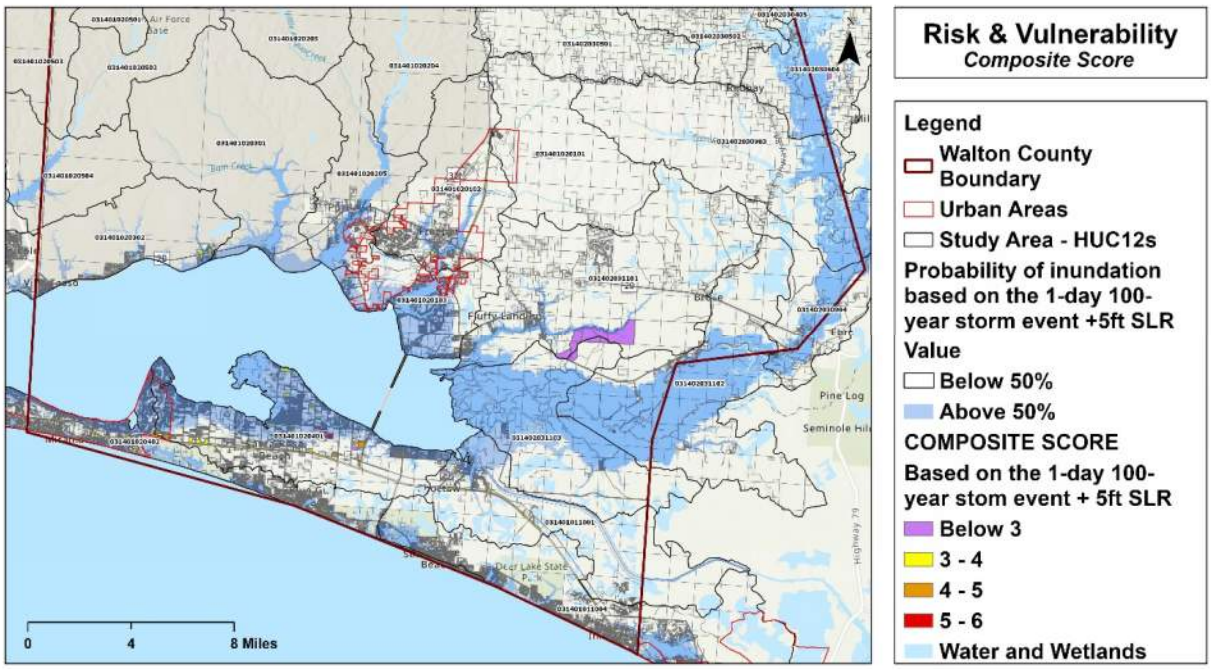

Figure 65. Coastal Area of Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

2.5.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401020301. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.5.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It is important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands: This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands: In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401020301. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401020301	29040.48
All of the 1-day 100-year storm event inundation	**1379.62**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	673.75
B. Federal Land in 1-day 100-year inundation > 10 acres	610.47
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	95.40
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	95.40

2.5.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be

openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

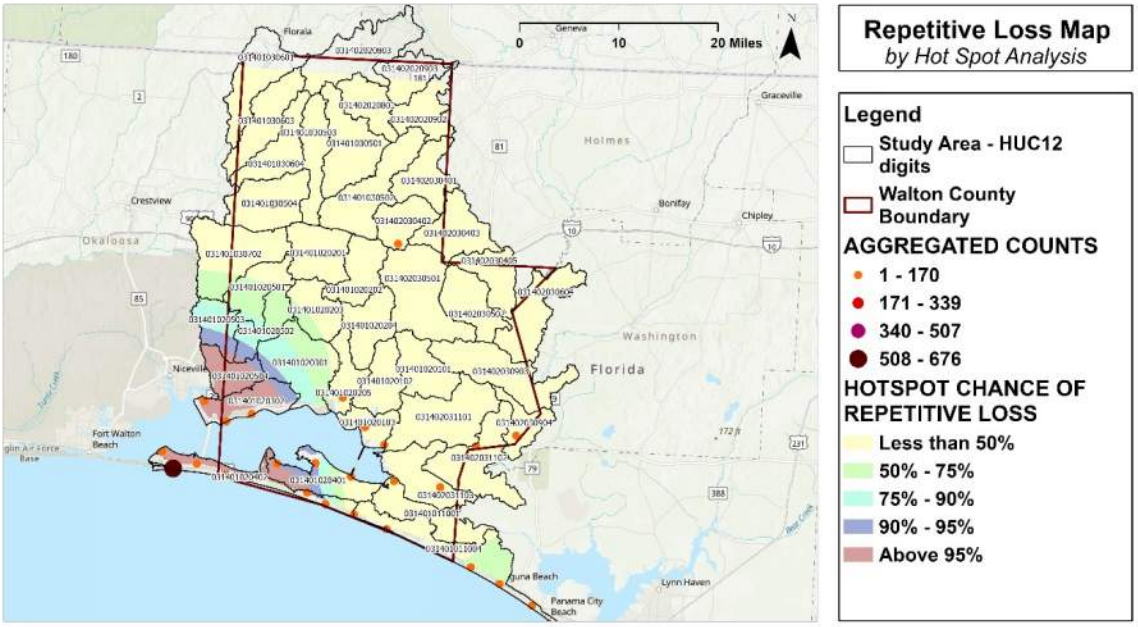

Figure 66. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.5.5 Priority Projects

The basin is mostly undeveloped, with only a small portion of the coast being populated. However, all the developed land falls within the flood zone. In terms of priority for land use, there are 18 parcels, all roads, classified as tier, that need some attention, especially when considering the 1-day 100-year storm event + 5 ft. SRL scenario. Additionally, there is a substantial number of parcels falling within tiers 4 and 5, signifying a lower priority for intervention. Notably, no critical facilities (tier 1) were identified within the basin.

Examining the composite score, there are nine parcels within score 5-6, all of them being roads (Dolphin Cv, Indian Cv, Marsh Dr, I D Martin Dr, Basin St, Dolphin Pl, Bay Cv, Indian Bay Dr, Cedar Beach Cv), representing the highest priority for intervention. There are also four parcels within score 4-5, including a restaurant/cafeteria, and two roads (Eglin Range Rd 218, and two

portions of the Highway 20), that also need some attention. Additionally, there are 10 mobile homes falling within score 3-4.

More detail about flood solutions are described in the community plan and in Section 5.5 where drilldown to specific neighborhoods is outlined.

APPENDIX M

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401020302

PIPPIN LAKE-TROUT CREEK FRONTAL

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Research Assistant: Leticia Sabio

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 sub-watershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401020302) is highlighted among all the HUCs to help identifying its location. (Figure 3).

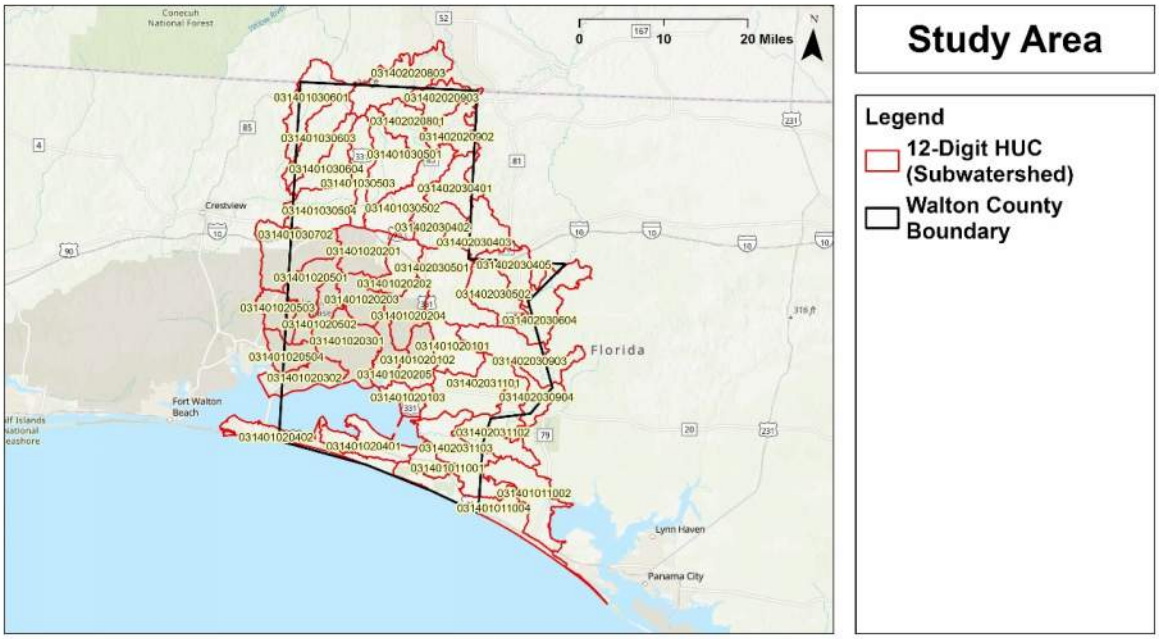

Figure 1. Walton County and all HUCs 12-digit sub-watershed, processed by FAU.

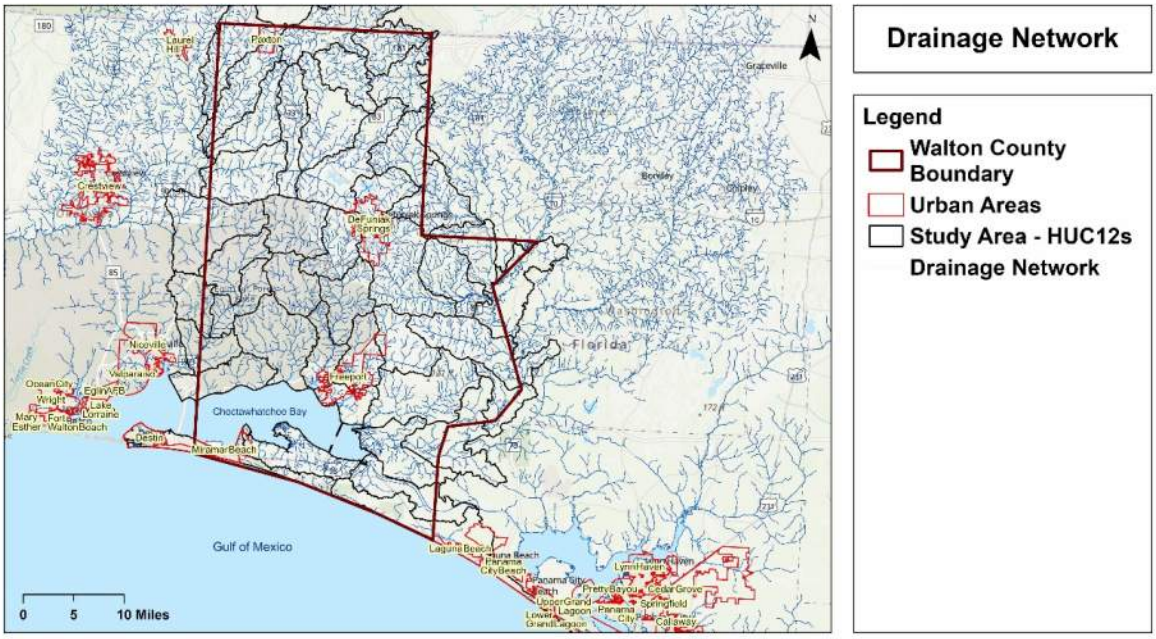

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

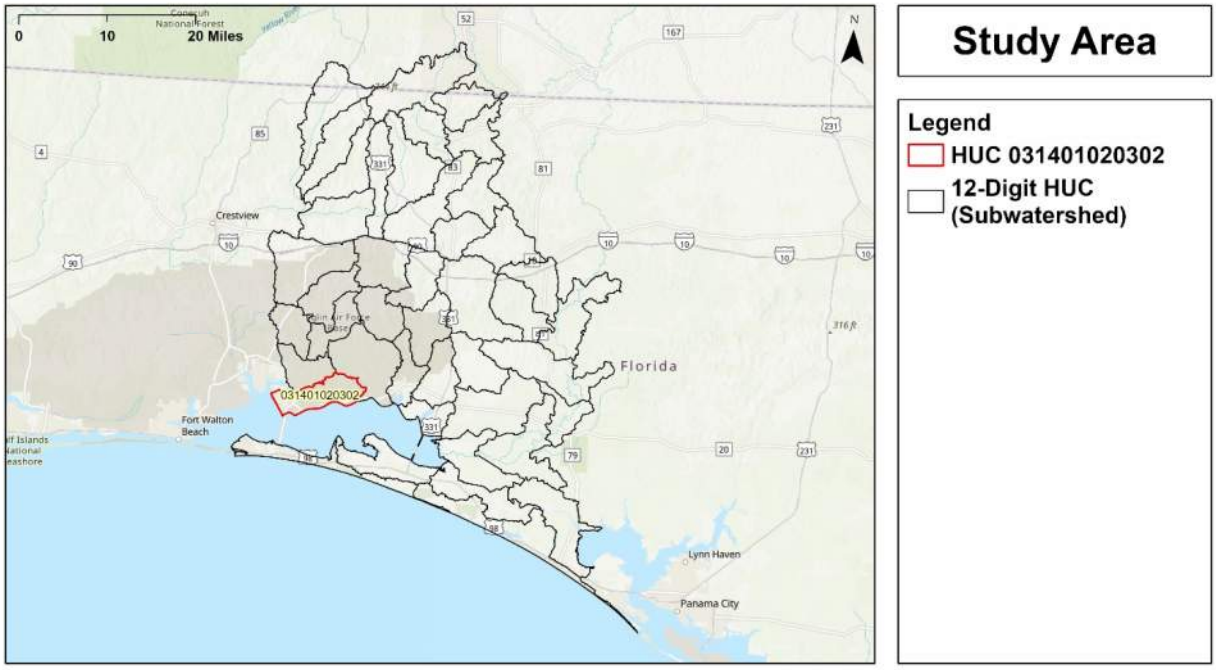

Figure 3. HUC 031401020302 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Figures 12 and 13 in the county-wide report show the current and projected land use for the County. Based on the 2017 future land use map for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL))

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 1.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water

in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

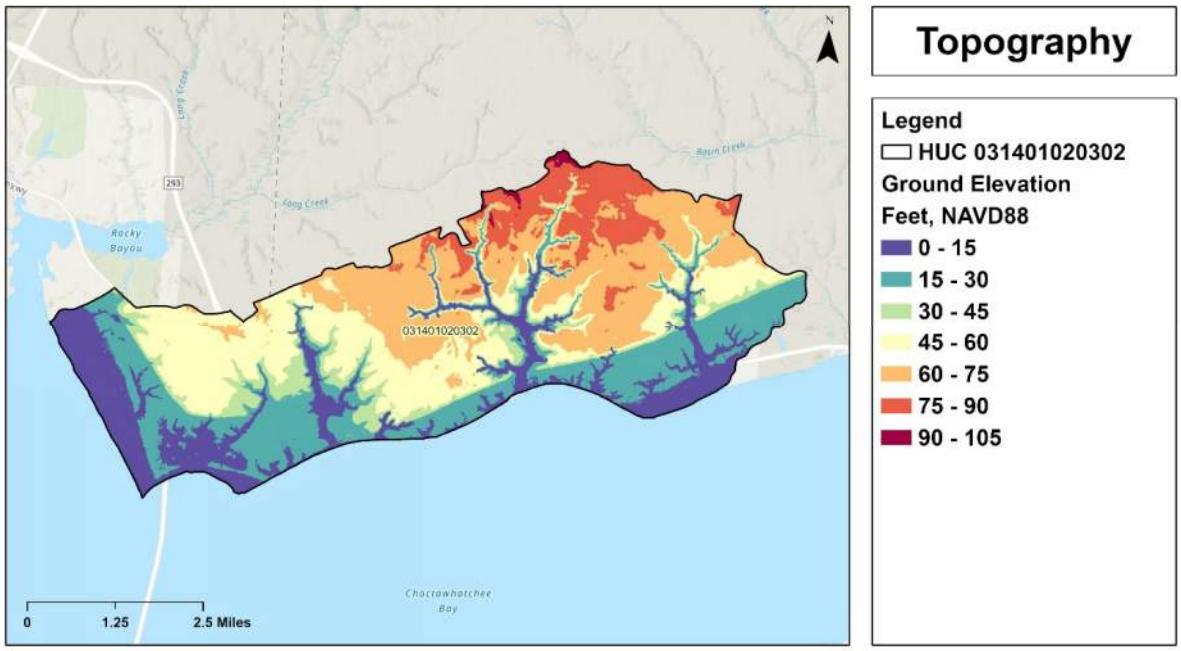

Figure 4. Topographic map of the HUC 031401020302 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology.
Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.
Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401020302 sub-watershed is shown in **Error! Reference source not found.**.

Figure 5. FEMA Flood Zone map (2020) for HUC 031401020302 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself

characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401020302 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

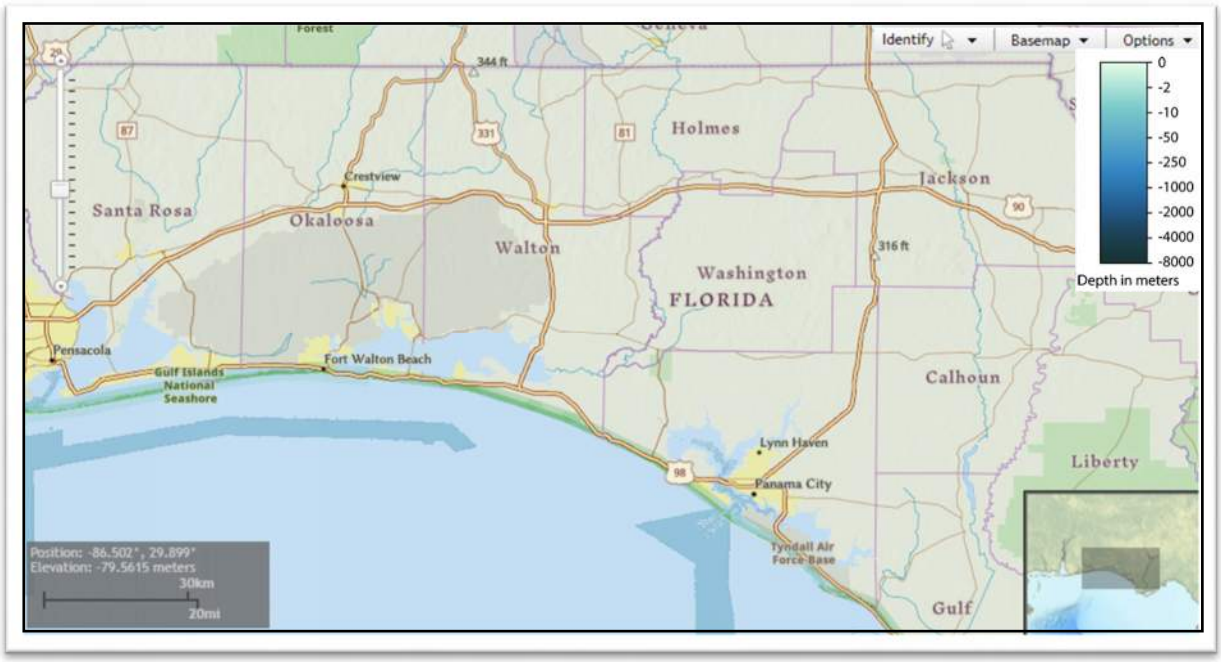

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

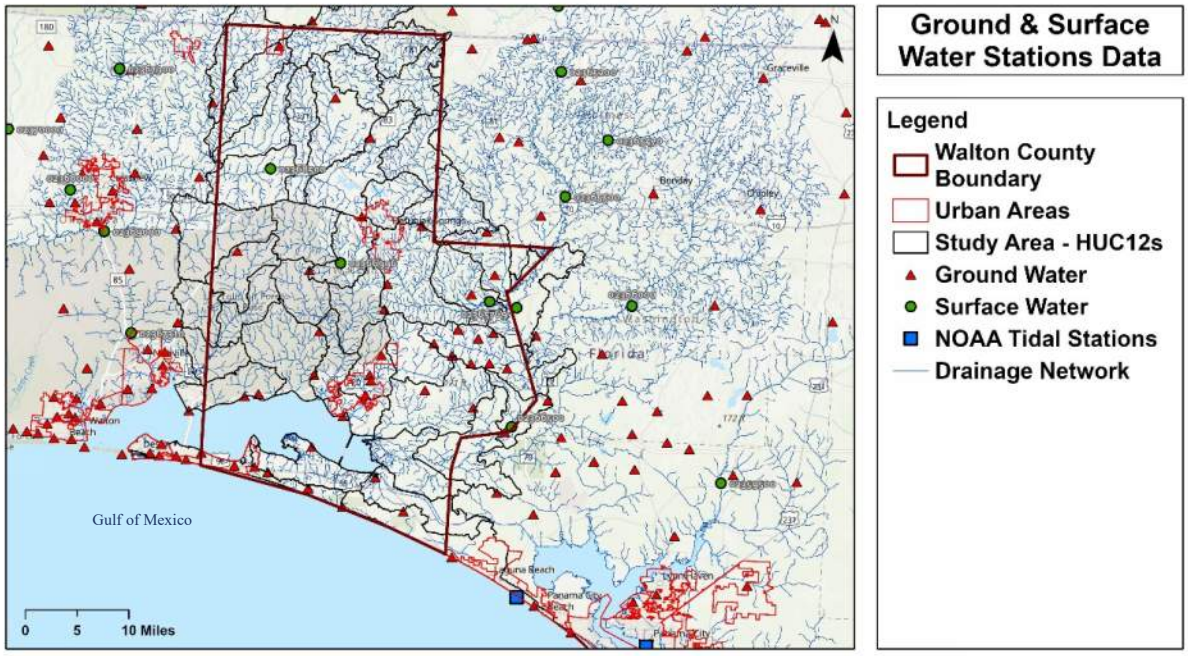

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The basin is connected to the Choctawhatchee Bay at its south side. The major water bodies in the HUC 031401020302 sub-watershed include

- Trout Creek
- Piney Creek

- Mullet Creek
- Eagle Creek
- Little Trout Creek

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366996. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401020302, which is USGS 02366996 Alaqua Creek Near Pleasant Ridge, FL.

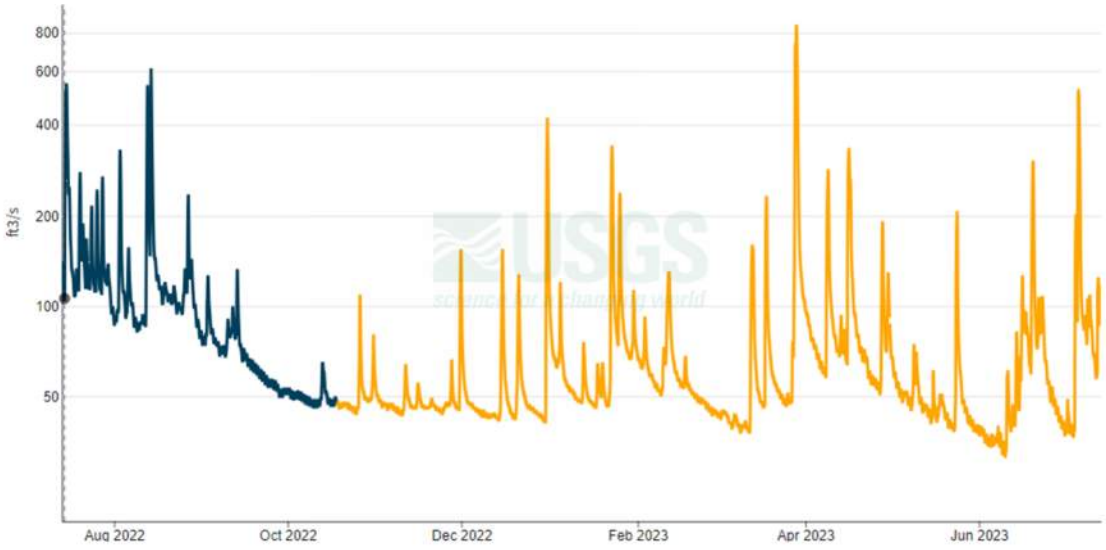

Figure 8. Average streamflow for Alaqua Creek Near Pleasant Ridge, FL (USGS 02366996 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366996/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are

estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401020302 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031401020302 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

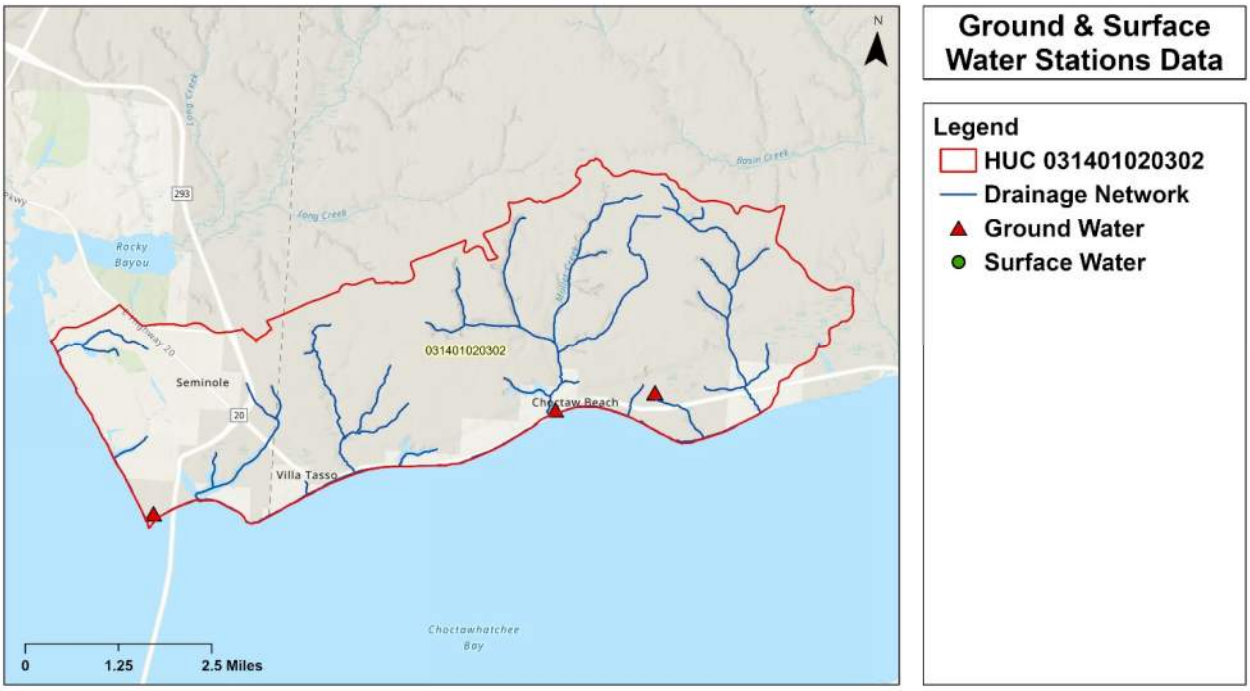

Figure 9. Ground and Surface Water Stations in the HUC 031401020302 sub-watershed, processed by FAU.

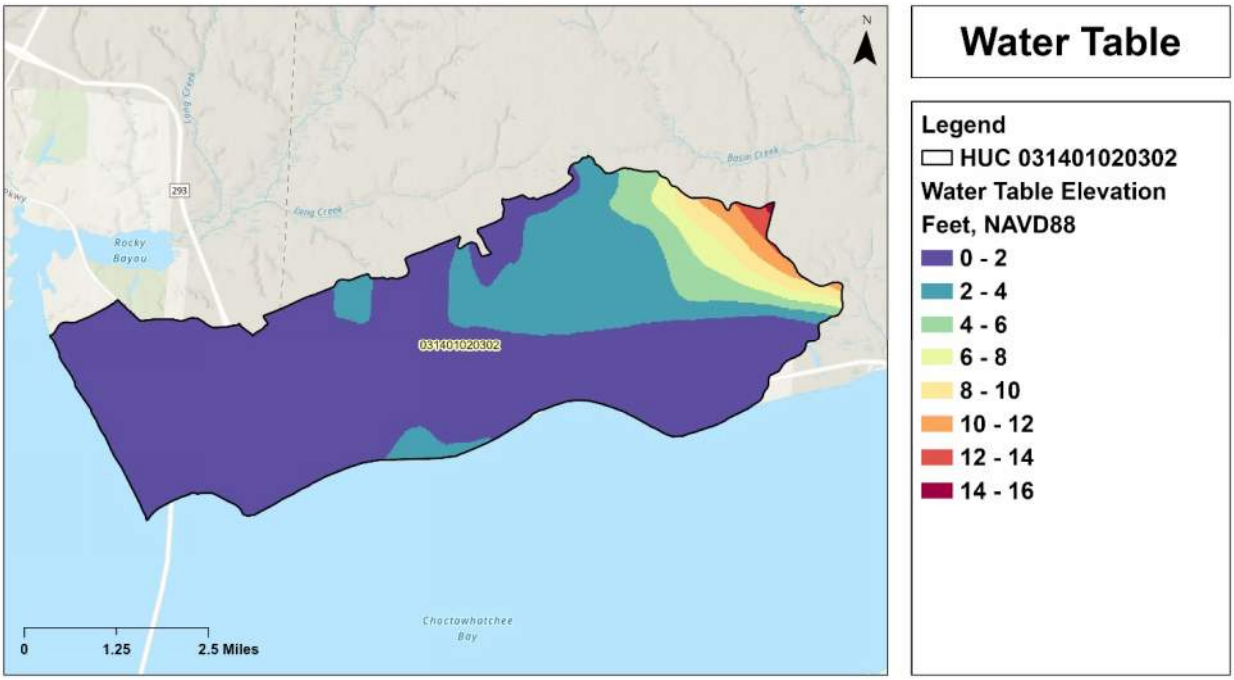

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401020302 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

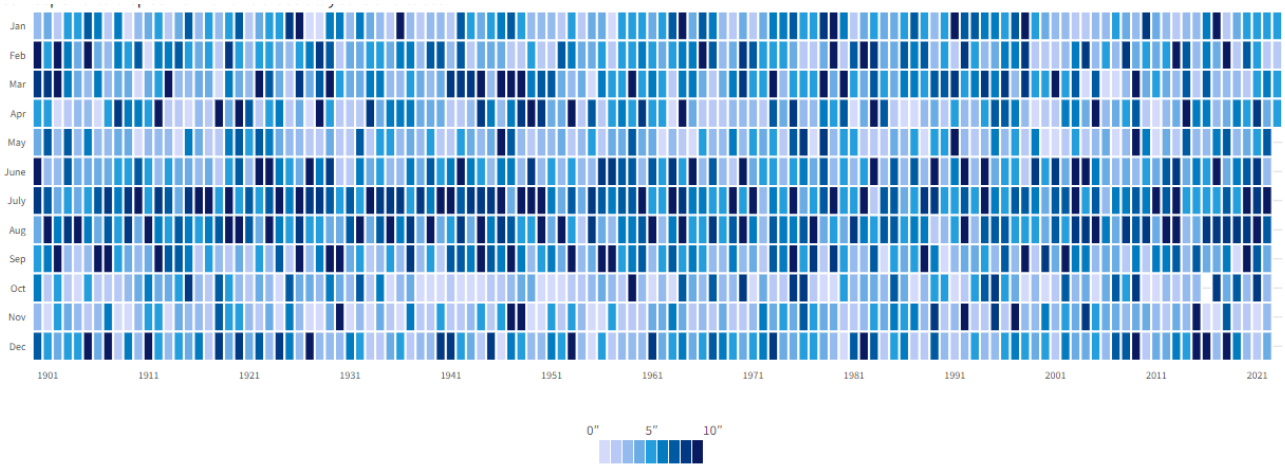

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/).

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

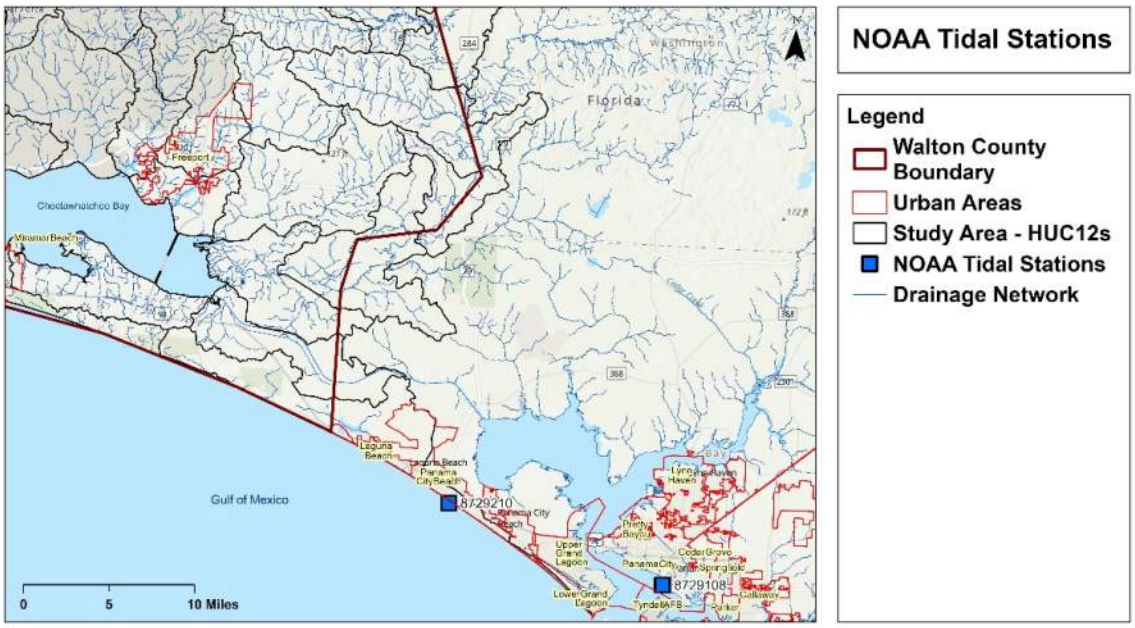

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

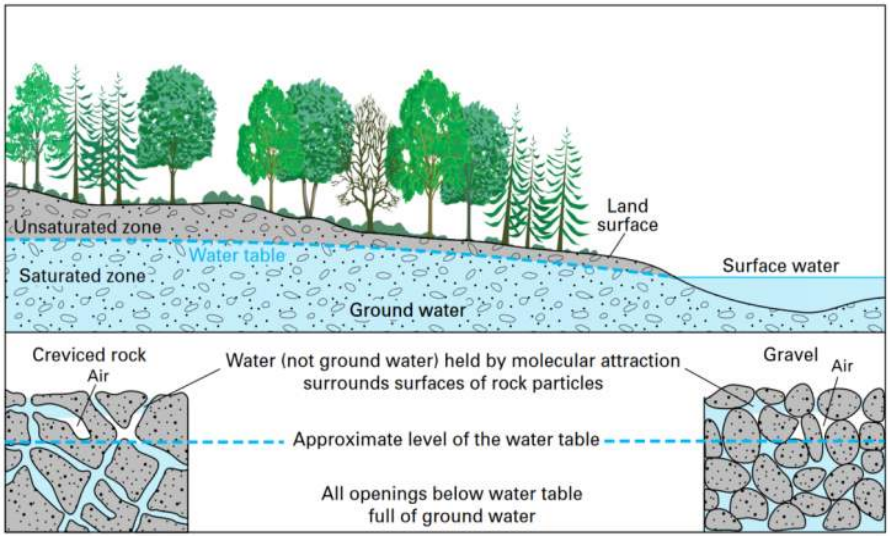

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

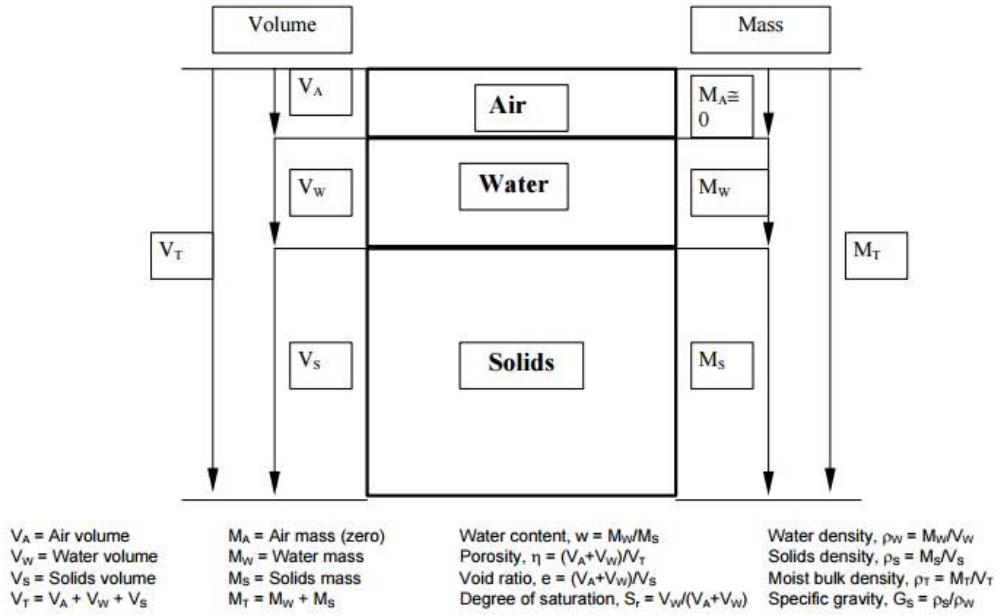

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

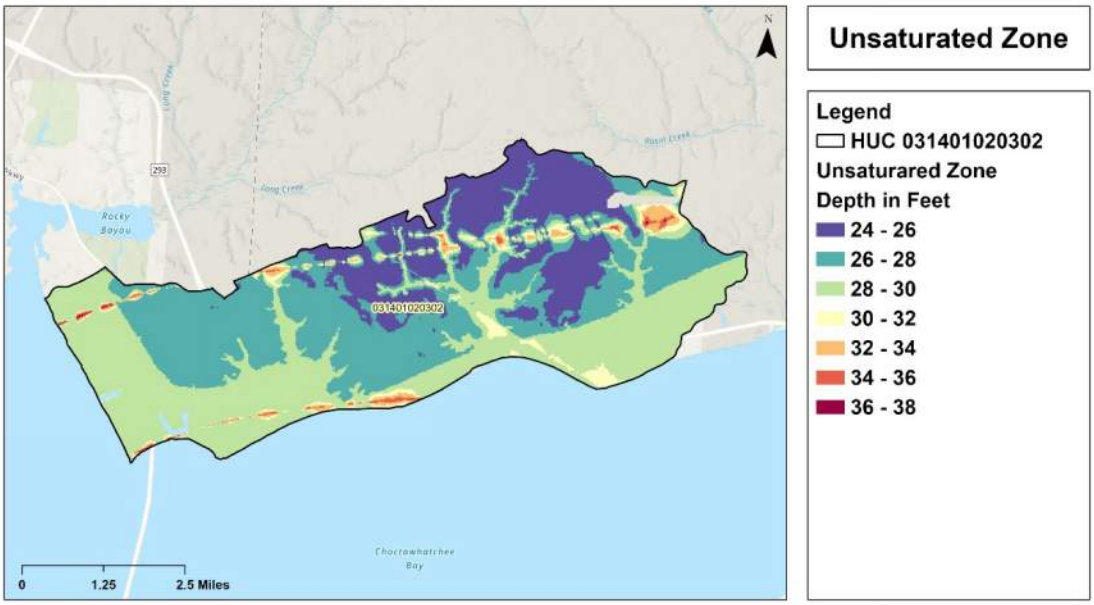

Figure 15. Unsaturated zone map for HUC 031401020302, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. The basin demonstrates a moderately favorable soil storage capacity, falling within the range of 24 to 38 feet of remaining capacity.

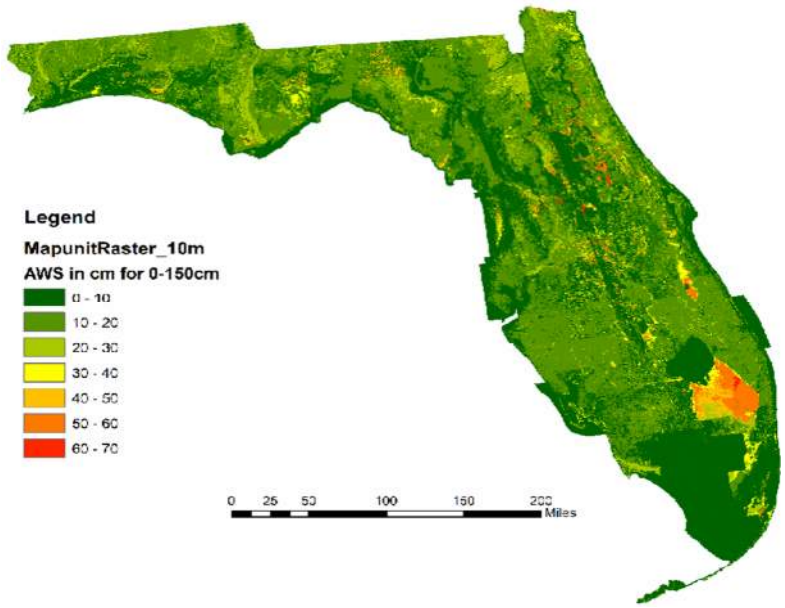

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

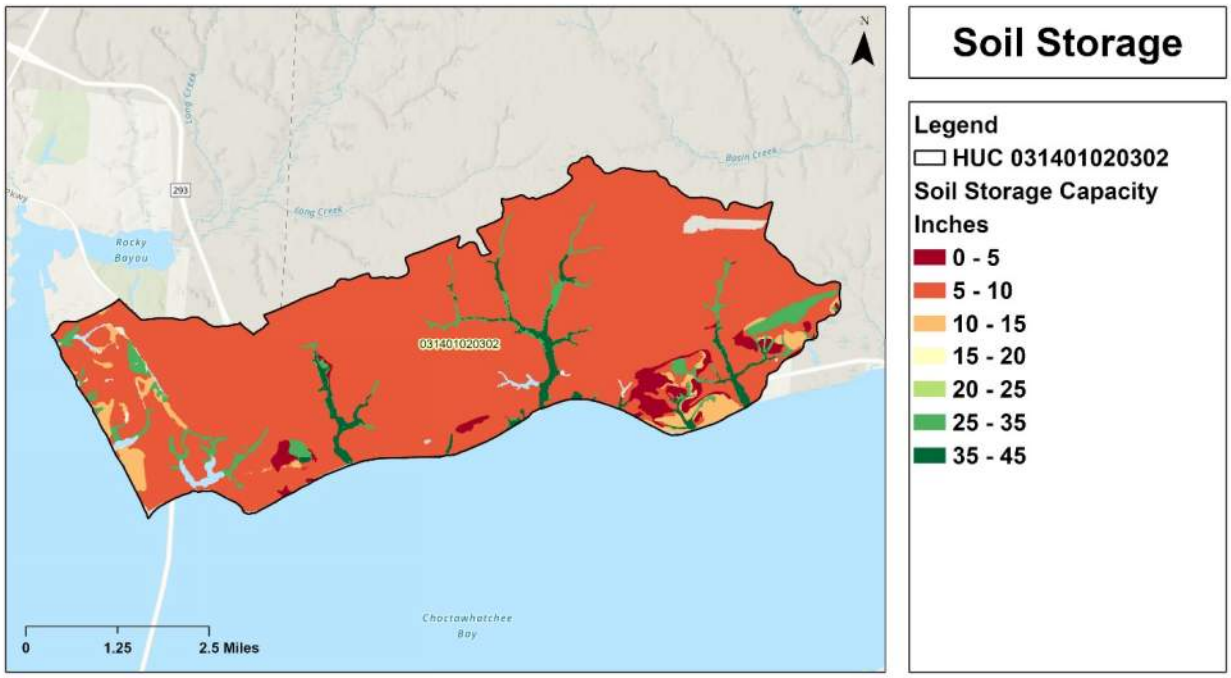

Figure 17. Water storage capacity of soil for the HUC 031401020302, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

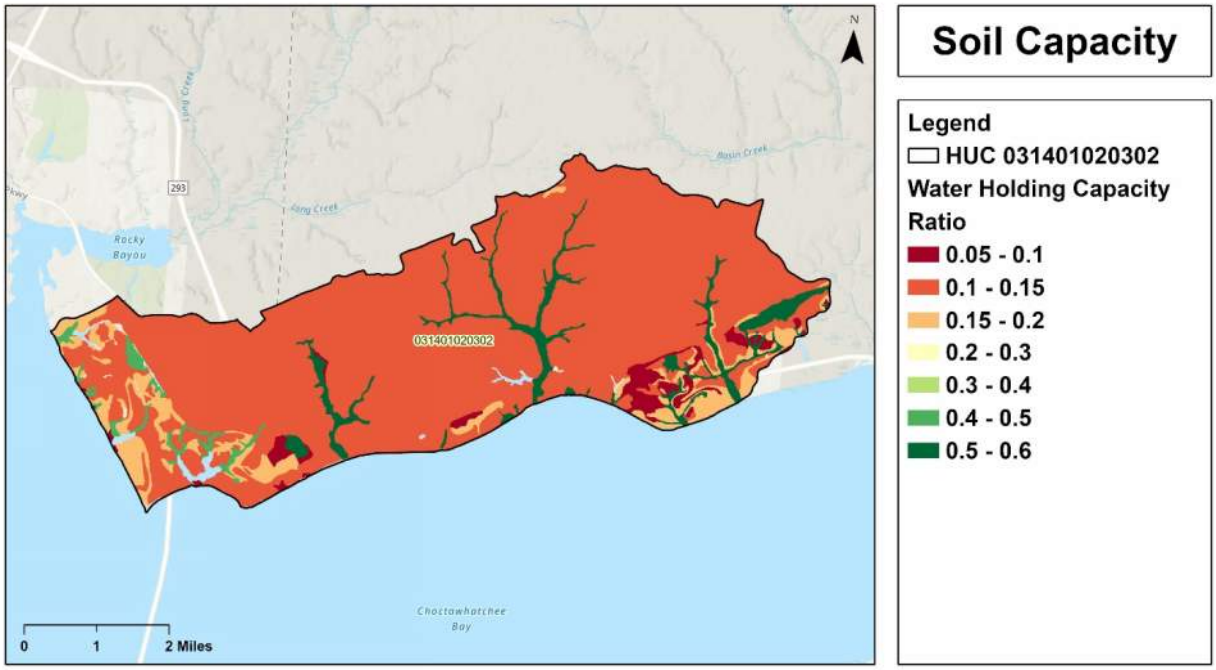

Figure 18. Water Holding Capacity (ratio) for the HUC 031401020302, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

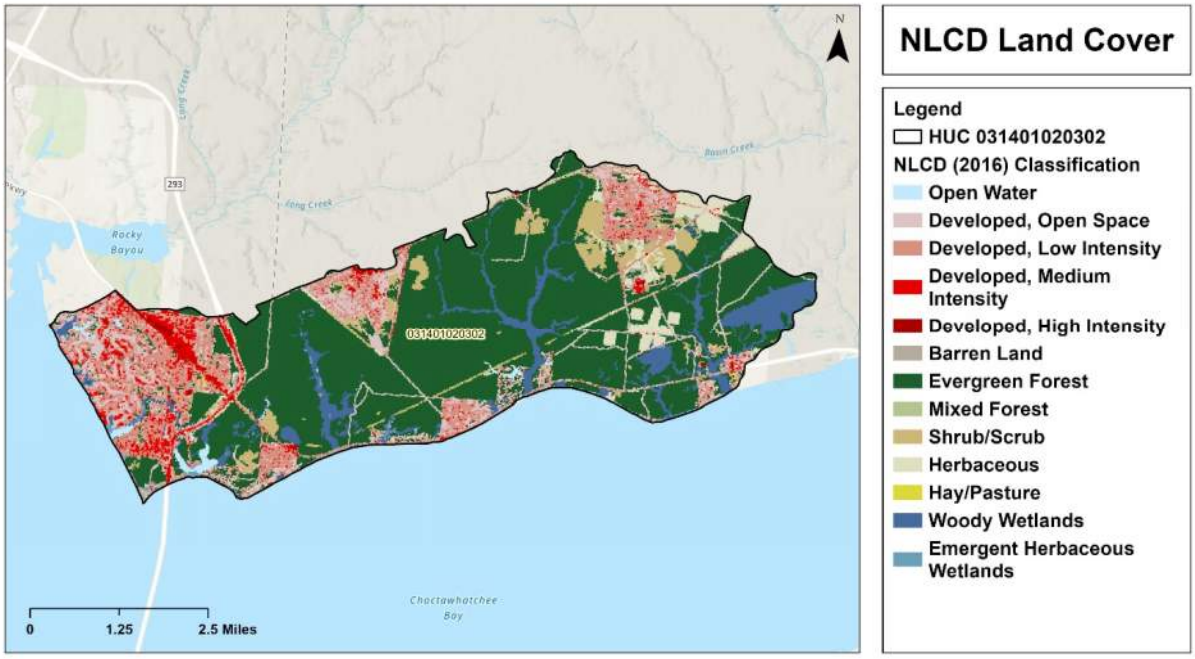

Figure 19. Land use in the HUC 031401020302 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

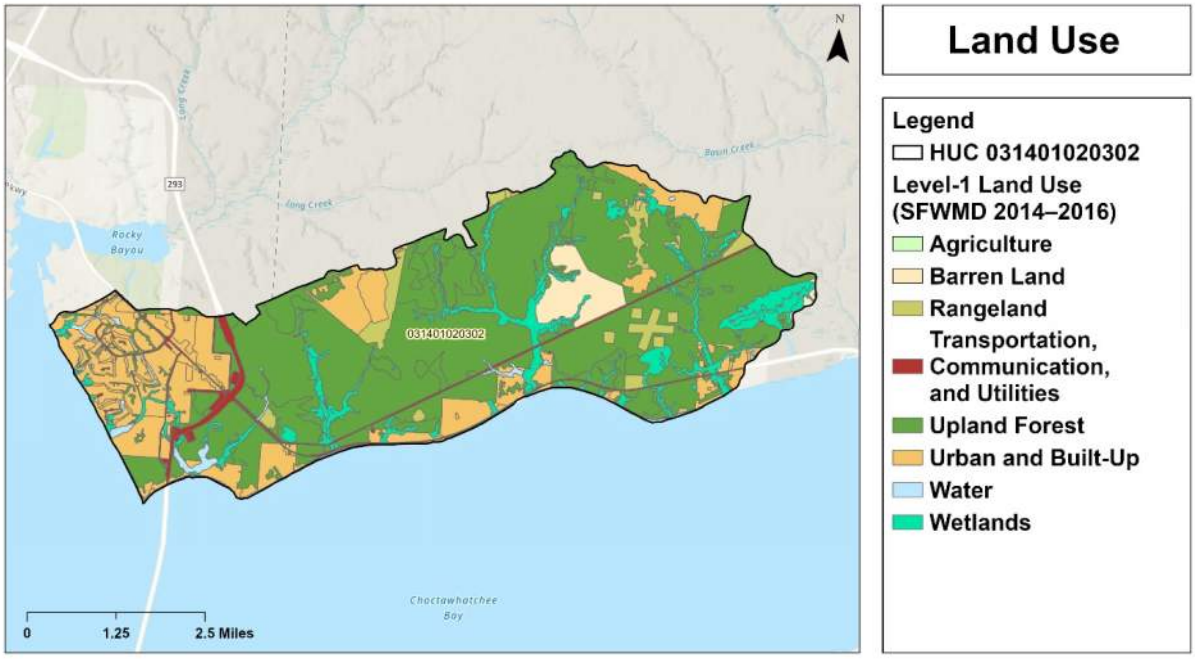

Figure 20. Land use in the HUC 031401020302 (from the (2023 Florida Geographic Data Library (FGDL)) database), processed by FAU.

In the HUC sub-watershed, the predominant land cover is upland forest, accounting for 50.05% of the area. Urban and built-up comes in second at 20.38%, followed by water at 9.46%, and wetlands at 6.96%, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface. The basin shares part of its area with Bluewater Bay, a coastal community outside Walton County boundaries.

Table 3. Land use for HUC 031401020302 sub-watershed (2023 Florida Geographic Data Library (FGDL))

Level 1 Land Use Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	4.47	0.02%
Barren Land	1000.65	4.42%
Rangeland	1400.23	6.19%
Transportation, Communication, and Utilities	572.64	2.53%
Upland Forest	11323.82	50.05%
Urban and Built-Up	4611.91	20.38%
Water	2139.42	9.46%
Wetlands	1573.84	6.96%
Grand Total:	**22626.99**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

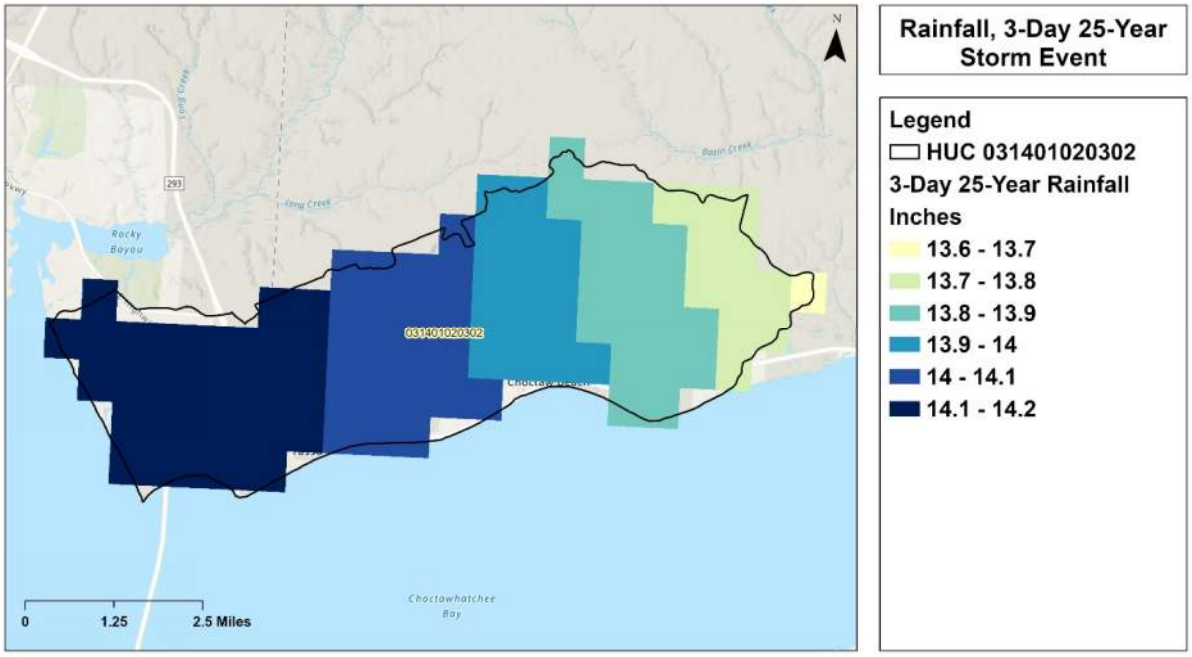

Figure 21. Rainfall distribution map across HUC 031401020302 sub-watershed, for 3-day 25-year storm event, processed by FAU.

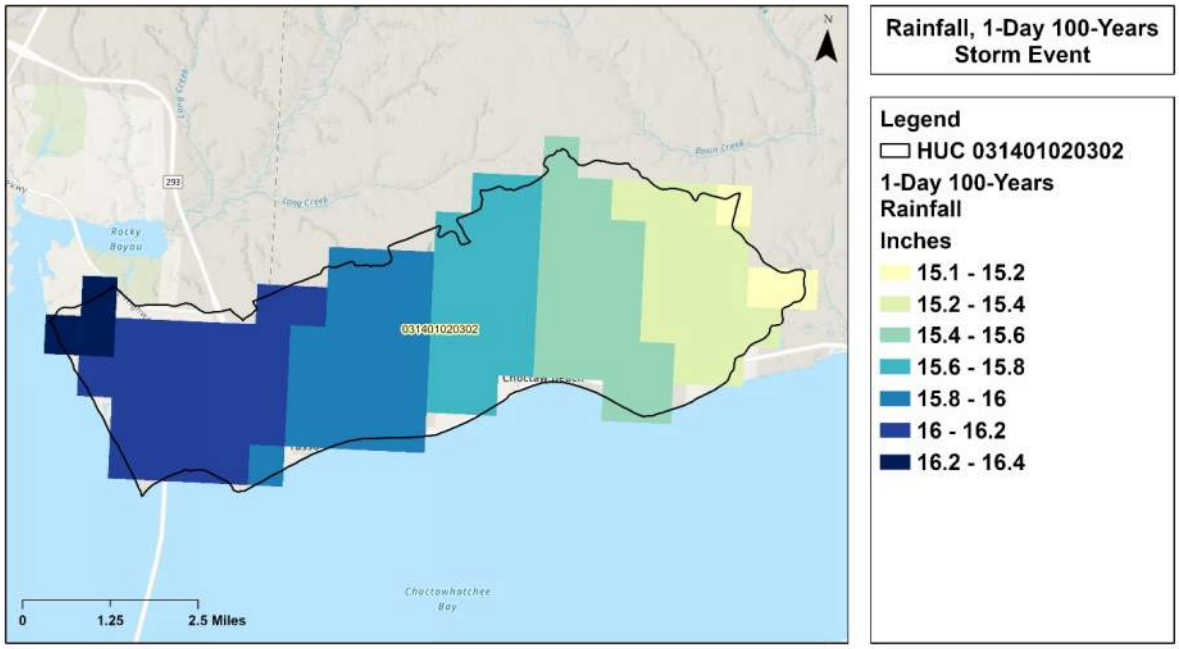

Figure 22. Rainfall distribution map across HUC 031401020302 sub-watershed, for 1-day 100-year storm event, processed by FAU.

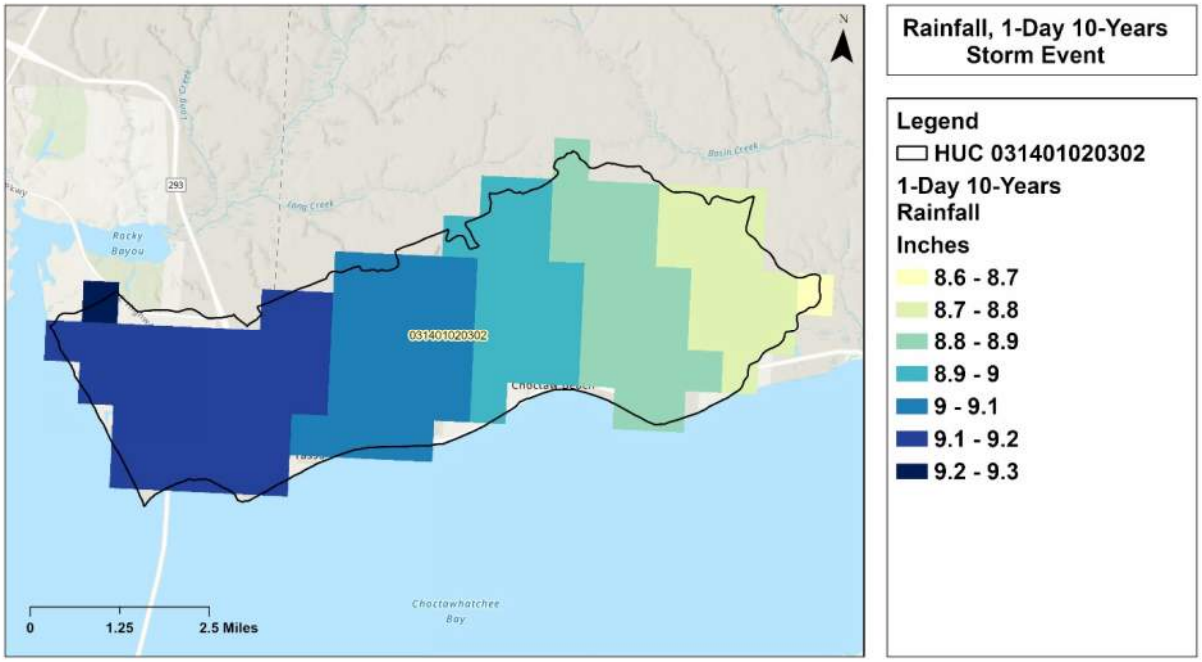

Figure 23. Rainfall distribution map across HUC 031401020302 sub-watershed, for 1-day 10-year storm event, processed by FAU.

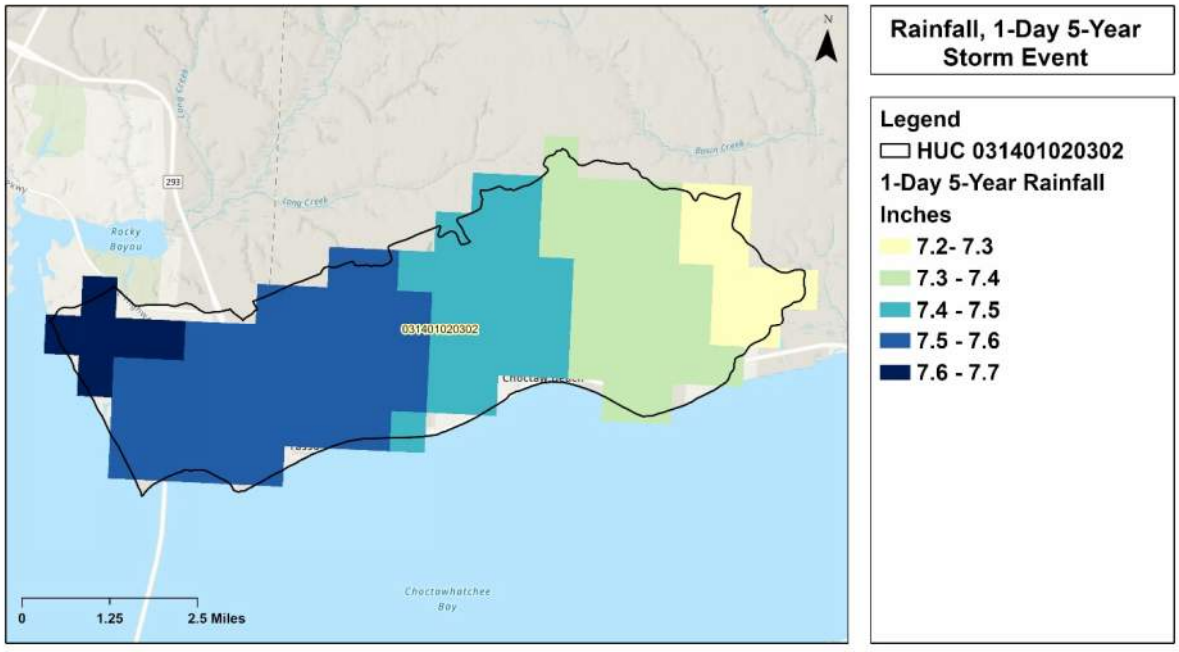

Figure 24. Rainfall distribution map across HUC 031401020302 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically

aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

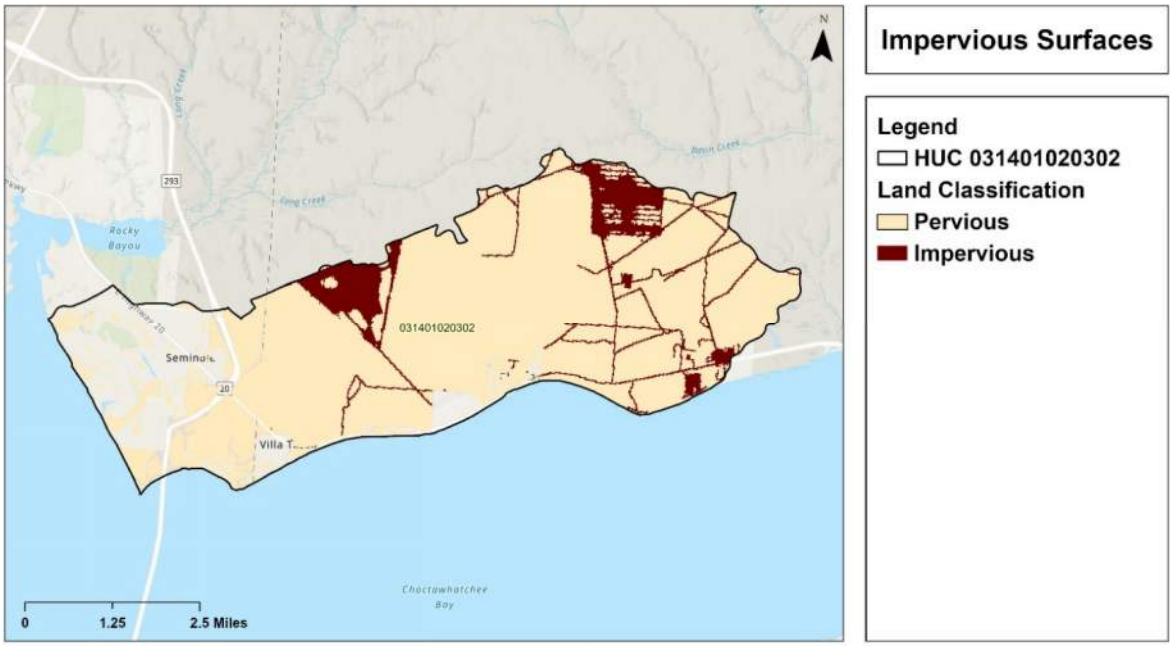

Figure 25. Impervious area map for the HUC 031401020302 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

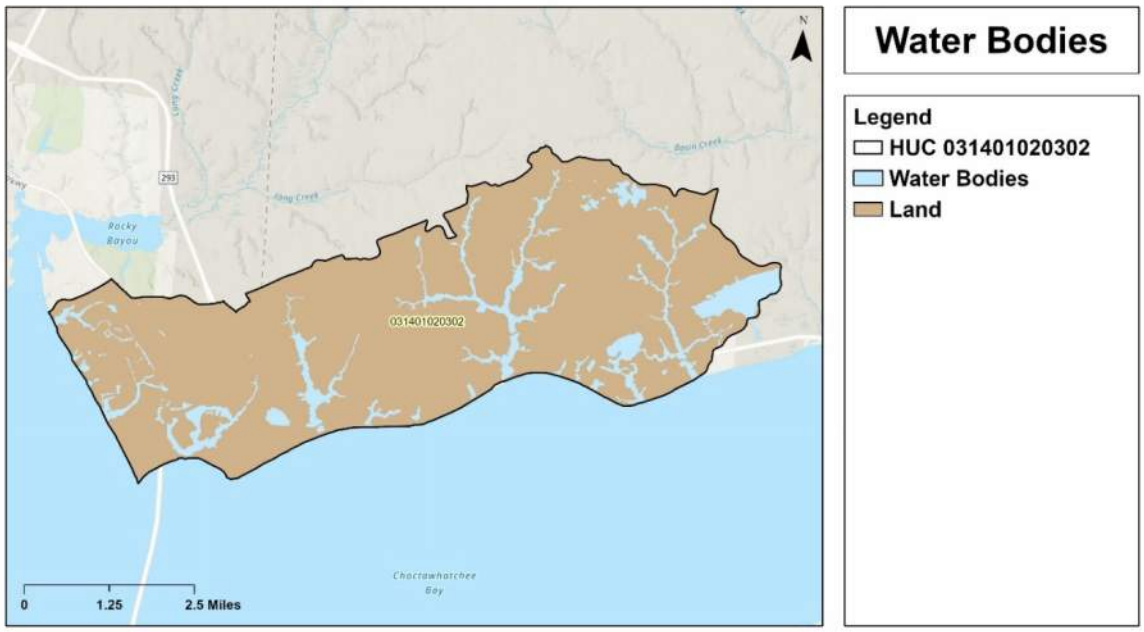

Figure 26. Water bodies map for the HUC 031401020302 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

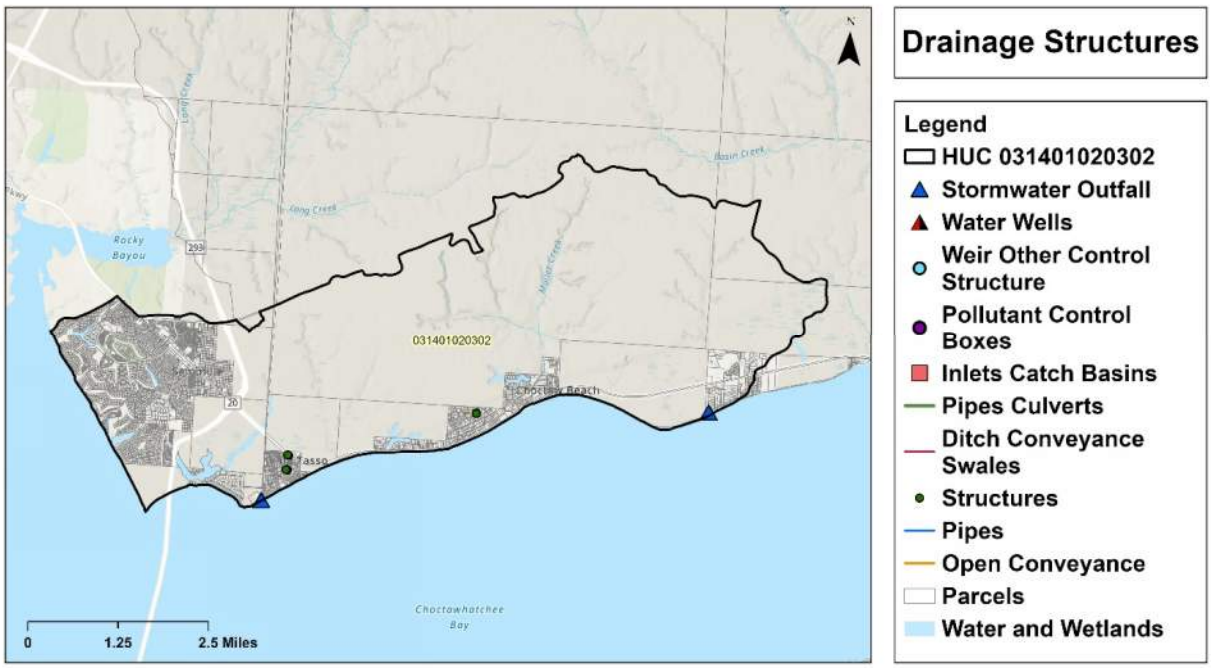

Figure 27. Stormwater Infrastructure for the HUC 031401020302. Processed by FAU.

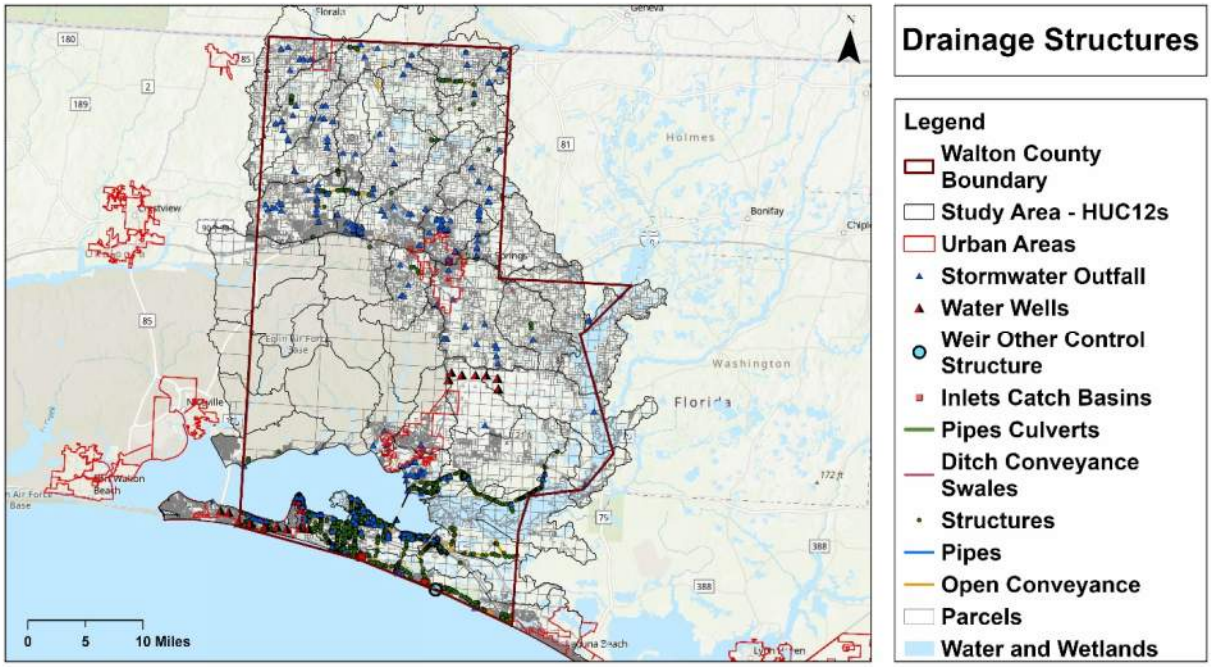

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401020302 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species

while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

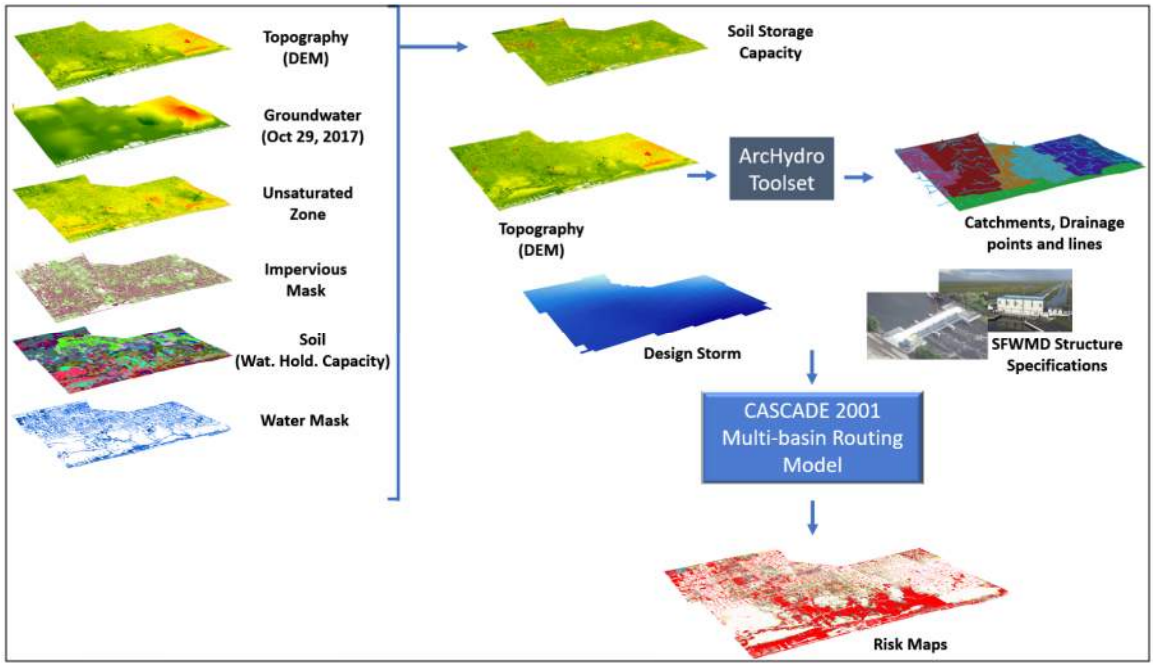

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are

critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

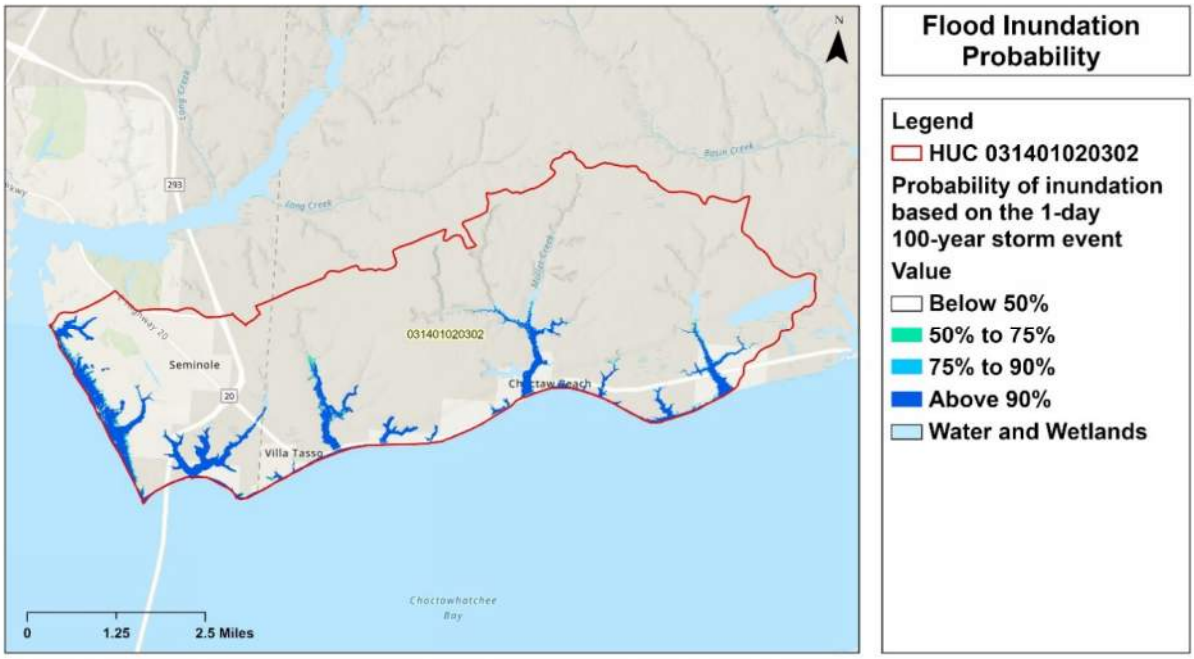

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401020302, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate

the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not

eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Future Challenges of Sea Level Rise and Climate Change

Global observations from satellites and long-term data collection have made it possible to document and analyze patterns in the Earth's climate. Scientific analysis of the impact of these changes has helped to improve the understanding of future flood hazard driving forces and long-term impacts on human activities and watershed master planning (http://www.research.noaa.gov/climate/t_observing.html). Examples of impacts are rising global average air and ocean temperatures, increased and earlier snow and ice melt, shorter subtropical rainy seasons, shifted seasons, sea level rise and greater variations in temperature and precipitation (IPCC, 2013; Freas et al., 2008; Marshall et al., 2004; Bloetscher et al., 2010). Marshall et al. (2004) specifically focused on the Florida peninsula to predict changes in rainfall and warmer temperatures but interspersed lower low temperatures due to the potential loss of wetlands.

Future changes in climate will add to the existing impacts, at a time when the population of the state is expected to nearly double by 2030. Additional research and high-resolution climate modeling for the Florida peninsula and local jurisdictions is needed to help guide long-term plans like WMPs. Rainfall appears to be decreasing and temperatures rising (see **Error! Reference source not found.**).

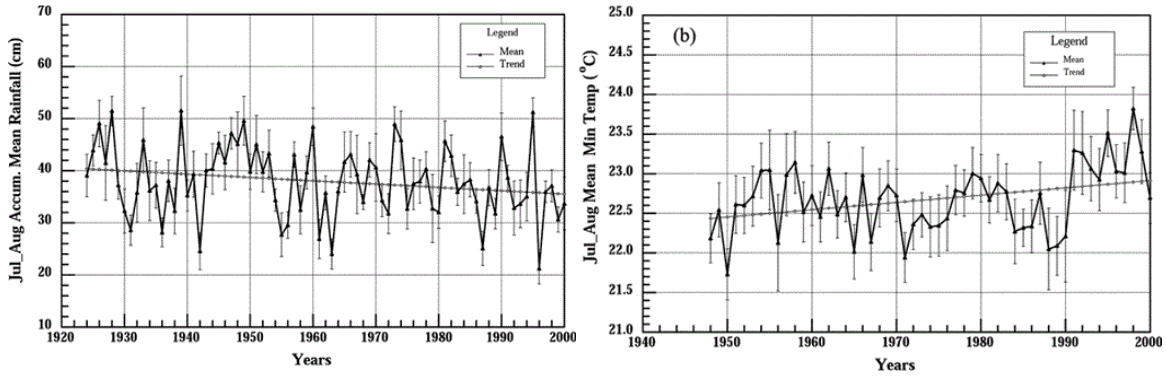

Figure 31. Change in average rainfall and change in average temp 1924 to 2000. Note the reversed trend, which means groundwater input variability is lessened. Source: Marshall et al., 2004.

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as

sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3 feet. Accompanying these drivers are potential changes in storm frequency and intensity, desertification, population migration, ocean acidification and coastal flooding (IPCC, 2007), exacerbated by the land cover and land use changes, which are substantially impacted by the fluxes, timing and quality of precipitation (Adrians et al., 2003; Scanlon et al., 2005; Marshall et al., 2004; Salmun and Molod, 2006), and leading to changes in the timing of peak flows and volumes (Richey and Costa-Cabral, 2006).

The results of these climatic changes are likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly An outcome of these climatic patterns is that during the past 140 years, an increase in sea levels has been observed (Bloetscher, 2012), a worrying pattern since sea level rise is a permanent phenomenon, that can be catastrophic to low lying areas in the long-term. The question is how much and how soon? Various studies (Bindoff et al., 2007; Domingues et al., 2008; Edwards, 2007; Gregory, 2008; Vermeer and Rahmstorf, 2009; Jevrejeva, Moore and Grinsted, 2010; Bloetscher, 2010, 2011; IPCC, 2007; Heimlich et al., 2009) indicate large uncertainty in projections of sea level rise by 2100. Gregory et al. (2012) note that during the last two decades, the global rate of sea level rise has been larger than the 20th-century time-mean, and Church et al. (2011) suggested that the cause was increased rates of thermal expansion, glacier mass loss, and ice discharge from icesheets. Gregory et al. (2012) suggested that there may also be increasing contributions to global sea level rise from the effects of groundwater depletion, reservoir impoundment, and loss of storage capacity in surface waters due to siltation. Measurements of Florida's east coast (Maul, 2008) show an average rate of sea level rise of 2.27 ± 0.04 mm per year from 1915 to 1992 based on tide gauge readings. Analyzing the tidal gauge readings for Florida shows that:

1. Florida average sea level rise is 2.10 ± 0.49 mm/yr
2. All but one location is within the 95% confidence limit range (the exception is Panama City where there is evidence of submergence and other land-based issues)

3. None of the Florida sea level rise rates differ statistically
4. Average global sea level rise for 1920-2000 was 2.0 mm/yr – within 95% confidence limit for Florida locations

From 1929 to 1992, over eight inches of sea, with another 6 inches added since 1992, which is already having significant impacts on coastal communities where population growth has increased the need for improved flood management strategies (Bloetscher, 2008; Parkinson, 2010; Zhang et al., 2011, 2011a; NFIP, 2011; Schmidt et al., 2011; Warner et al., 2012).

As a result, the SFRCCC (2015) adopted USACE's methodology to derive scenarios of sea level change intermediate to high rates of sea level rise for years 2030 (3" to 7") and 2060 (9" to 24") as the consensus projection to guide future planning. The path keeps increasing – now 14 inches since 1929 (**Error! Reference source not found.**) caused by thermal expansion of the ocean and melting ice caps (Jevrejeva et al., 2010; Vermeer and Rahmstorf, 2009). Sea level rise is a major concern in Florida, including Walton County, since the majority of the state's population live on the coast, involving most major commercial, residential, and economic enterprises. **Error! Reference source not found.** demonstrate the estimated sea level change for Panama City, considering the predictions of NOAA 2017. For NOAA high scenario SLR change scenario, the estimated level change is higher than 8 ft., while for the intermediate and low scenarios are about 3.9 feet and 1.7 feet respectively.

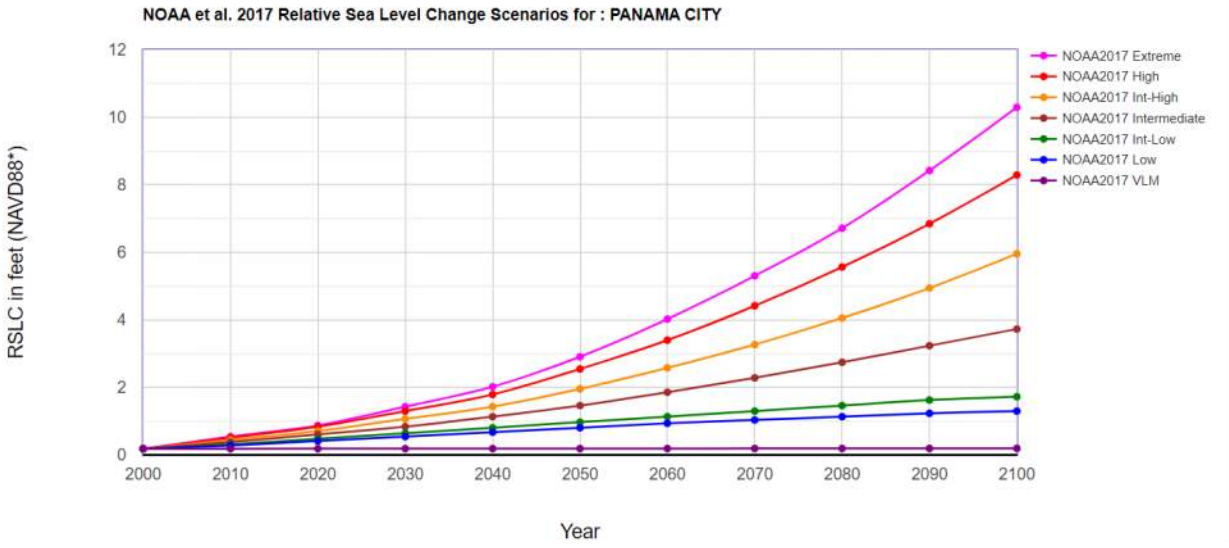

Figure 32. Relative Sea Level Change Scenarios for gauge 8729108, Panama City, FL. Source: NOAA 2017 (https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html).

NOAA (2017) outlines five scenarios for sea level rise. The NFIP proposes the use of the intermediate high projection, which is 1.2 meters or 4 ft globally from current sea level elevations (**Error! Reference source not found.**).

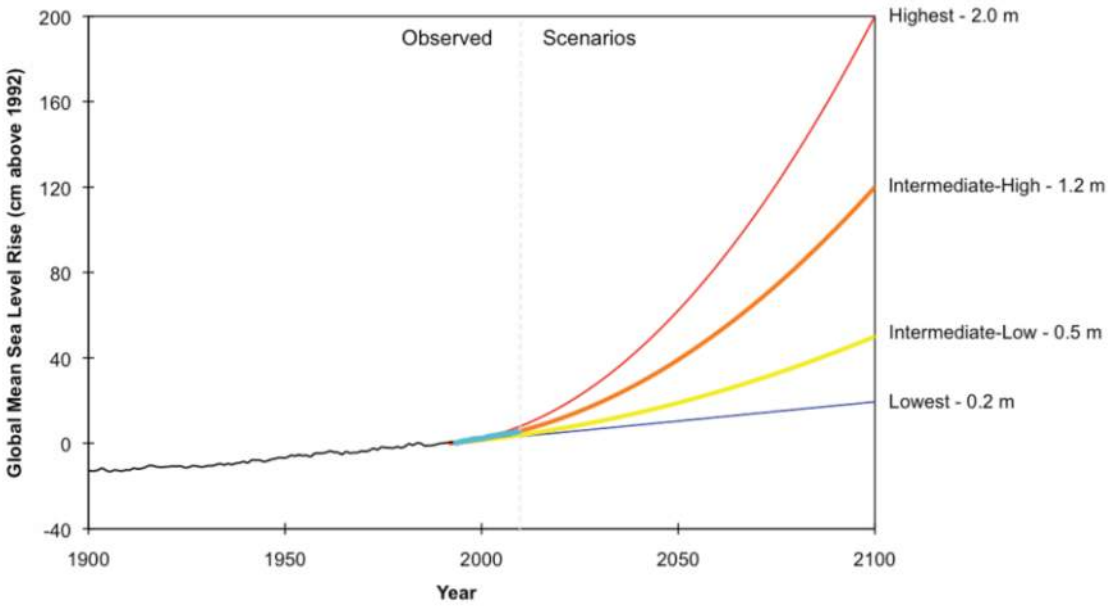

Figure 33. Graphic of global sea level rise projections from NOAA (2017). Source:https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

As sea level rises, access to roads, bridges, rail, and transit could be at risk of flooding, causing the effects of sea level rise to spread indirectly throughout the entire transportation network, affecting the overall system performance. For example, the flooding of a critical road or facility access can cause a shifting of traffic flow causing congested conditions in other roadways that are not actually flooded. Since the roadway network would be unable to carry the traffic demand, the system would experience operational failure; as a result, causing travel times and delays. Moreover, the inundation of a critical access could cause transportation connectivity problems to essential infrastructure like ports or airports. Transportation infrastructure relies on the effectiveness of flood control and stormwater drainage systems for the transportation corridors. Road integrity relies on adequate drainage. The increased risk of severe flooding in Florida's low-lying terrain can adversely affect transportation infrastructure along the coastline; roads can be inundated, and roadway beds can be damaged. Sea level rise will cause increased water table levels (FDOT, 2012), as regional water tables cannot exist naturally below mean high tide (2 feet in Florida). Adding 3 feet of sea level rise on top of groundwater would compound the risk of flooding in low-lying areas. Road bases below 5 feet NVGD would become saturated under this scenario, likely causing premature base failure. As soil storage capacity is diminished due to rising groundwater elevations associated with sea level rise, the potential for more frequently flooded roadways would likely damage pavements (FDOT, 2012). Hence sea level rise must be accounted for in WMPs in coastal areas. To allow flexibility in the analysis due to the range of increases within the different time periods, an approach that uses incremental increases of 1, 2, and 3 feet of sea level rise is suggested for modeling. The increments can work as threshold values in planning

considerations in terms of allowing planners the ability to know ahead of time where the next set of vulnerable areas will be, to allow for a proactive response approach that can be matched to the observed future rates. Sea level rise is a major concern since nearly half the US population lives within 50 miles of the coast, involving most major commercial, residential, and economic enterprises. The effects of 5 ft sea level rise, King tide, and 1-day 100-year storm event are shown in **Error! Reference source not found.**.

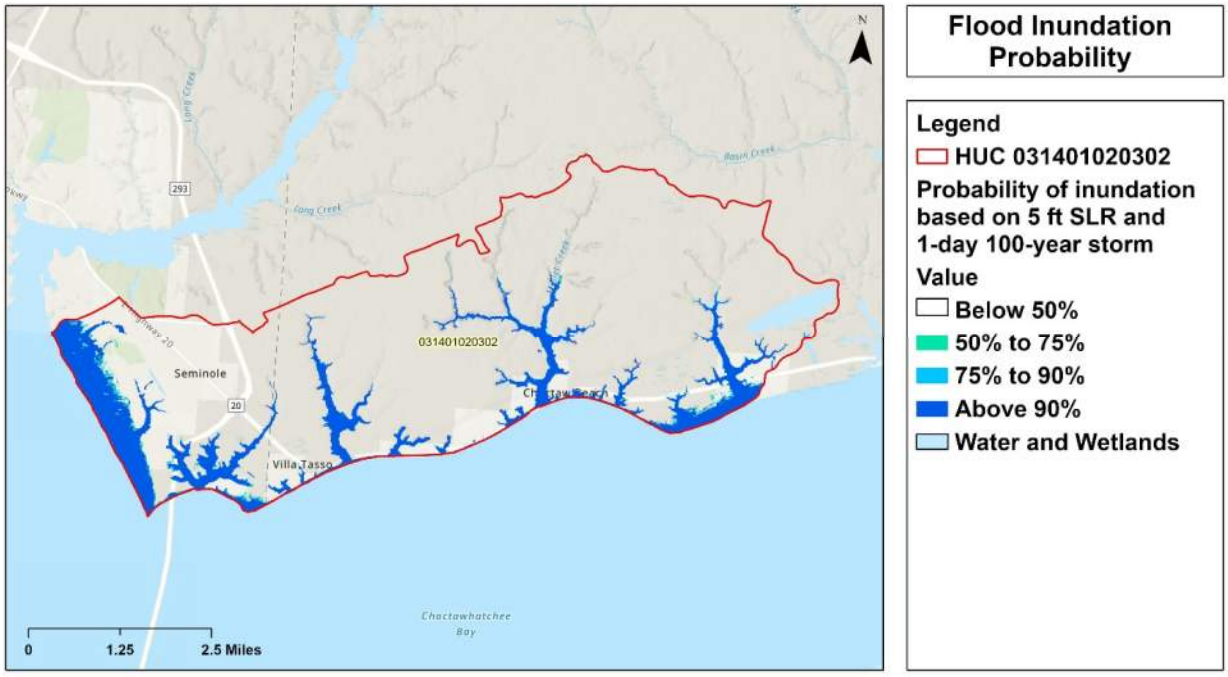

Figure 34. Flood Inundation Probability for a Sea level rise of 5 ft + 1-day 100-year storm event for HUC 031401020302 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Dark blue is area under 5 ft NAVD88 and potentially inundated at the 99th percentile tidal conditions. Processed by FAU.

2.4 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. **3-day 25-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 35)
2. **1-day 100-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 36)

3. **1-day 10-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 37)
4. **1-day 5-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 38)
5. **Sea level rise of 1 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 39)
6. **Sea level rise of 1 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations storm (Figure 40)
7. **Sea level rise of 1 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 41)
8. **Sea level rise of 1 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 42)
9. **Sea level rise of 2 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 43)
10. **Sea level rise of 2 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 44)
11. **Sea level rise of 2 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 45)
12. **Sea level rise of 2 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 46)
13. **Sea level rise of 3 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 47)
14. **Sea level rise of 3 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 48)
15. **Sea level rise of 3 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 49)
16. **Sea level rise of 3 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 50)

17. **Sea level rise of 4 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 51)
18. **Sea level rise of 4 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 52)
19. **Sea level rise of 4 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 53)
20. **Sea level rise of 4 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 54)
21. **Sea level rise of 5 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 55)
22. **Sea level rise of 5 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 56)
23. **Sea level rise of 5 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 57)
24. **Sea level rise of 5 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 58)

In all scenarios, a considerable amount of flooding is noted along the coast and following the waterbodies flow path. As this basin connects to the ocean though Choctawhatchee Bay, SLR scenarios plays an important hole, implying a considered growth as the projected scenario of rising tides rises.

The design storm simulation determined that approximately 5.5% of the HUC total area or 1.46 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 6% of the HUC's total area, or 1.60 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 5% of the HUC's total area, or 1.32 mi^2, would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 4.7% of the HUC's total area, or 1.25 mi^2, would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401020302 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	25.19	1.46	94.5%	5.5%
1-day 100-year	25.05	1.60	94.0%	6.0%
1-day 10-year	25.32	1.32	95.0%	5.0%
1-day 5-year	25.40	1.25	95.3%	4.7%

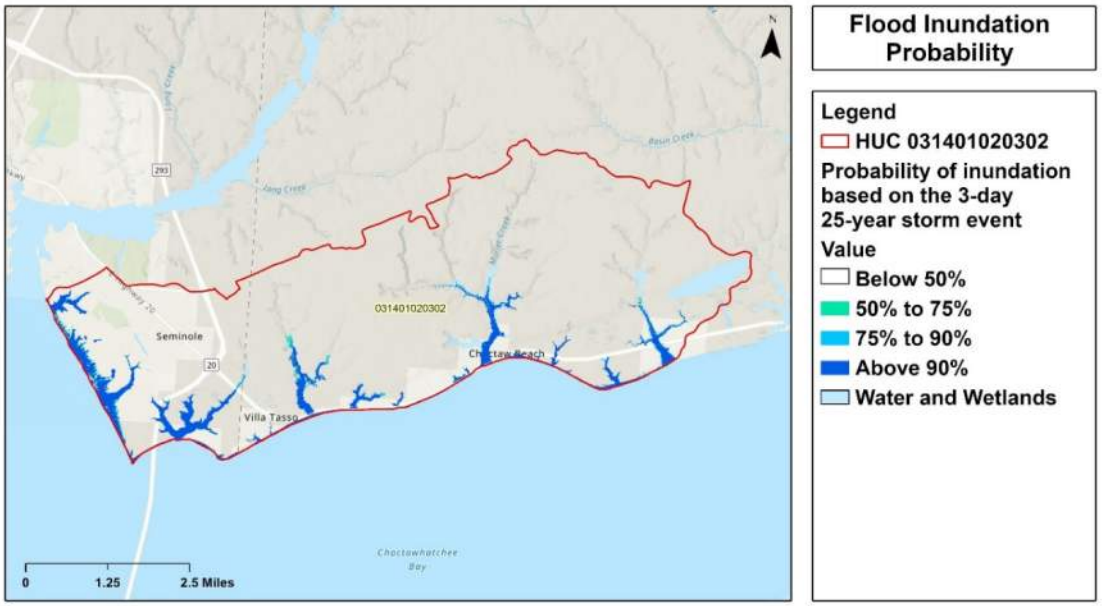

Figure 35. 3-day 25-year storm event for HUC 031401020302 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

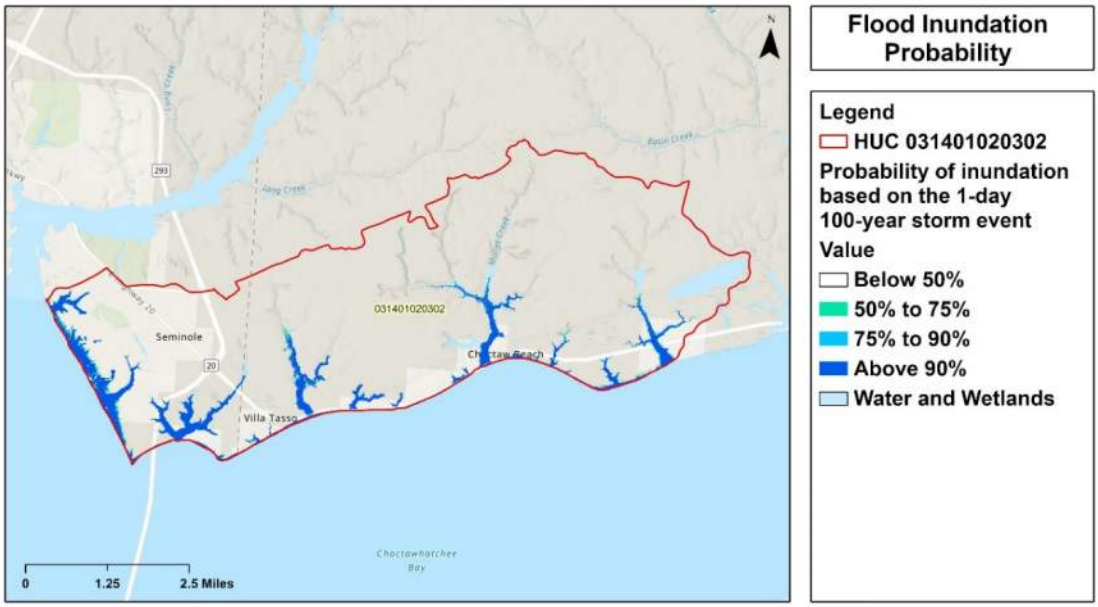

Figure 36. 1-day 100-year storm event for HUC 031401020302 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

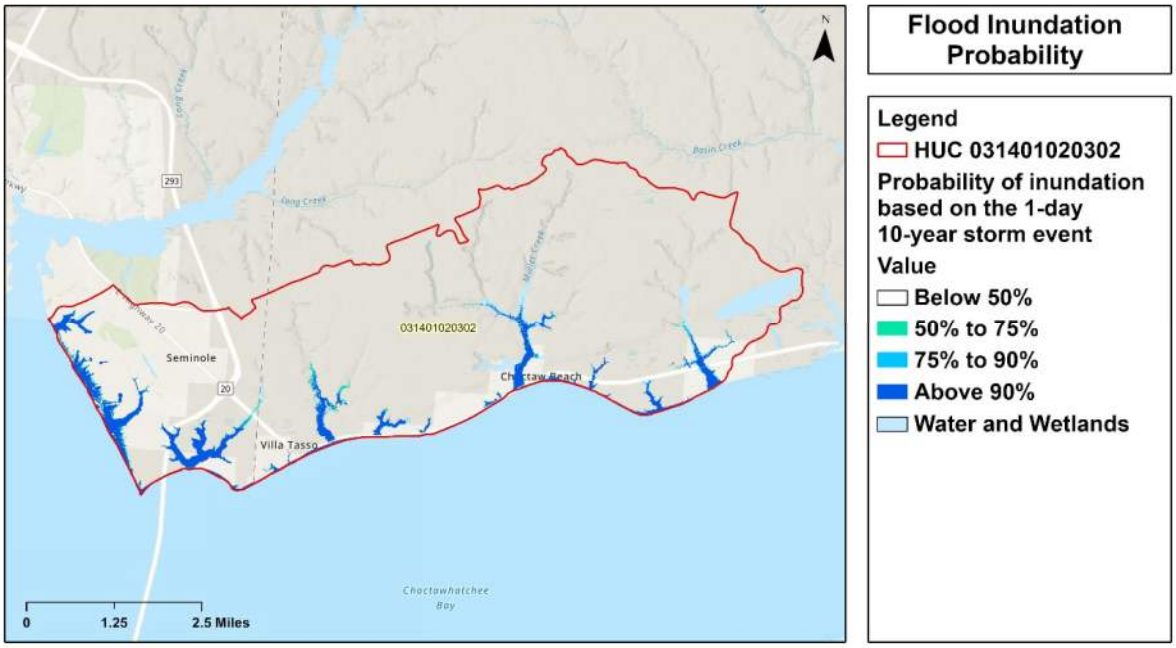

Figure 37. 1-day 10-year storm event for HUC 031401020302 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

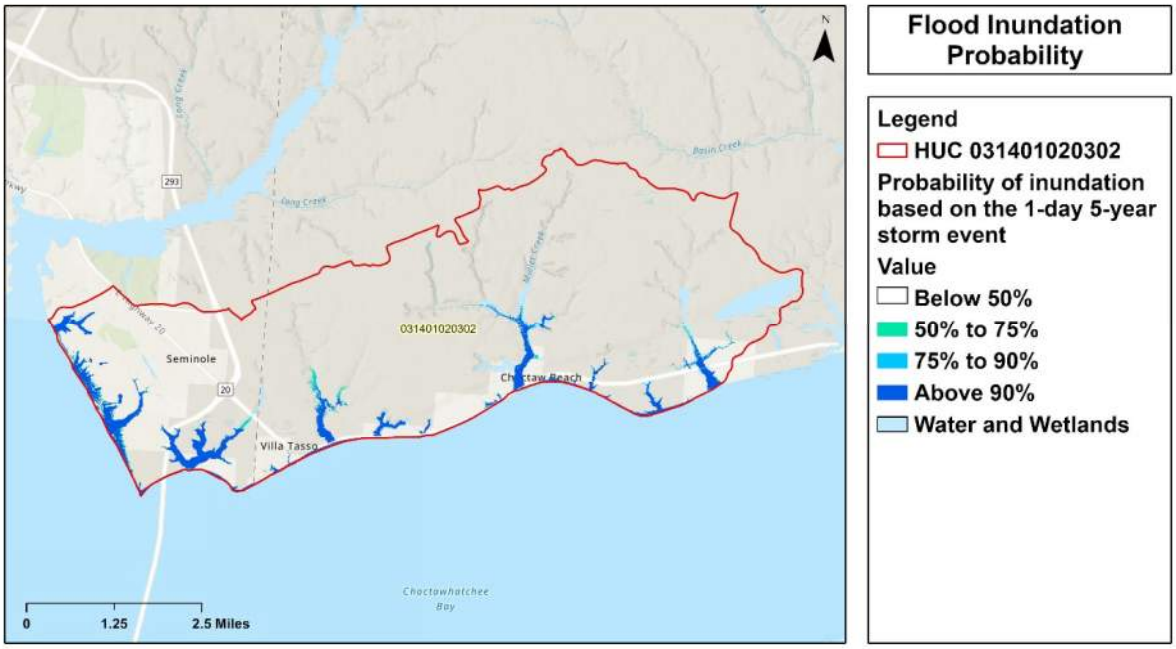

Figure 38. 1-day 5-year storm event for HUC 031401020302 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

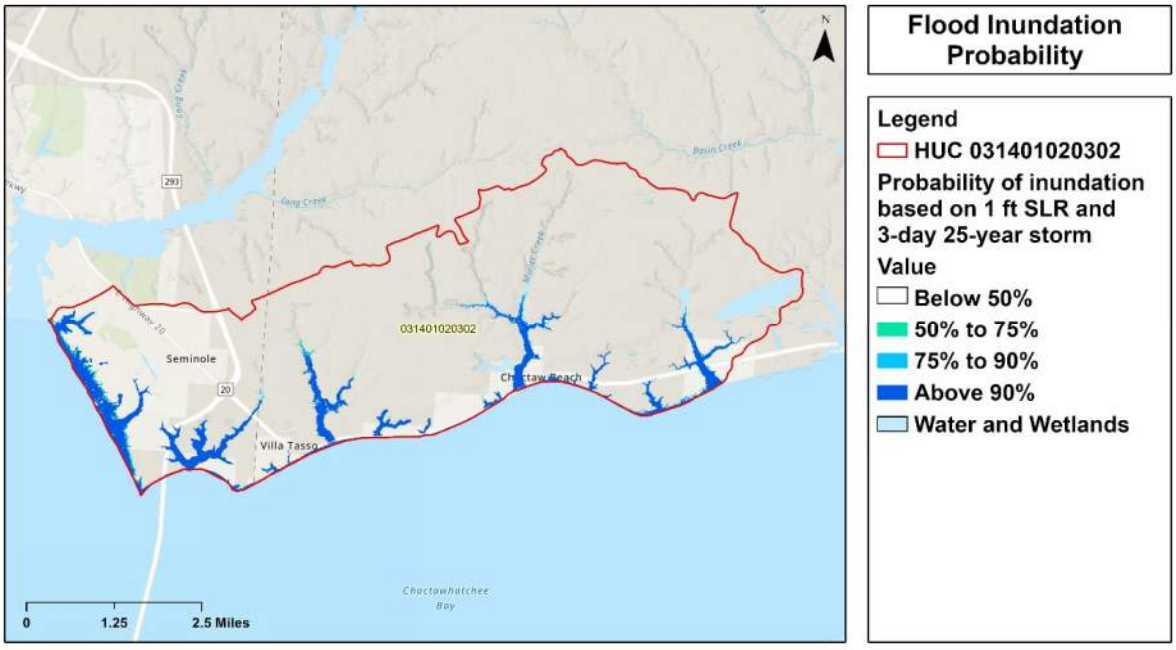

Figure 39. Sea level rise of 1 ft + 3-day 25-year storm for HUC 031401020302 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

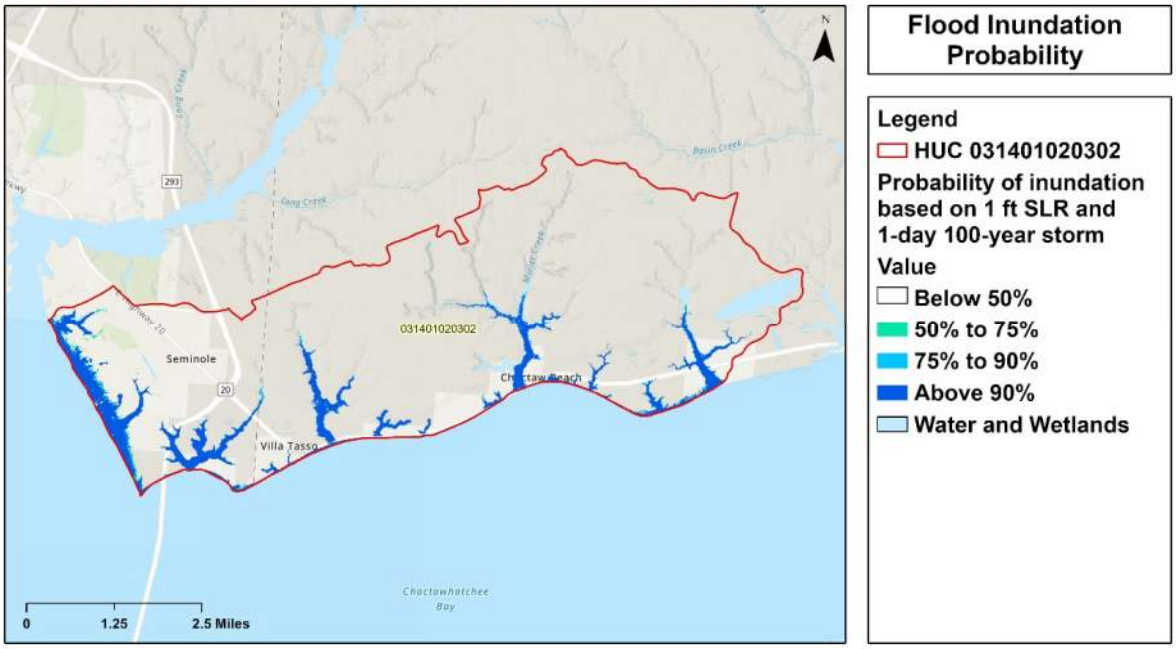

Figure 40. Sea level rise of 1 ft + 1-day 100-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

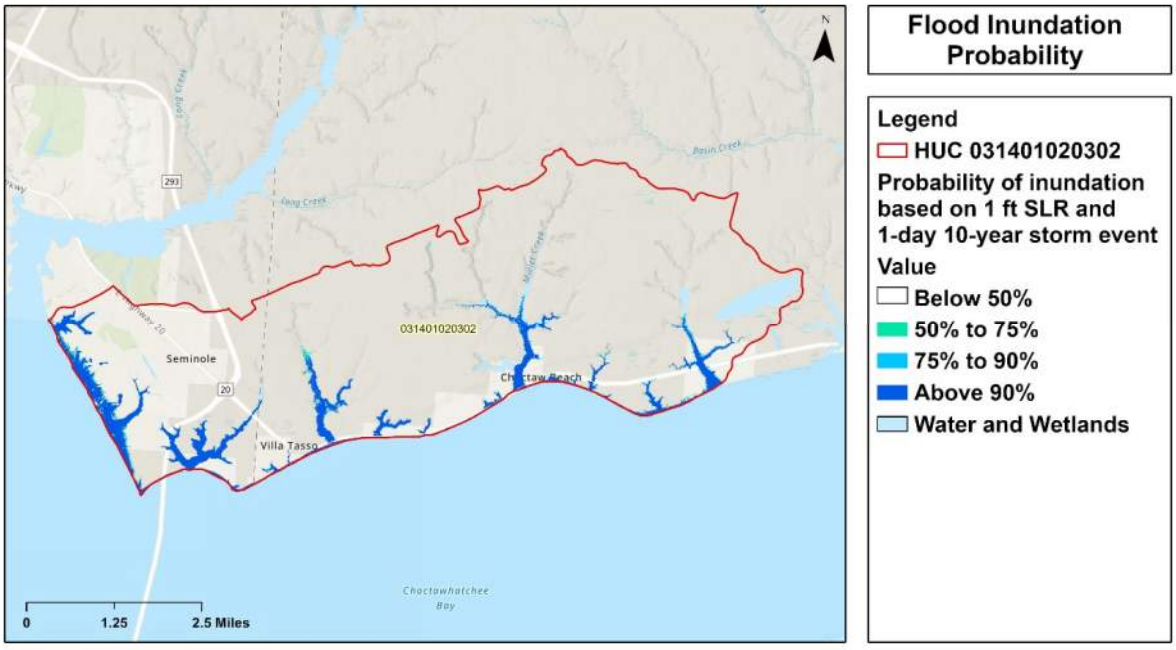

Figure 41. Sea level rise of 1 ft + 1-day 10-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

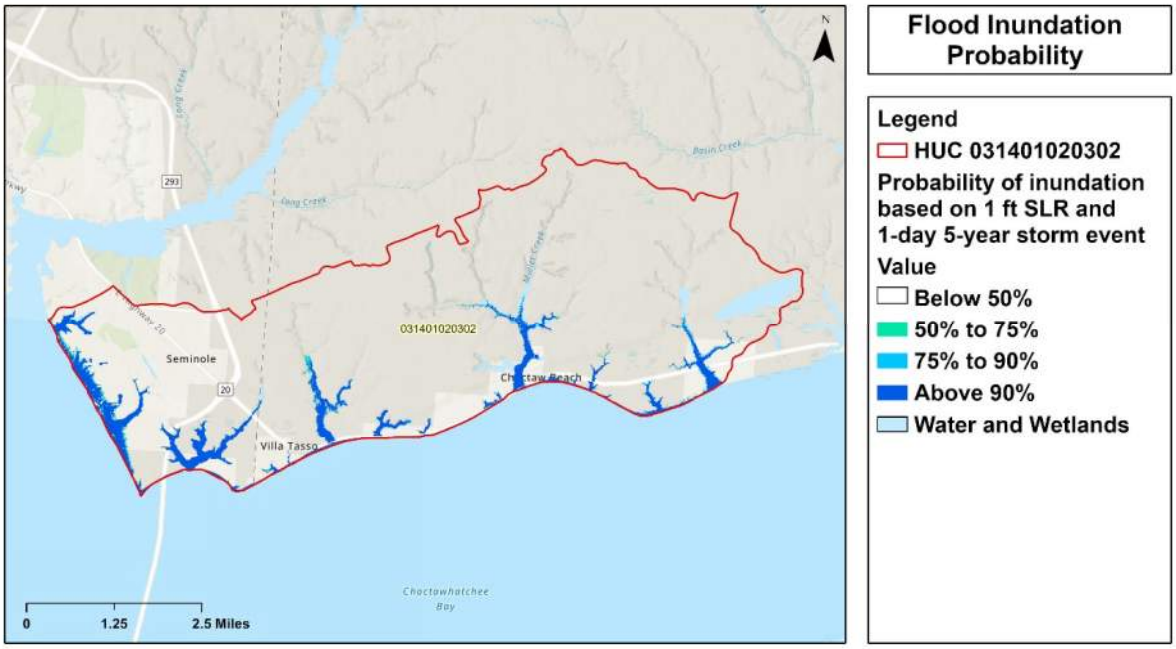

Figure 42. Sea level rise of 1 ft + 1-day 5-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

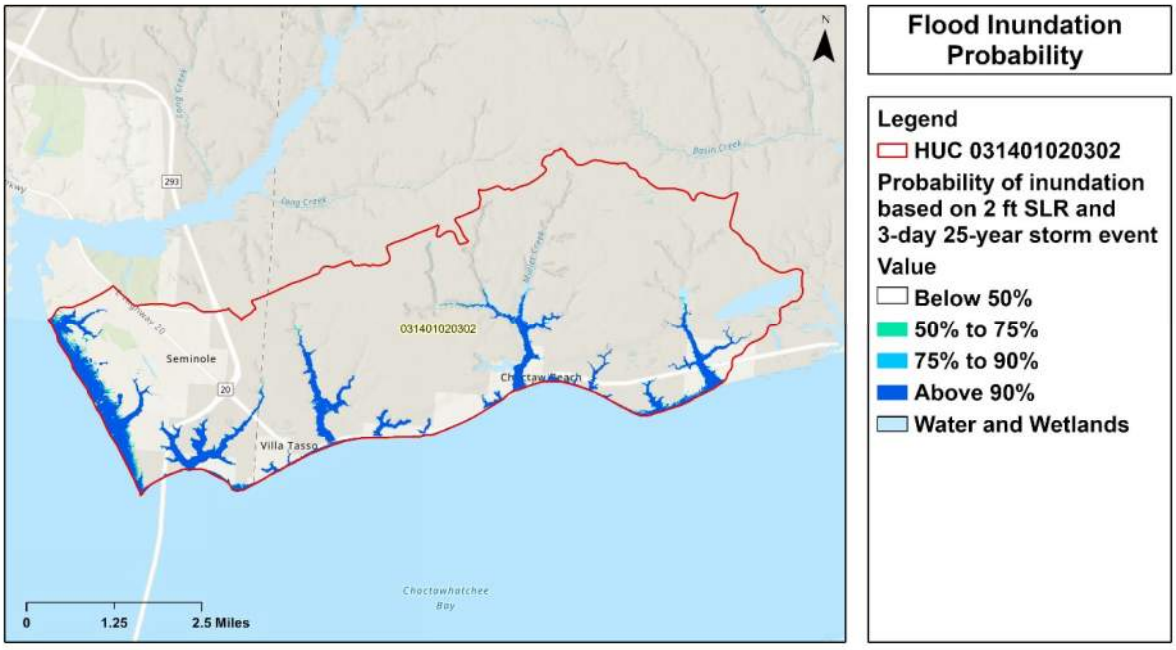

Figure 43. Sea level rise of 2 ft + 3-day 25-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

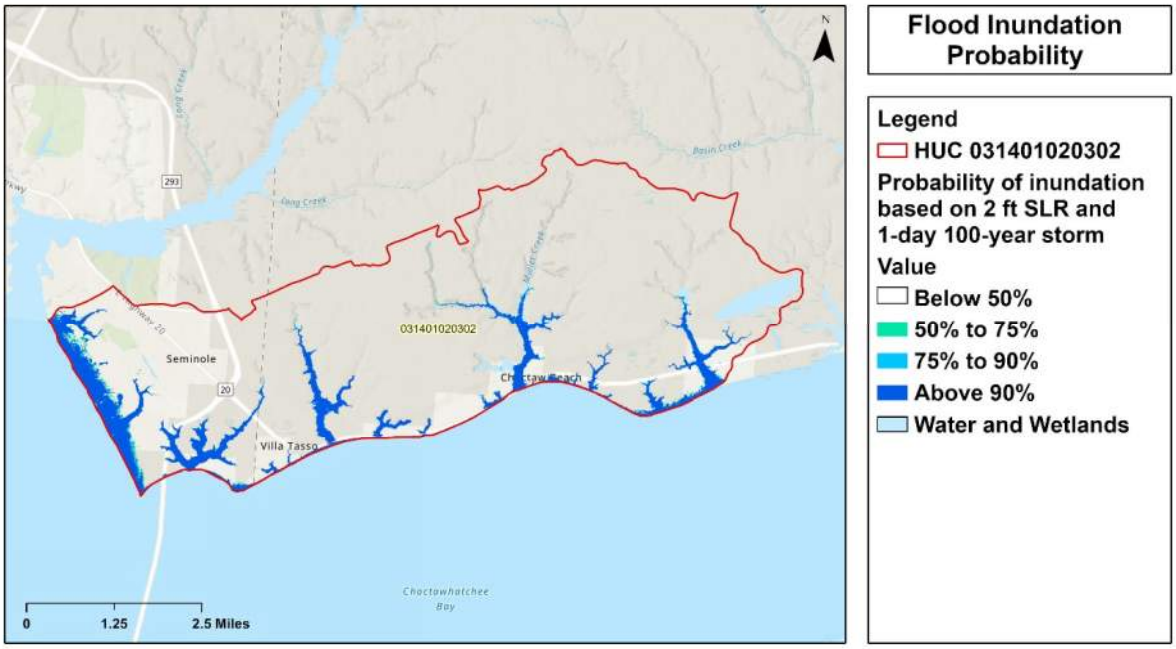

Figure 44. Sea level rise of 2 ft + 1-da, 100-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

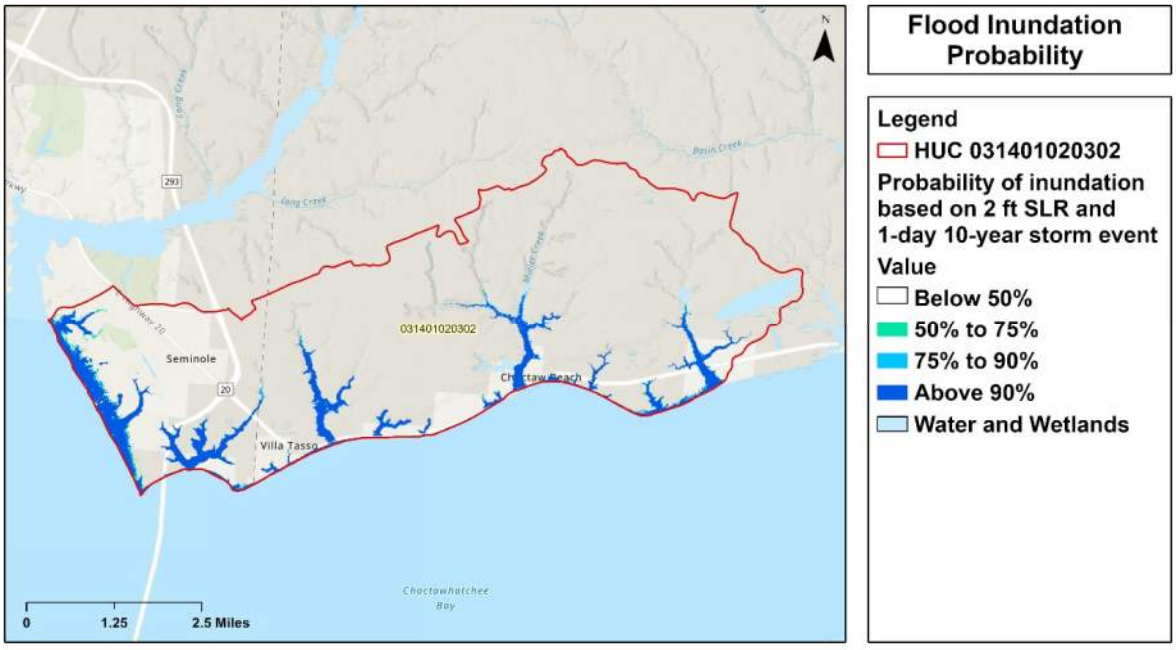

Figure 45. Sea level rise of 2 ft + 1-day 10-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

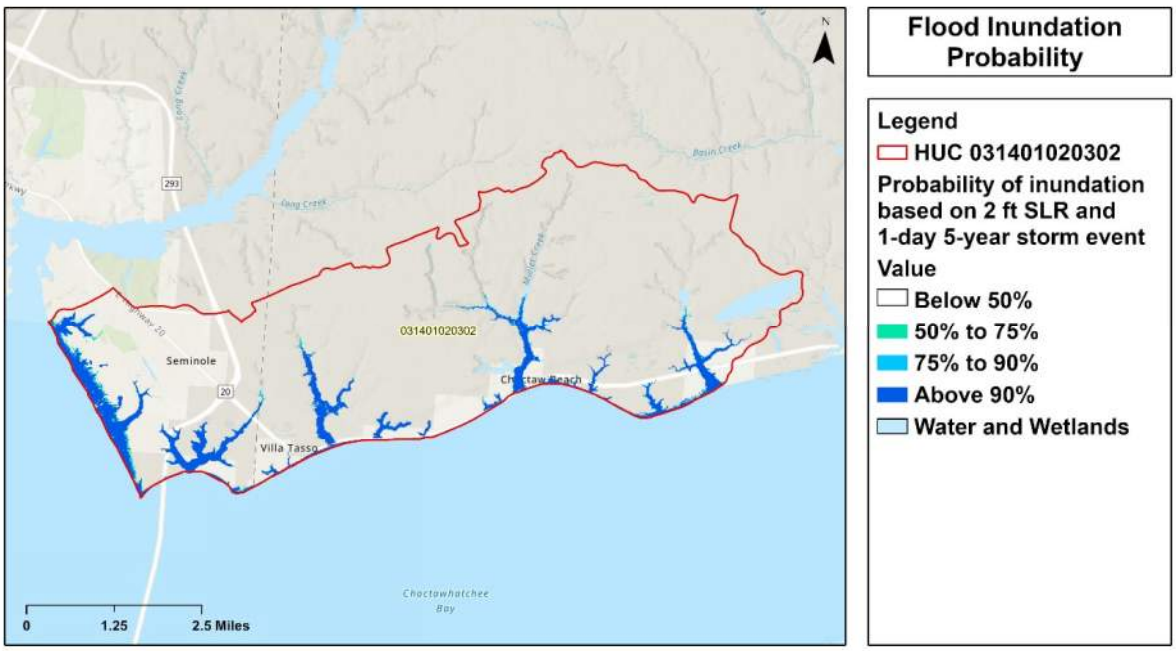

Figure 46. Sea level rise of 2 ft + 1-day 5-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

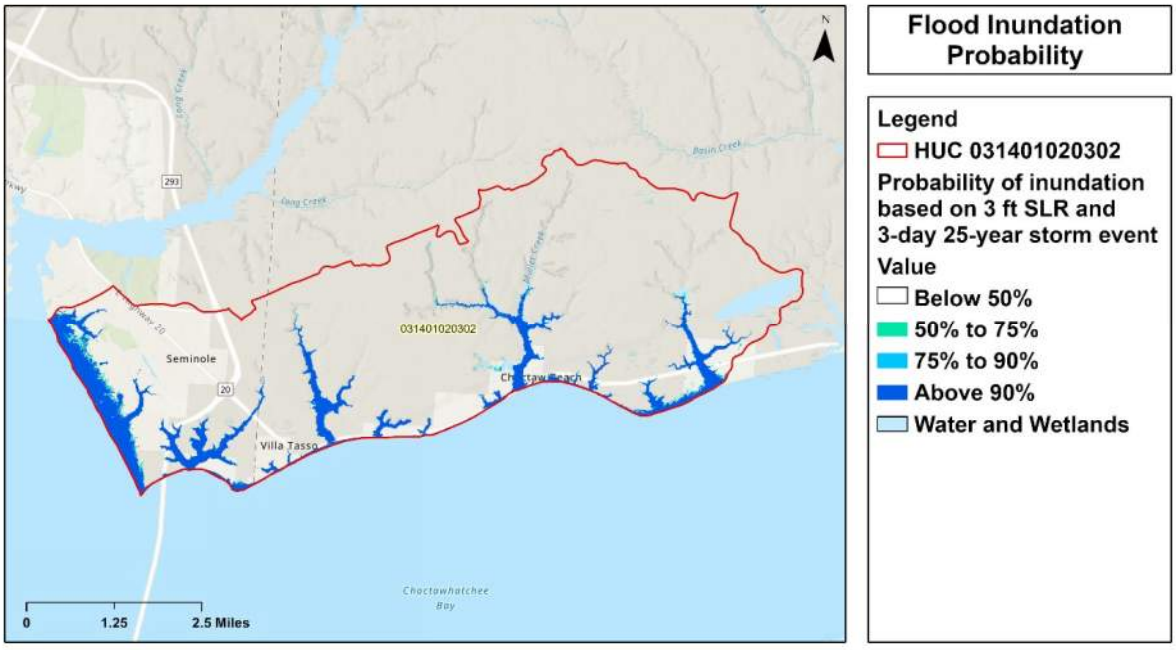

Figure 47. Sea level rise of 3 ft + 3-day 25-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

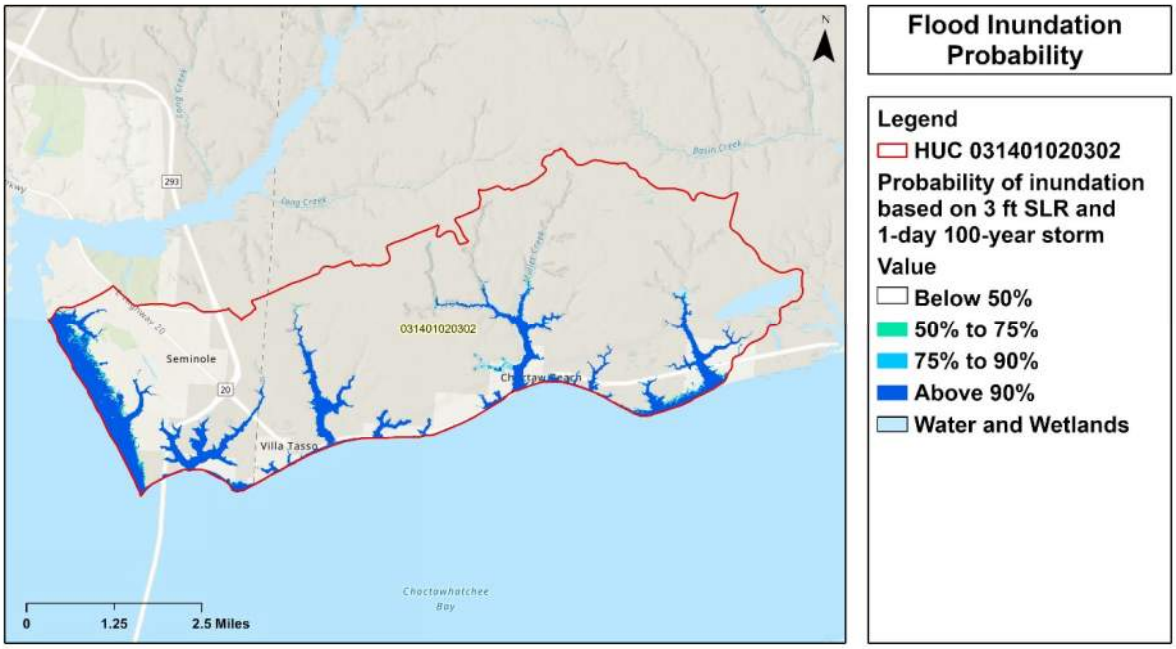

Figure 48. Sea level rise of 3 ft + 1-day 100-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

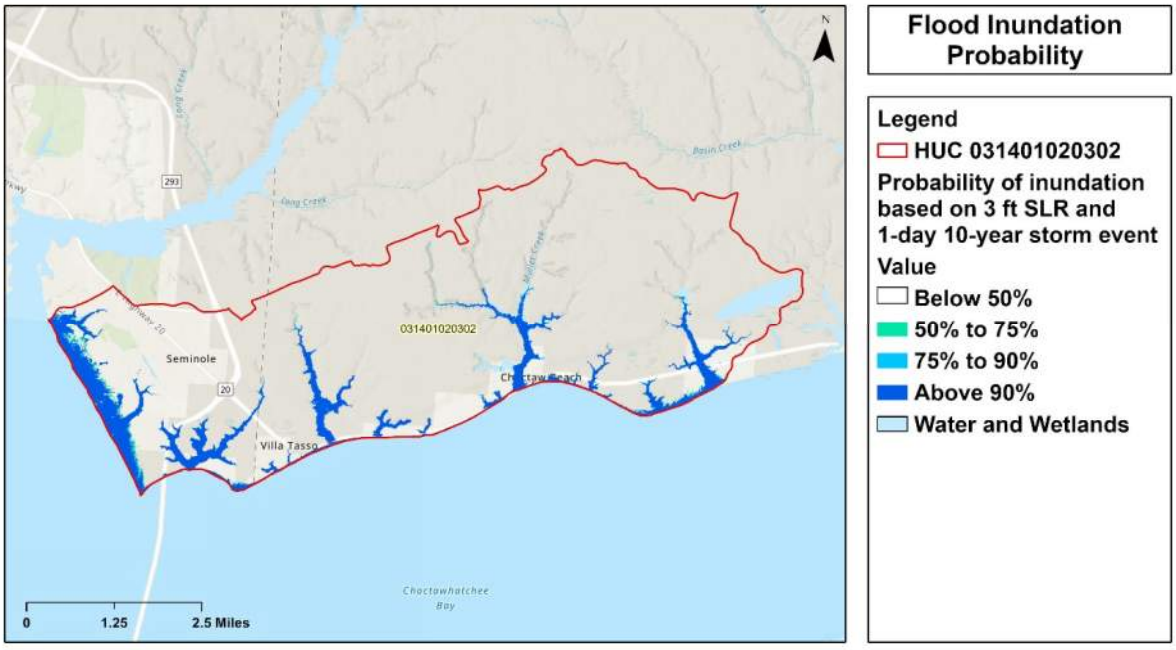

Figure 49. Sea level rise of 3 ft + 1-day 10-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

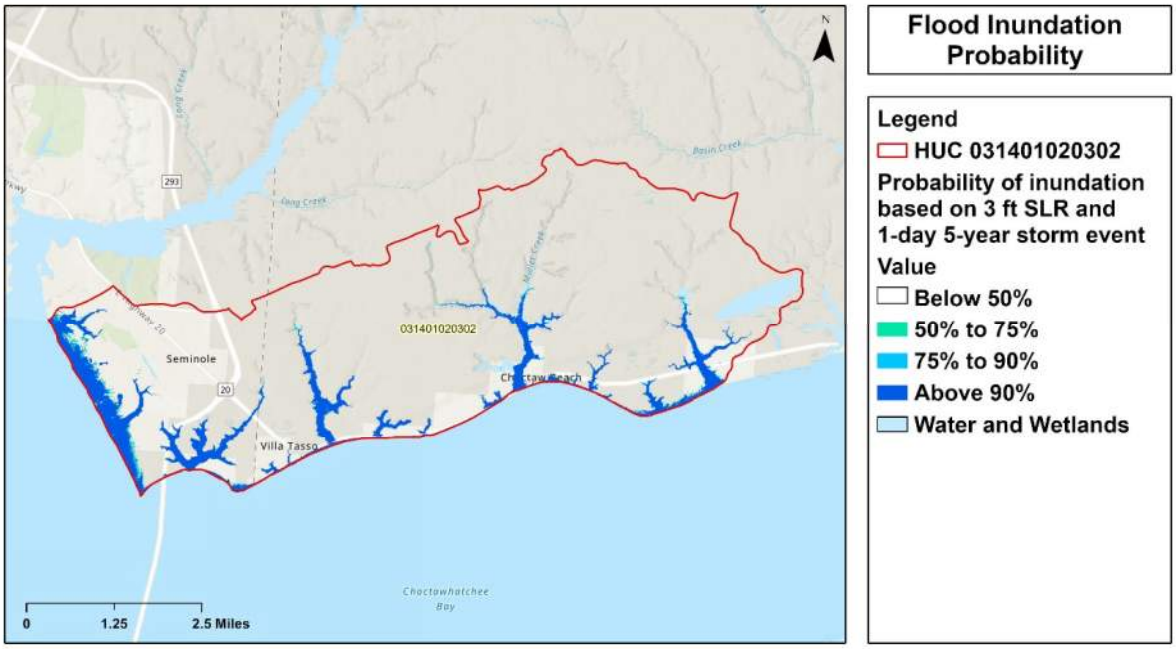

Figure 50. Sea level rise of 3 ft + 1-day 5-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

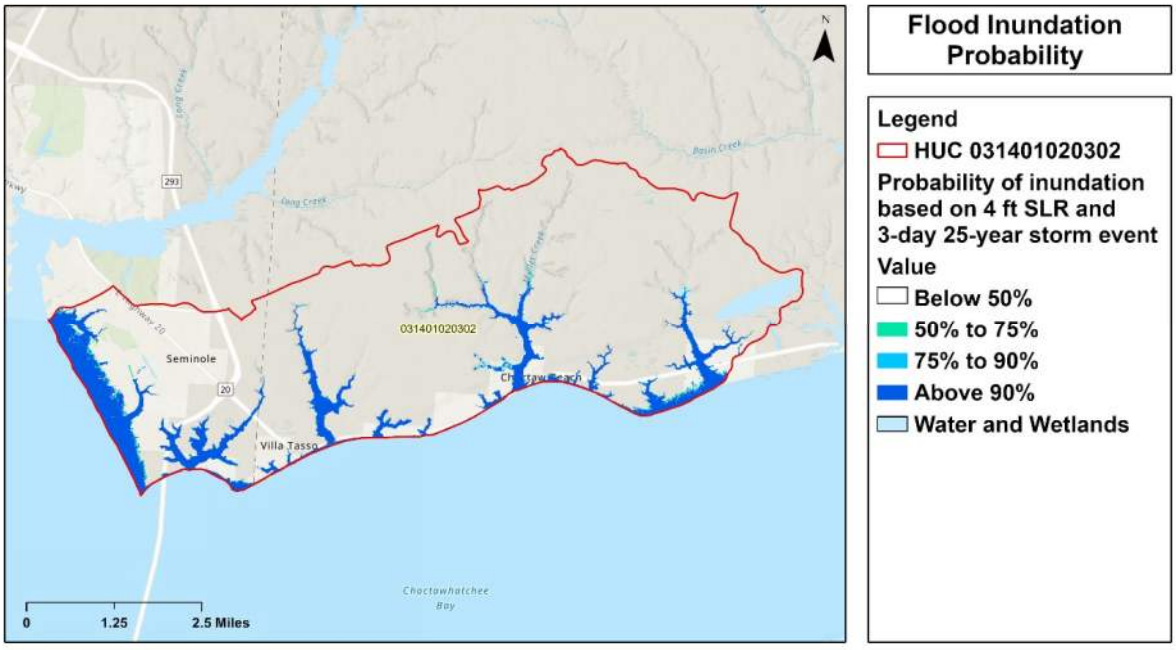

Figure 51. Sea level rise of 4 ft + 3-day 25-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

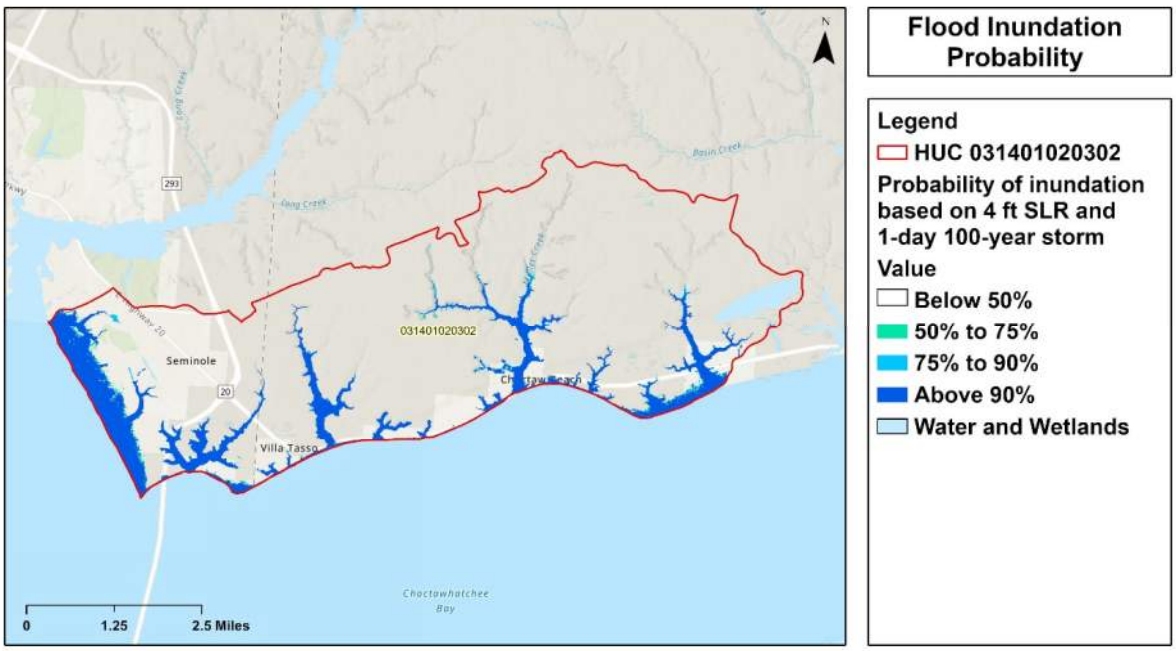

Figure 52. Sea level rise of 4 ft + 1-day 100-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

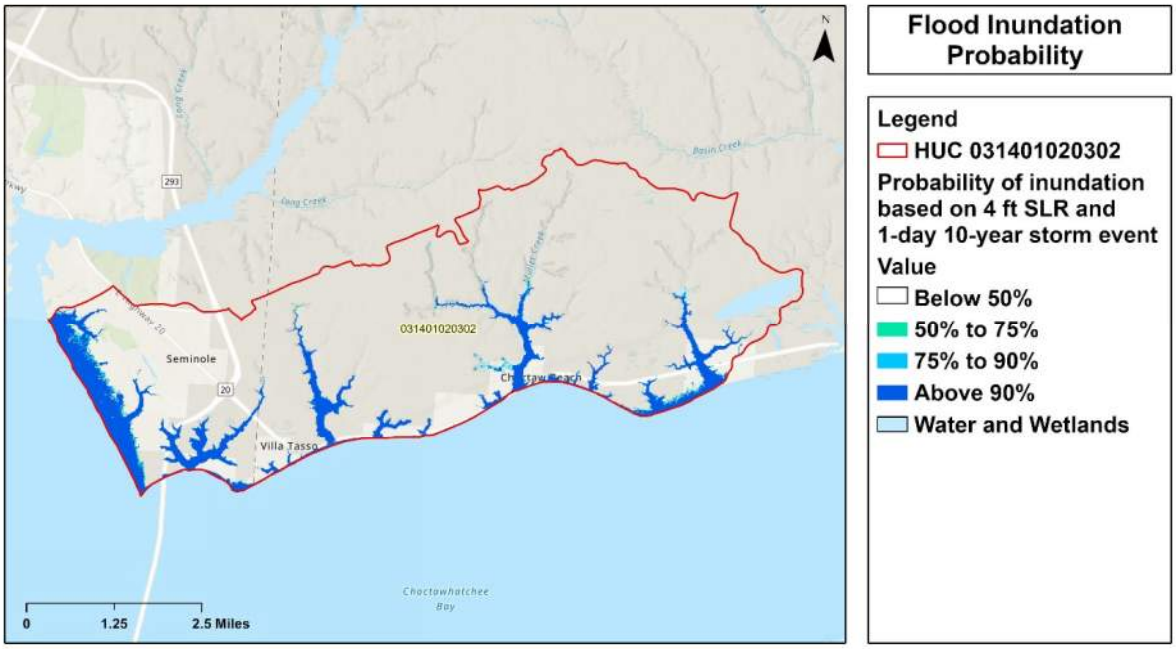

Figure 53. Sea level rise of 4 ft + 1-day 10-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

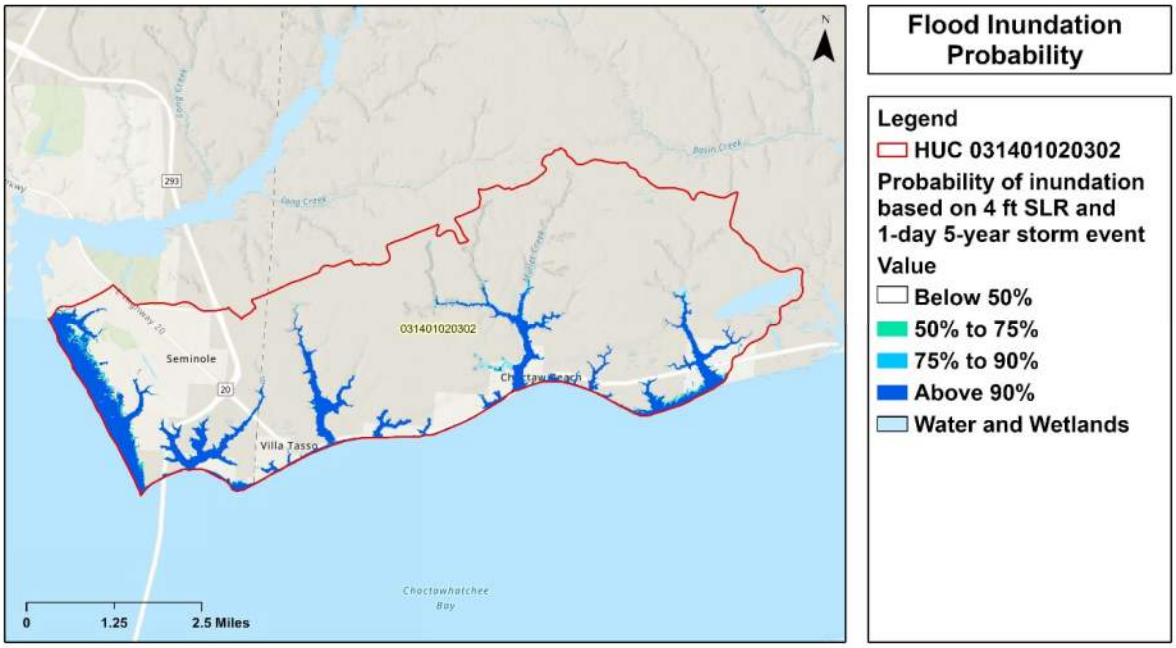

Figure 54. Sea level rise of 4 ft + 1-day 5-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

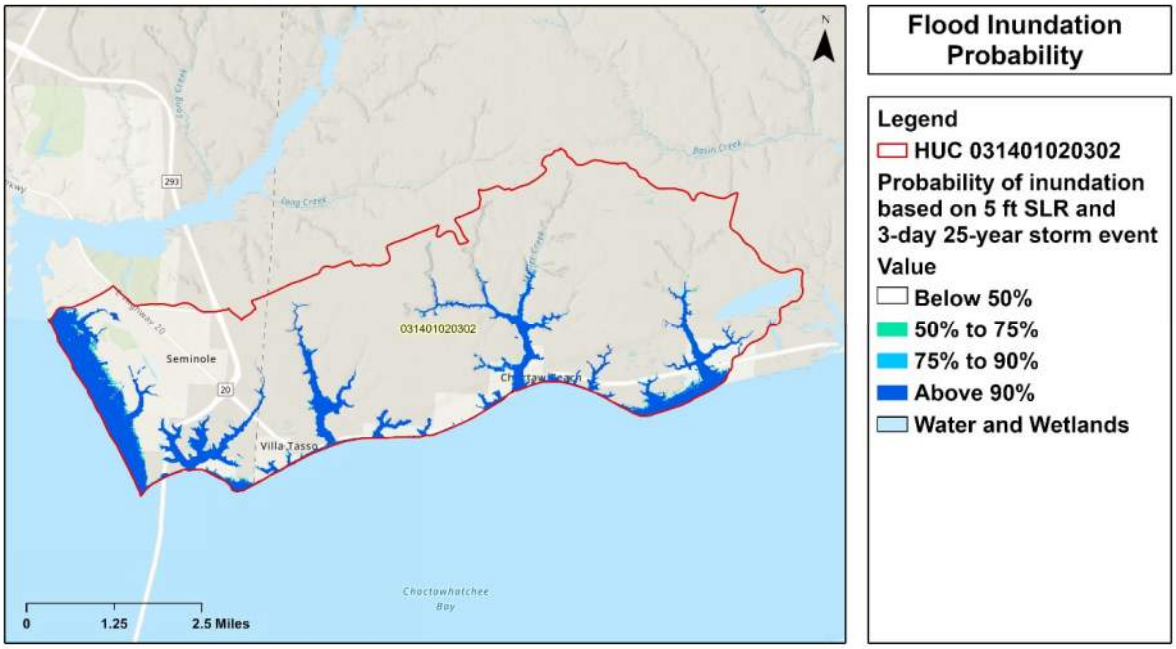

Figure 55. Sea level rise of 5 ft + 3-day 25-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

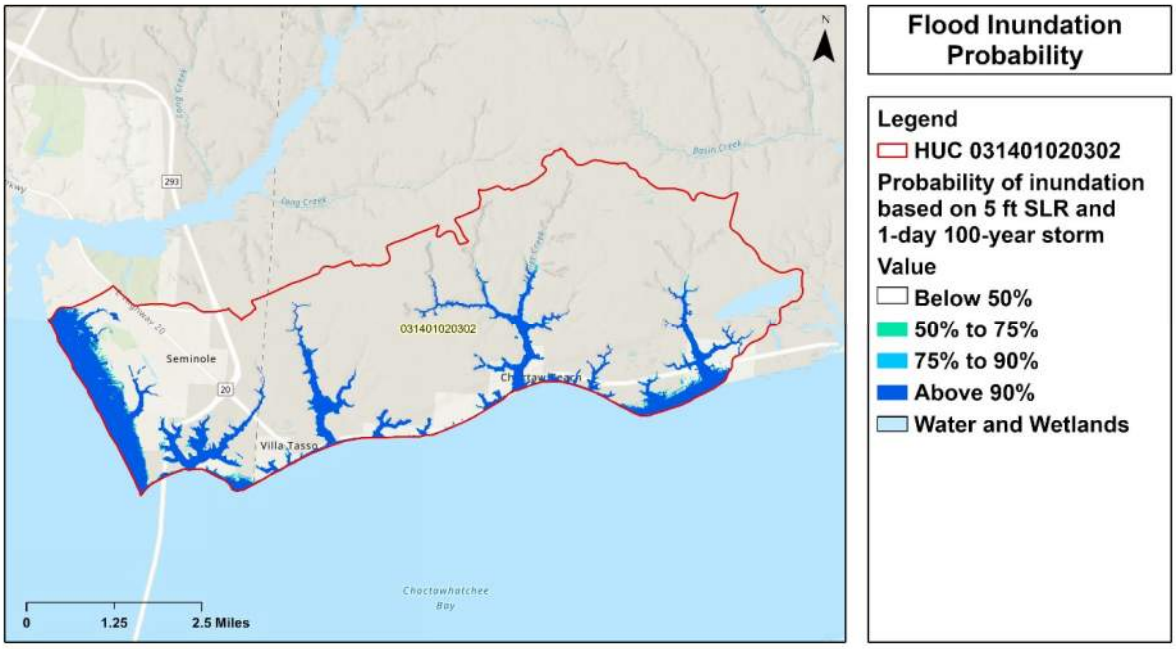

Figure 56. Sea level rise of 5 ft + 1-day 100-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

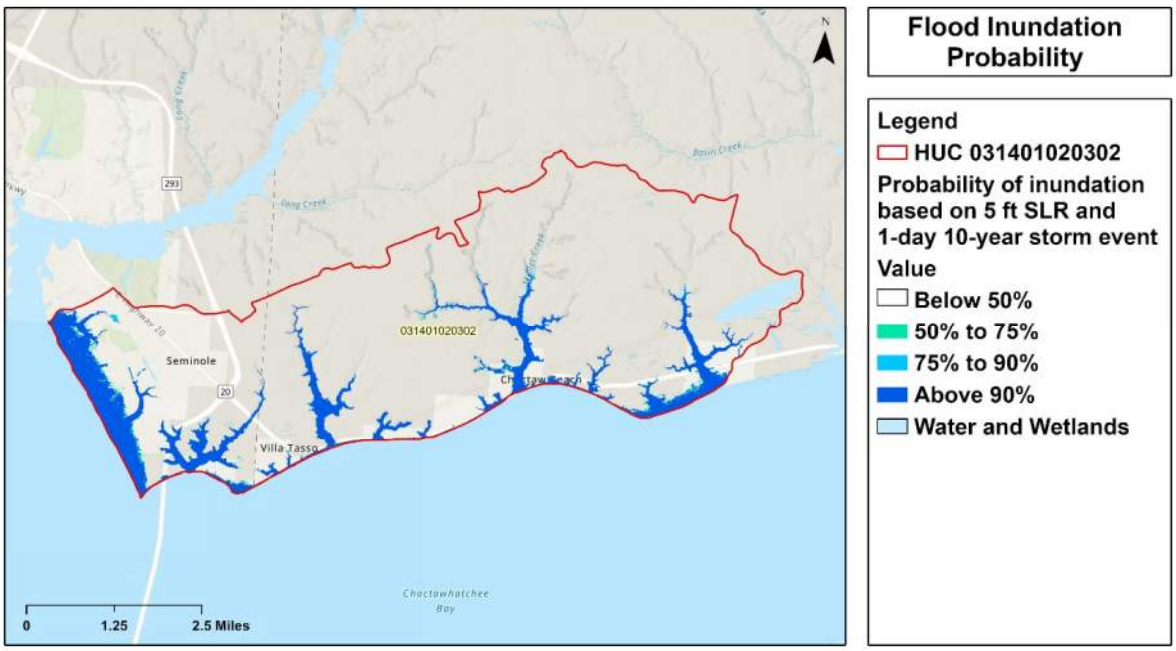

Figure 57. Sea level rise of 5 ft + 1-day 10-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

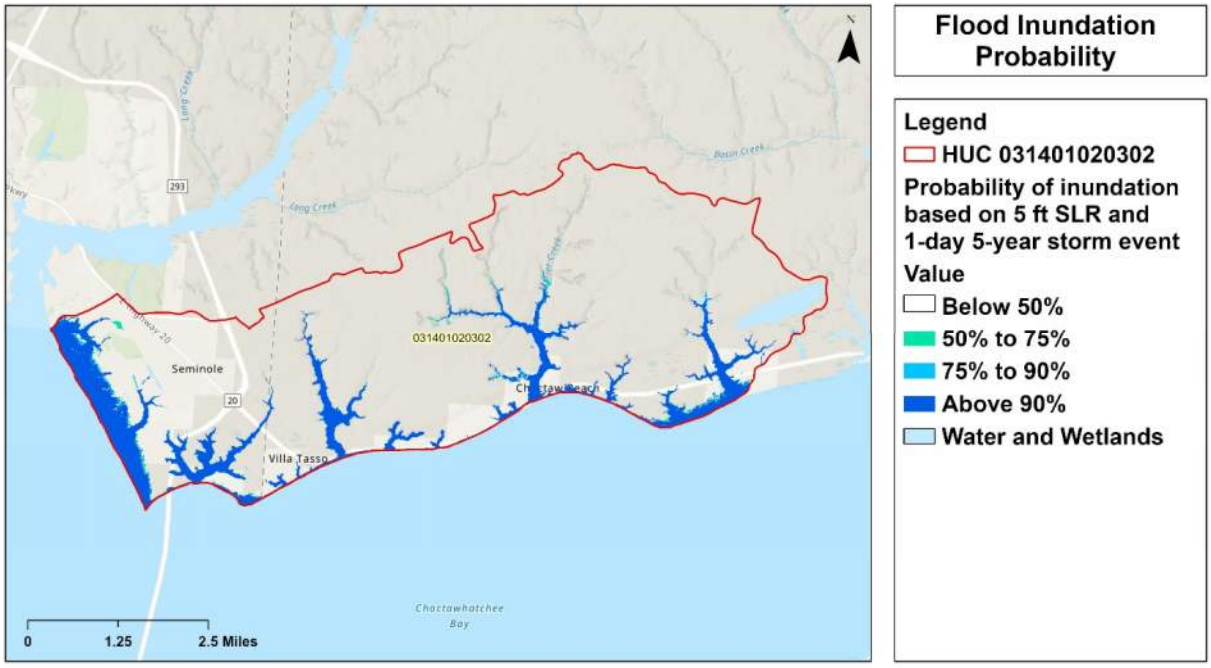

Figure 58. Sea level rise of 5 ft + 1-day 5-year storm for HUC 031401020302 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.5 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6

11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3

43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5

78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, as shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.5.1 Results

Error! Reference source not found. to **Error! Reference source not found.** depict the HUC 031401020302 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 60) overlays critical facilities onto the 1-day 100-year storm event scenario, while the third map (**Error! Reference source not found.**) represents the same overlay within the context of 5 feet of sea level rise (SLR) combined with the 1-day 100-year storm event. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 5 feet SLR + 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** and **Error! Reference source not found.** illustrate the composite score for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. **Error! Reference source not found.** represents the calculation for composite score based on 1-day 100-year storm event, while **Error! Reference source not found.** shows the calculation for composite score for the same storm event, but including a 5 feet of Sea Level Rise scenario. **Error! Reference source not found.** shows the same area zoomed out.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

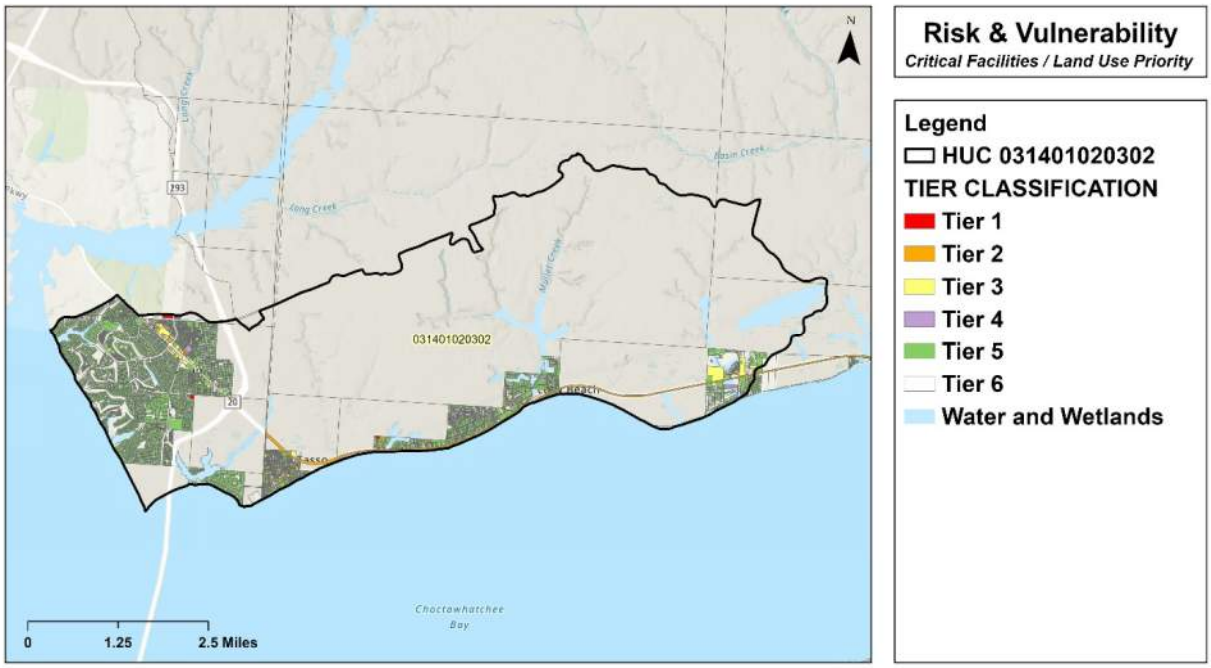

Figure 59. HUC 031401020302 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

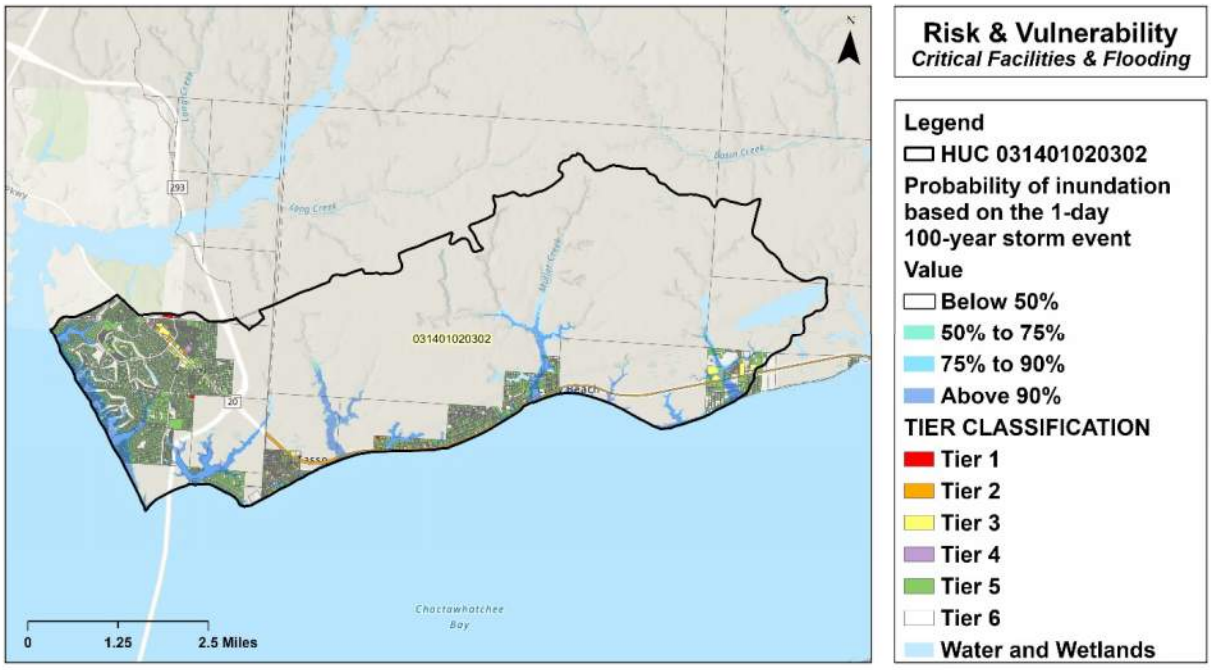

Figure 60. HUC 031401020302 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

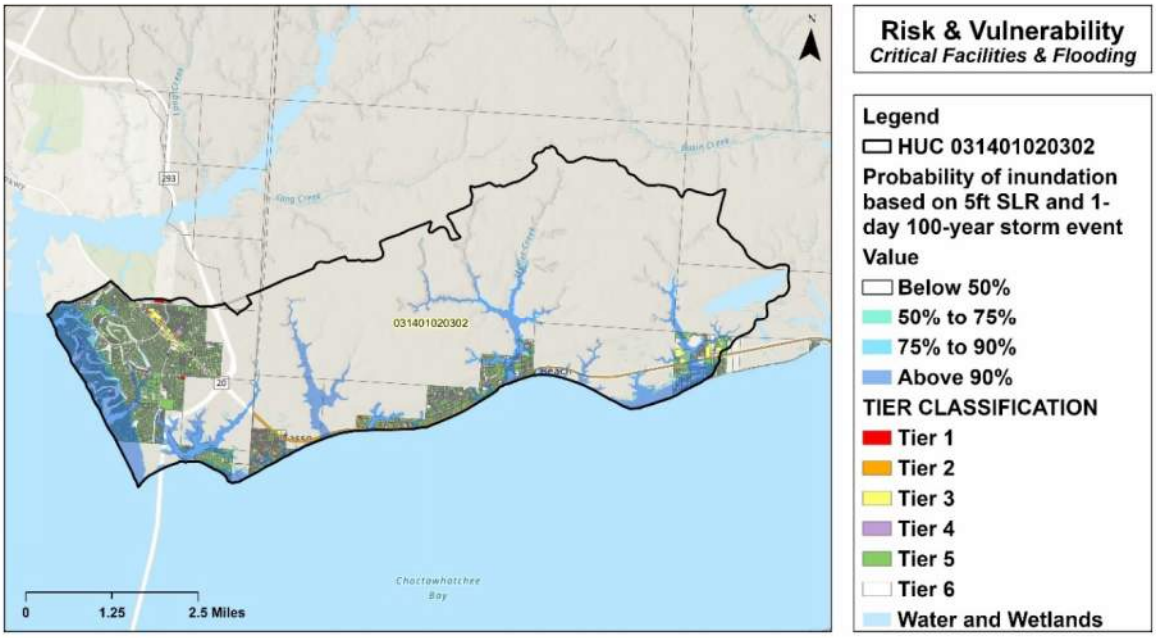

Figure 61. HUC 031401020302 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

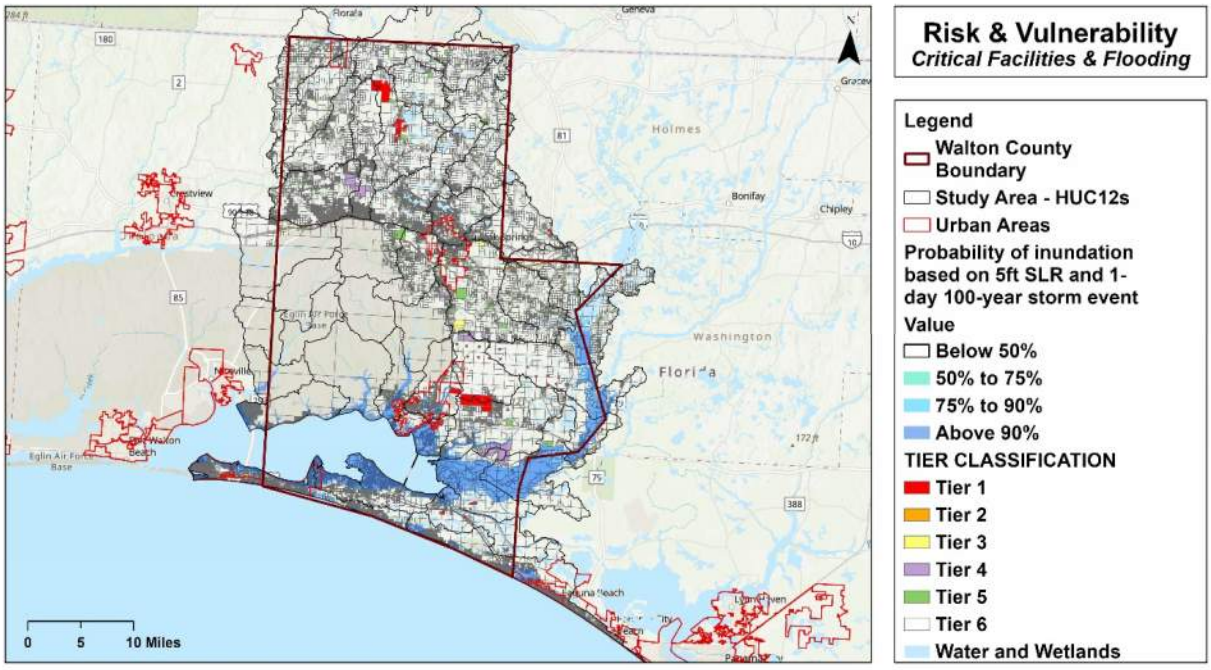

Figure 62. Walton County (mosaic) - Critical Facilities (priority of land uses) map, overlaid on the 1-day 100-year storm event + 5 ft. SLR probability of inundation for Walton County. Processed by FAU.

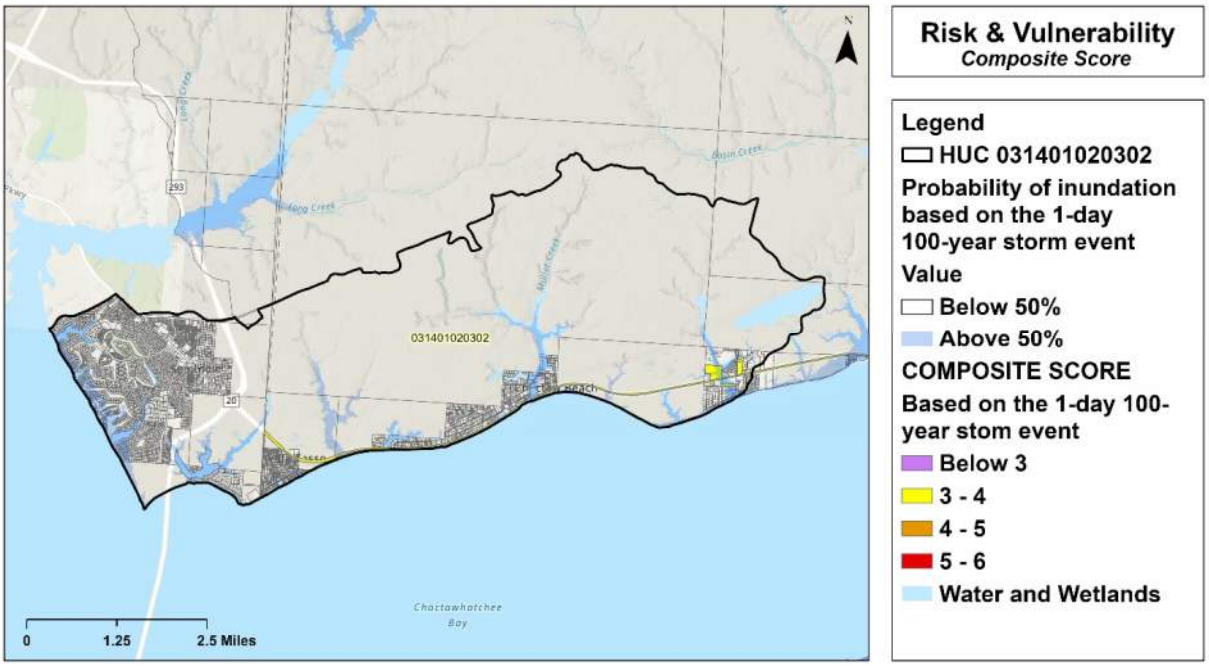

Figure 63. HUC 031401020302 sub-watershed Composite Score Risk map based on the 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation. Processed by FAU.

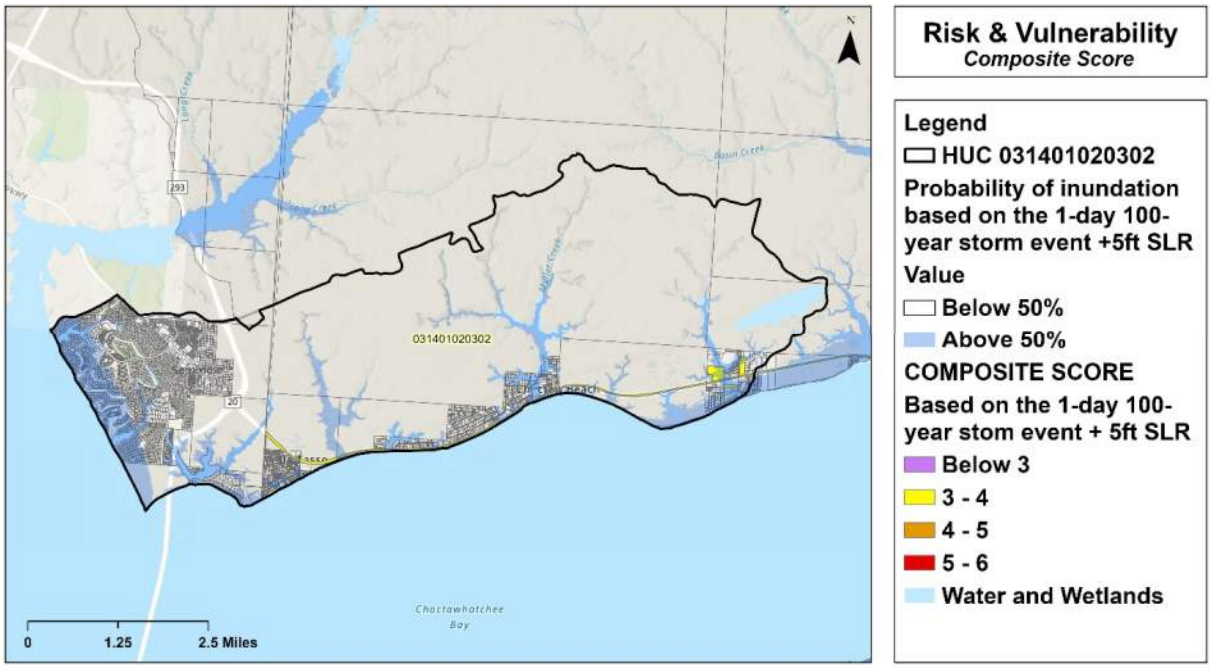

Figure 64. HUC 031401020302 sub-watershed Composite Score Risk map based on 1-day 100-year storm event + 5 ft. SRL, overlaid on the 1-day 100-year + 5 ft. SLR probability of inundation. Processed by FAU.

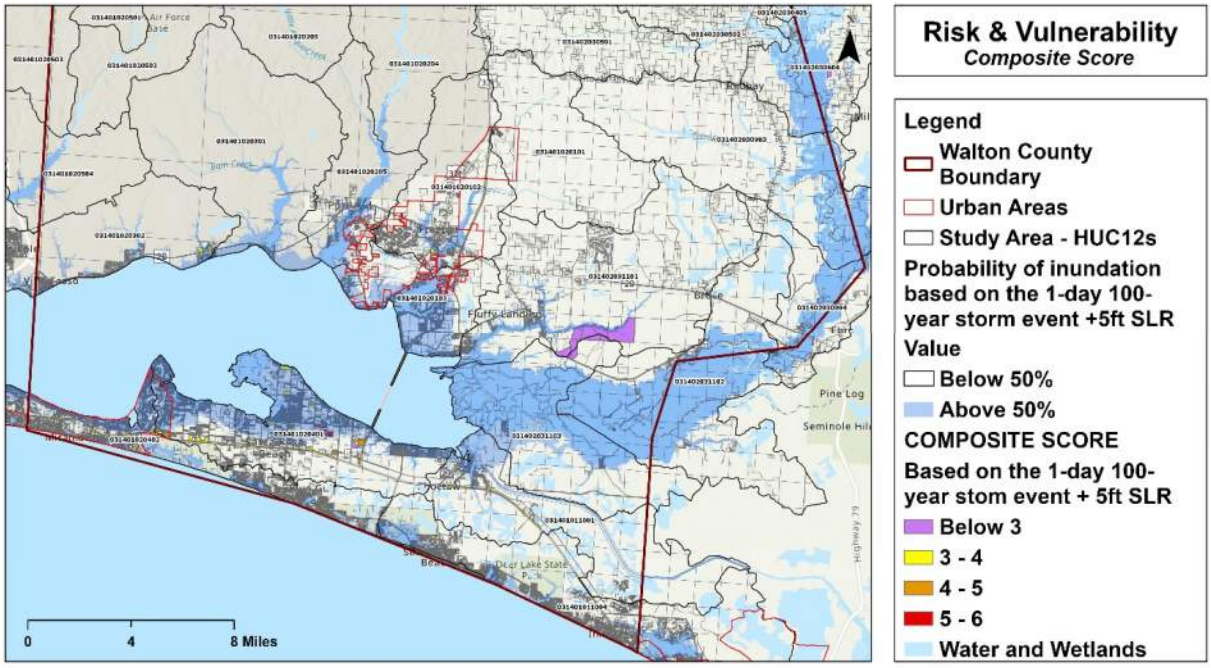

Figure 65. Coastal Area of Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

2.5.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401020302. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.5.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It is important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands: This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands: In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401020302. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401020302	17056.82
All of the 1-day 100-year storm event inundation	**1023.41**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	287.56
B. Federal Land in 1-day 100-year inundation > 10 acres	329.39
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	406.46
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	406.46

2.5.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not**

found. indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

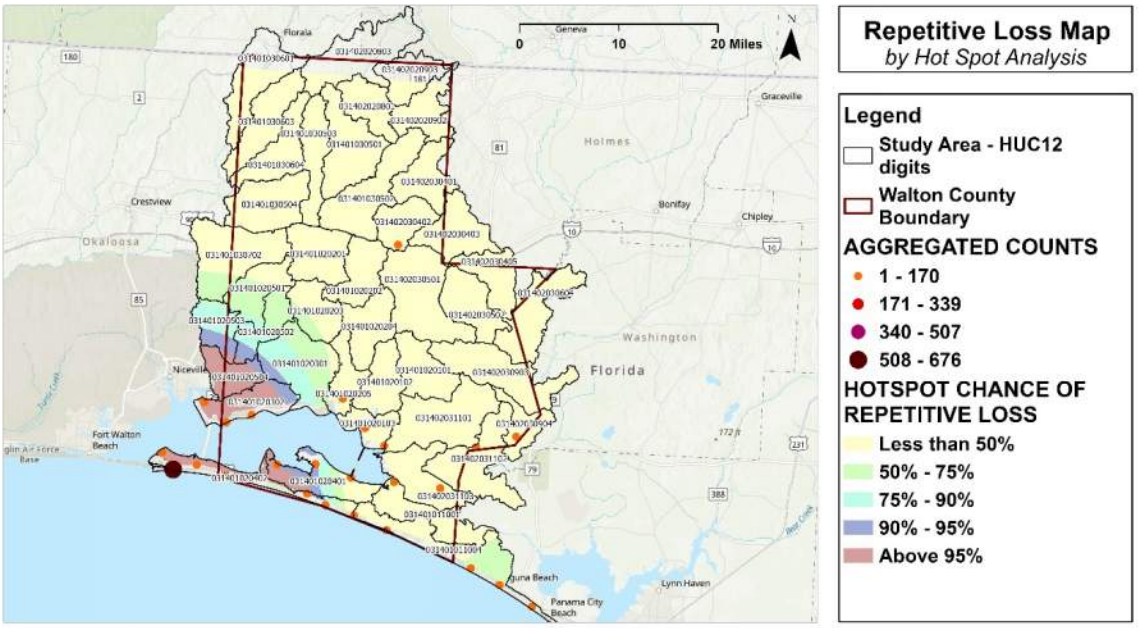

Figure 66. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.5.5 Priority Projects

The basin has a significant amount of developed land, since encompass the communities of Seminole (outside Walton County boundary), Villa Tasso, and Choctaw Beach. Unfortunately, a substantial portion of these communities faces the risk of flooding, particularly in the event of a 1-day 100-year storm event + 5 ft. SRL scenario.

In terms of priority for land use, there are five critical facilities (tier 1) within the basin, although none of them are situated within the flood zone. There is also a considerable number of parcels, specifically 123, categorized as tier 2. Among these, four are supermarkets, four are financial institutions, three are private schools, and the remainder consists of roads, with a notable portion of them being within the flood zone.

Furthermore, the basin includes 137 parcels categorized as tier 3, 275 as tier 4, and over 4,800 as tier 5. A substantial number of these parcels are within the flood zone.

When examining the composite score, seven parcels fall within the score range of 5-6, representing the highest priority for intervention. Notably, all of these parcels are roads, including Indian Cv, County Park, Restabit Ln, Bay Shore Dr, Nimrod Cir, Restabit Ln, and Cedar Beach Cv. Additionally, there are 37 parcels with a score of 4-5, which includes one office building, with the

rest being roads such as County Park, Crestview St, Streets, Restabit Ln, County Line Rd, Marina Ct, Magnolia St, Eastern Street, and Hudson Dr.

In the score range of 3-4, there are 13 parcels, encompassing three light manufacturing facilities and ten mobile homes. Finally, there are 16 parcels with a score below 3, all of which are mobile homes.

More detail about flood solutions are described in the community plan and in Section 5.5 where drilldown to specific neighborhoods is outlined.

APPENDIX N

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401020401

MCQUAGE BAYOU-MACK BAYOU FRONTAL

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 sub-watershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub- watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401020401) is highlighted among all the HUCs to help identifying its location. (Figure 3).

Santa Rosa Beach, a coastal community in Walton County, is within the HUC 031401020401 boundary. Demographics data and other considerations of Santa Rosa Beach, along with other cities and communities in Walton County, will be covered in subsequent discussions.

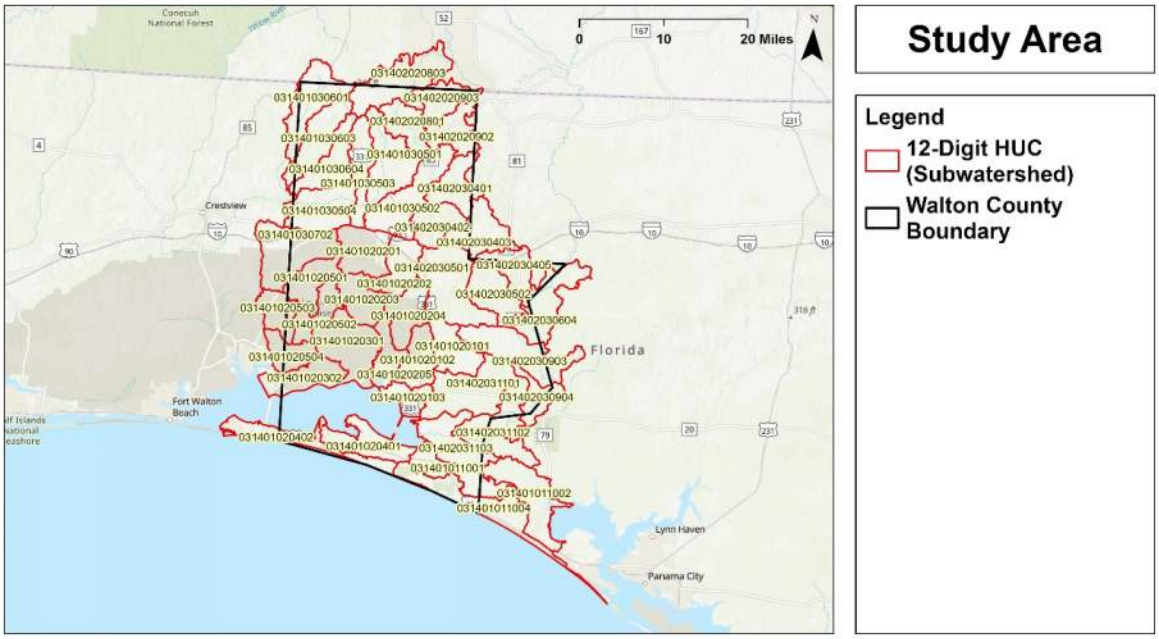

Figure 1. Walton County and all HUCs 12-digit sub-watershed, processed by FAU.

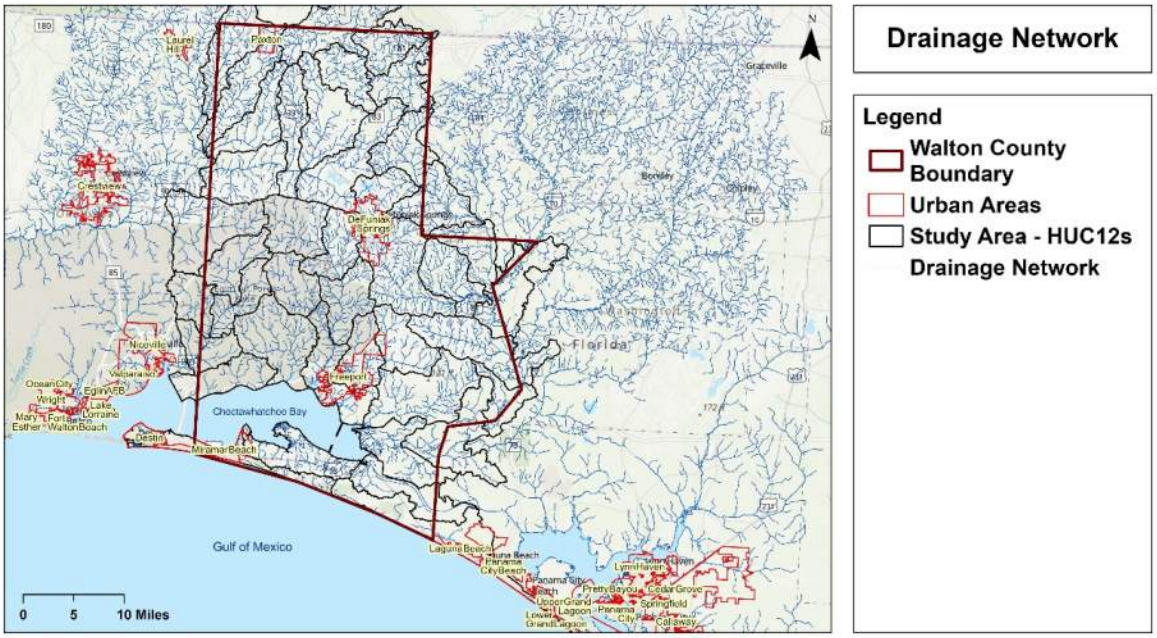

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

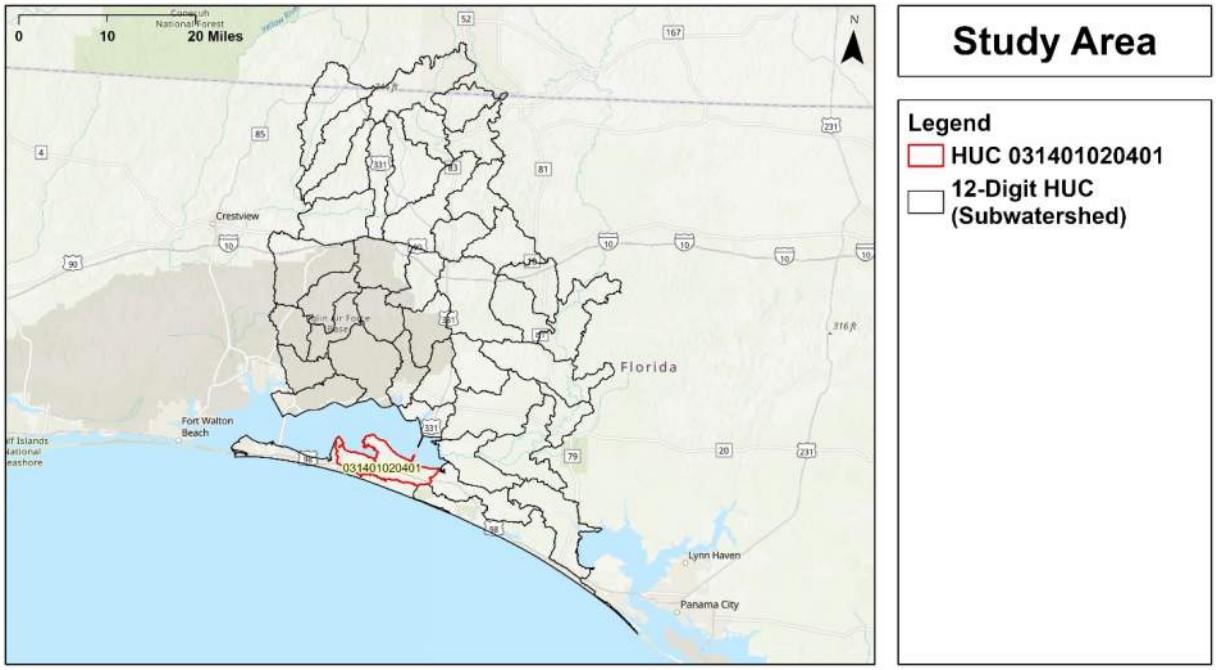

Figure 3. HUC 031401020401 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse

demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

Figures 12 and 13 in the county-wide report show the current and projected land use for the County. Based on the 2017 future land use map for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in Table 2.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In

order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (Figure 4). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

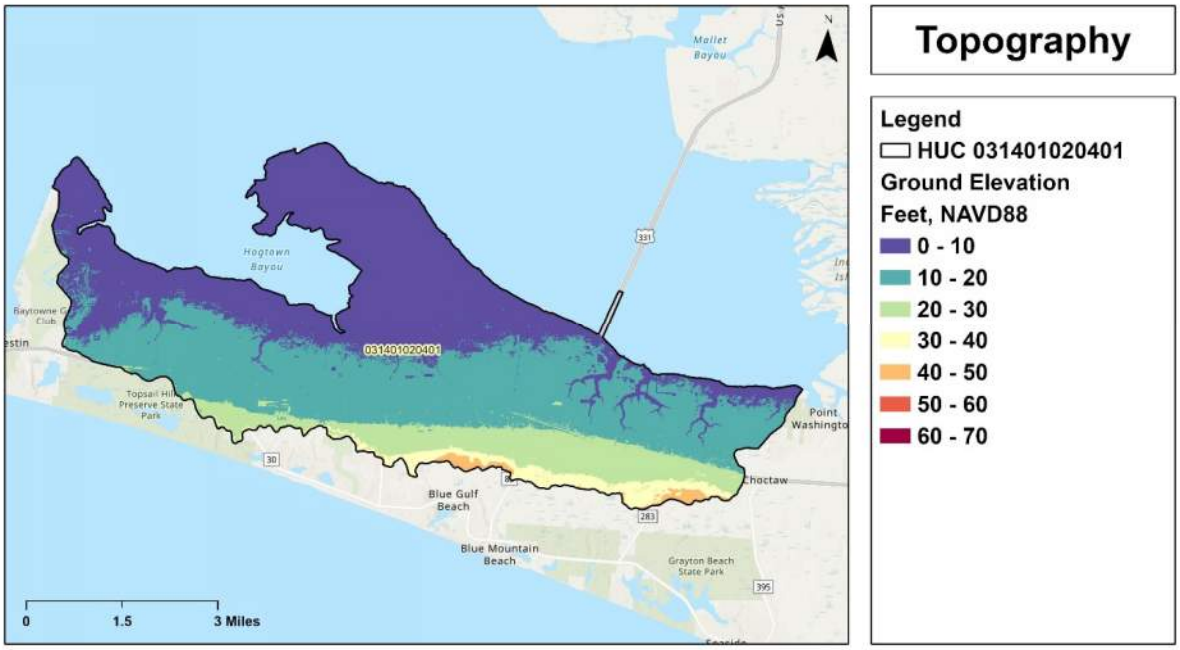

Figure 4. Topographic map of the HUC 031401020401 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology.
Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.
Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401020401 sub-watershed is shown in **Error! Reference source not found.**.

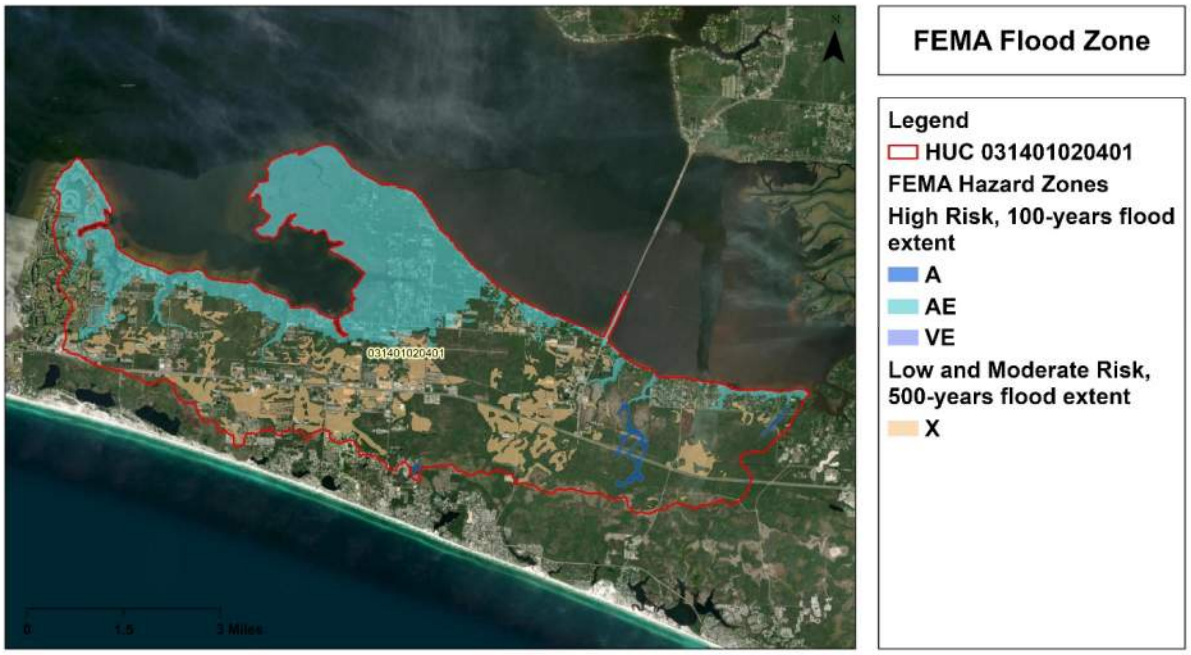

Figure 5. FEMA Flood Zone map (2020) for HUC 031401020401 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401020401 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall

biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

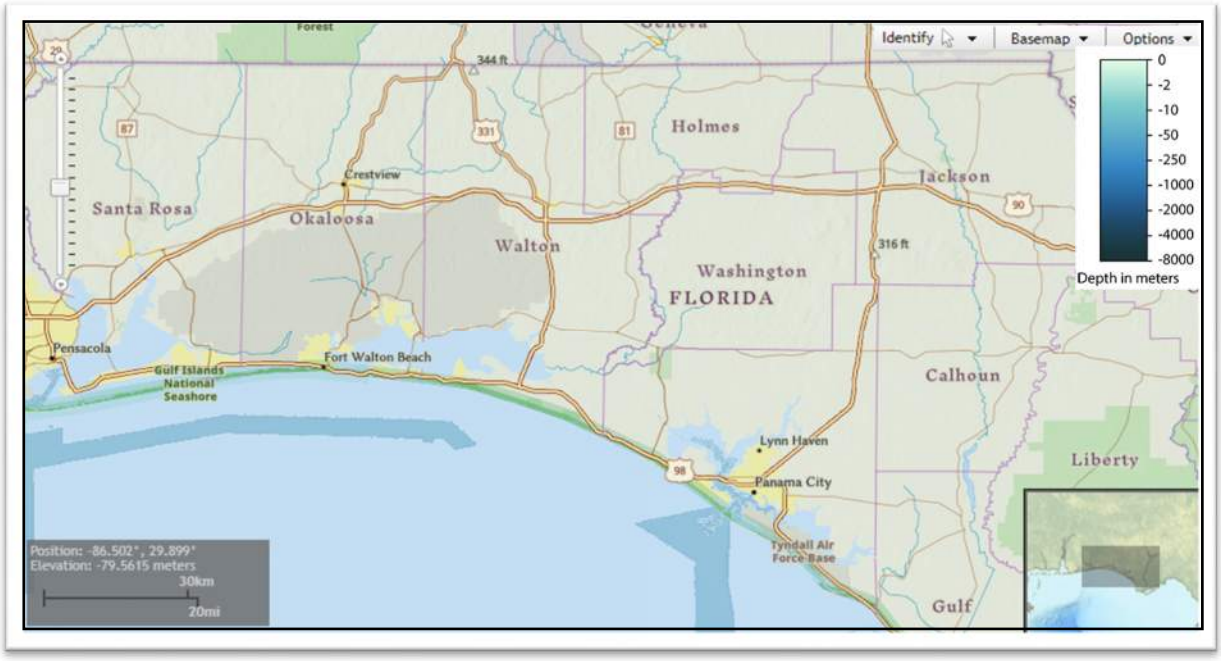

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

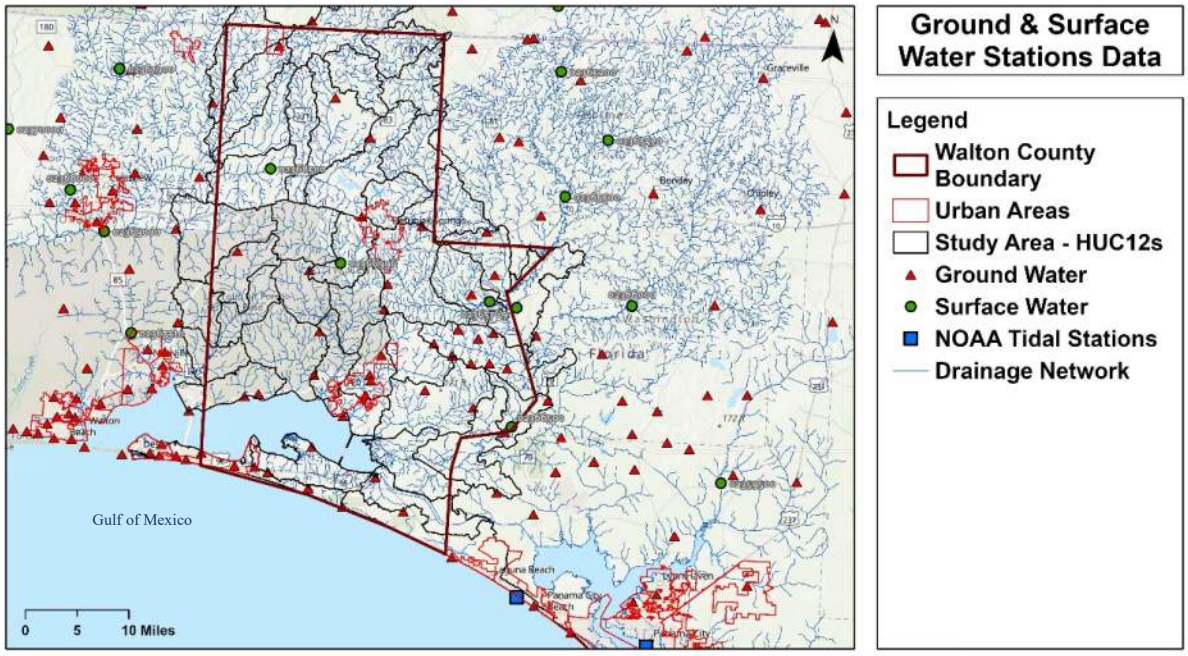

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The major water bodies in the sub-watershed are the Choctawhatchee Bay and Hogtown Bayou, with the associated rivers and canals:

- Mack Bayou
- Buck Bayou
- Hewett Bayou

- Mussett Bayou
- Bowman Bayou
- Littles Bayou
- McQuage Bayou

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401020401, which is USGS 02366500 Choctawhatchee River NR Bruce FLA.

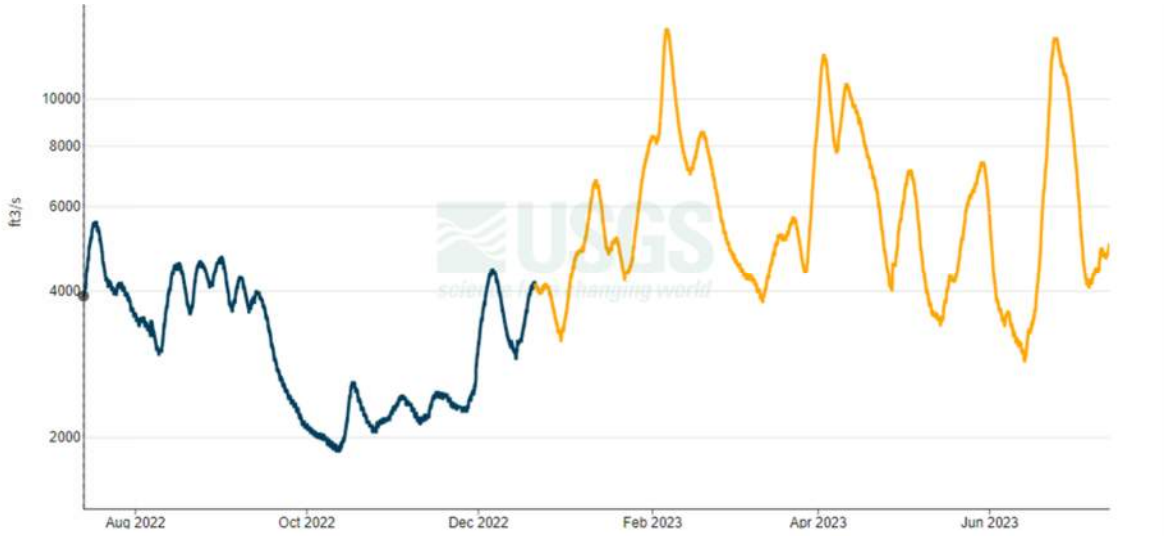

Figure 8. Average streamflow for Choctawhatchee River NR Bruce FLA (USGS 02366500 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366500/#parameterCode=00065&period=P365D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific

mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Figure 9 shows the drainage network of HUC 031401020401 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031401020401 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

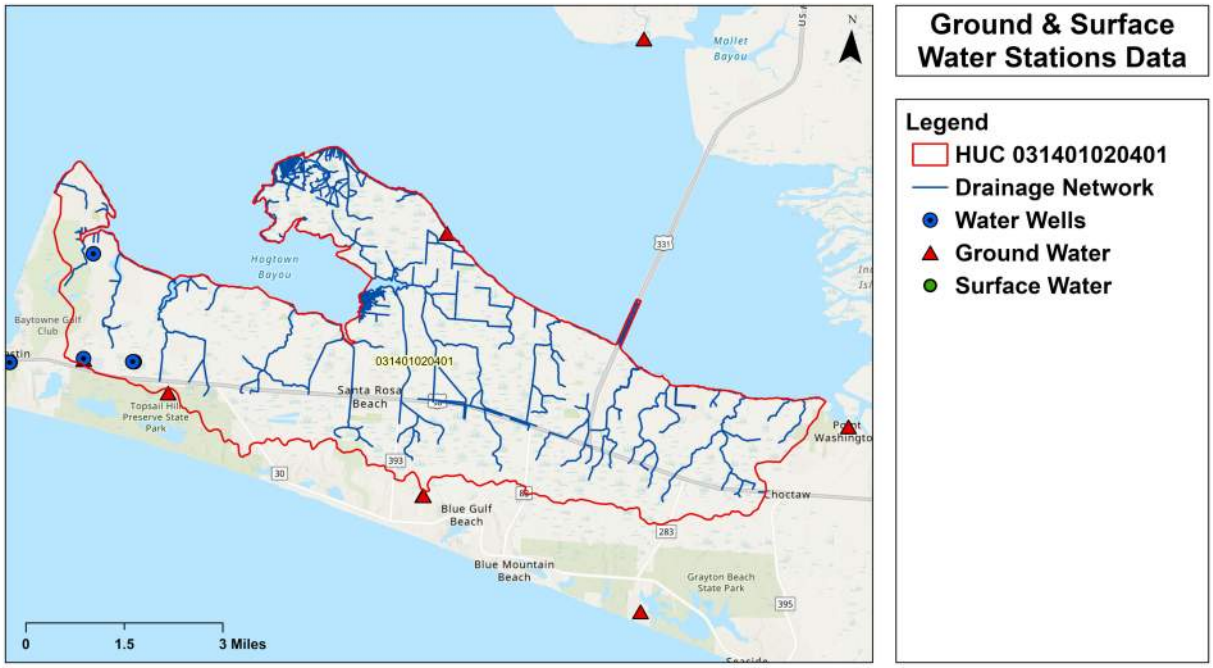

Figure 9. Ground and Surface Water Stations in the HUC 031401020401 sub-watershed, processed by FAU.

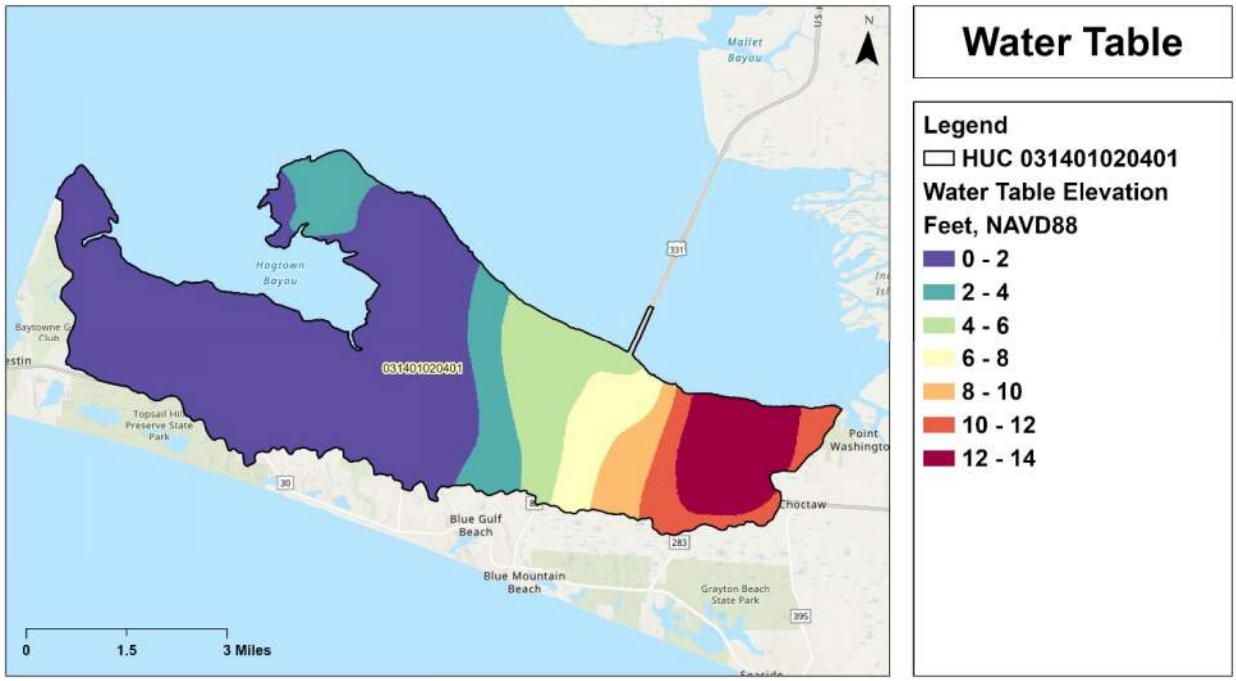

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401020401 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

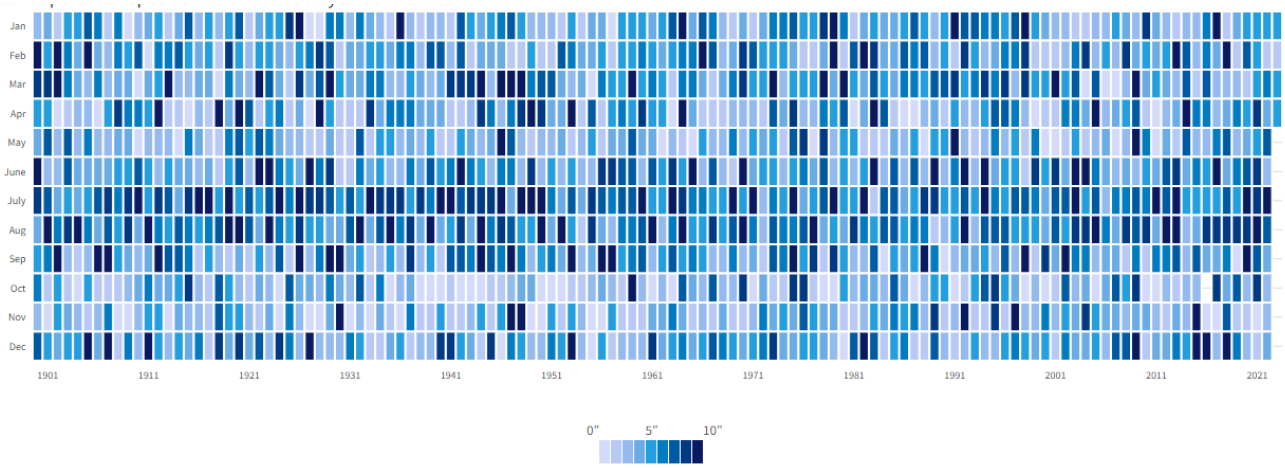

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/).

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

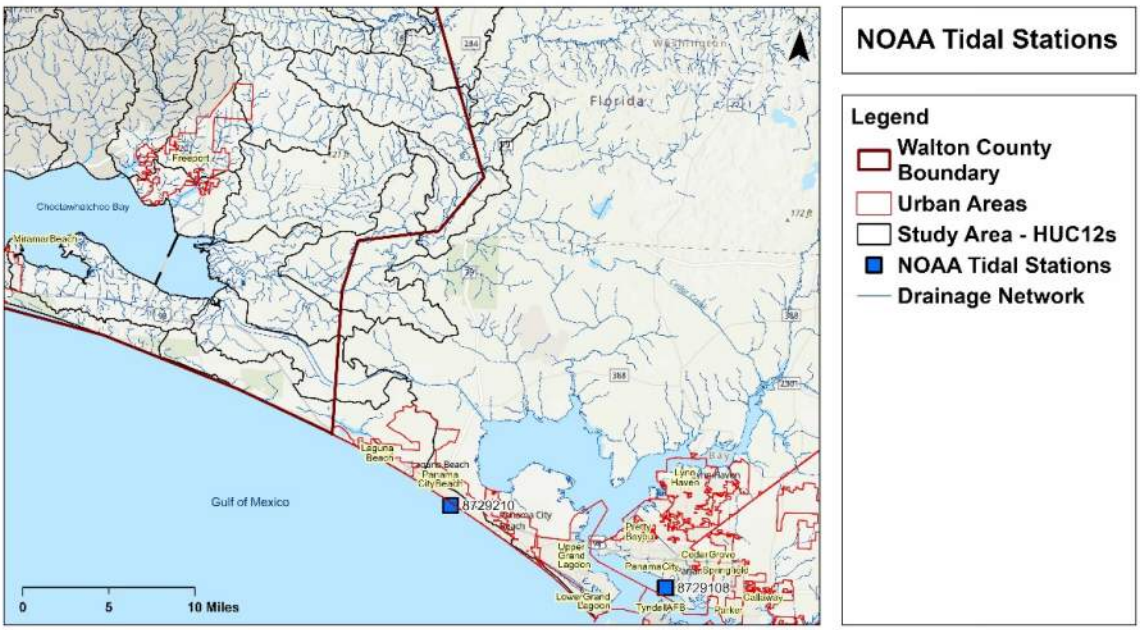

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

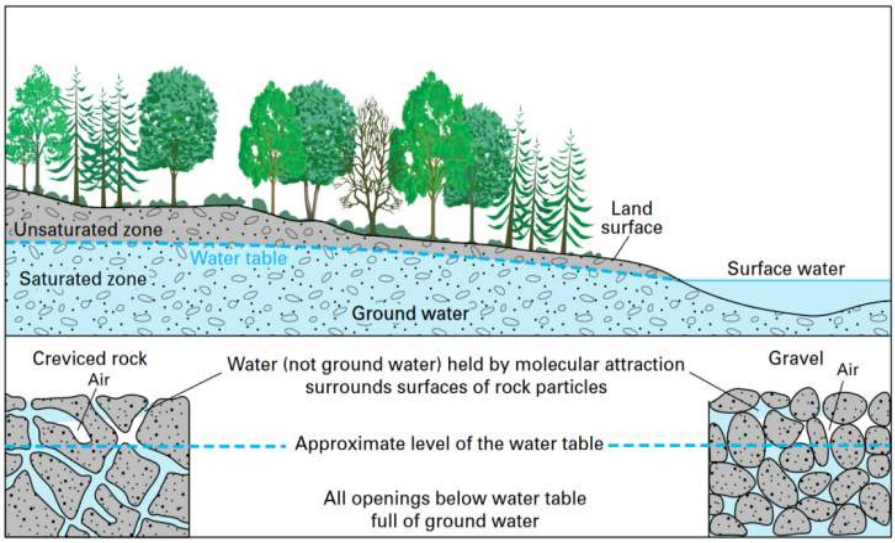

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

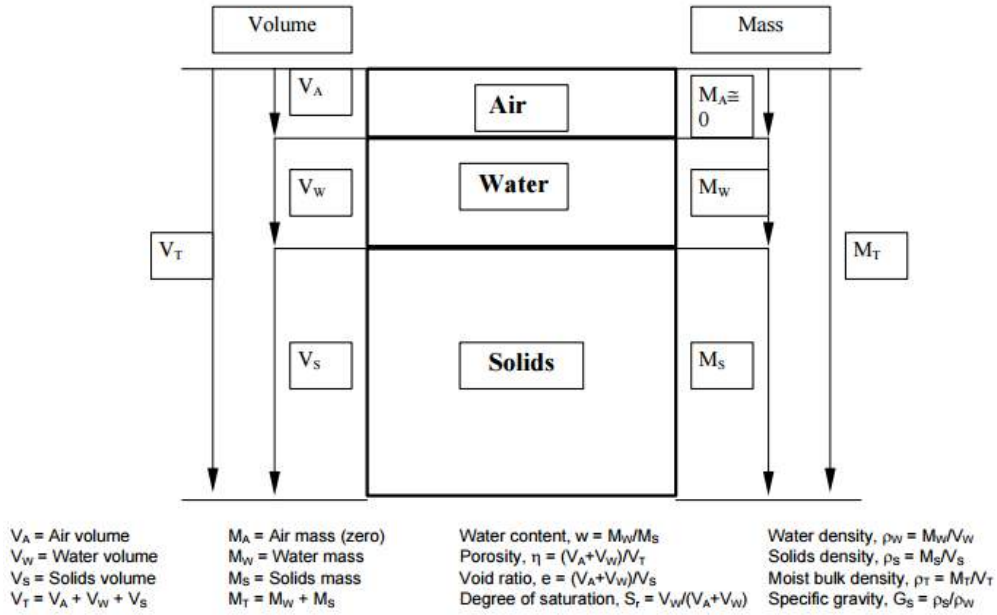

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

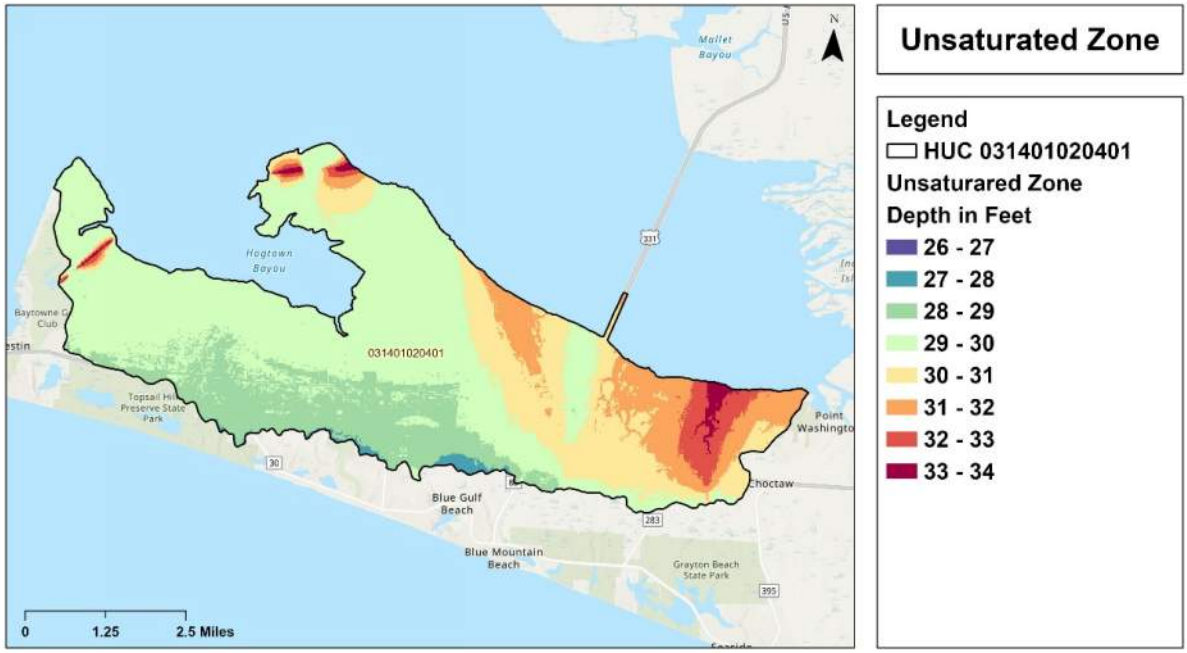

Figure 15. Unsaturated zone map for HUC 031401020401, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately favorable soil storage capacity, falling within the range of 28 to 33 feet of remaining capacity.

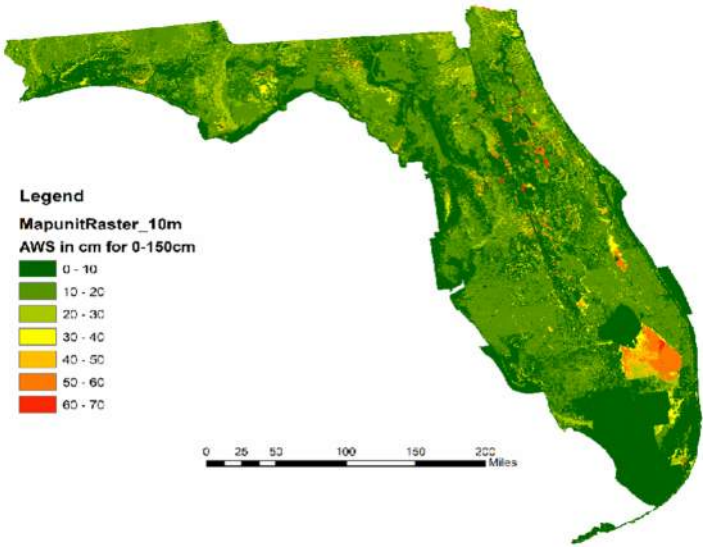

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

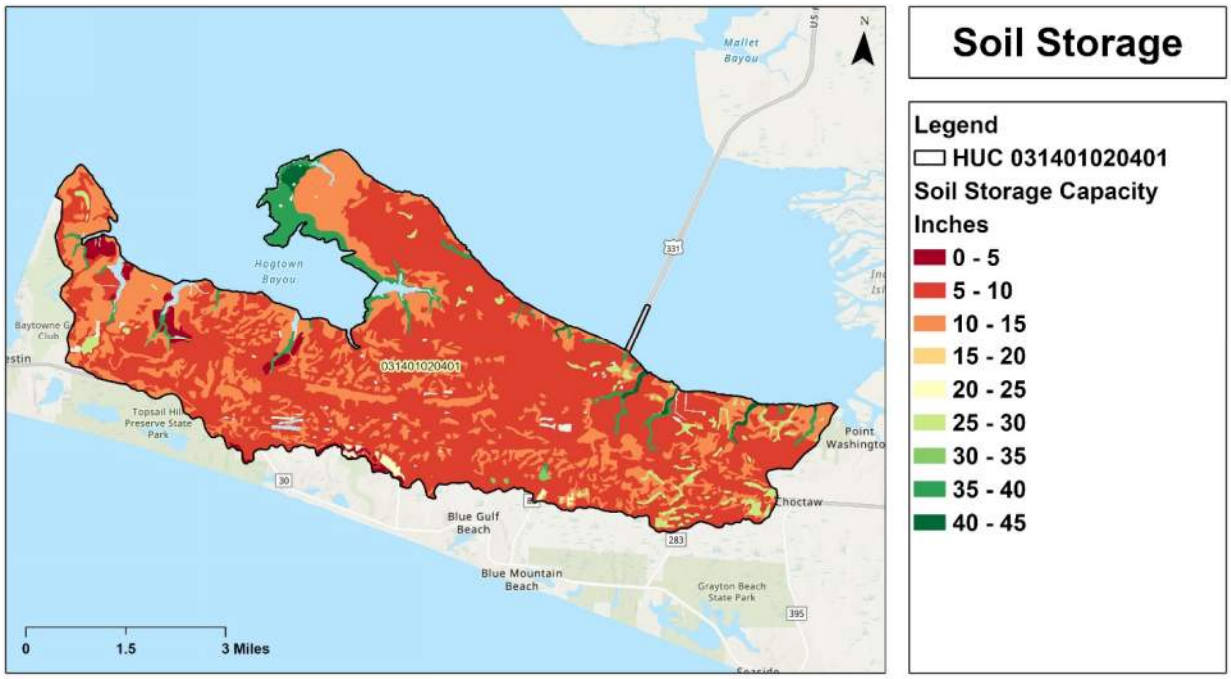

Figure 17. Water storage capacity of soil for the HUC 031401020401, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

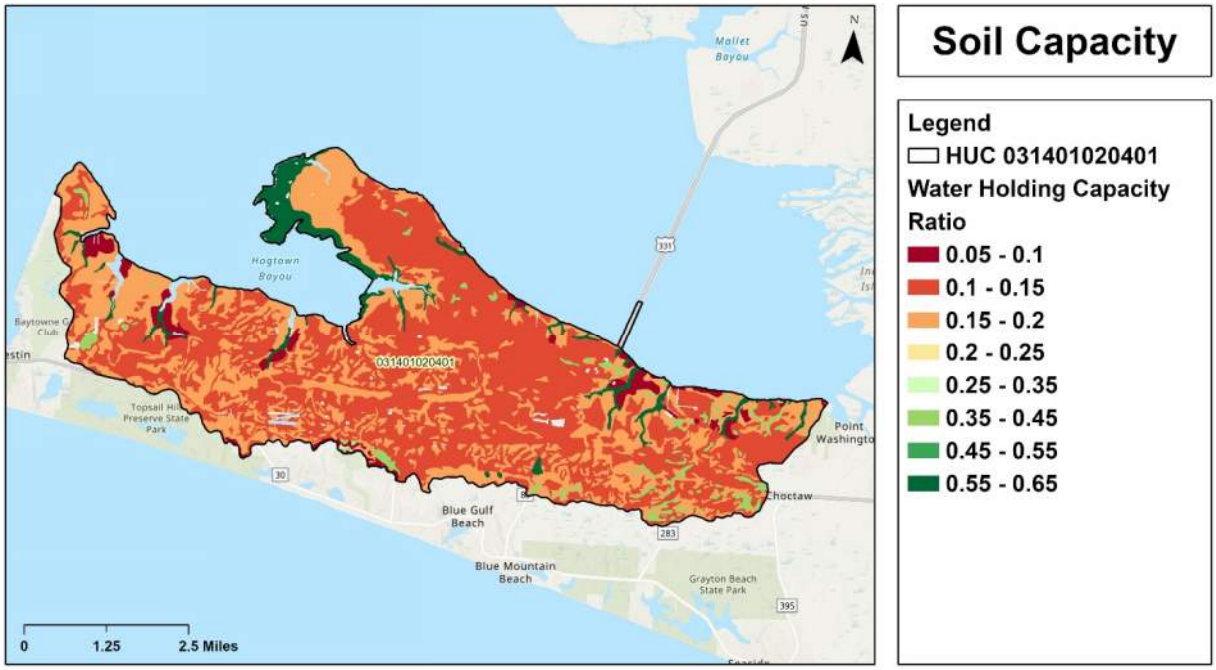

Figure 18. Water Holding Capacity (ratio) for the HUC 031401020401, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

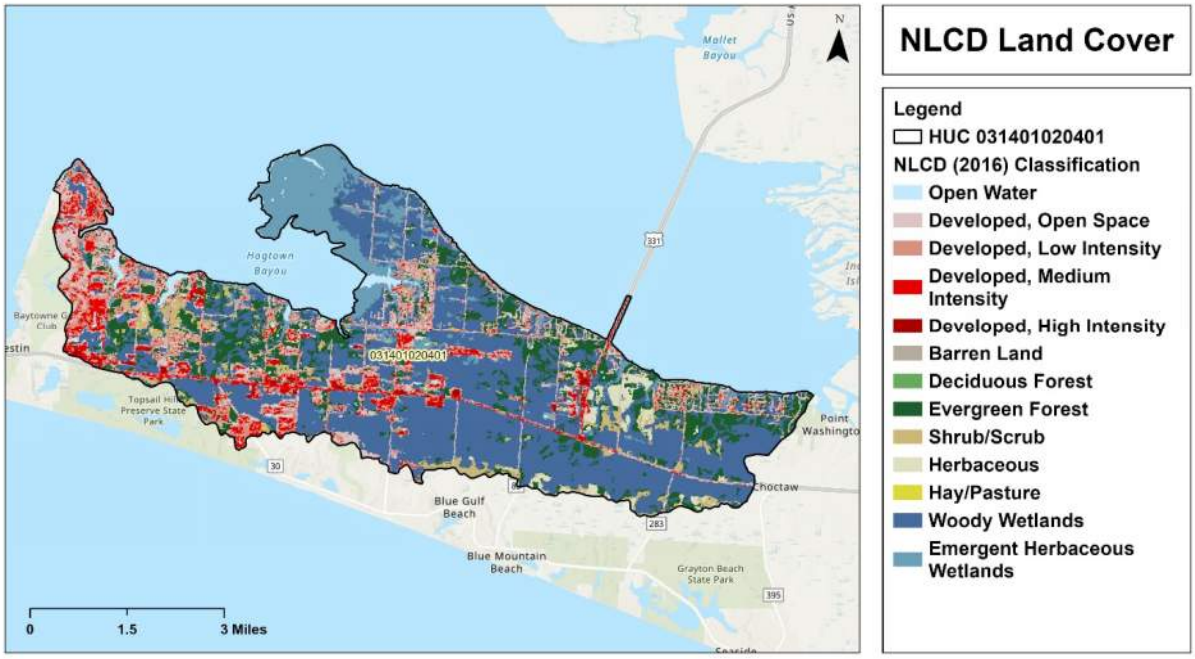

Figure 19. Land use in the HUC 031401020401 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

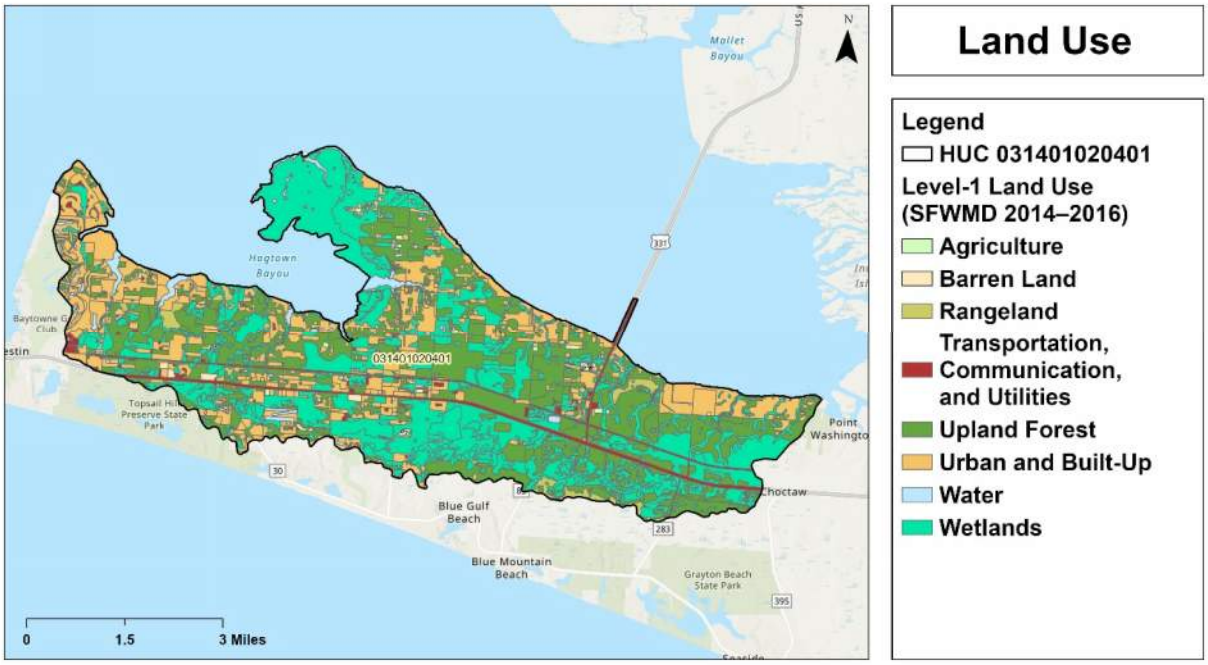

Figure 20. Land use in the HUC 031401020401 (from the 2023 Florida Geographic Data Library (FGDL) database), processed by FAU.

In the HUC 031401020401 sub-watershed, the predominant is wetland, accounting for 31.58% of the area. Upland forest comes in second at 29.87%, followed by urban and built-up at 20.19%, as indicated in as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface. It is important to remember that the HUC 031401020401 covers the community of Santa Rosa Beach.

Table 3. Land use for HUC 031401020401 sub-watershed (2023 Florida Geographic Data Library (FGDL))

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	57.54	0.24%
Barren Land	183.39	0.77%
Rangeland	611.26	2.56%
Transportation, Communication, and Utilities	1292.14	5.41%
Upland Forest	7136.70	29.87%
Urban and Built-Up	4823.58	20.19%
Water	2242.26	9.38%
Wetlands	7546.02	31.58%
Grand Total:	**23892.90**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

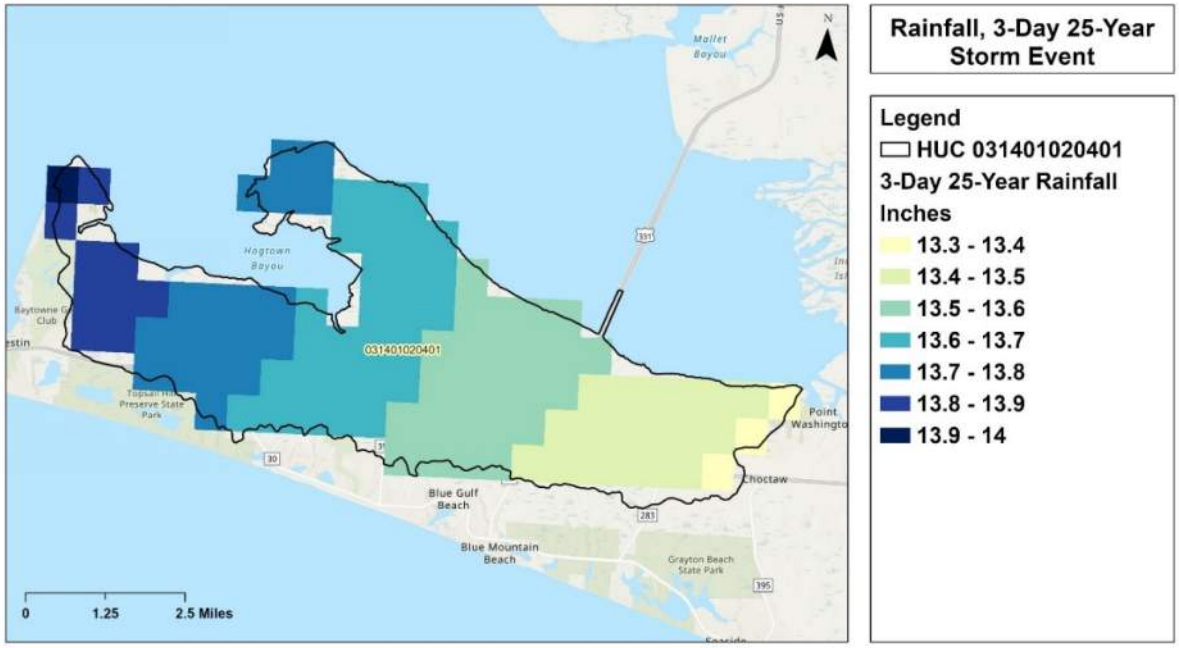

Figure 21. Rainfall distribution map across HUC 031401020401 sub-watershed, for 3-day 25-year storm event, processed by FAU.

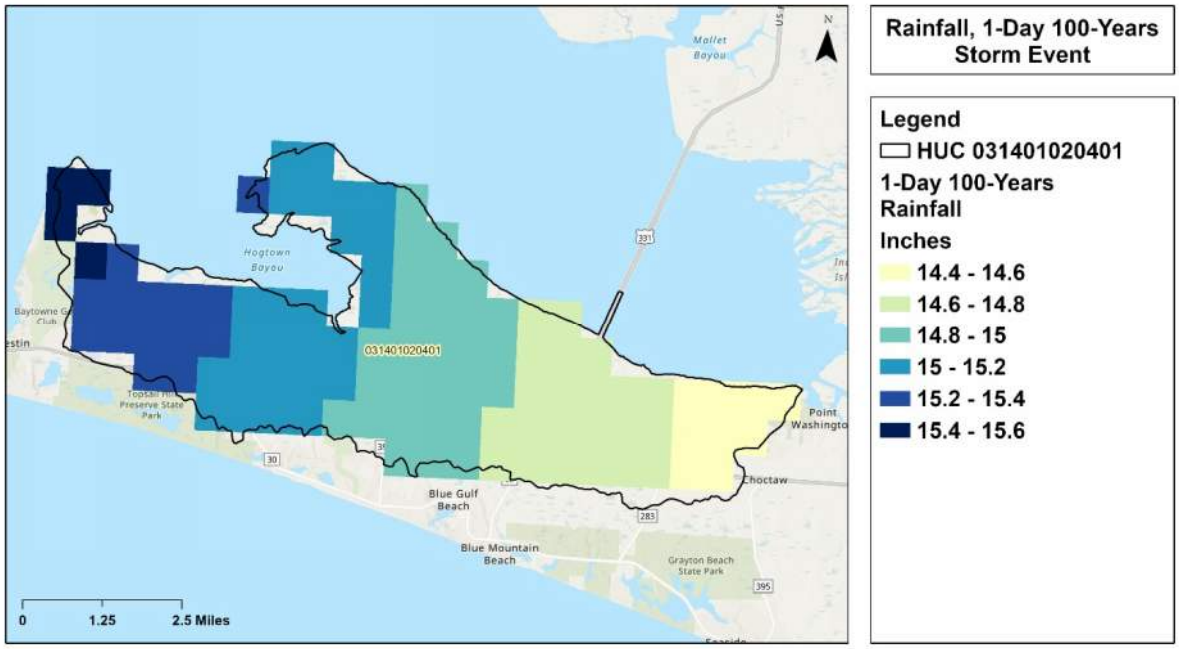

Figure 22. Rainfall distribution map across HUC 031401020401 sub-watershed, for 1-day 100-year storm event, processed by FAU.

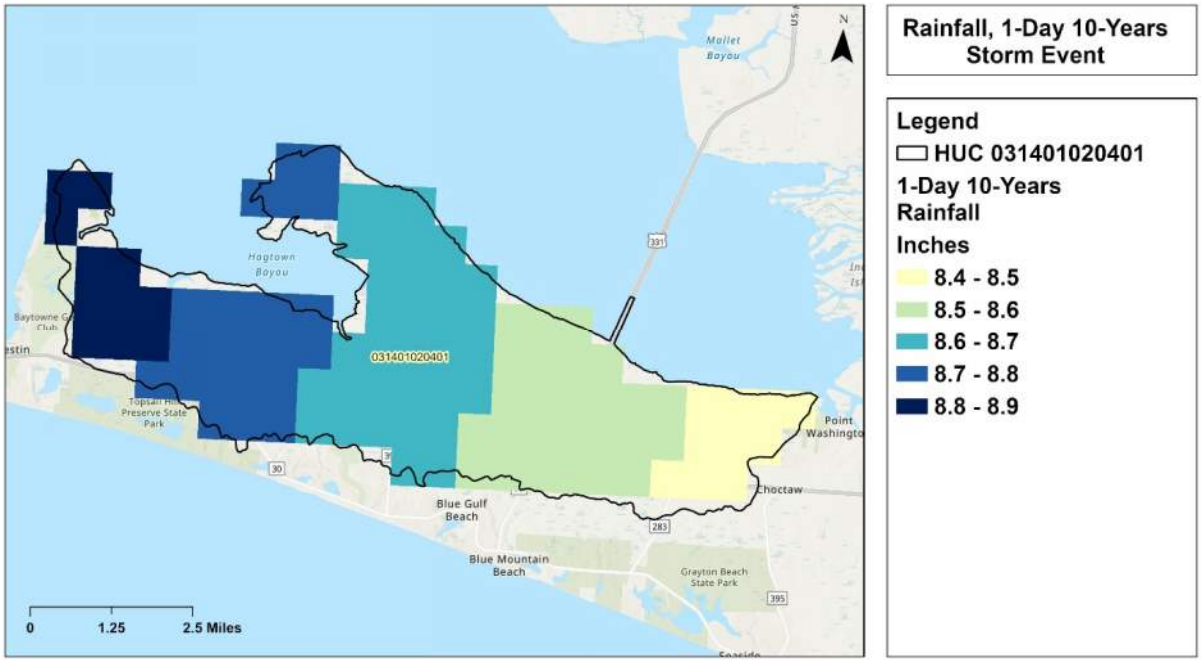

Figure 23. Rainfall distribution map across HUC 031401020401 sub-watershed, for 1-day 10-year storm event, processed by FAU.

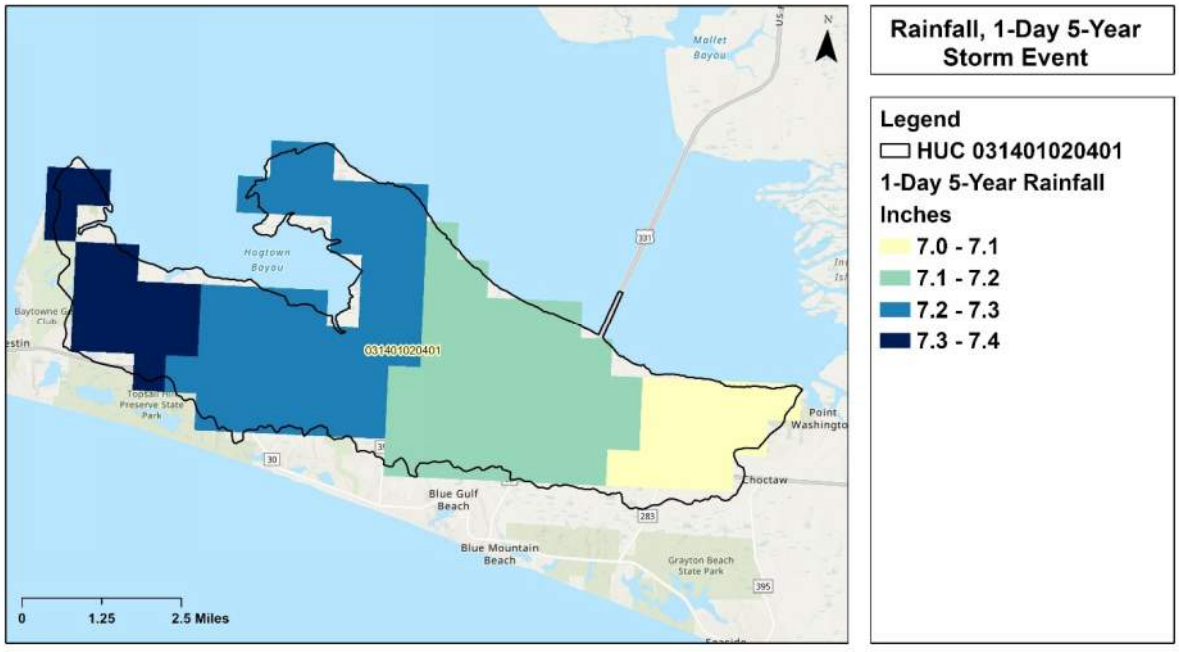

Figure 24. Rainfall distribution map across HUC 031401020401 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land

cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

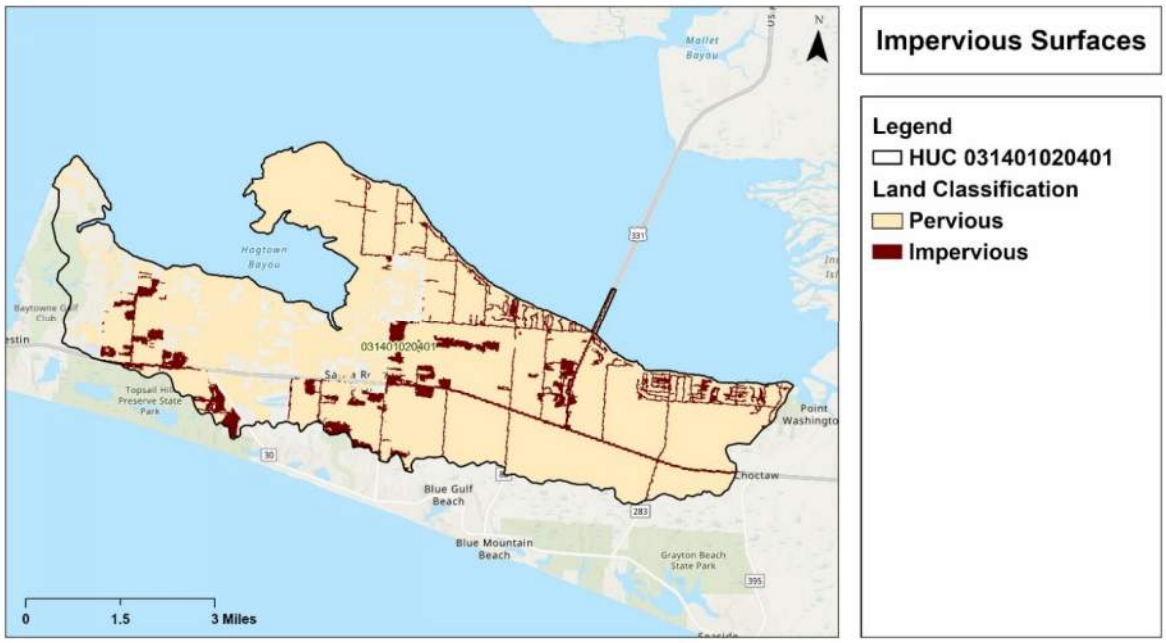

Figure 25. Impervious area map for the HUC 031401020401 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

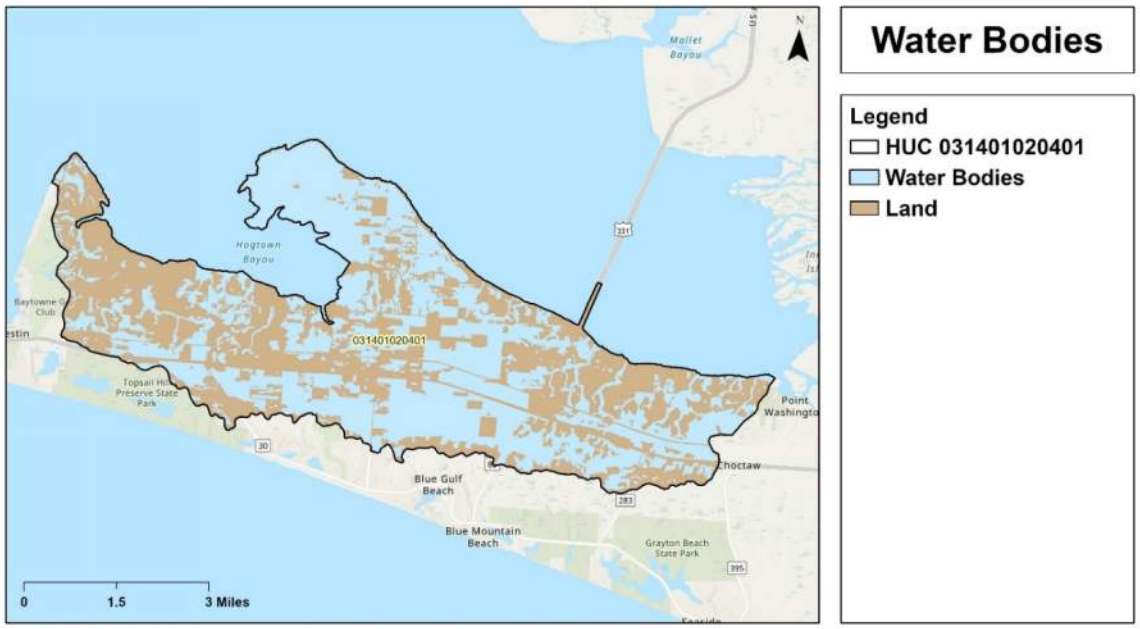

Figure 26. Water bodies map for the HUC 031401020401 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other

waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant

control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

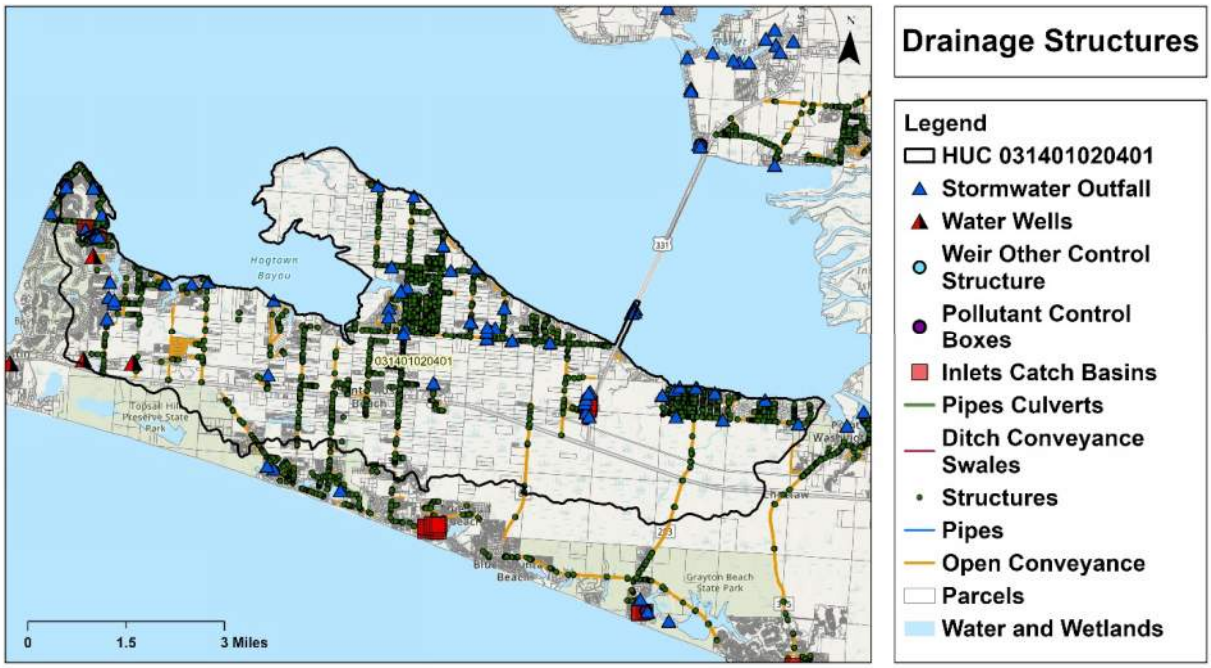

Figure 27. Stormwater Infrastructure for the HUC 031401020401. Processed by FAU.

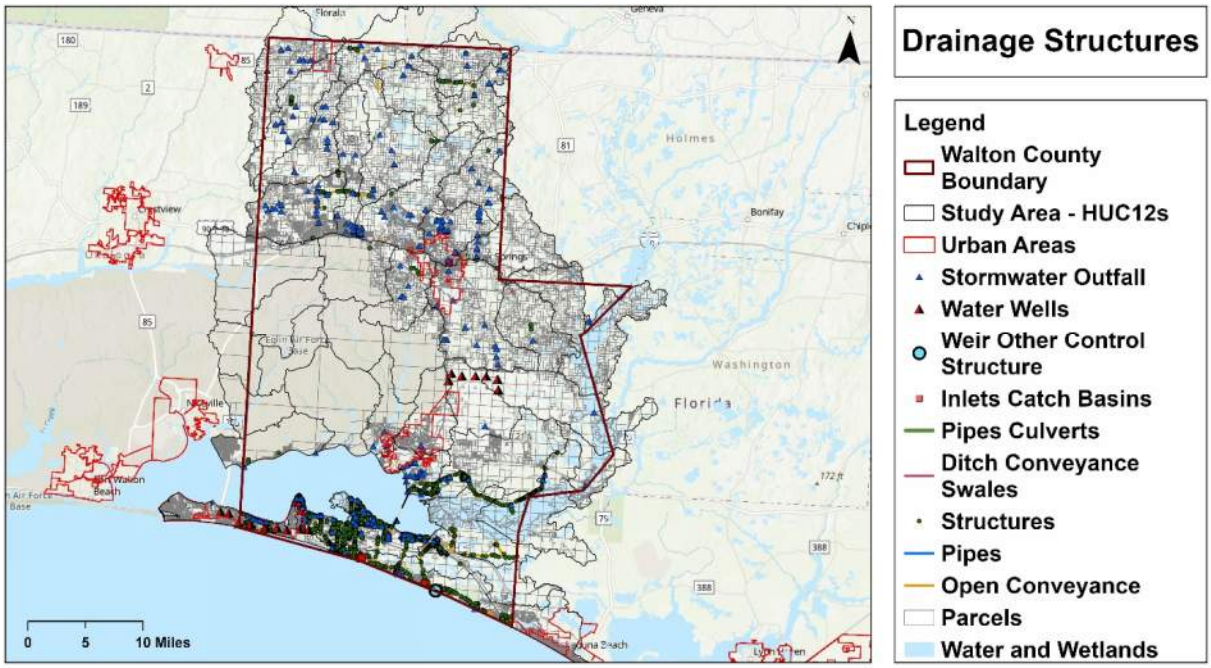

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in Table 5. The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings, as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401020401 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

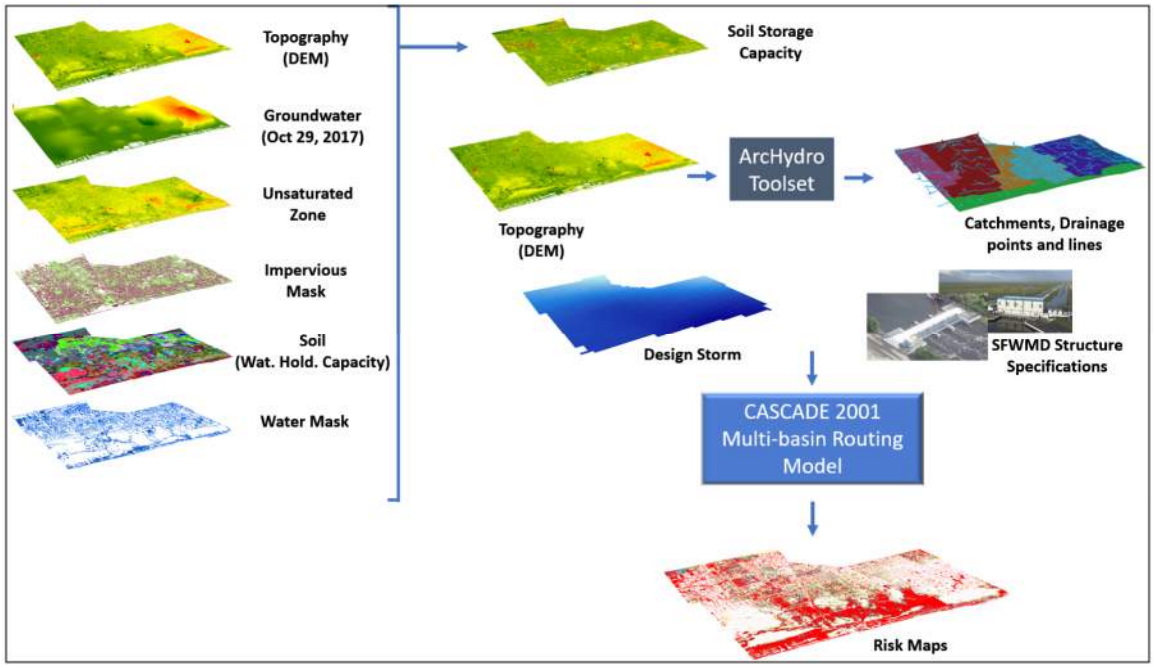

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)

= 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

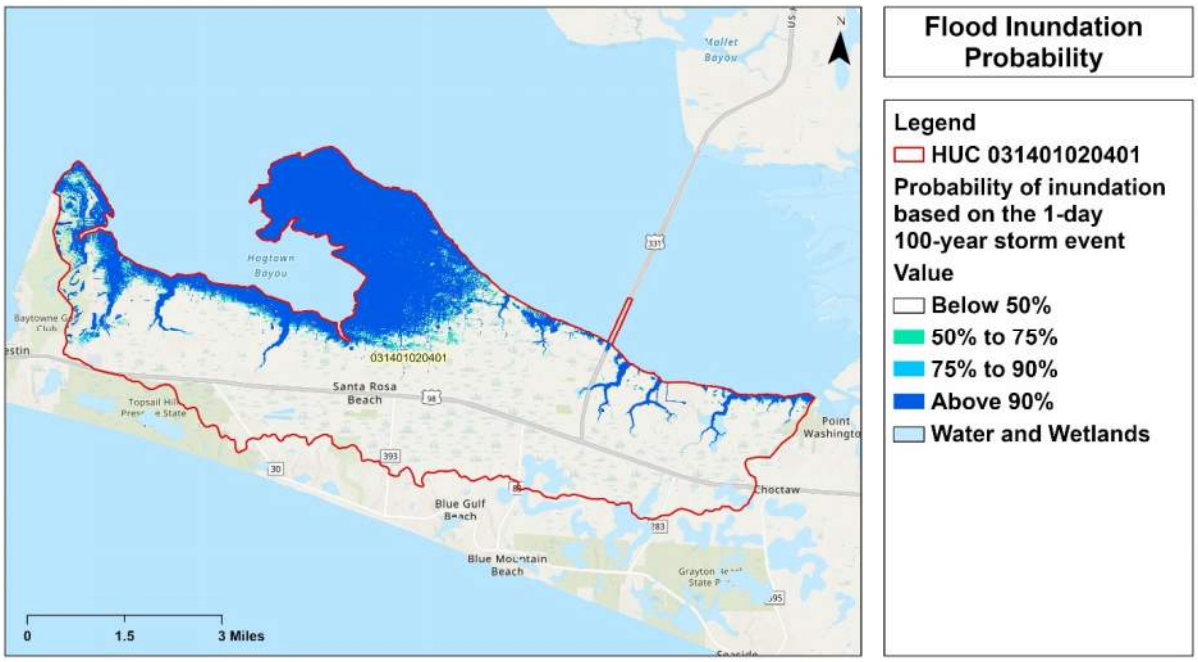

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401020401, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data

to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Future Challenges of Sea Level Rise and Climate Change

Global observations from satellites and long-term data collection have made it possible to document and analyze patterns in the Earth's climate. Scientific analysis of the impact of these changes has helped to improve the understanding of future flood hazard driving forces and long-term impacts on human activities and watershed master planning (http://www.research.noaa.gov/climate/t_observing.html). Examples of impacts are rising global average air and ocean temperatures, increased and earlier snow and ice melt, shorter subtropical rainy seasons, shifted seasons, sea level rise and greater variations in temperature and precipitation (IPCC, 2013; Freas et al., 2008; Marshall et al., 2004; Bloetscher et al., 2010). Marshall et al. (2004) specifically focused on the Florida peninsula to predict changes in rainfall and warmer temperatures but interspersed lower low temperatures due to the potential loss of wetlands.

Future changes in climate will add to the existing impacts, at a time when the population of the state is expected to nearly double by 2030. Additional research and high-resolution climate modeling for the Florida peninsula and local jurisdictions is needed to help guide long-term plans like WMPs. Rainfall appears to be decreasing and temperatures rising (see **Error! Reference source not found.**).

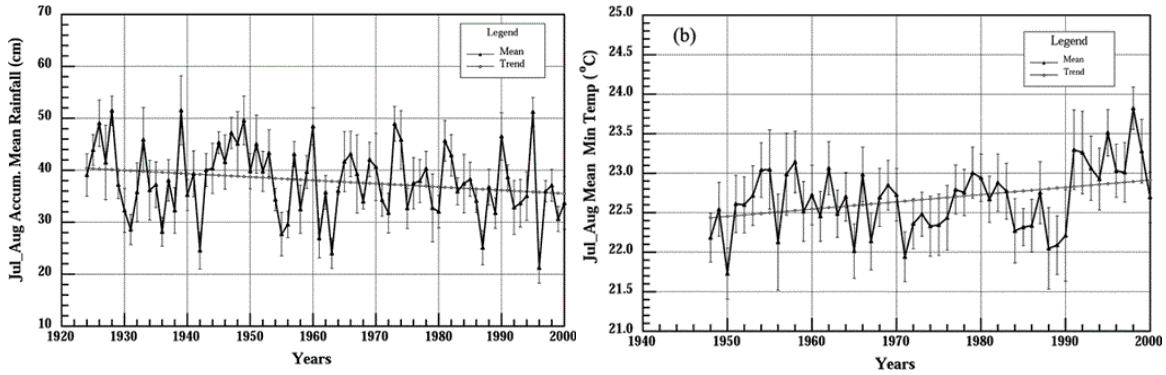

Figure 31. Change in average rainfall and change in average temp 1924 to 2000. Note the reversed trend, which means groundwater input variability is lessened. Source: Marshall et al., 2004.

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3 feet. Accompanying these drivers are potential changes in storm frequency and intensity, desertification, population migration, ocean acidification and coastal flooding (IPCC, 2007), exacerbated by the land cover and land use changes, which are substantially impacted by the fluxes, timing and quality of precipitation (Adrians et al., 2003; Scanlon et al., 2005; Marshall et al., 2004; Salmun and Molod, 2006), and leading to changes in the timing of peak flows and volumes (Richey and Costa-Cabral, 2006).

The results of these climatic changes are likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to

the ocean, c) increasingly An outcome of these climatic patterns is that during the past 140 years, an increase in sea levels has been observed (Bloetscher, 2012), a worrying pattern since sea level rise is a permanent phenomenon, that can be catastrophic to low lying areas in the long-term. The question is how much and how soon? Various studies (Bindoff et al., 2007; Domingues et al., 2008; Edwards, 2007; Gregory, 2008; Vermeer and Rahmstorf, 2009; Jevrejeva, Moore and Grinsted, 2010; Bloetscher, 2010, 2011; IPCC, 2007; Heimlich et al., 2009) indicate large uncertainty in projections of sea level rise by 2100. Gregory et al. (2012) note that during the last two decades, the global rate of sea level rise has been larger than the 20th-century time-mean, and Church et al. (2011) suggested that the cause was increased rates of thermal expansion, glacier mass loss, and ice discharge from icesheets. Gregory et al. (2012) suggested that there may also be increasing contributions to global sea level rise from the effects of groundwater depletion, reservoir impoundment, and loss of storage capacity in surface waters due to siltation. Measurements of Florida's east coast (Maul, 2008) show an average rate of sea level rise of 2.27 ± 0.04 mm per year from 1915 to 1992 based on tide gauge readings. Analyzing the tidal gauge readings for Florida shows that:

1. Florida average sea level rise is 2.10 ± 0.49 mm/yr
2. All but one location is within the 95% confidence limit range (the exception is Panama City where there is evidence of submergence and other land-based issues)
3. None of the Florida sea level rise rates differ statistically
4. Average global sea level rise for 1920-2000 was 2.0 mm/yr – within 95% confidence limit for Florida locations

From 1929 to 1992, over eight inches of sea, with another 6 inches added since 1992, which is already having significant impacts on coastal communities where population growth has increased the need for improved flood management strategies (Bloetscher, 2008; Parkinson, 2010; Zhang et al., 2011, 2011a; NFIP, 2011; Schmidt et al., 2011; Warner et al., 2012).

As a result, the SFRCCC (2015) adopted USACE's methodology to derive scenarios of sea level change intermediate to high rates of sea level rise for years 2030 (3" to 7") and 2060 (9" to 24") as the consensus projection to guide future planning. The path keeps increasing – now 14 inches since 1929 (**Error! Reference source not found.**) caused by thermal expansion of the ocean and melting ice caps (Jevrejeva et al., 2010; Vermeer and Rahmstorf, 2009). Sea level rise is a major concern in Florida, including Walton County, since the majority of the state's population live on the coast, involving most major commercial, residential, and economic enterprises. **Error! Reference source not found.** demonstrate the estimated sea level change for Panama City, considering the predictions of NOAA 2017. For NOAA high scenario SLR change scenario, the estimated level change is higher than 8 ft., while for the intermediate and low scenarios are about 3.9 feet and 1.7 feet respectively.

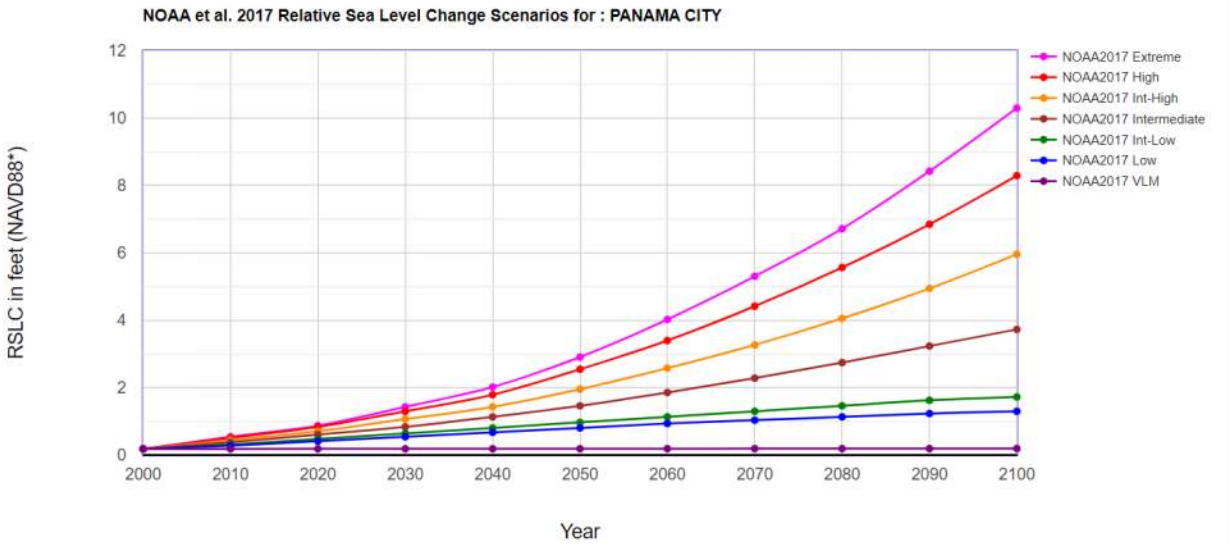

Figure 32. Relative Sea Level Change Scenarios for gauge 8729108, Panama City, FL. Source: NOAA, 2017 (https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html).

NOAA (2017) outlines five scenarios for sea level rise. The NFIP proposes the use of the intermediate high projection, which is 1.2 meters or 4 ft globally from current sea level elevations (**Error! Reference source not found.**).

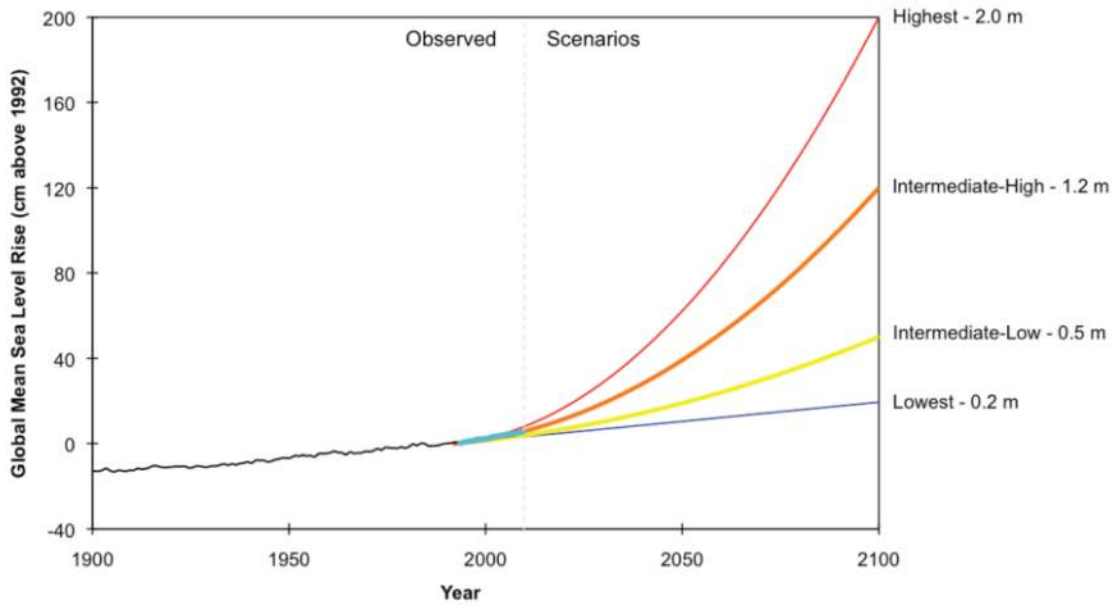

Figure 33. Graphic of global sea level rise projections from NOAA (2017). Source:https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

As sea level rises, access to roads, bridges, rail, and transit could be at risk of flooding, causing the effects of sea level rise to spread indirectly throughout the entire transportation network, affecting the overall system performance. For example, the flooding of a critical road or facility access can cause a shifting of traffic flow causing congested conditions in other roadways that are not actually flooded. Since the roadway network would be unable to carry the traffic demand, the system would experience operational failure; as a result, causing travel times and delays. Moreover, the inundation of a critical access could cause transportation connectivity problems to essential infrastructure like ports or airports. Transportation infrastructure relies on the effectiveness of flood control and stormwater drainage systems for the transportation corridors. Road integrity relies on adequate drainage. The increased risk of severe flooding in Florida's low-lying terrain can adversely affect transportation infrastructure along the coastline; roads can be inundated, and roadway beds can be damaged. Sea level rise will cause increased water table levels (FDOT, 2012), as regional water tables cannot exist naturally below mean high tide (2 feet in Florida). Adding 3 feet of sea level rise on top of groundwater would compound the risk of flooding in low-lying areas. Road bases below 5 feet NVGD would become saturated under this scenario, likely causing premature base failure. As soil storage capacity is diminished due to rising groundwater elevations associated with sea level rise, the potential for more frequently flooded roadways would likely damage pavements (FDOT, 2012). Hence sea level rise must be accounted for in WMPs in coastal areas. To allow flexibility in the analysis due to the range of increases within the different time periods, an approach that uses incremental increases of 1, 2, and 3 feet of sea level rise is suggested for modeling. The increments can work as threshold values in planning considerations in terms of allowing planners the ability to know ahead of time where the next set of vulnerable areas will be, to allow for a proactive response approach that can be matched to the observed future rates. Sea level rise is a major concern since nearly half the US population lives within 50 miles of the coast, involving most major commercial, residential, and economic enterprises. The effects of 5 ft sea level rise, King tide, and 1-day 100-year storm event are shown in **Error! Reference source not found.**.

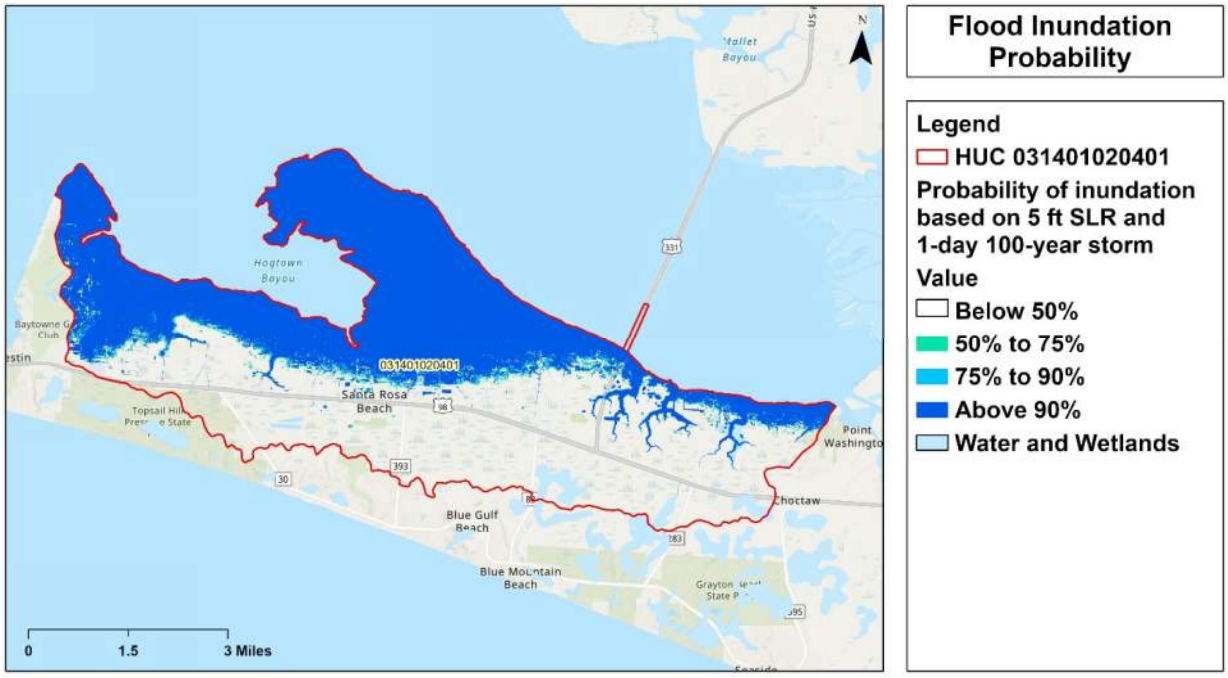

Figure 34. Flood Inundation Probability for a Sea level rise of 5 ft + 1-day 100-year storm event for HUC 031401020401 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Dark blue is area under 5 ft NAVD88 and potentially inundated at the 99th percentile tidal conditions. Processed by FAU.

2.4 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. **3-day 25-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 35)
2. **1-day 100-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 36)
3. **1-day 10-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 37)
4. **1-day 5-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 38)
5. **Sea level rise of 1 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 39)

6. **Sea level rise of 1 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations storm (Figure 40)
7. **Sea level rise of 1 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 41)
8. **Sea level rise of 1 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 42)
9. **Sea level rise of 2 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 43)
10. **Sea level rise of 2 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 44)
11. **Sea level rise of 2 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 45)
12. **Sea level rise of 2 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 46)
13. **Sea level rise of 3 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 47)
14. **Sea level rise of 3 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 48)
15. **Sea level rise of 3 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 49)
16. **Sea level rise of 3 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 50)
17. **Sea level rise of 4 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 51)
18. **Sea level rise of 4 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 52)

19. **Sea level rise of 4 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 53)
20. **Sea level rise of 4 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 54)
21. **Sea level rise of 5 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 55)
22. **Sea level rise of 5 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 56)
23. **Sea level rise of 5 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 57)
24. **Sea level rise of 5 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 58)

In all scenarios, a considerable amount of flooding is noted along the coast and, following the waterbodies flow path. As this basin connects to the ocean though Choctawhatchee River, SLR scenarios plays an important hole, implying a considered growth as the projected scenario of rising tides rises.

The design storm simulation determined that approximately 26% of the HUC total area or 7.78 mi² has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 27.3% of the HUC's total area, or 8.18 mi² would be expected to be inundated during a 1-day 100-year design storm. Approximately 24.3% of the HUC's total area, or 7.29 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 23.6% of the HUC's total area, or 7.08 mi², would be expected to be inundated during the 1-day 5-year storm. Table 7 compares the four storm events.

Table 7. HUC 031401020401 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	22.09	7.78	73.8%	26.0%
1-day 100-year	21.69	8.18	72.5%	27.3%
1-day 10-year	22.59	7.29	75.5%	24.3%
1-day 5-year	22.80	7.08	76.2%	23.6%

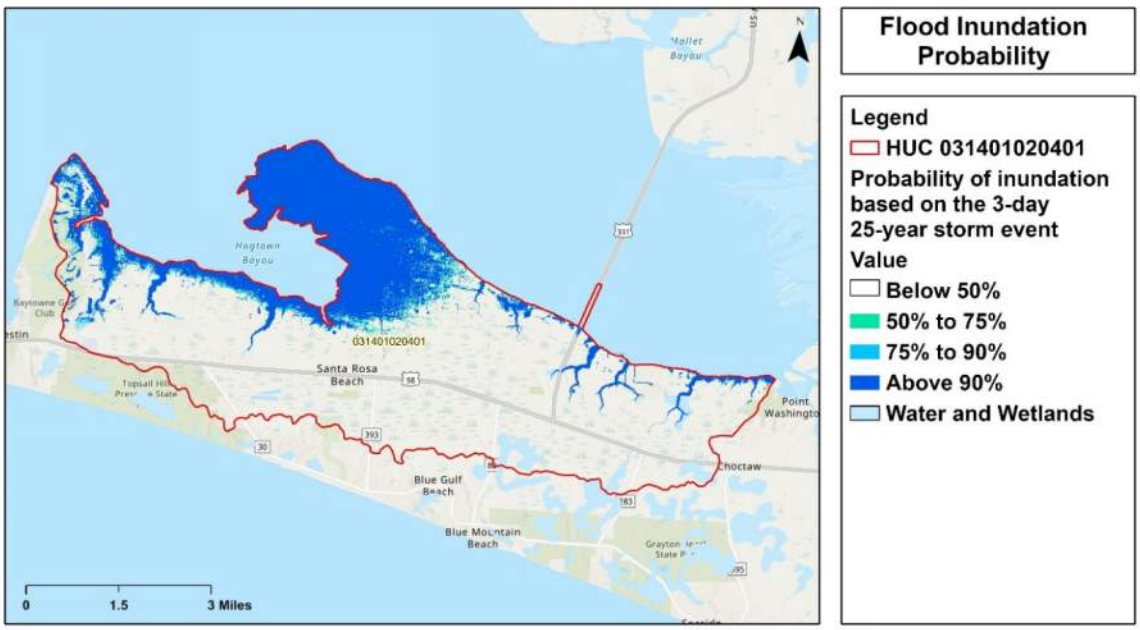

Figure 35. 3-day 25-year storm event for HUC 031401020401 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

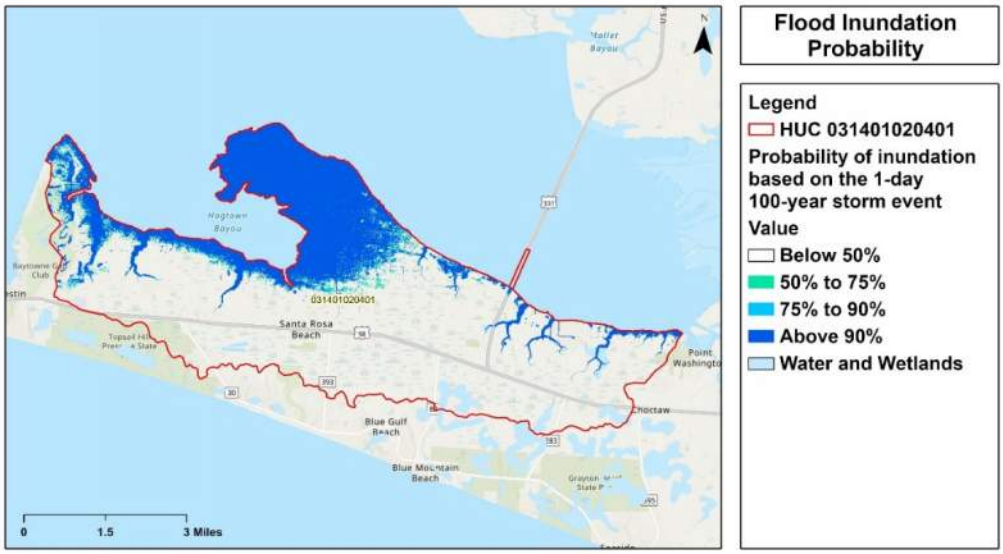

Figure 36. 1-day 100-year storm event for HUC 031401020401 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

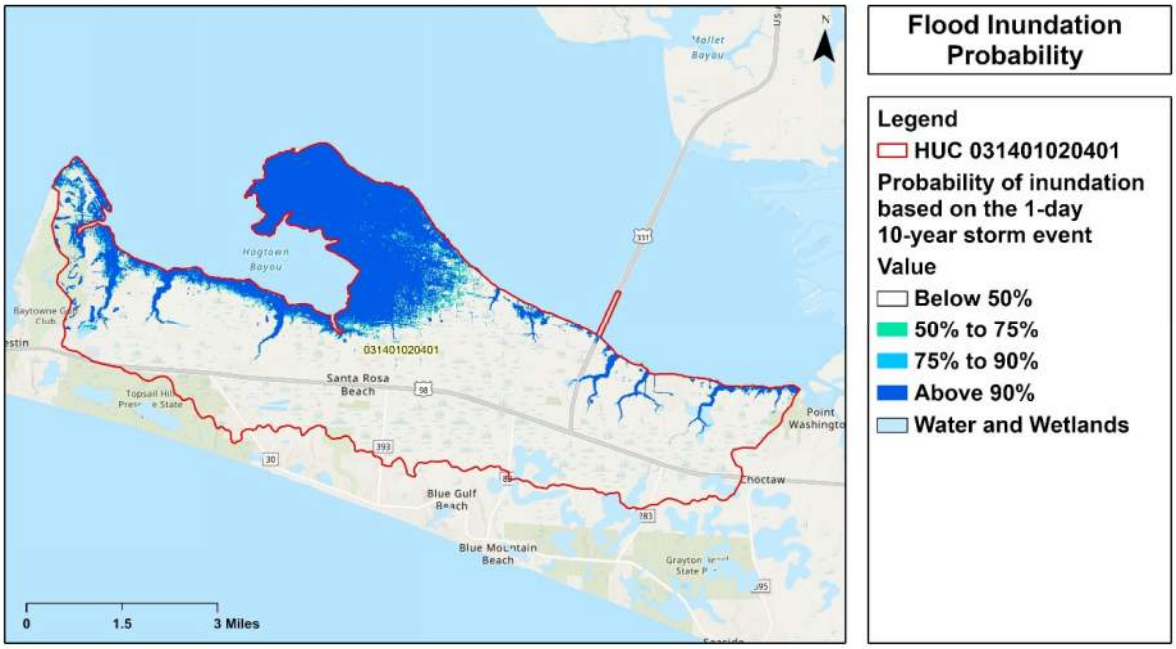

Figure 37. 1-day 10-year storm event for HUC 031401020401 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

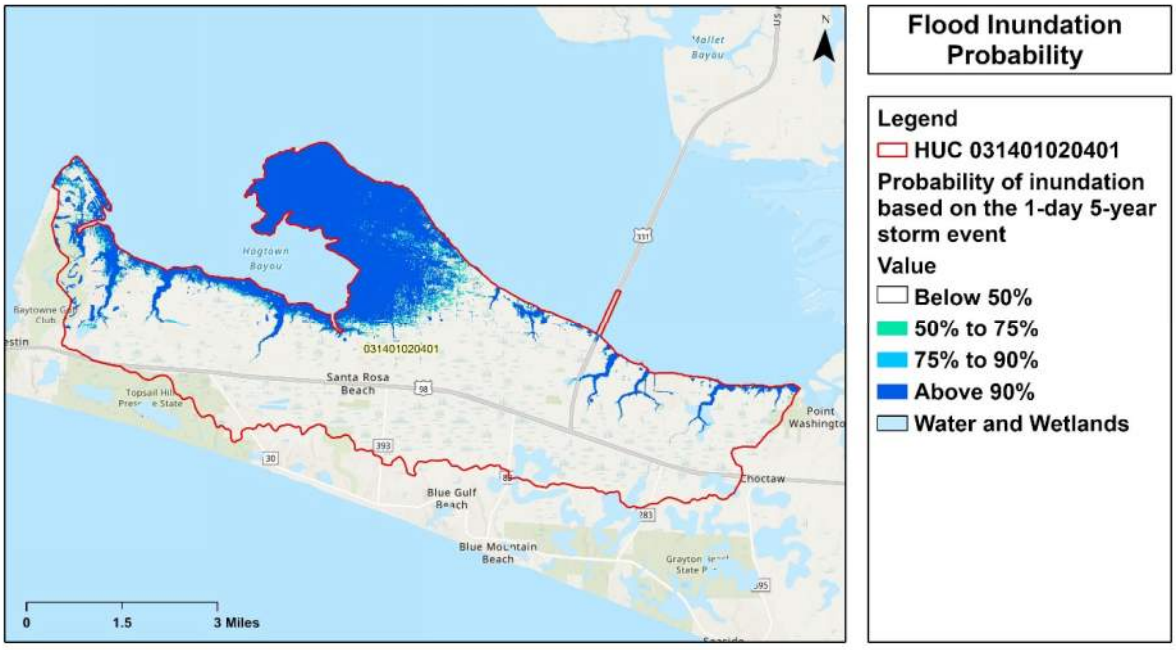

Figure 38. 1-day 5-year storm event for HUC 031401020401 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

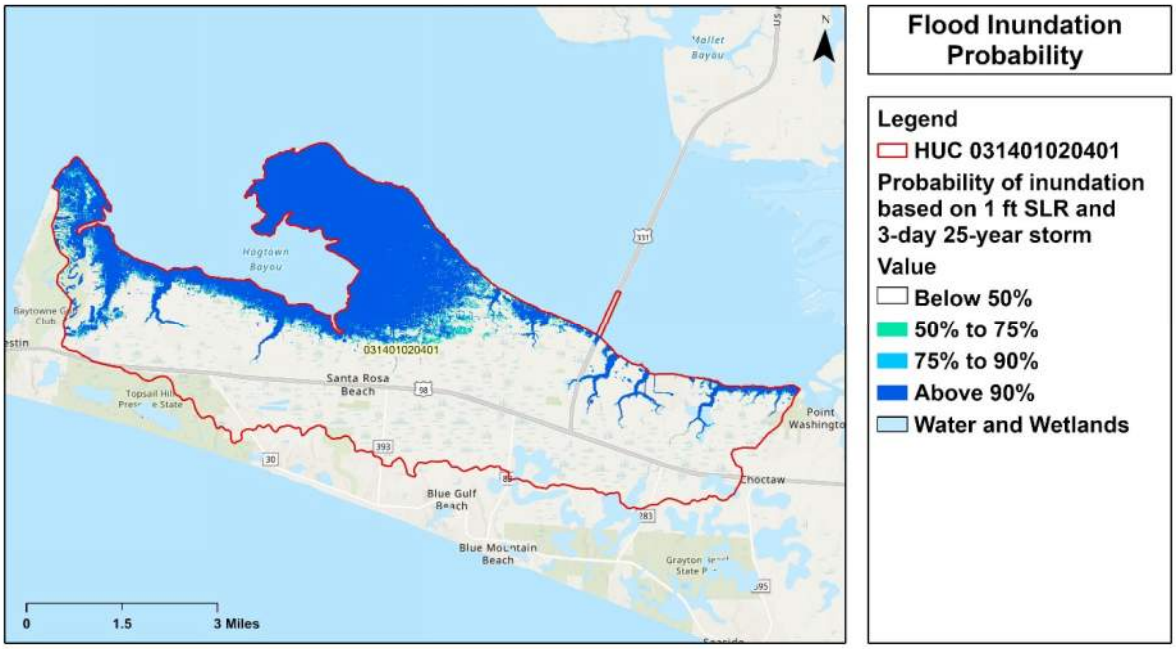

Figure 39. Sea level rise of 1 ft + 3-day 25-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

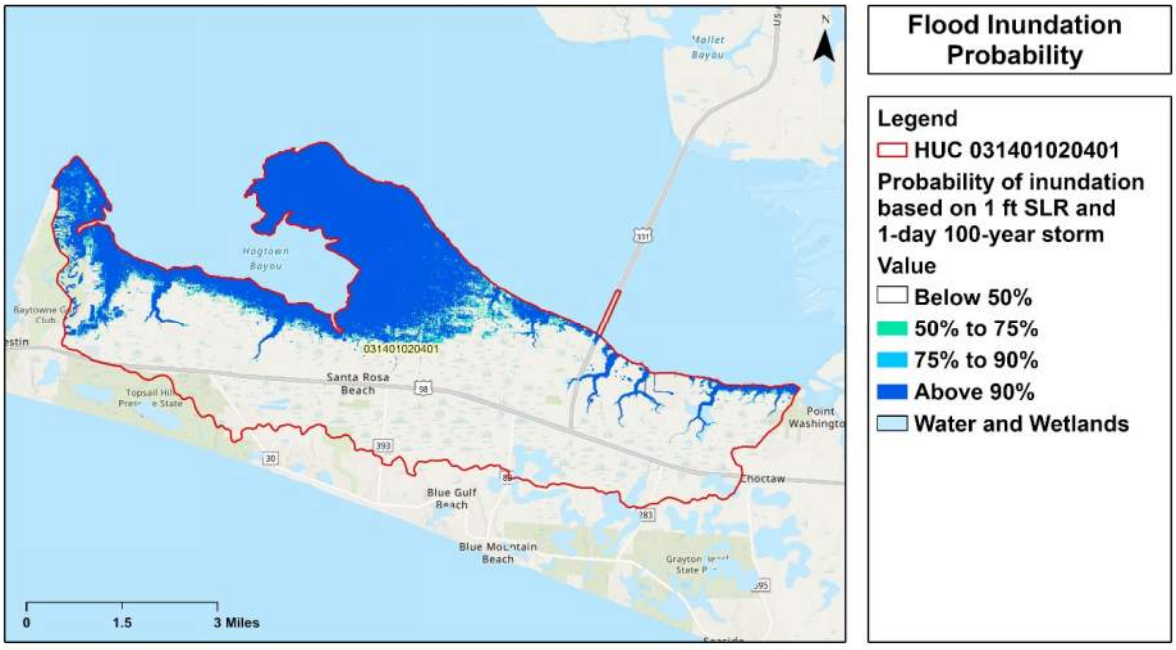

Figure 40. Sea level rise of 1 ft + 1-day 100-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

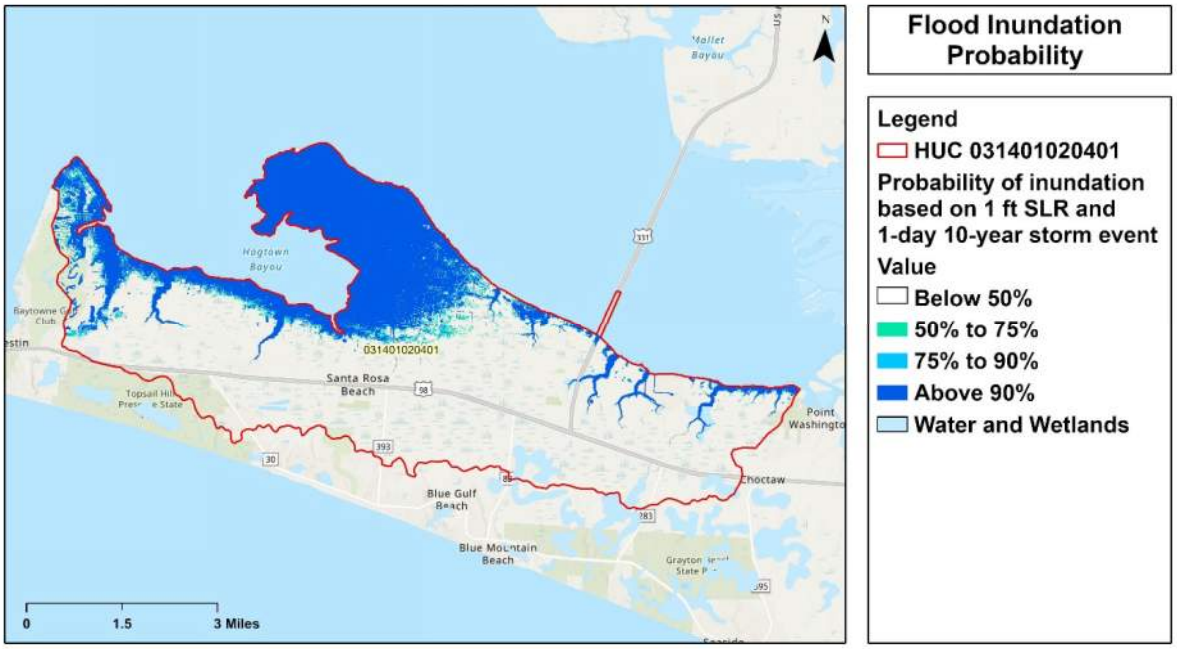

Figure 41. Sea level rise of 1 ft + 1-day 10-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

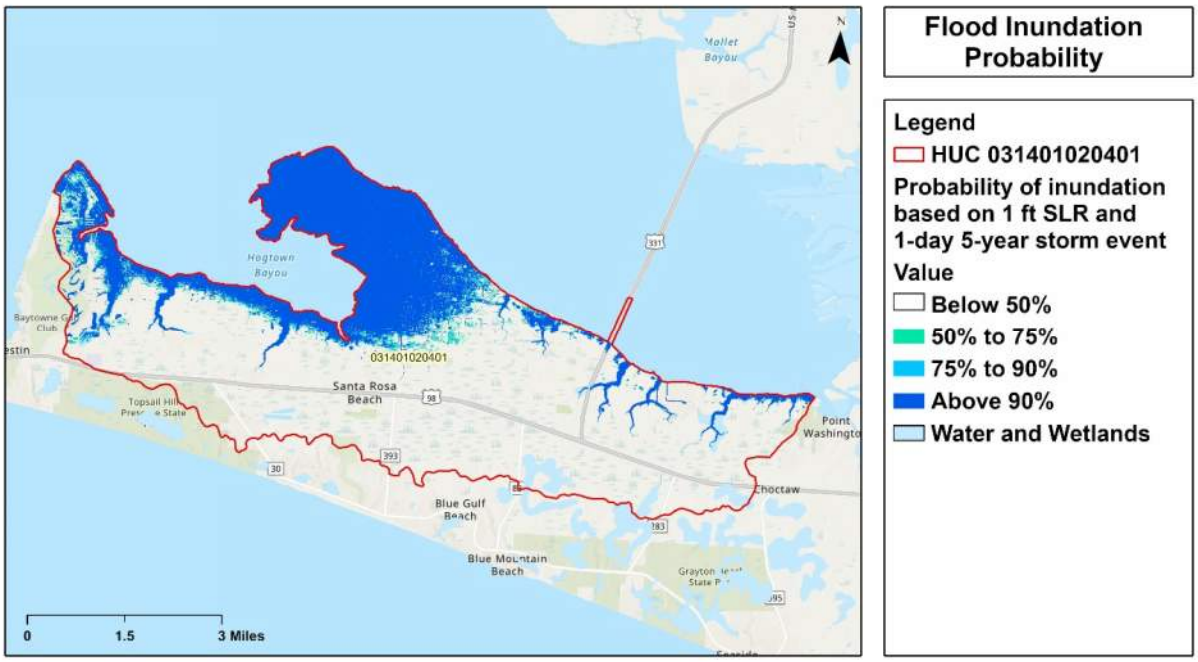

Figure 42. Sea level rise of 1 ft + 1-day 5-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

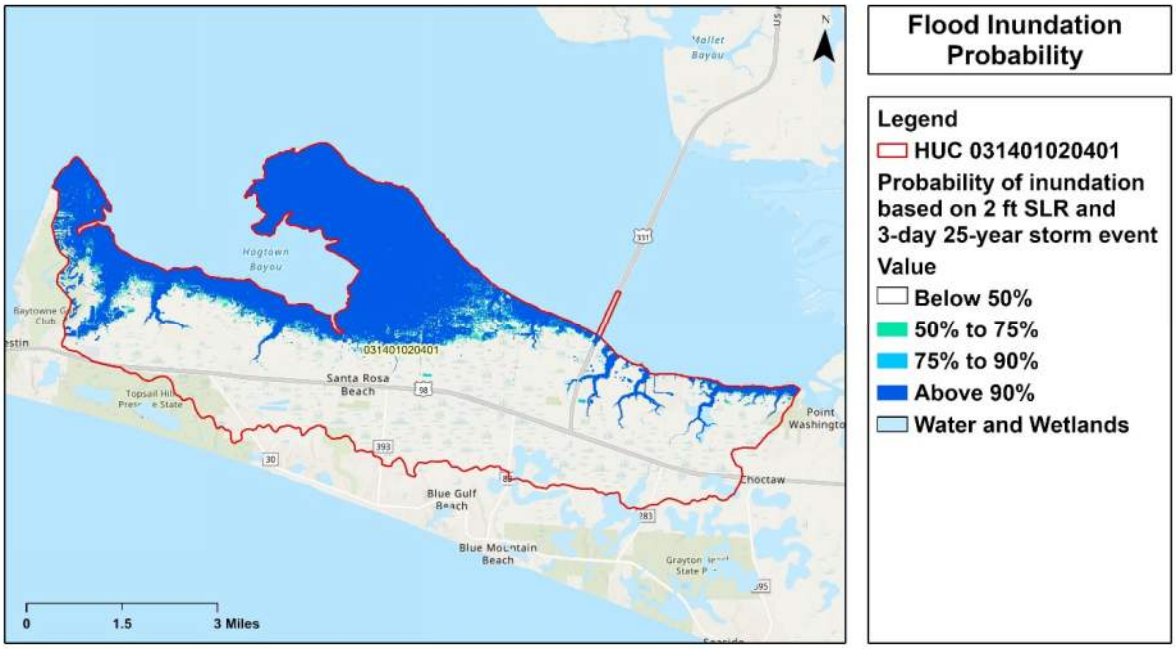

Figure 43. Sea level rise of 2 ft + 3-day 25-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

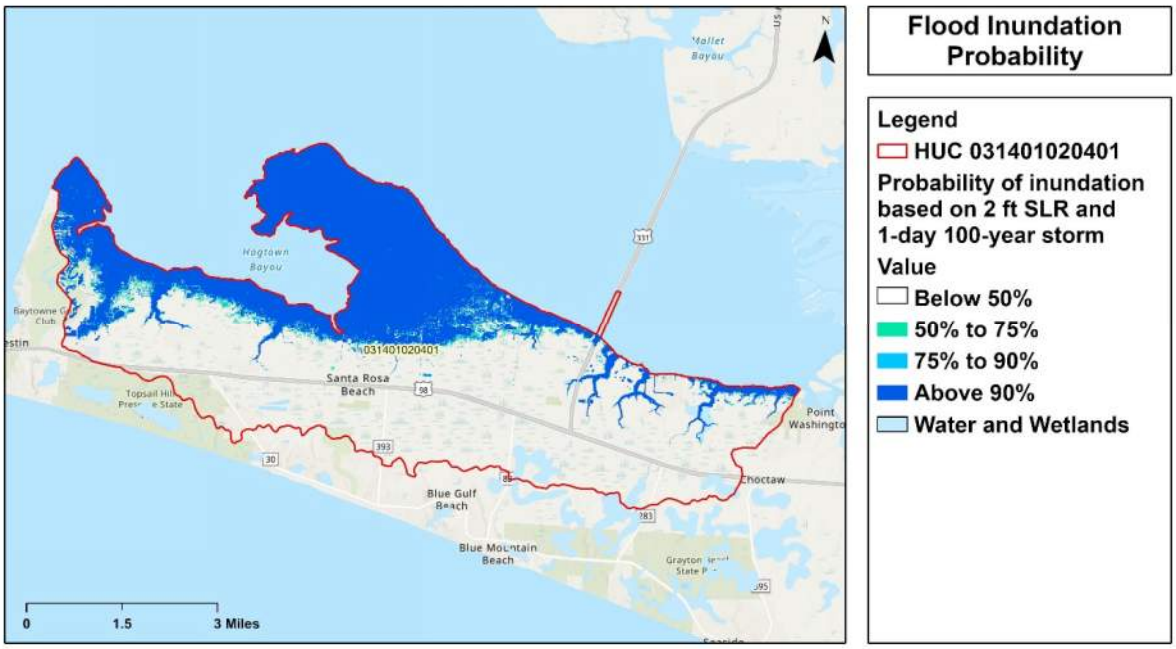

Figure 44. Sea level rise of 2 ft + 1-day 100-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

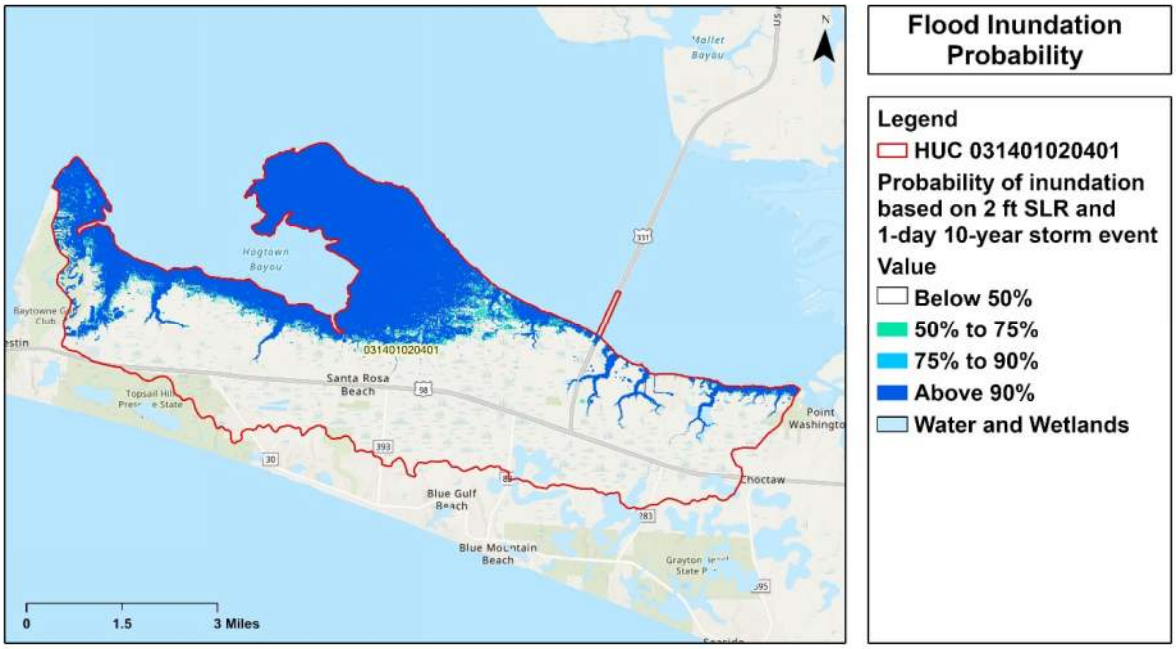

Figure 45. Sea level rise of 2 ft + 1-day 10-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

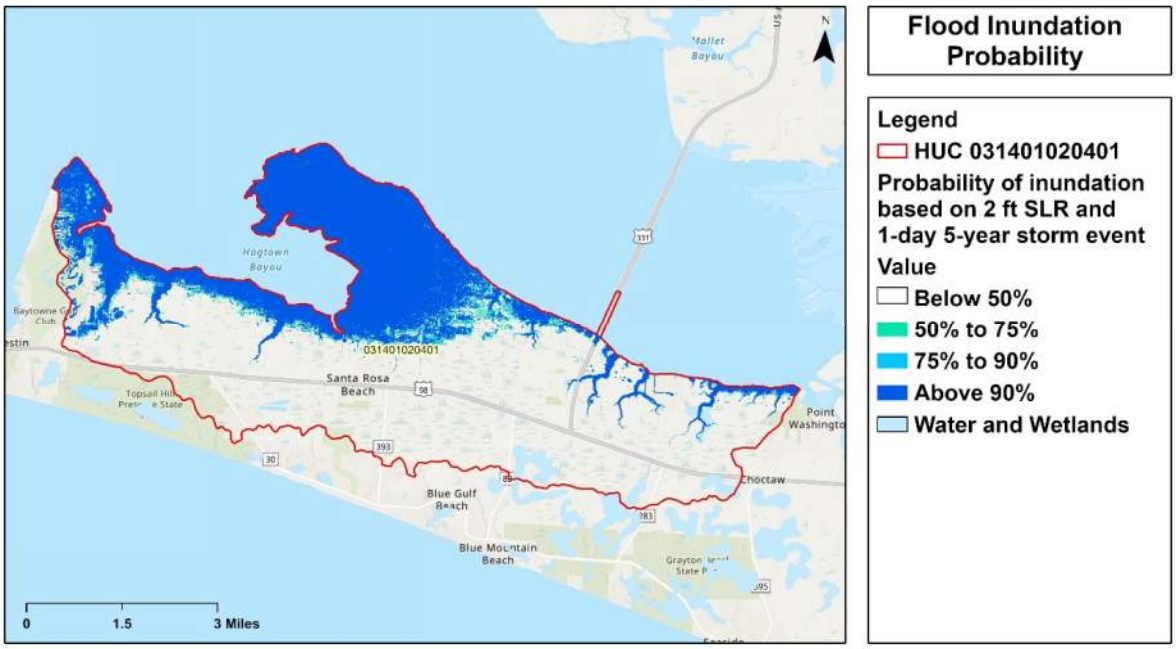

Figure 46. Sea level rise of 2 ft + 1-day 5-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

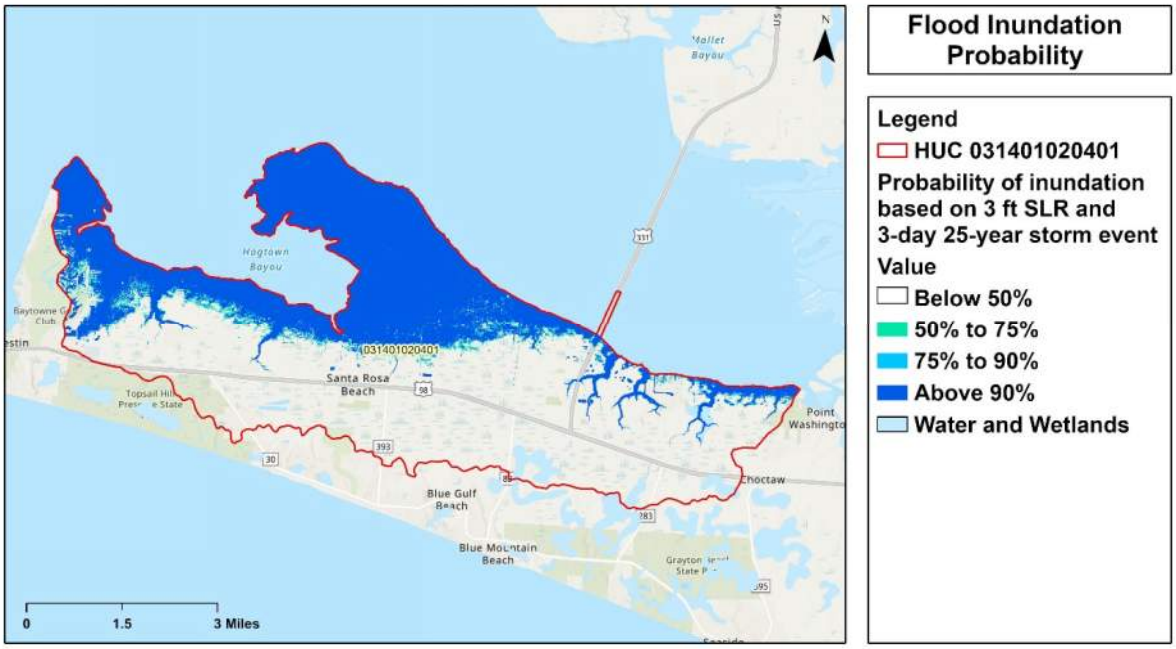

Figure 47. Sea level rise of 3 ft + 3-day 25-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

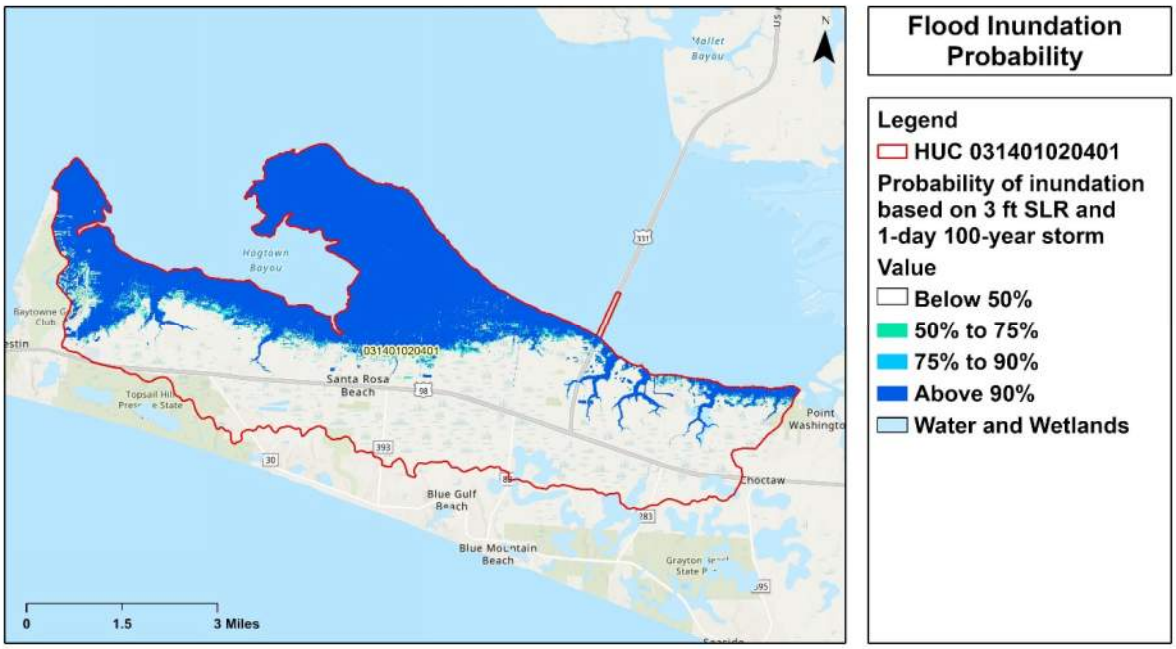

Figure 48. Sea level rise of 3 ft + 1-day 100-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

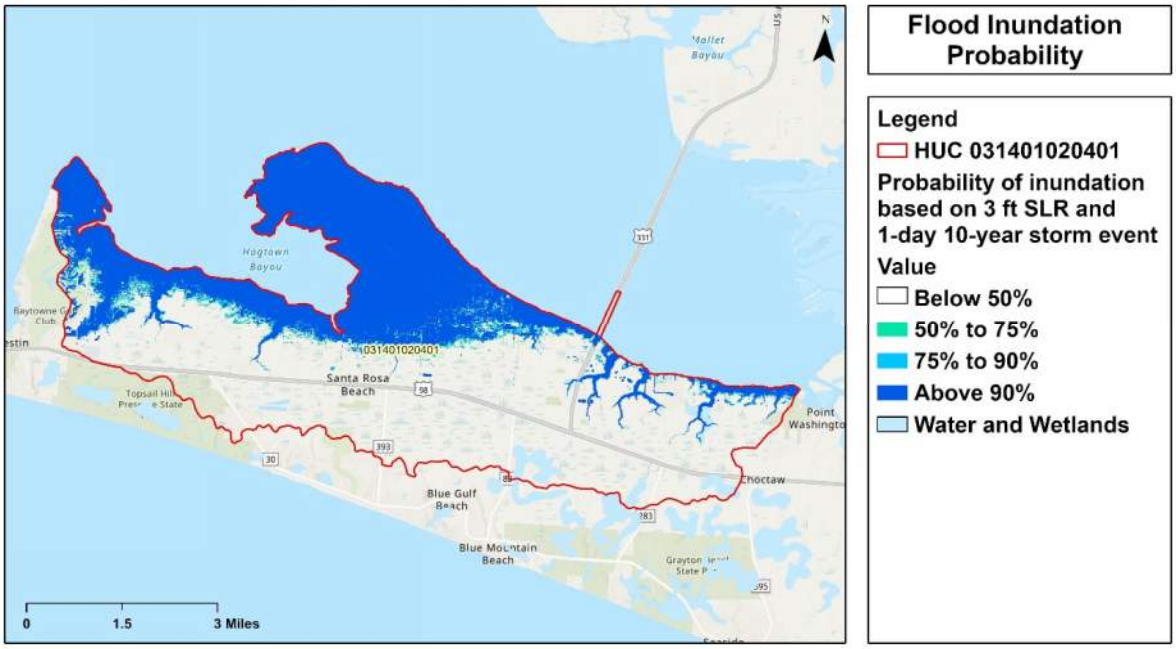

Figure 49. Sea level rise of 3 ft + 1-day 10-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

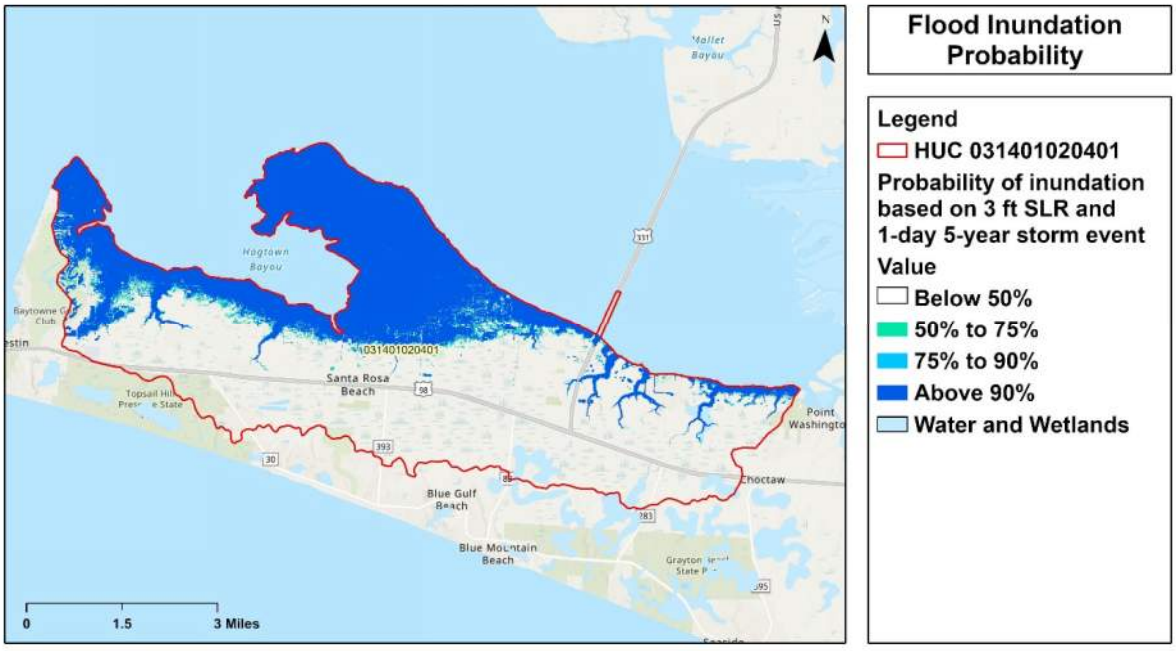

Figure 50.Sea level rise of 3 ft + 1-day 5-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

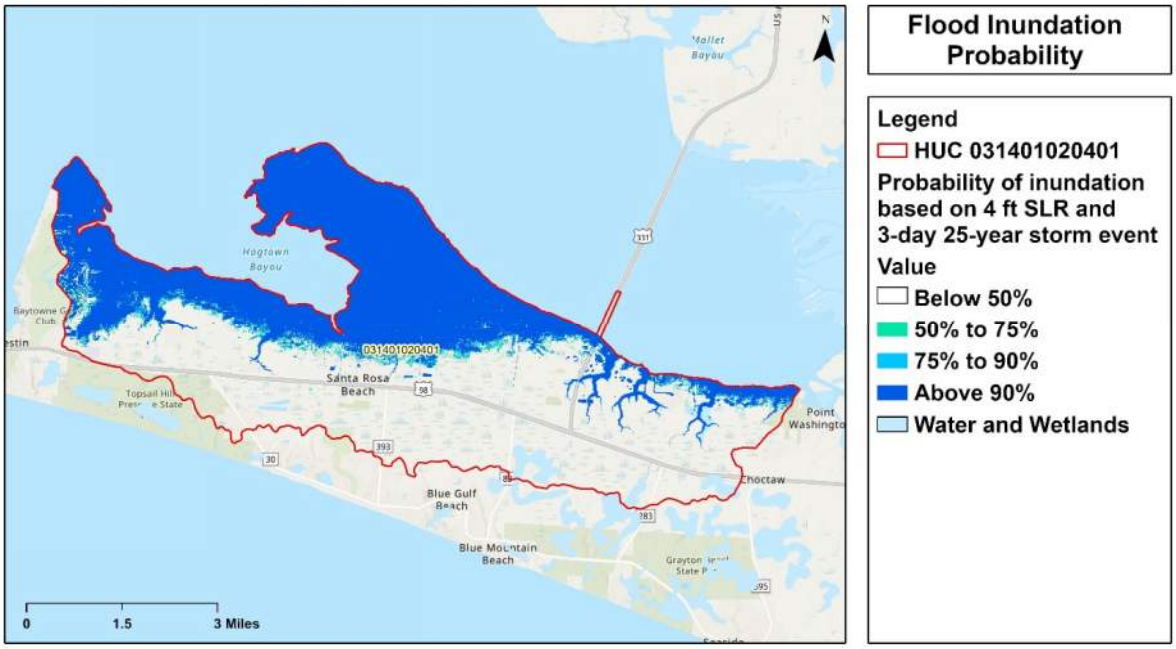

Figure 51. Sea level rise of 4 ft + 3-day 25-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

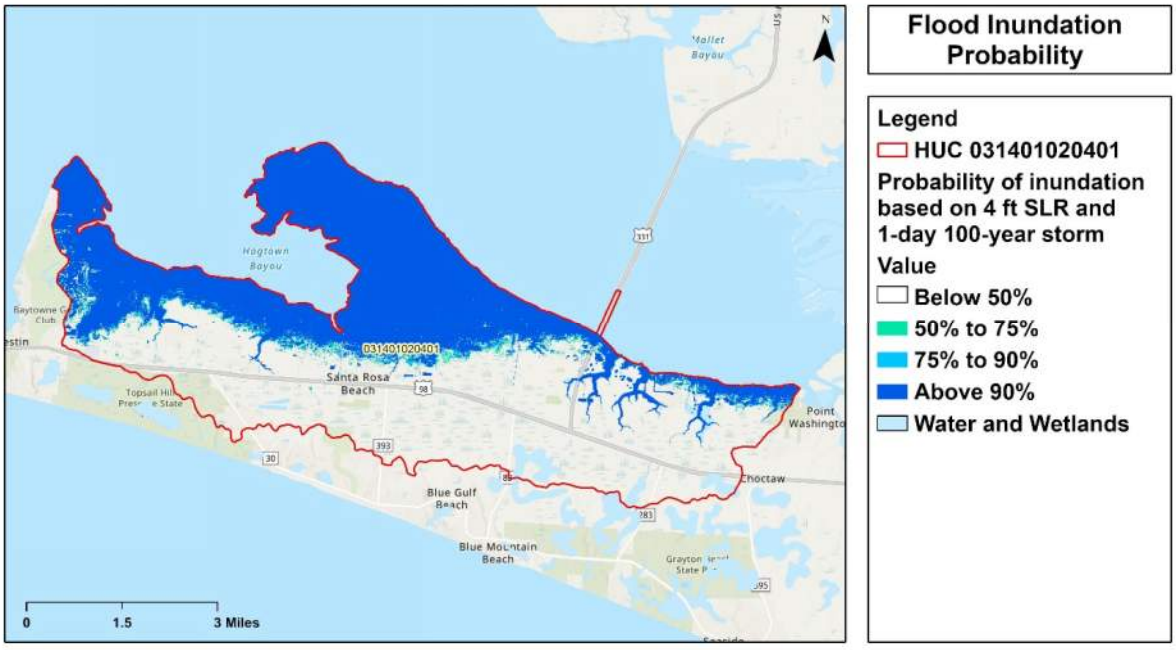

Figure 52. Sea level rise of 4 ft + 1-day 100-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

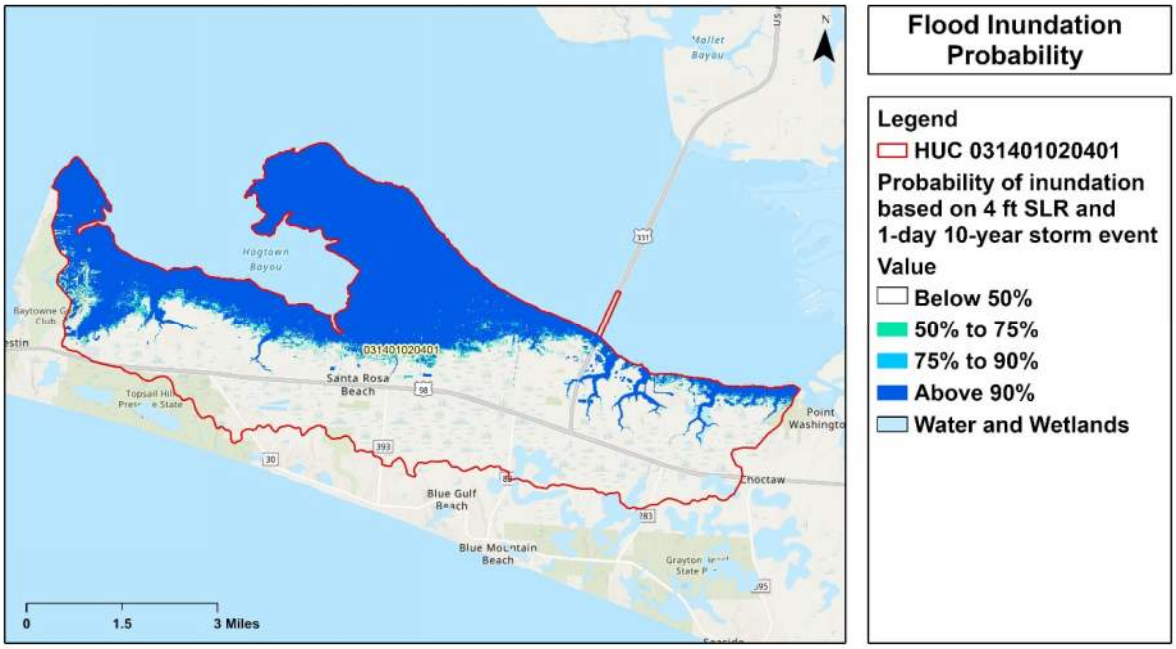

Figure 53. Sea level rise of 4 ft + 1-day 10-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

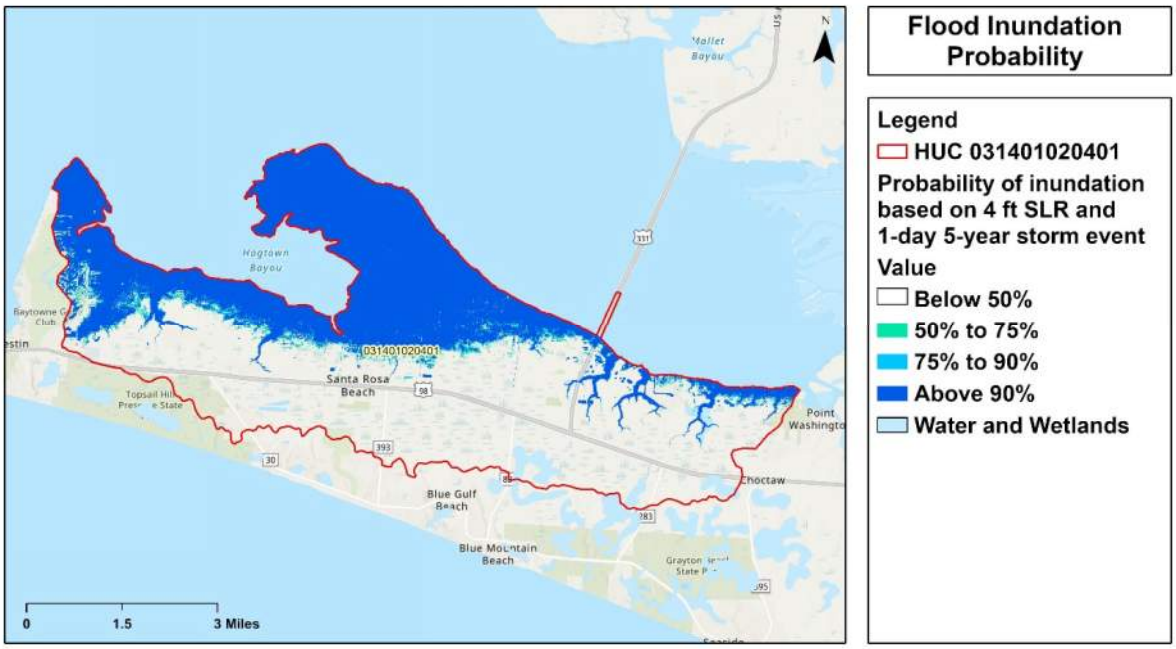

Figure 54. Sea level rise of 4 ft + 1-day 5-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

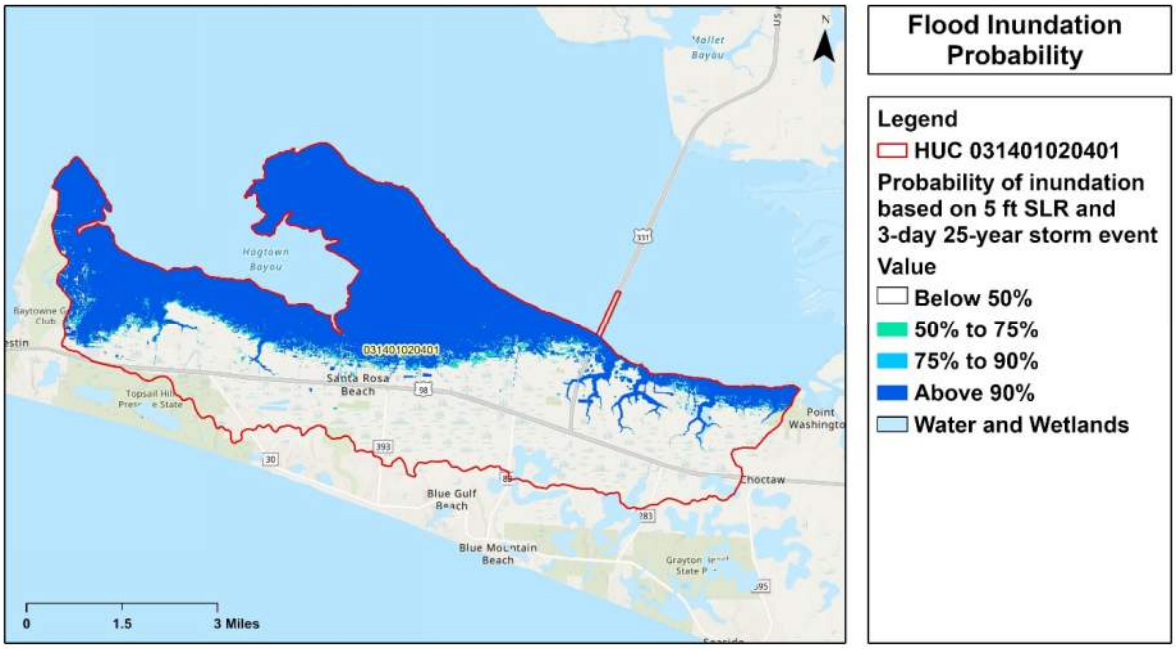

Figure 55. Sea level rise of 5 ft + 3-day 25-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

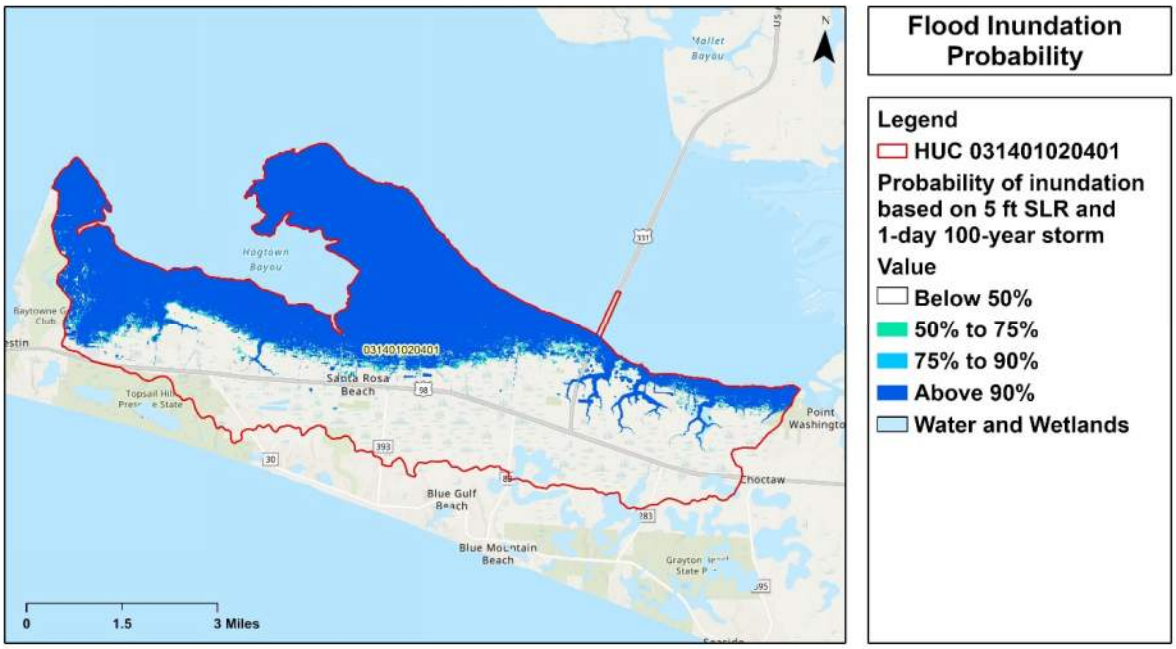

Figure 56. Sea level rise of 5 ft + 1-day 100-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

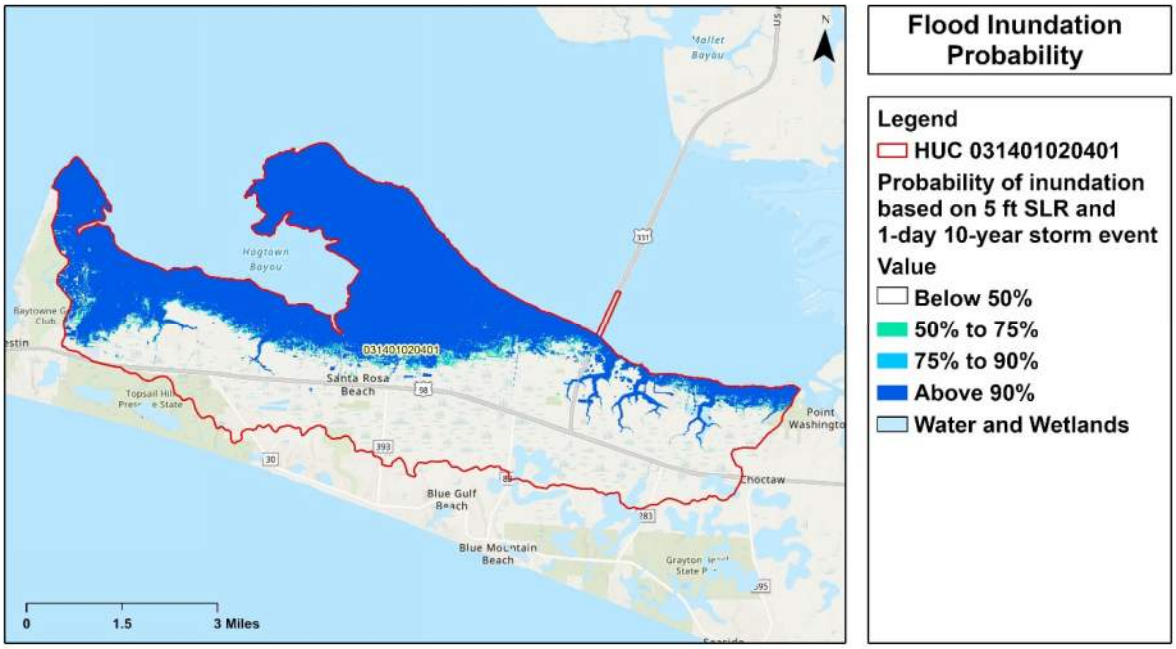

Figure 57. Sea level rise of 5 ft + 1-day 10-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

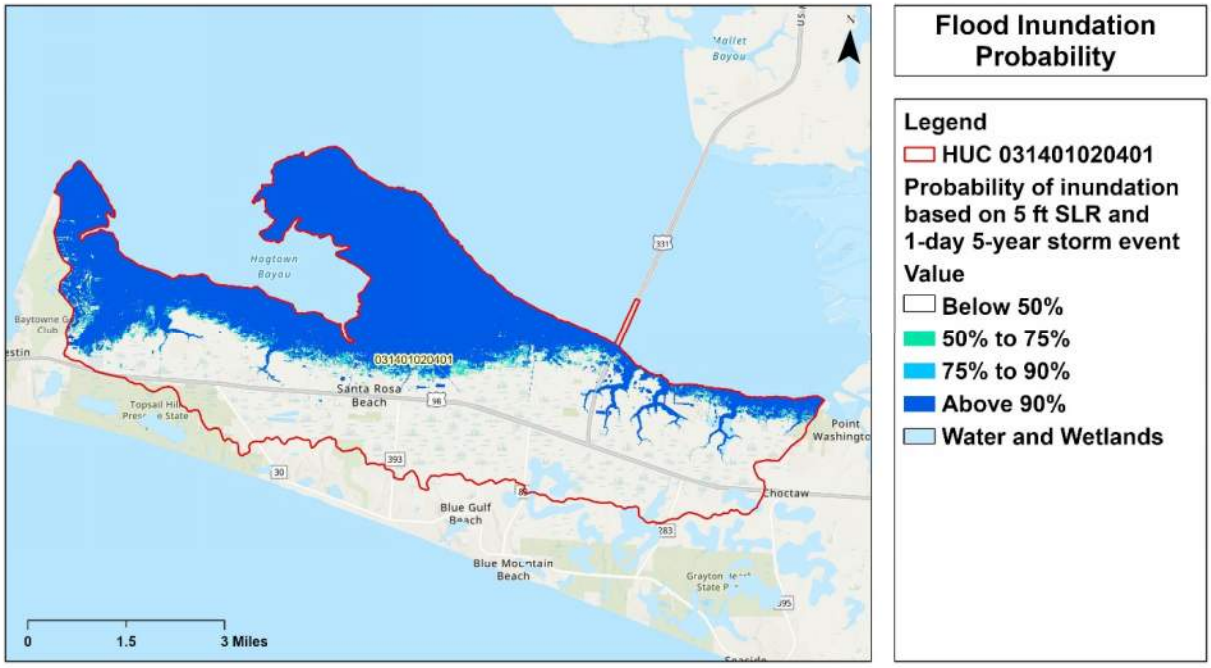

Figure 58. Sea level rise of 5 ft + 1-day 5-year storm for HUC 031401020401 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.5 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6

11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3

43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5

78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, as shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.5.1 Results

Error! Reference source not found. to **Error! Reference source not found.** depict the HUC 031401020401 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 60) overlays critical facilities onto the 1-day 100-year storm event scenario, while the third map (**Error! Reference source not found.**) represents the same overlay within the context of 5 feet of sea level rise (SLR) combined with the 1-day 100-year storm event. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 5 feet SLR + 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** and **Error! Reference source not found.** illustrate the composite score for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. **Error! Reference source not found.** represents the calculation for composite score based on 1-day 100-year storm event, while **Error! Reference source not found.** shows the calculation for composite score for the same storm event, but including a 5 feet of Sea Level Rise scenario. **Error! Reference source not found.** shows the same area zoomed out.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

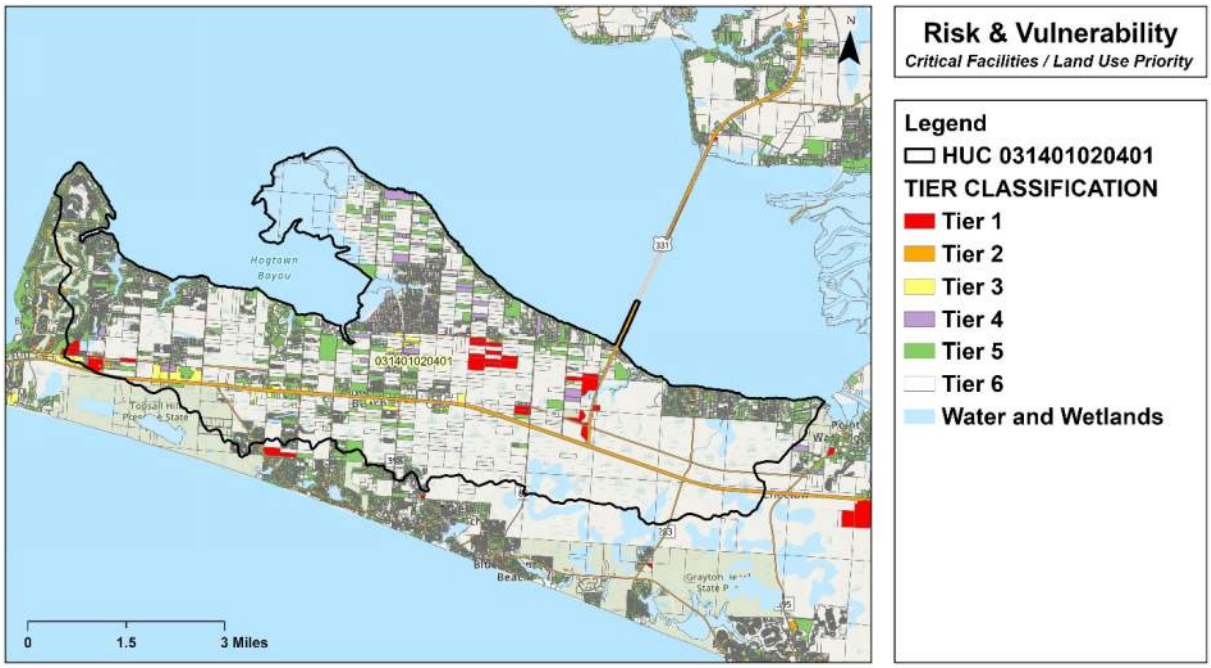

Figure 59. HUC 031401020401 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

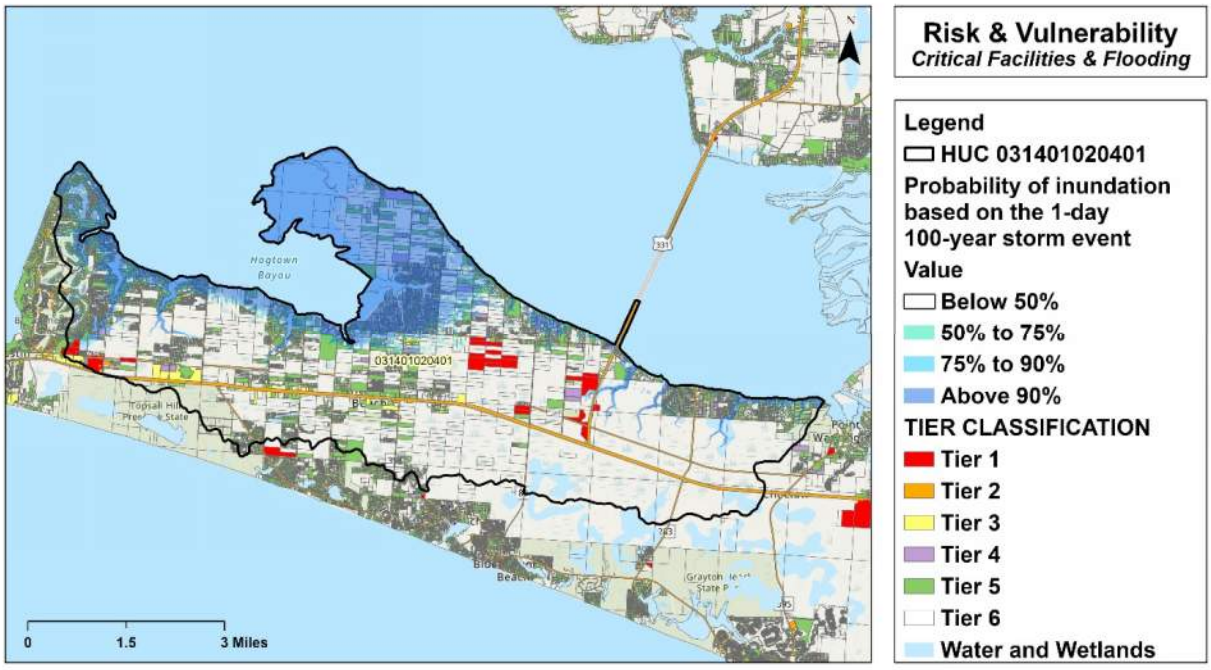

Figure 60. HUC 031401020401 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

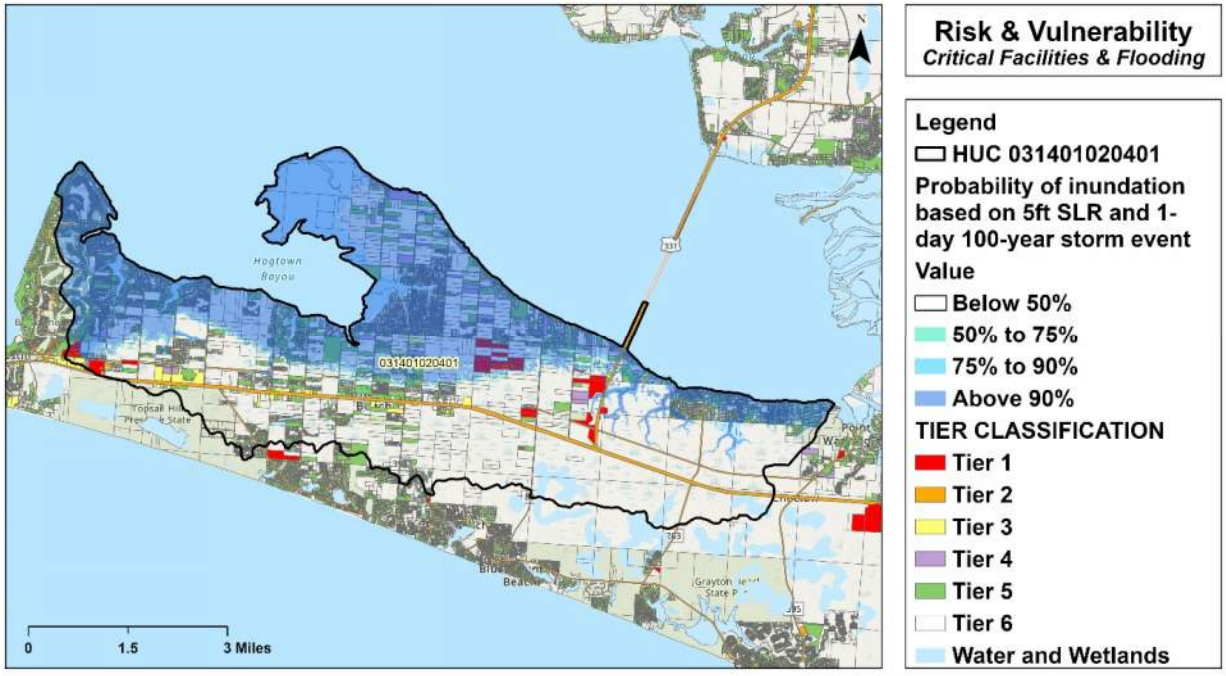

Figure 61. HUC 031401020401 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

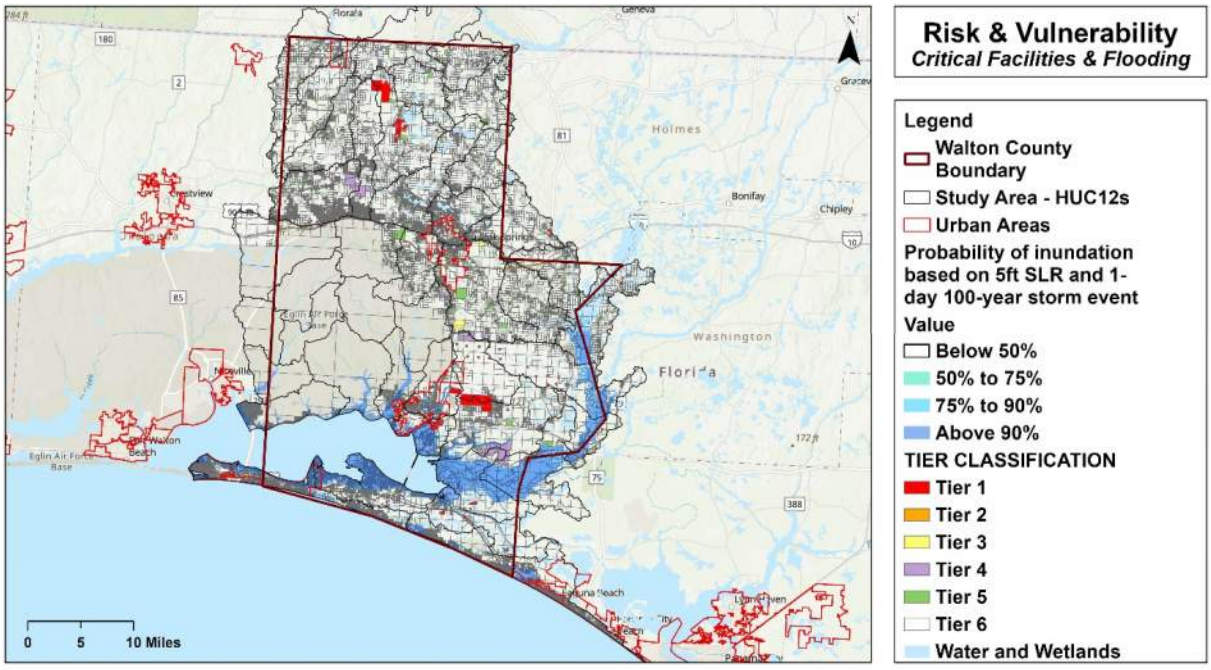

Figure 62. Walton County (mosaic) - Critical Facilities (priority of land uses) map, overlaid on the 1-day 100-year storm event + 5 ft. SLR probability of inundation for Walton County. Processed by FAU.

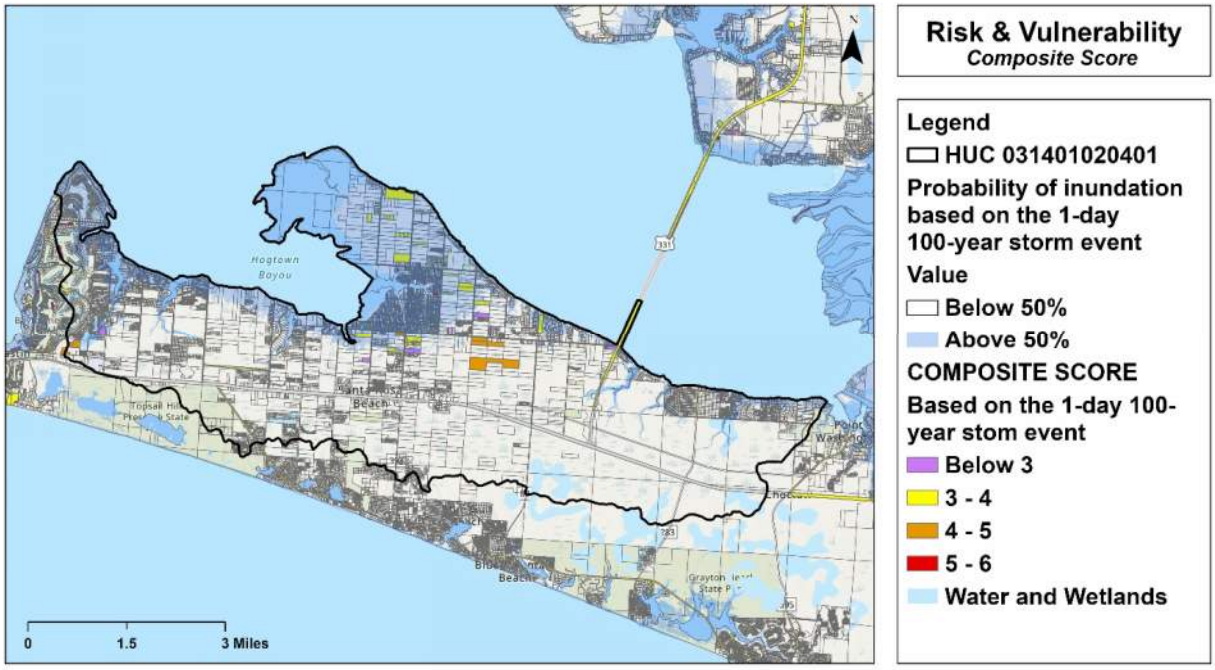

Figure 63. HUC 031401020401 sub-watershed Composite Score Risk map based on the 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation. Processed by FAU.

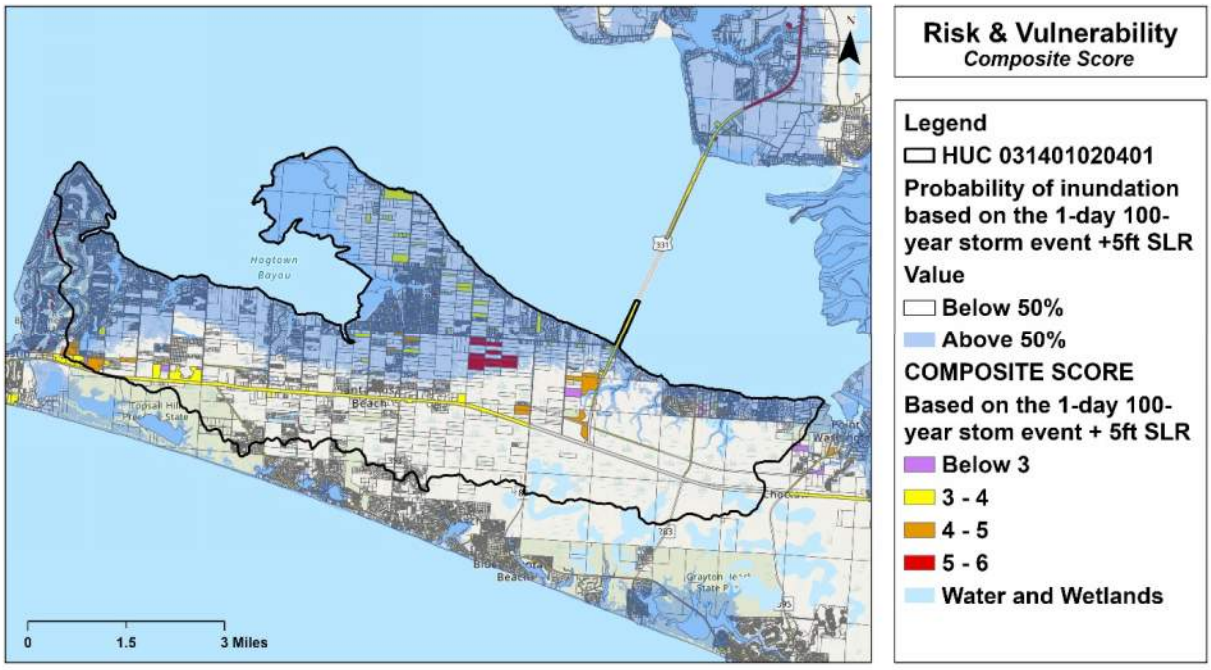

Figure 64. HUC 031401020401 sub-watershed Composite Score Risk map based on 1-day 100-year storm event + 5 ft. SRL, overlaid on the 1-day 100-year + 5 ft. SLR probability of inundation. Processed by FAU.

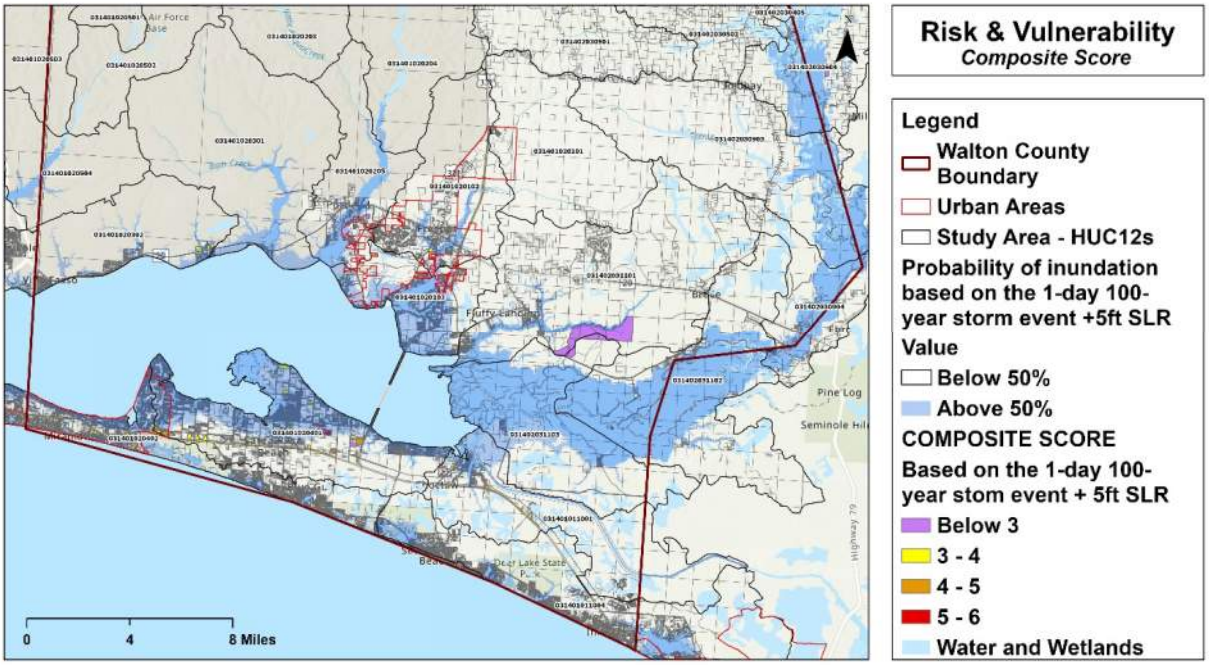

Figure 65. Coastal Area of Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

2.5.2 Drill-down – Santa Rosa Beach

For enhanced visualization of the urban areas within this HUC 031401020401, **Error! Reference source not found.** to **Error! Reference source not found.** illustrate the same results for critical facilities (land use priorities) and composite scores, but on a reduced scale, which better facilitates the examination of finer details within the urban area (Santa Rosa Beach). These maps cover both the 1-day 100-year scenario and the 1-day 100-year + 5 feet SLR scenario.

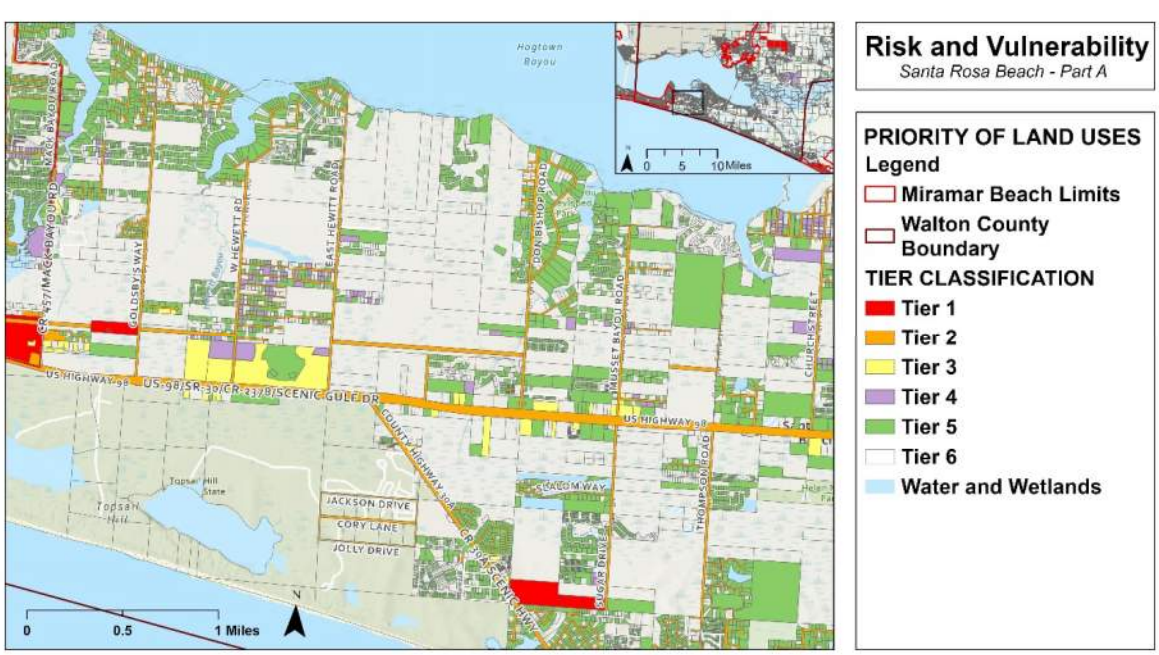

Figure 66. Critical Facilities (priority of land uses) map for Santa Rosa Beach (part A). Processed by FAU.

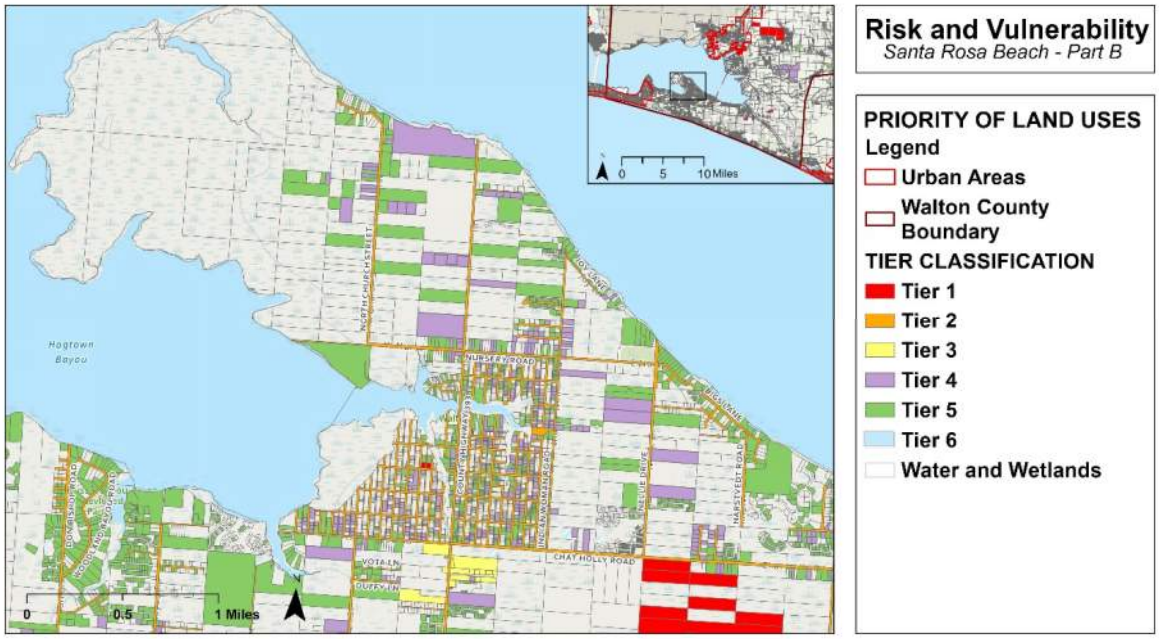

Figure 67. Critical Facilities (priority of land uses) map for Santa Rosa Beach (part B). Processed by FAU.

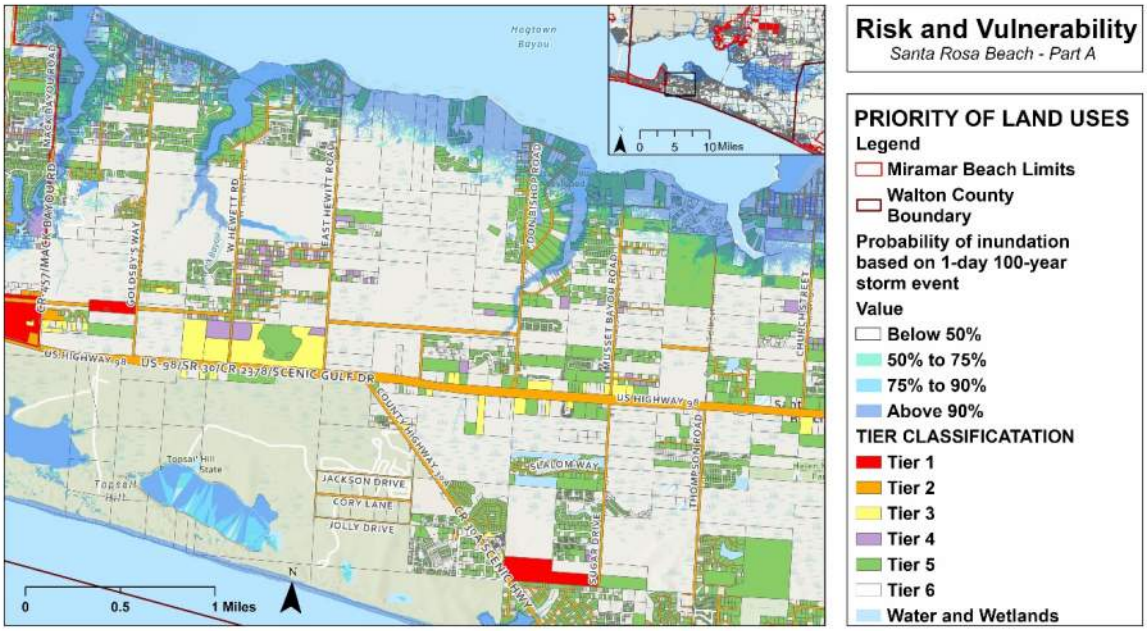

Figure 68. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event for Santa Rosa Beach (part A). Processed by FAU.

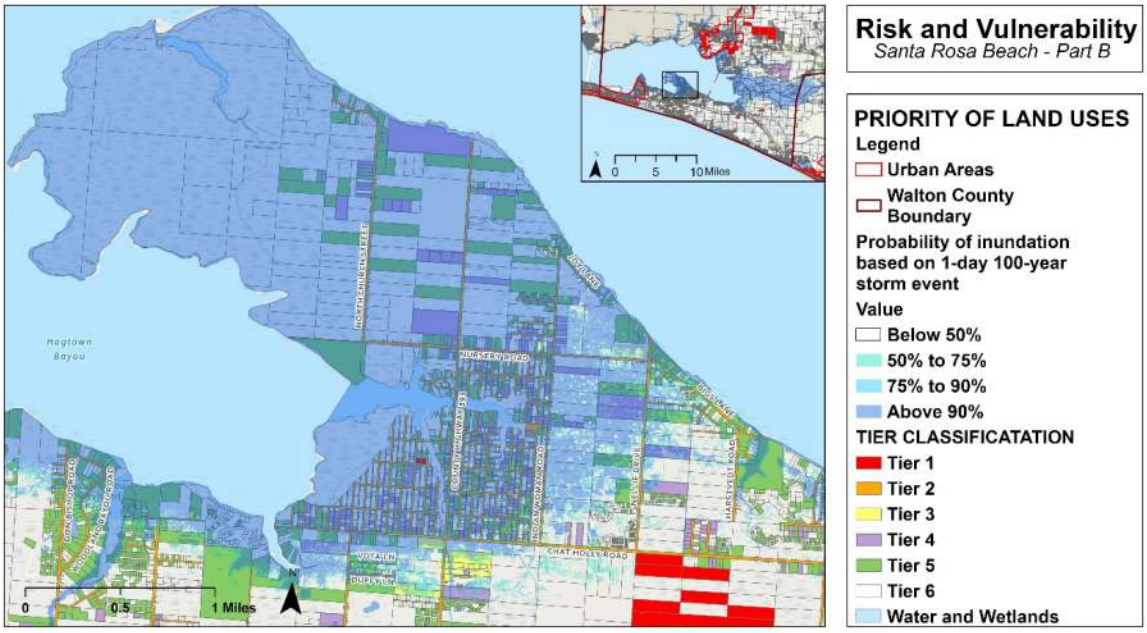

Figure 69. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event for Santa Rosa Beach (part B). Processed by FAU.

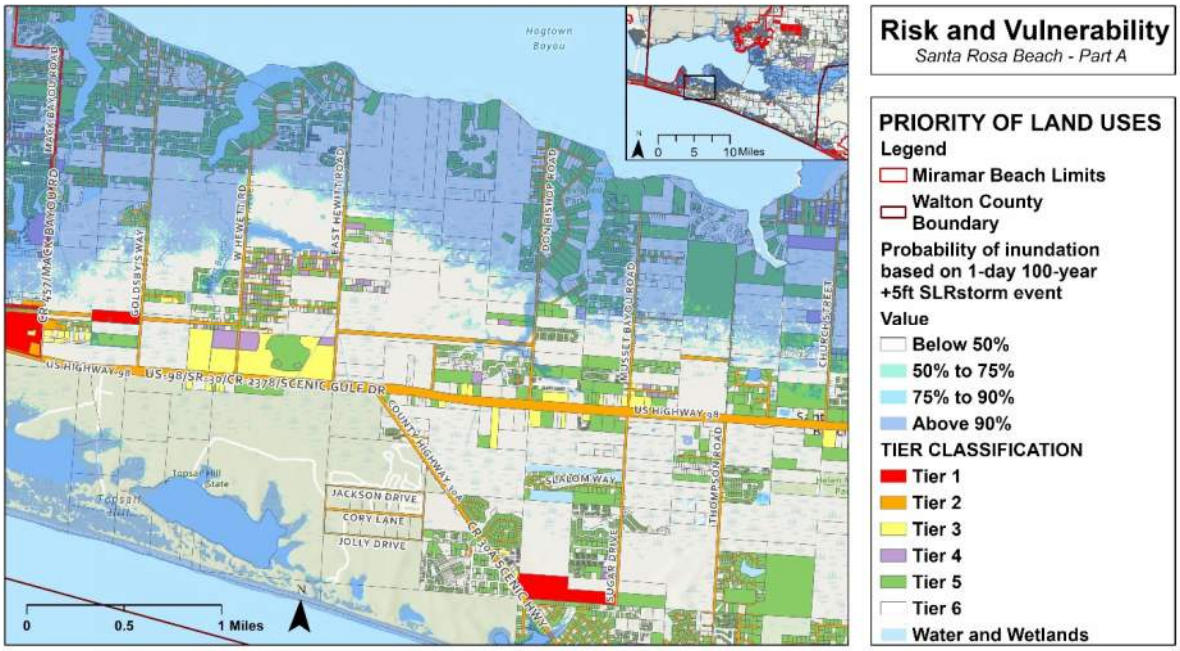

Figure 70. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event + 5 feet SLR for Santa Rosa Beach (part A). Processed by FAU.

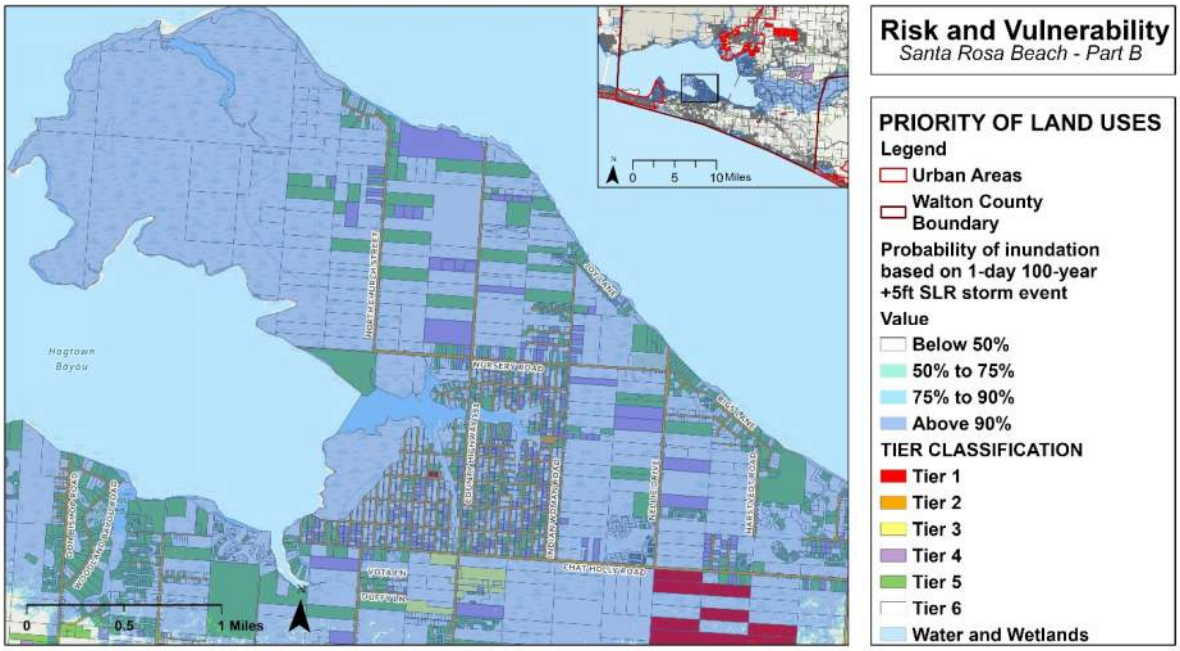

Figure 71. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event + 5 feet SLR for Santa Rosa Beach (part B). Processed by FAU.

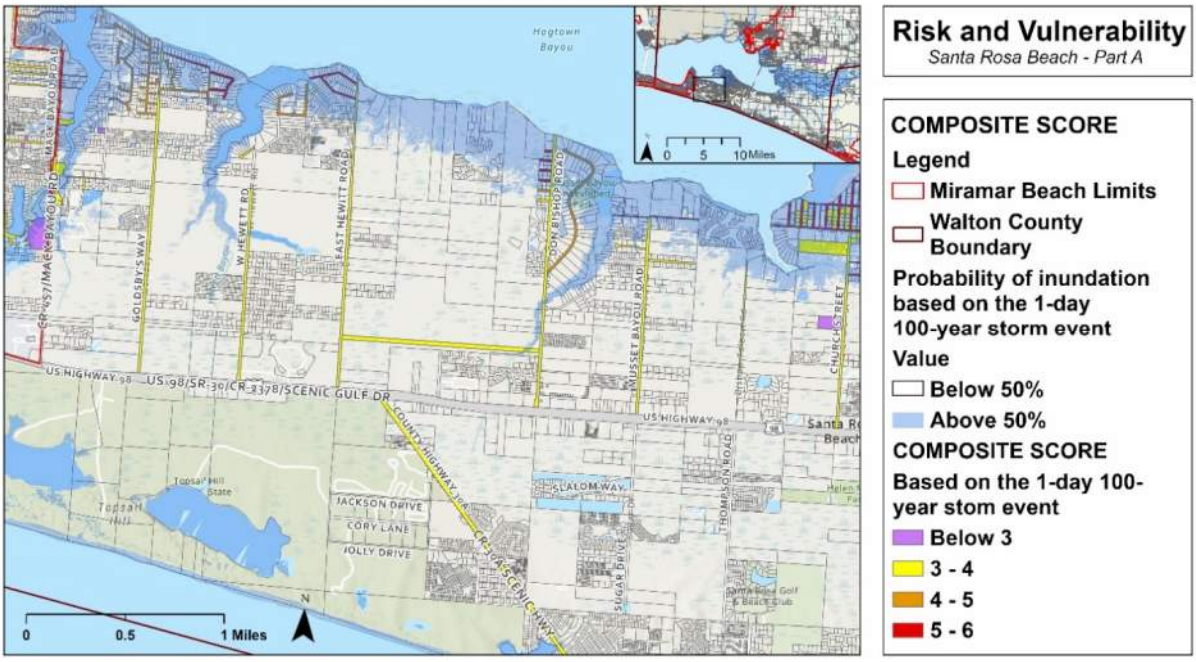

Figure 72. Composite Score map based on 1-day 100-year storm event, overlaid in flooding layer for Santa Rosa Beach (part A). Processed by FAU.

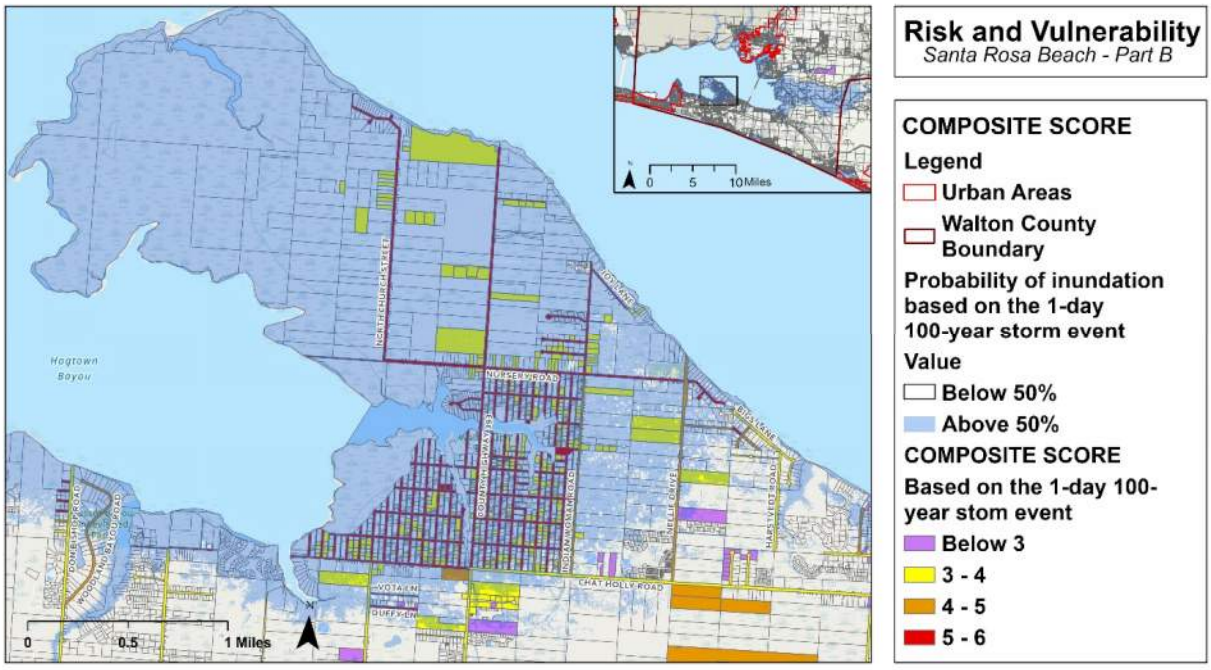

Figure 73. Composite Score map based on 1-day 100-year storm event, overlaid in flooding layer for Santa Rosa Beach (part B). Processed by FAU.

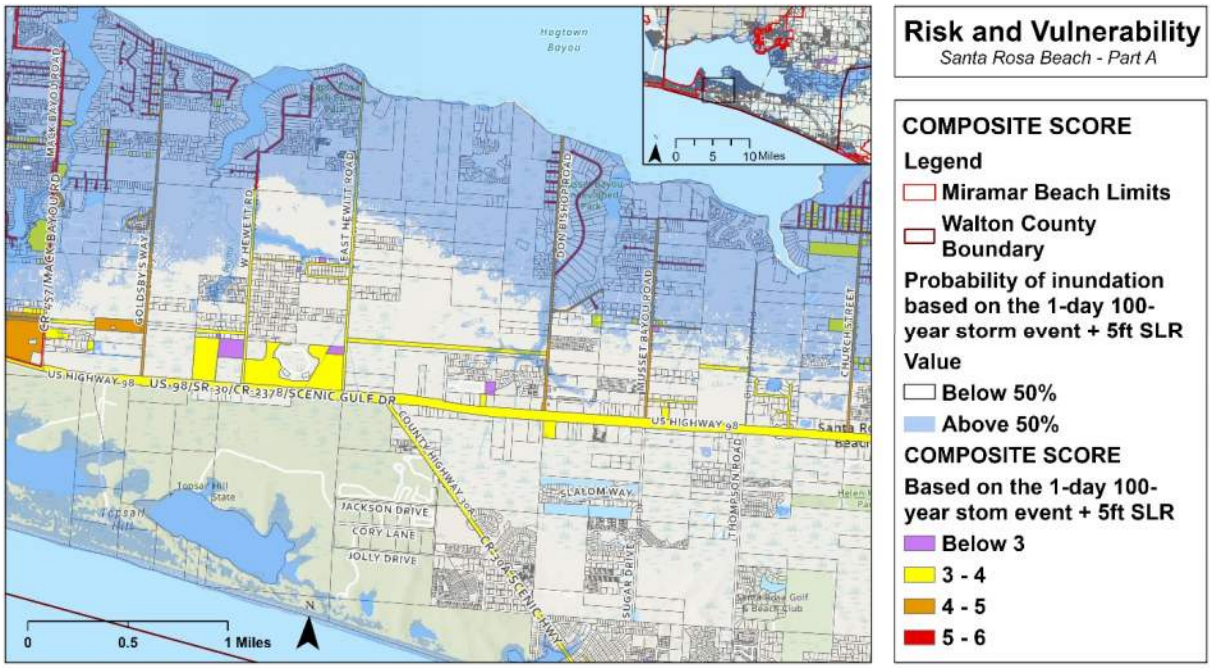

Figure 74. Composite Score map based on 1-day 100-year storm event + 5 feet SLR, overlaid in flooding layer for Santa Rosa Beach (part A). Processed by FAU.

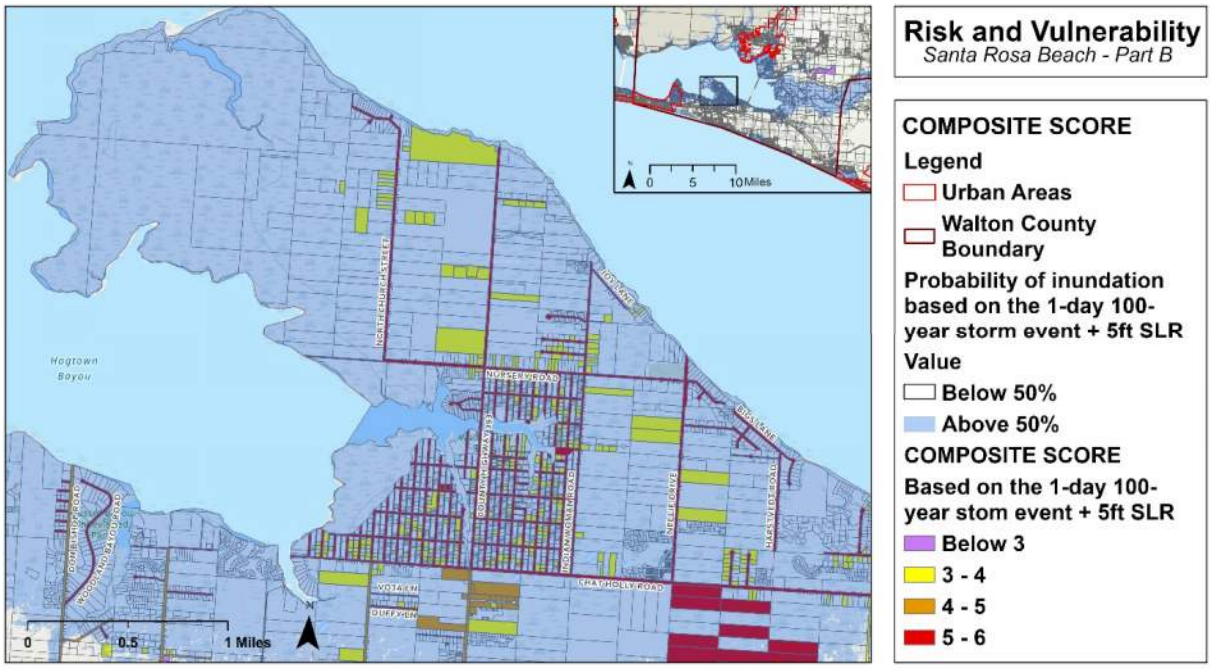

Figure 75. Composite Score map based on 1-day 100-year storm event + 5 feet SLR, overlaid in flooding layer for Santa Rosa Beach (part B). Processed by FAU.

2.5.3 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401020401. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**.. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.5.4 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It is important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands: This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands: In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401020401. Processed by FAU.

AREAS	ACRES
HUC-12 Sub-watershed: 031401020401	19156.62
All of the 1-day 100-year storm event inundation	**5235.98**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	1195.95
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	169.22
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	2.80
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	4040.03
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	3868.01

2.5.5 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

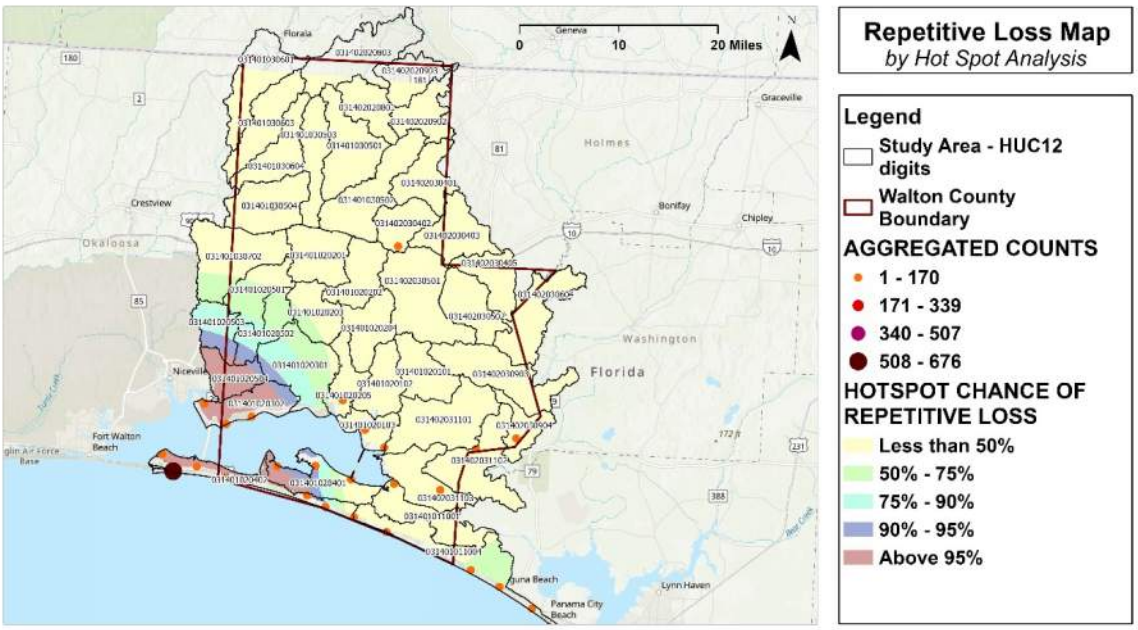

Figure 76. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.5.6 Priority Projects

The basin encompasses the community of Santa Rosa Beach, featuring a significant amount of developed land. Unfortunately, a substantial portion of this community is at risk of flooding, especially during a 1-day 100-year storm event + 5 ft. SRL scenario.

In terms of land use priority, there are 30 critical facilities (tier 1) within the basin, although not all are within the flood zone. Additionally, there are 473 parcels categorized as tier 2, including four financial institutions, four private schools, and numerous roads, with a significant portion within the flood zone. The basin also includes 98 parcels categorized as tier 3, 590 as tier 4, and over 6,900 as tier 5. Many of these parcels are within the flood zone.

Examining the composite score provides more detailed information about parcels within the flood zone. A total of 967 parcels are affected by the 1-day 100-year storm event + 5 ft. SRL scenario, and 746 parcels by the 1-day 100-year storm event alone.

In the worst scenario (1-day 100-year storm event + 5 ft. SRL), 381 parcels fall within the score range of 5-6, representing the highest priority for intervention. These include 8 county public schools, 5 utilities, and all remaining are roads, such as W Shipwreck Rd, Chat Holly Road, County Highway 393, North Church Street, Shelter Cove Dr/Pelican Bay Dr, Chat Holly Road, Rendevous Drive, 5th Street, etc.

Within the score range of 4-5, there are 56 parcels, including 3 community shopping centers, 14 office buildings, 2 professional service buildings, 2 restaurants/cafeterias, 9 light manufacturing facilities, 2 public schools, 1 college, 1 hospital, 7 utilities, and 11 roads, such as Cypress Point

Ln, W Point Washington Rd, Church Street , Goldsby's Way, County Road 393, Co Highway 283 N, and Mason Ave.

Within score 3-4, there are 495 parcels, including 426 mobile homes, 1 retirement home, 3 regional shopping centers, 3 community shopping centers, 5 office buildings, 3 restaurants, 1 financial institution, 1 auto sales/repair, 4 private schools and colleges, 11 orphanages or other non-profit service facilities, and 32 roads.

Additionally, the neighborhood of Long Leaf Circle in Santa Rosa Beach has shown a high interest in addressing flooding issues, as it has experienced multiple flooding incidents, affecting properties. This area includes parcels within score 3-4 and below 3 in the composite score calculations, indicating it should also receive priority for flood risk mitigation projects.

APPENDIX O

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401020402

DESTIN HARBOR-ALLIGATOR LAKE FRONTAL

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 sub-watershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub- watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401020402) is highlighted among all the HUCs to help identifying its location. (Figure 3).

The cities of Destin, which is outside Walton County's boundary, Miramar Beach, and the community of Sacred Oaks are situated within the HUC 0314010402 boundary. Demographic data and other relevant information about these locations, as well as other cities and communities in Walton County, will be covered in subsequent discussions.

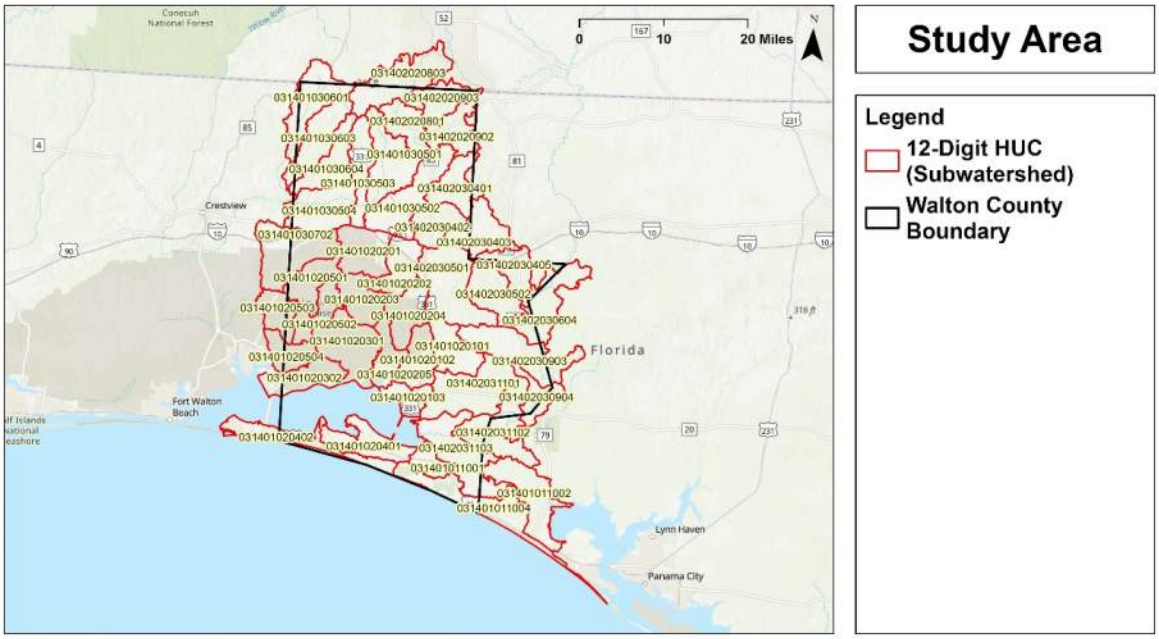

Figure 1. Walton County and all HUCs 12-digit sub-watershed, processed by FAU.

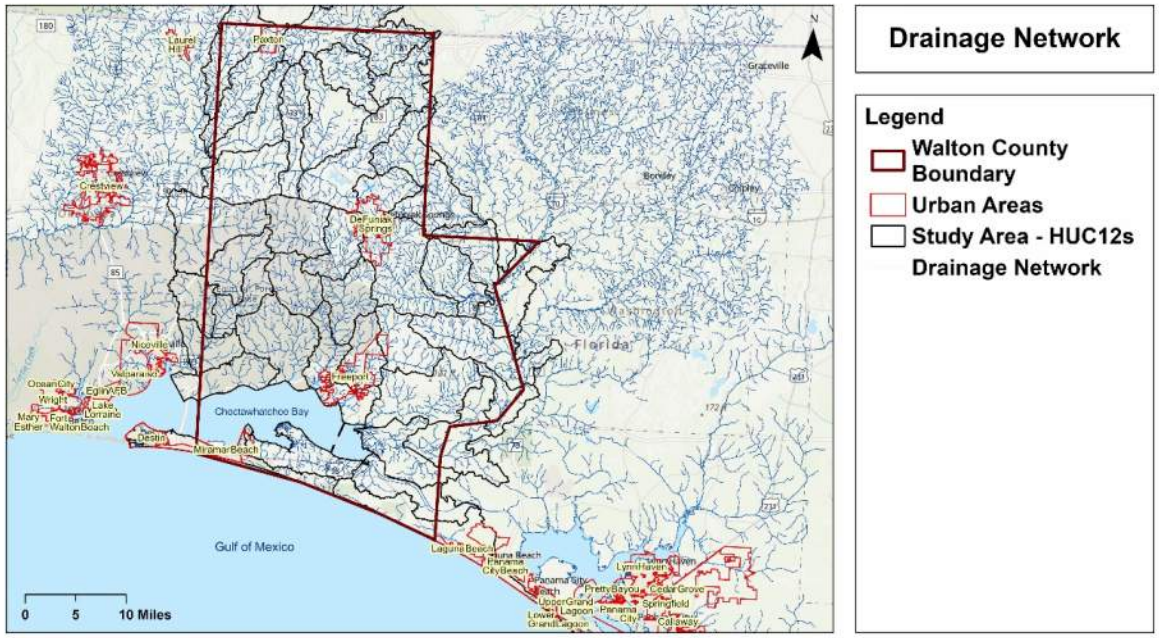

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

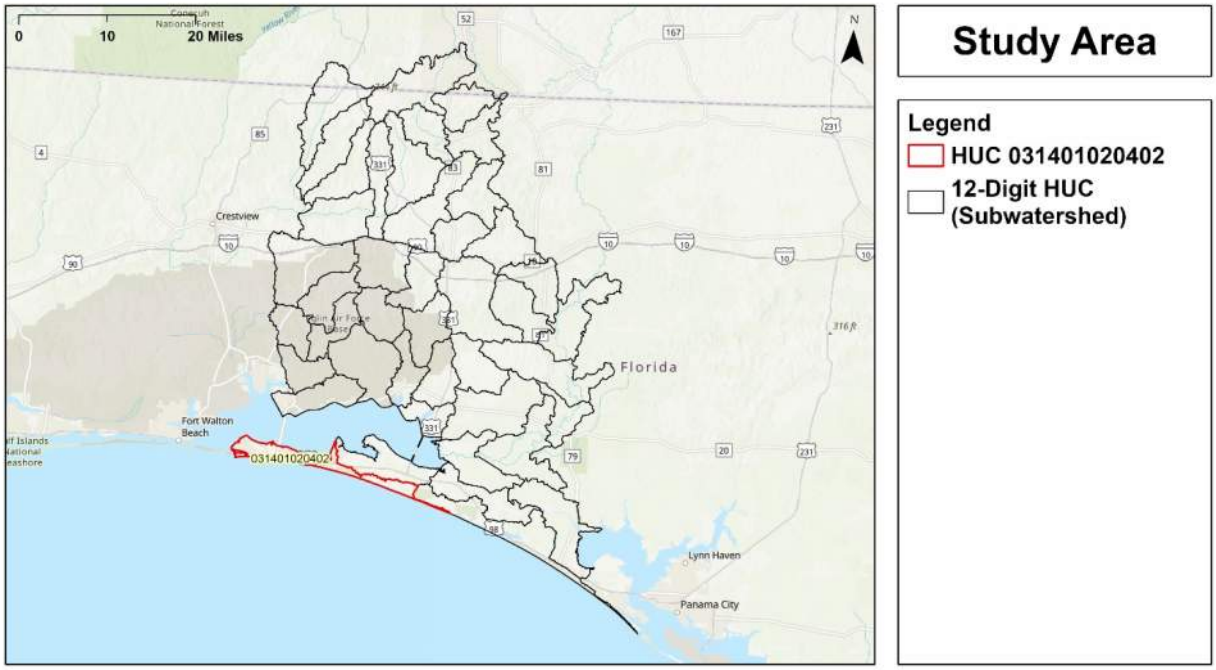

Figure 3. HUC 031401020402 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse

demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

Figures 12 and 13 in the county-wide report show the current and projected land use for the County. Based on the 2017 future land use map for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in Table 2.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In

order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (Figure 4). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

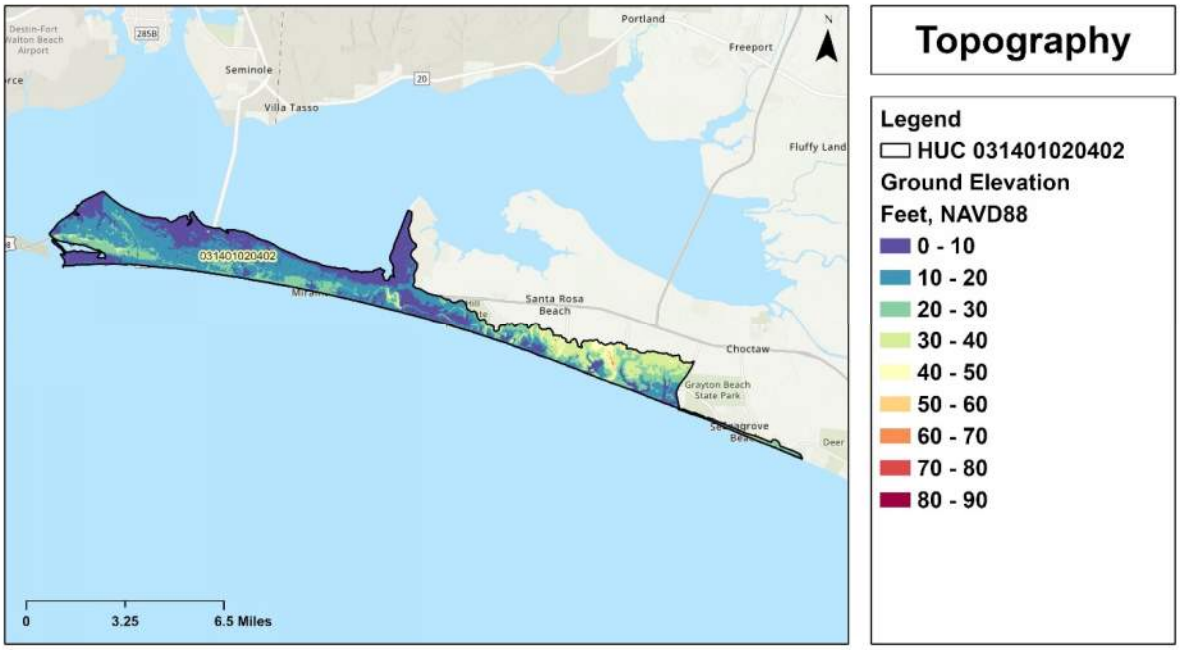

Figure 4. Topographic map of the HUC 031401020402 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology.
Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.
Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401020402 sub-watershed is shown in **Error! Reference source not found.**.

Figure 5. FEMA Flood Zone map (2020) for HUC 031401020402 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401020402 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall

biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

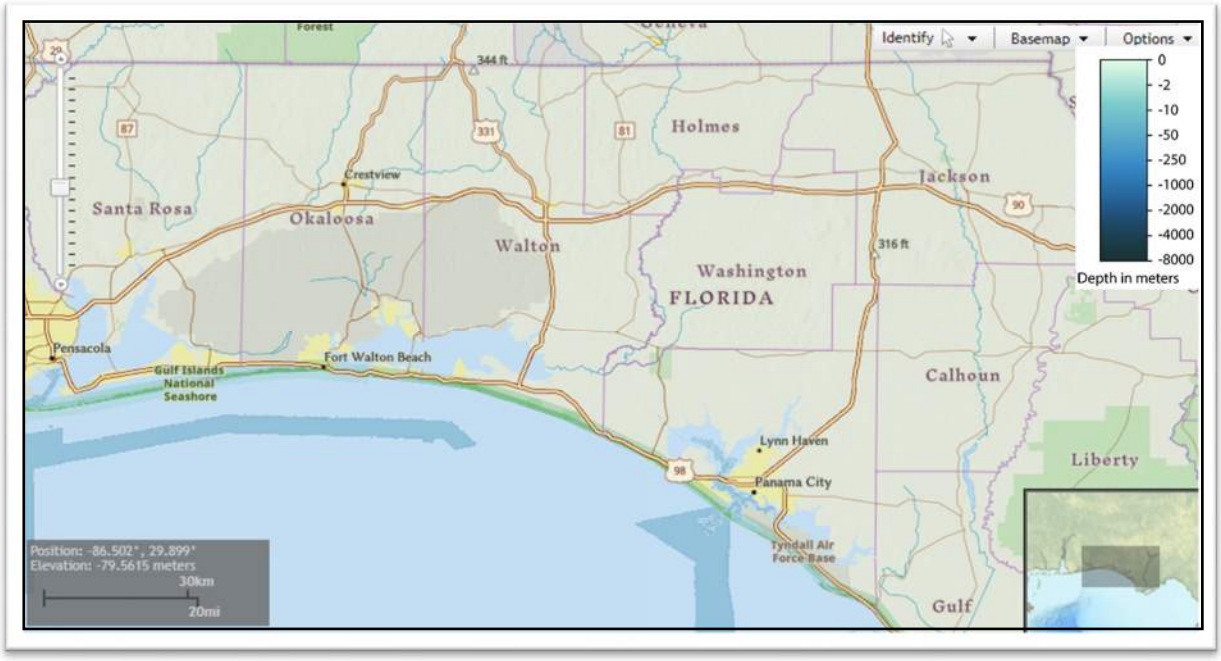

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

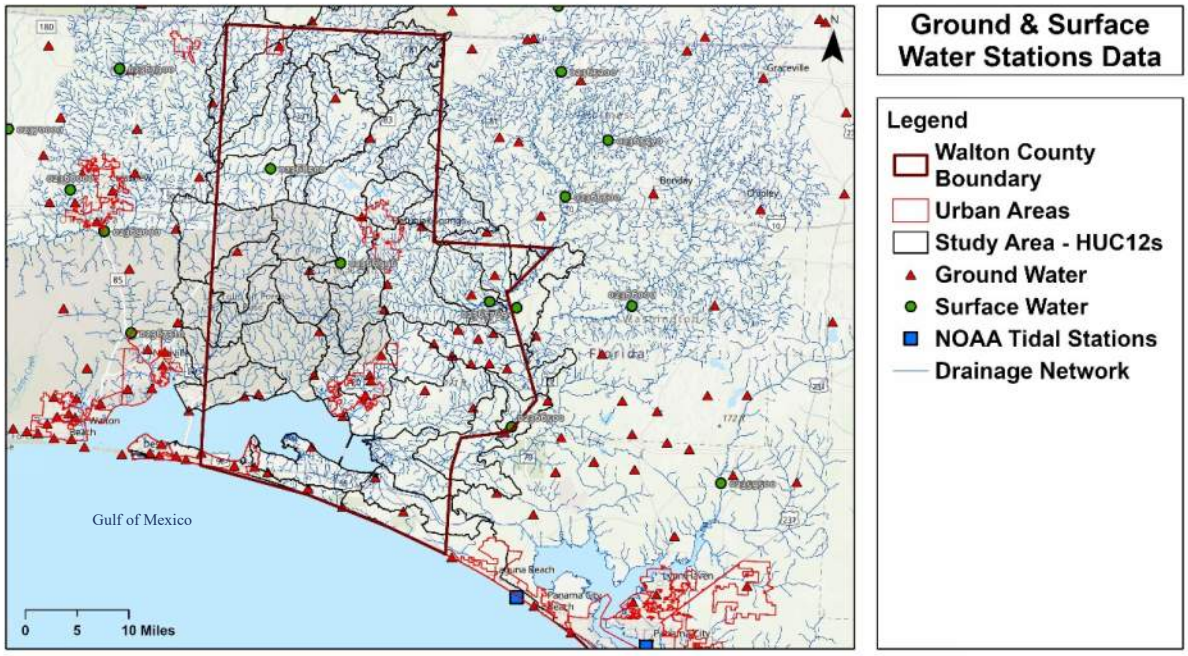

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031401020402 is situated between the Gulf of Mexico and Choctawhatchee Bay. There are no other major waterbodies within the basin.

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366500. However, as there are only four surface water station within Walton County, it was necessary to

use the nearest station to the sub-watershed 031401020402, which is USGS 02366500 Choctawhatchee River NR Bruce FLA.

Figure 8. Average streamflow for Choctawhatchee River NR Bruce FLA (USGS 02366500 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366500/#parameterCode=00065&period=P365D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides

water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Figure 9 shows the drainage network of HUC 031401020402 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031401020402 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

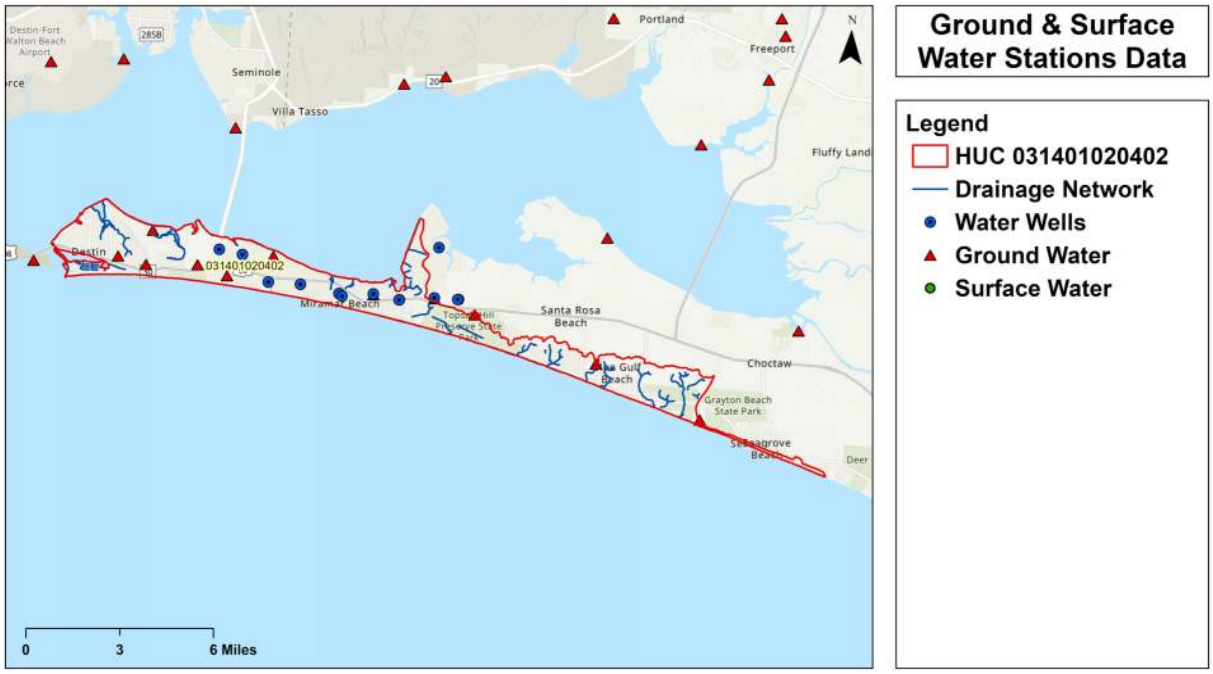

Figure 9. Ground and Surface Water Stations in the HUC 031401020402 sub-watershed, processed by FAU.

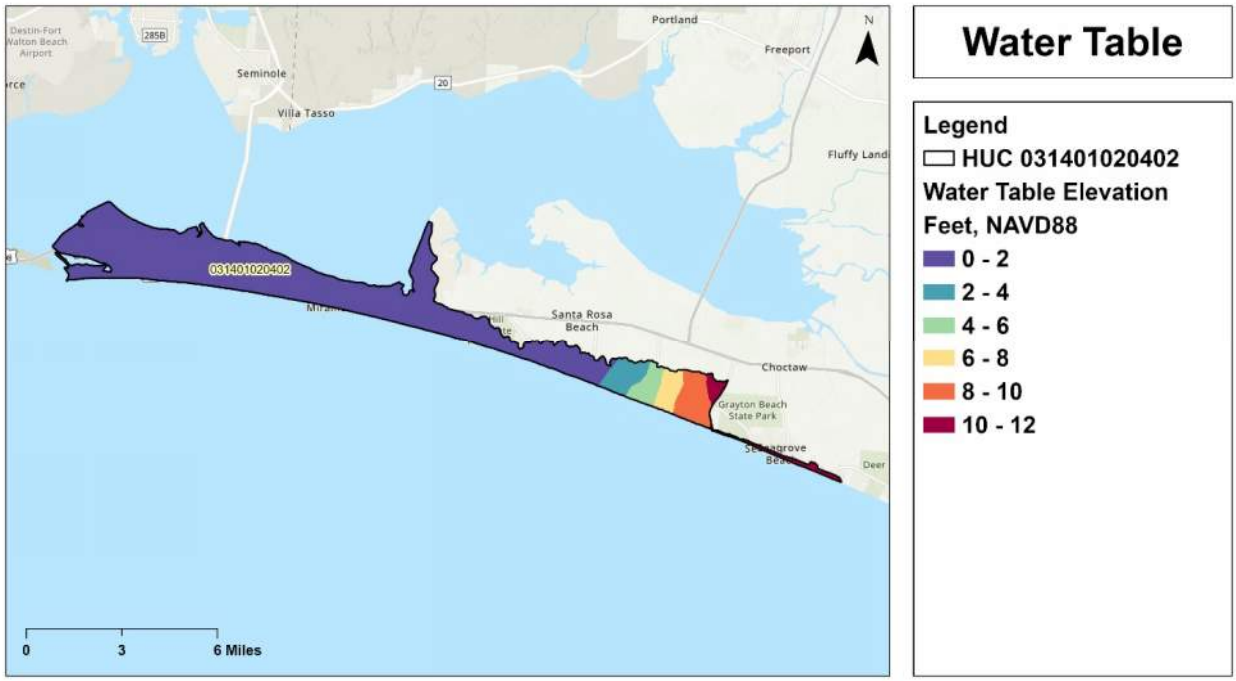

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401020402 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

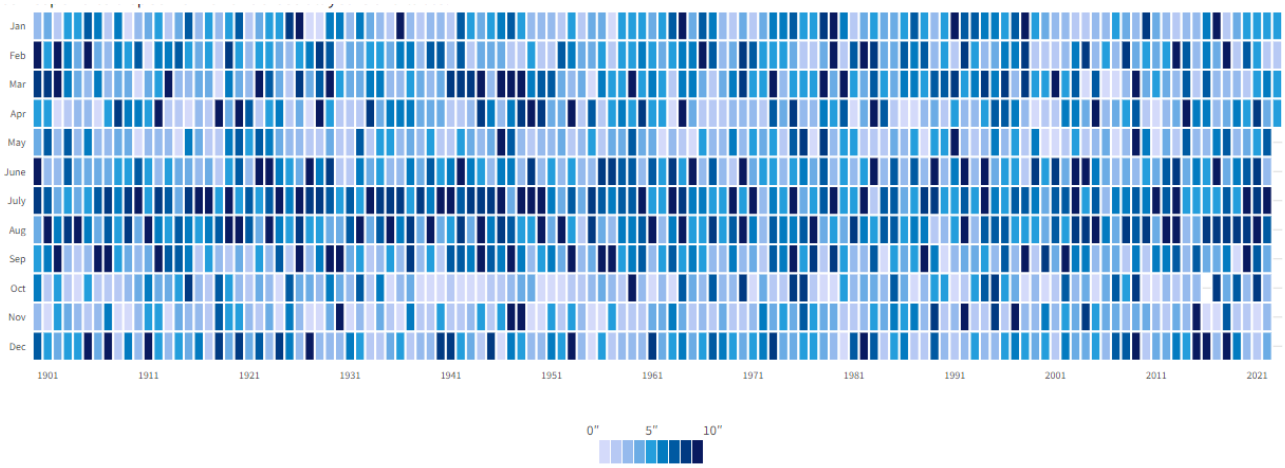

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/)

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

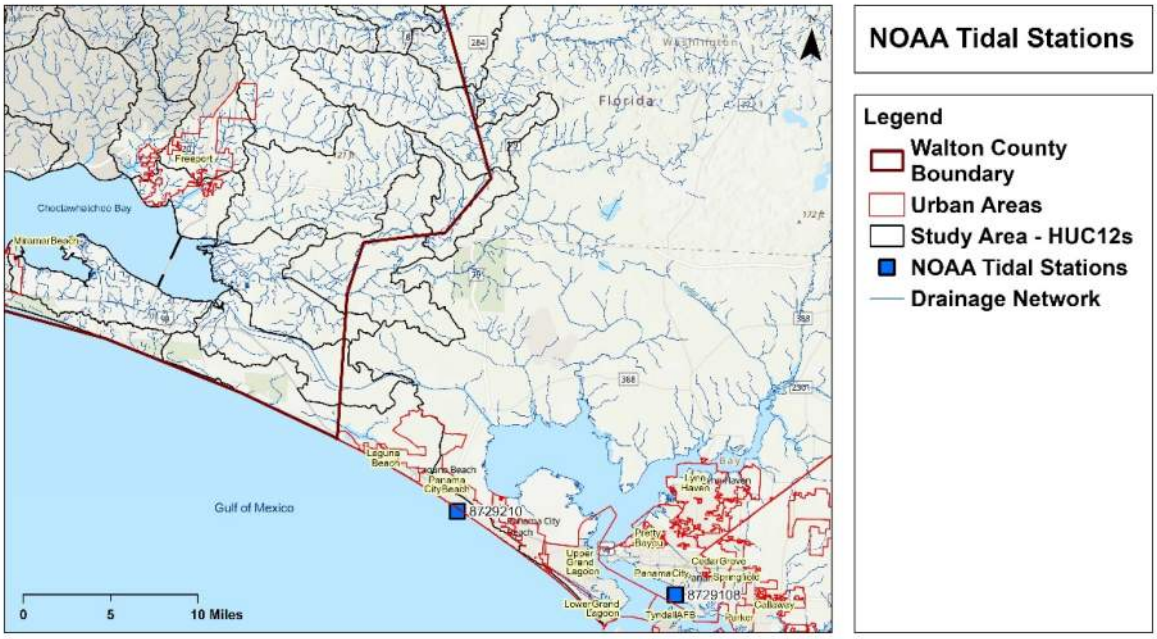

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

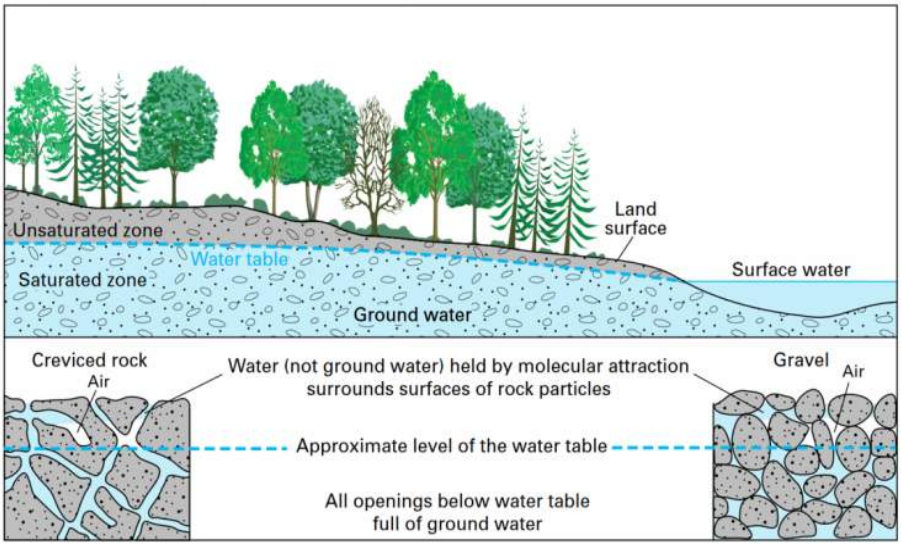

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

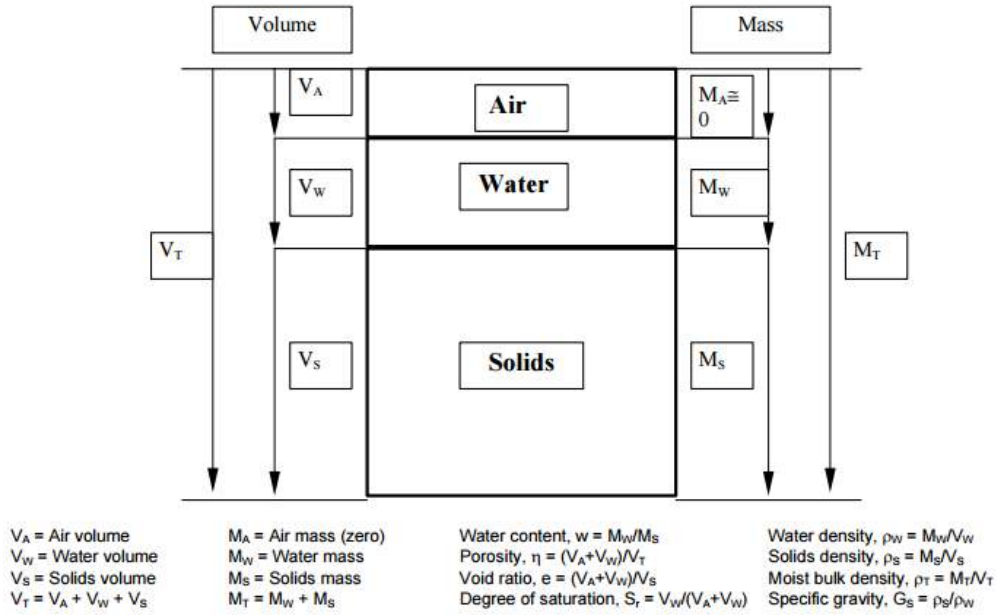

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

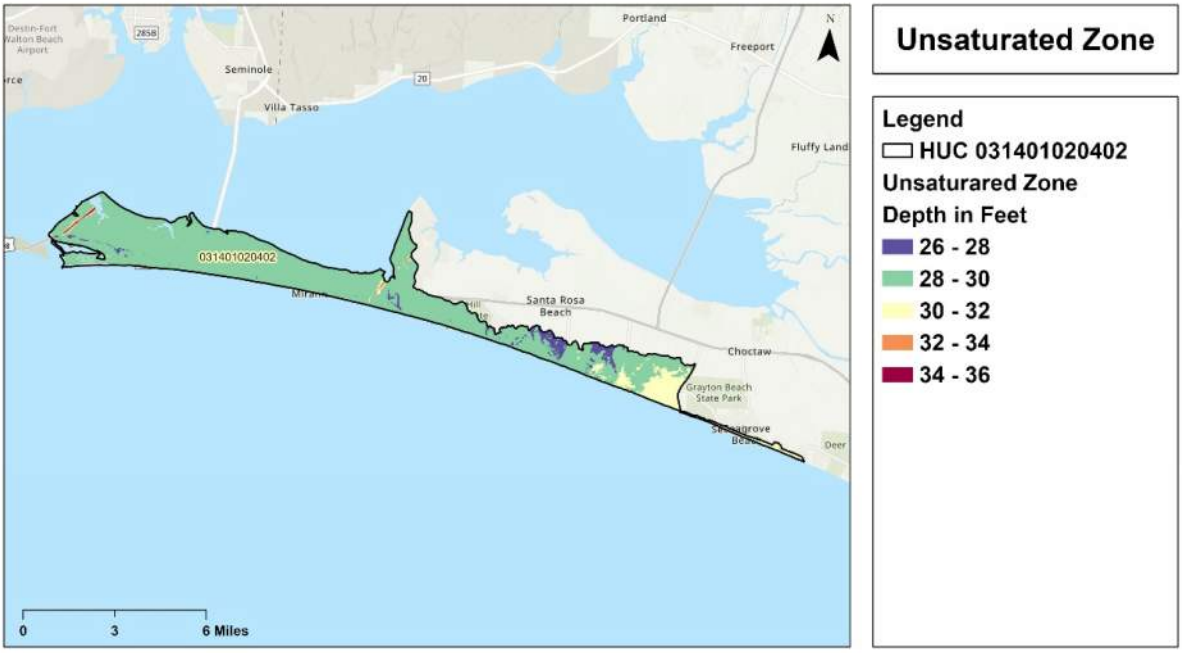

Figure 15. Unsaturated zone map for HUC 031401020402, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A very significant portion of the basin demonstrates a moderately soil storage capacity, falling within the range of 28 to 30 feet of remaining capacity.

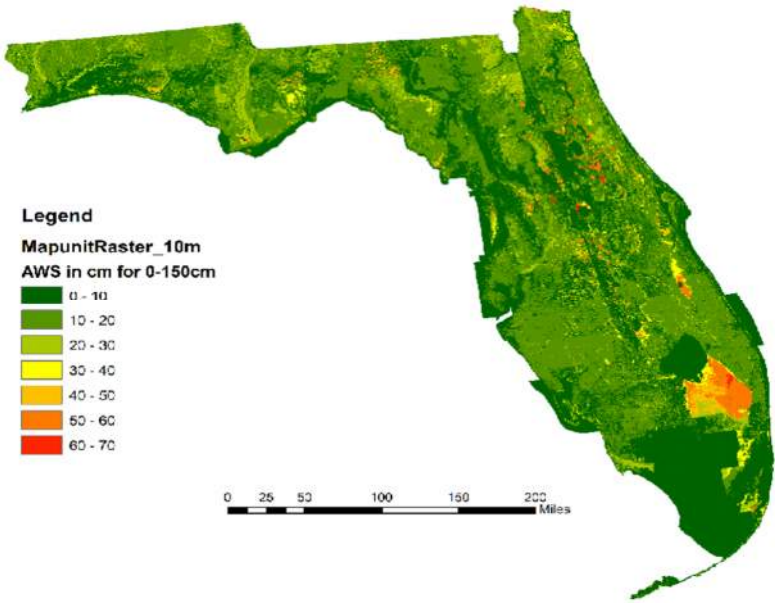

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

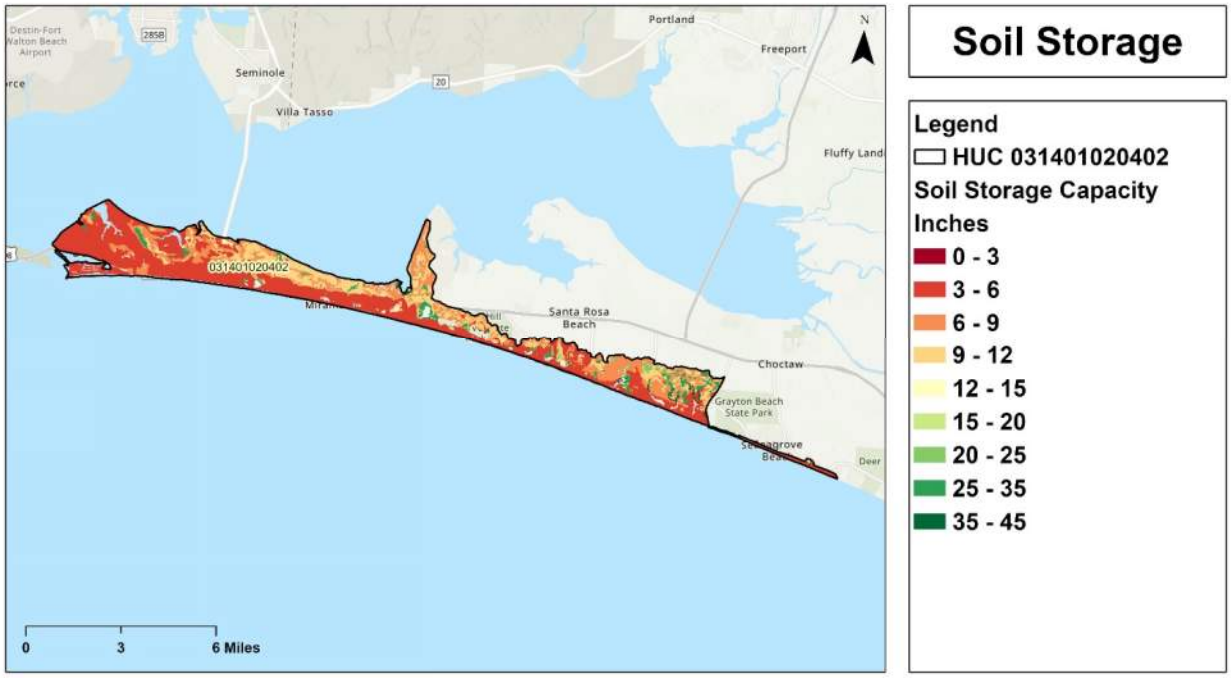

Figure 17. Water storage capacity of soil for the HUC 031401020402, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

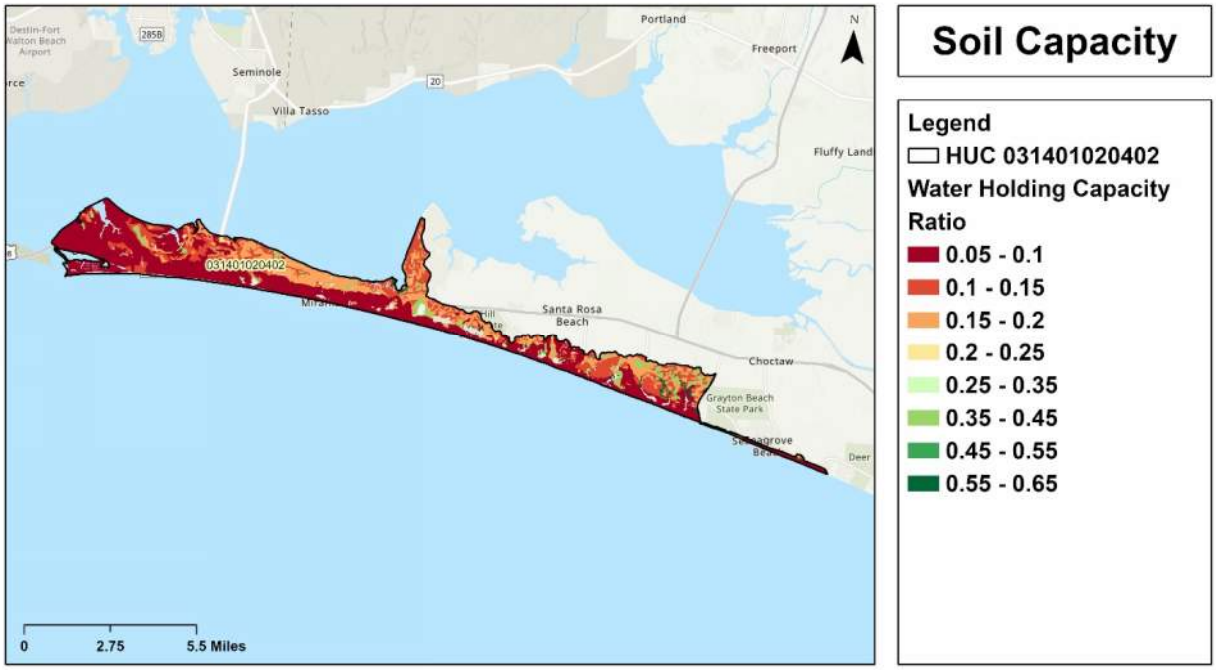

Figure 18. Water Holding Capacity (ratio) for the HUC 031401020402, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

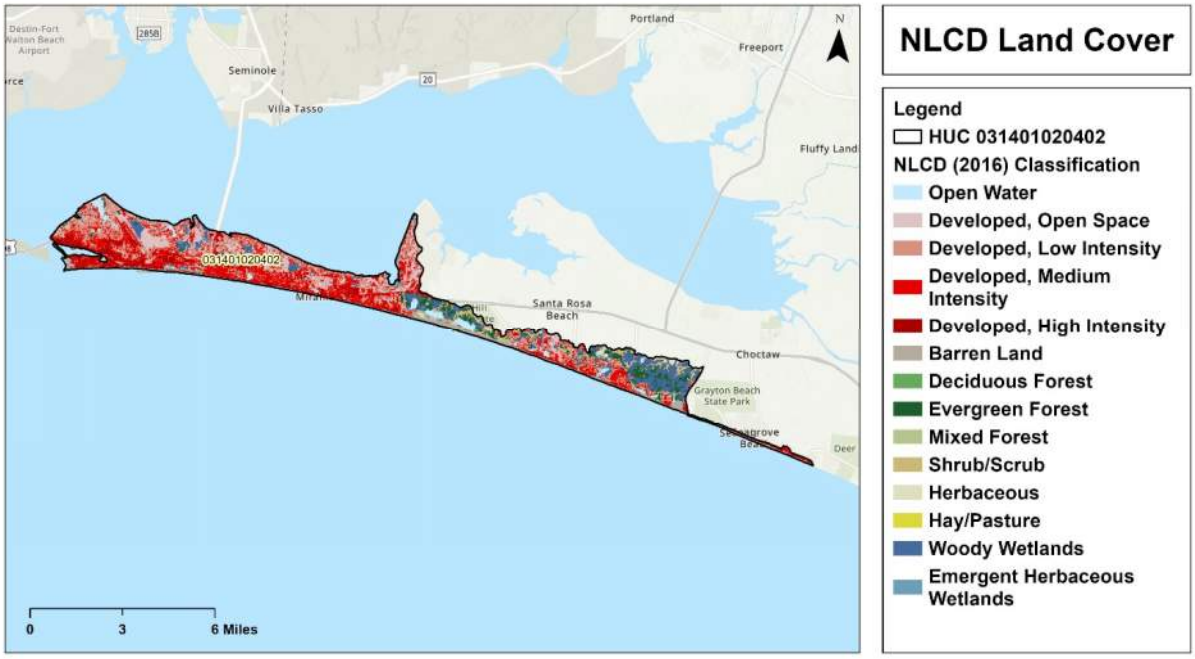

Figure 19. Land use in the HUC 031401020402 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

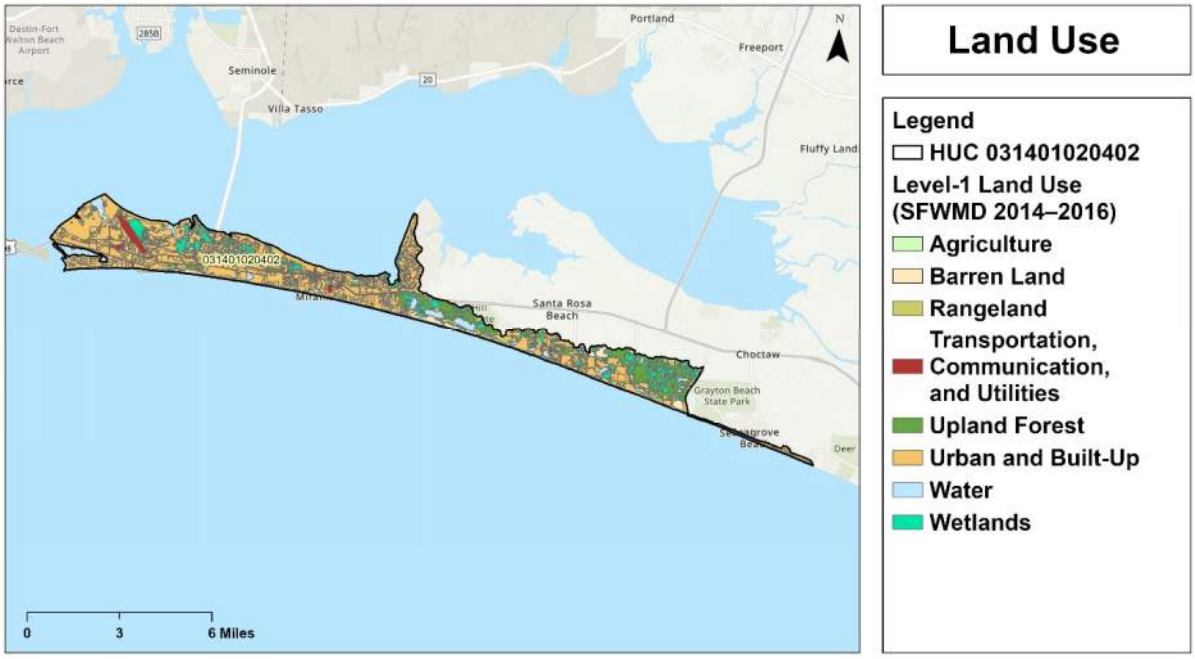

Figure 20. Land use in the HUC 031401020402 (from the 2023 Florida Geographic Data Library (FGDL)), processed by FAU.

In the HUC 031401020402 sub-watershed, the predominant land cover is urban and built-up, accounting for 48.41% of the area. Wetlands comes in second at 14.31%, followed by water at 12.68%, and upland forest at 12.23%, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.It is important to remember that the cities of Destin (outside Walton County's boundary), Miramar Beach and the community of Sacred Oaks are within the HUC's boundary. This is also the more urbanized and populated basin in Walton County.

Table 3. Land use for HUC 031401020402 sub-watershed (2023 Florida Geographic Data Library (FGDL))).

Level 1 Land Use Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	10.49	0.05%
Barren Land	585.74	2.63%
Rangeland	742.53	3.34%
Transportation, Communication, and Utilities	1411.47	6.35%
Upland Forest	2720.19	12.23%
Urban and Built-Up	10764.19	48.41%
Water	2818.95	12.68%
Wetlands	3182.00	14.31%
Grand Total:	**22235.57**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

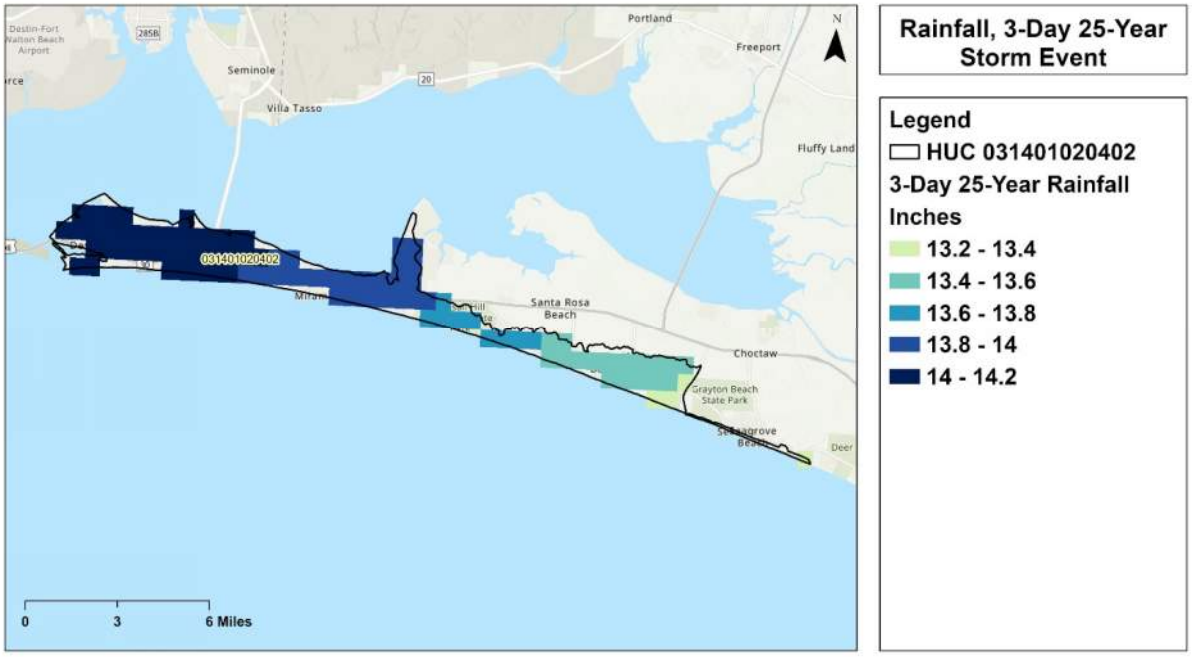

Figure 21. Rainfall distribution map across HUC 031401020402 sub-watershed, for 3-day 25-year storm event, processed by FAU.

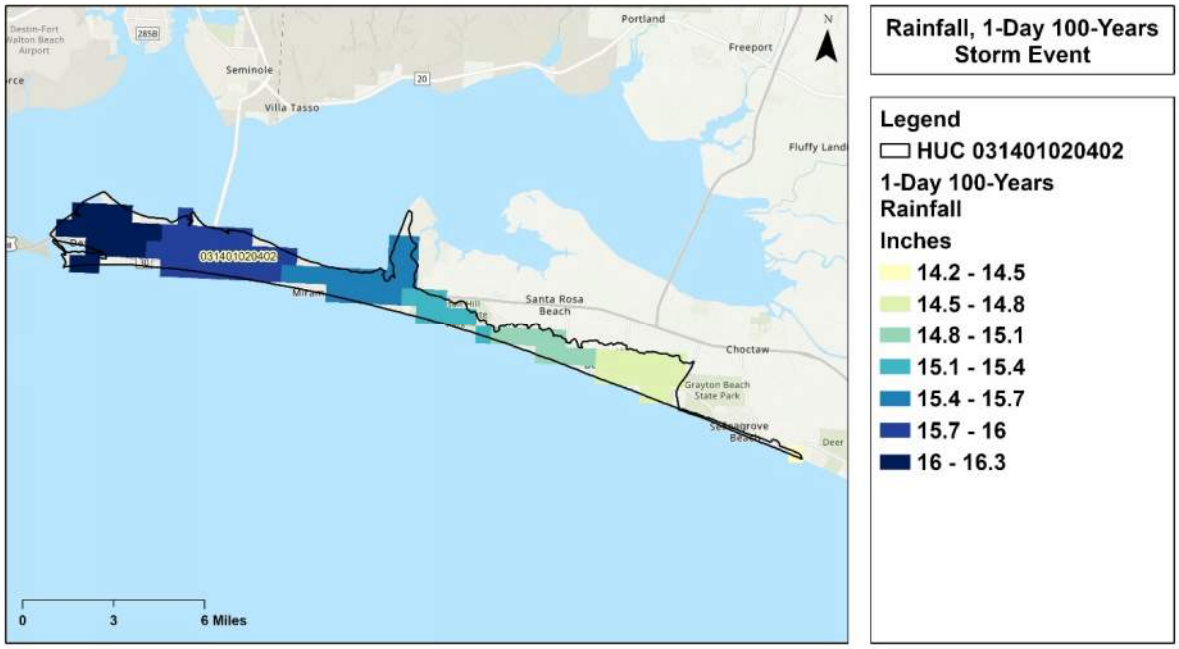

Figure 22. Rainfall distribution map across HUC 031401020402 sub-watershed, for 1-day 100-year storm event, processed by FAU.

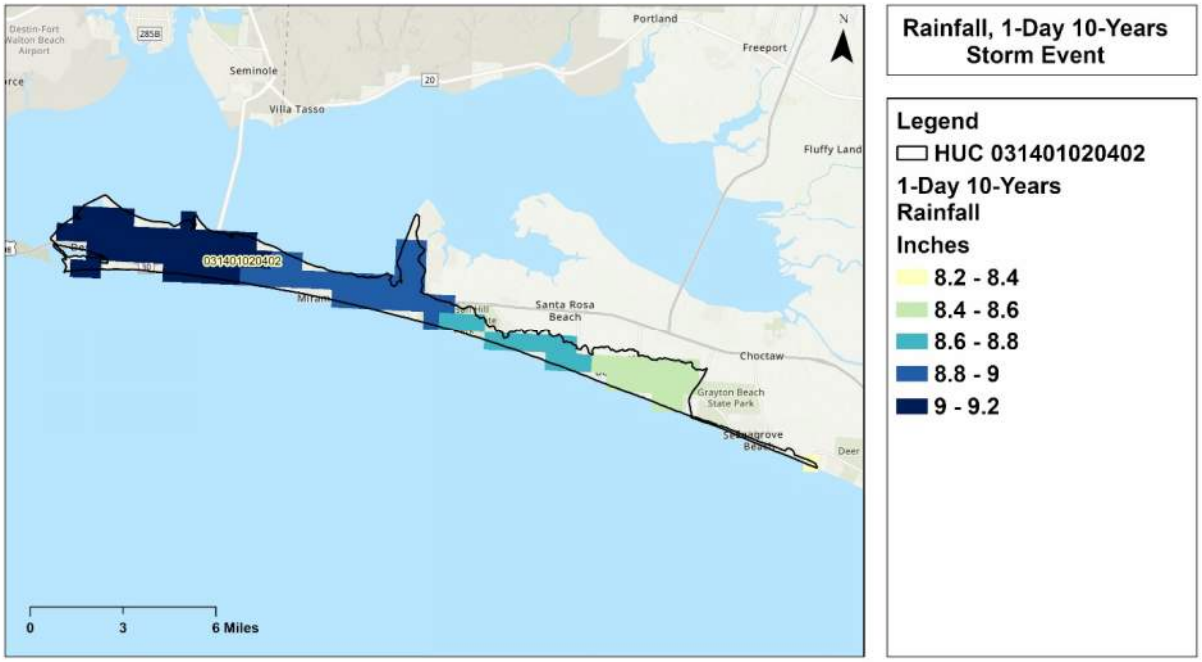

Figure 23. Rainfall distribution map across HUC 031401020402 sub-watershed, for 1-day 10-year storm event, processed by FAU.

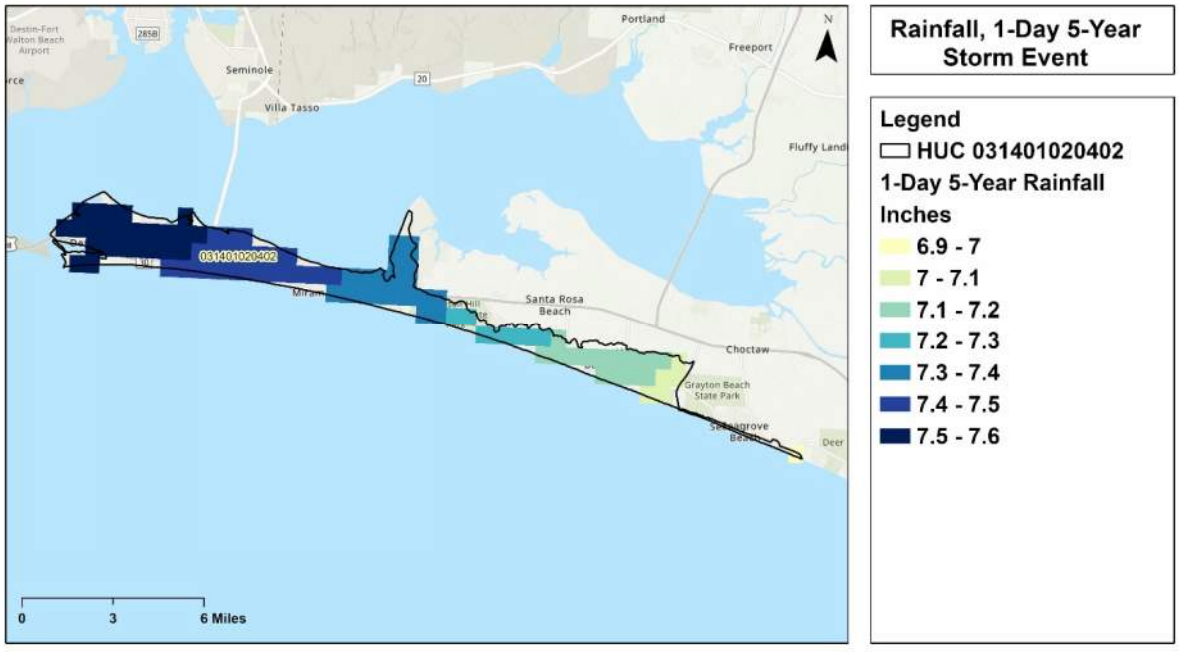

Figure 24. Rainfall distribution map across HUC 031401020402 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically

aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

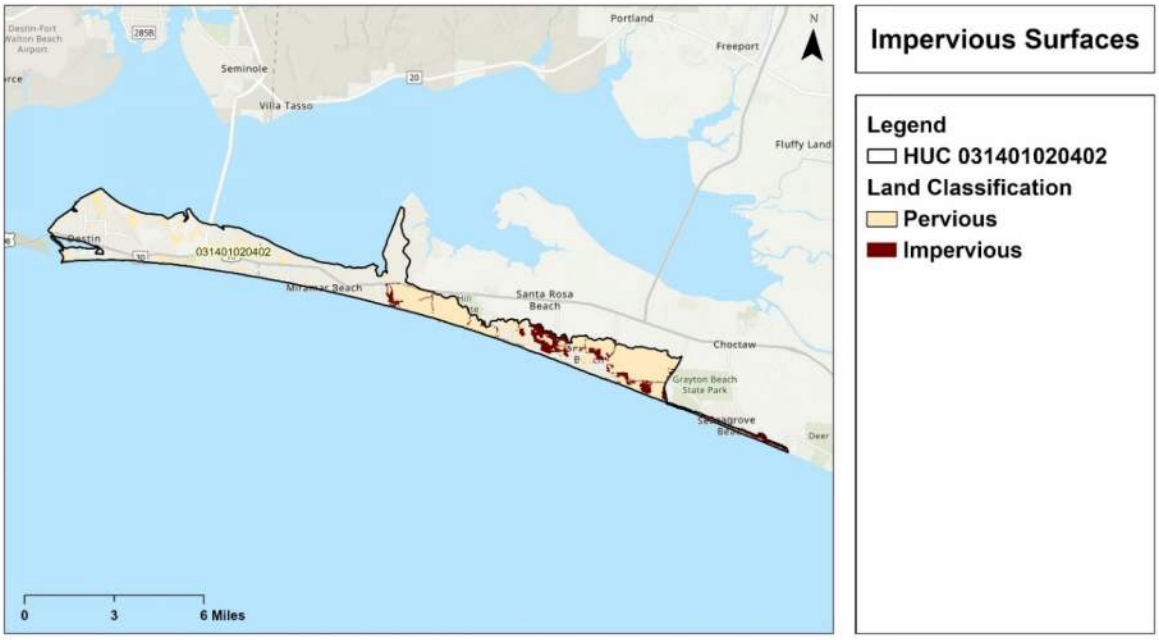

Figure 25. Impervious area map for the HUC 031401020402 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

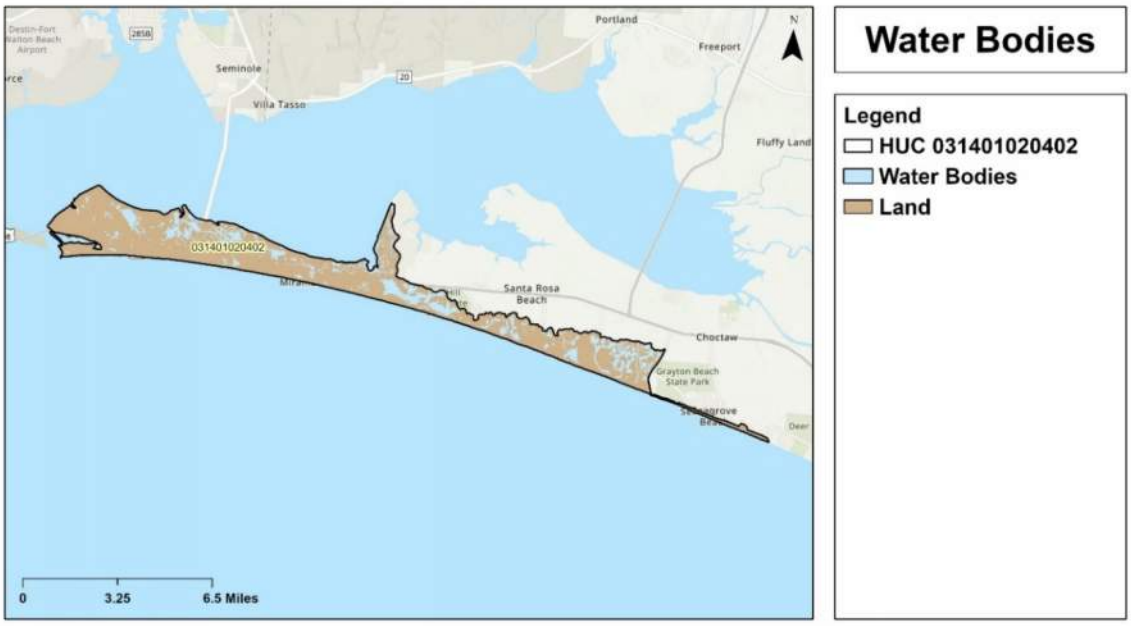

Figure 26. Water bodies map for the HUC 031401020402 sub-watershed, processed by FAU.

1.10. Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other

waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property. Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Figure 29 presents a zoom in into the drainage structures in Miramar Beach, which is within the basin. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant

control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

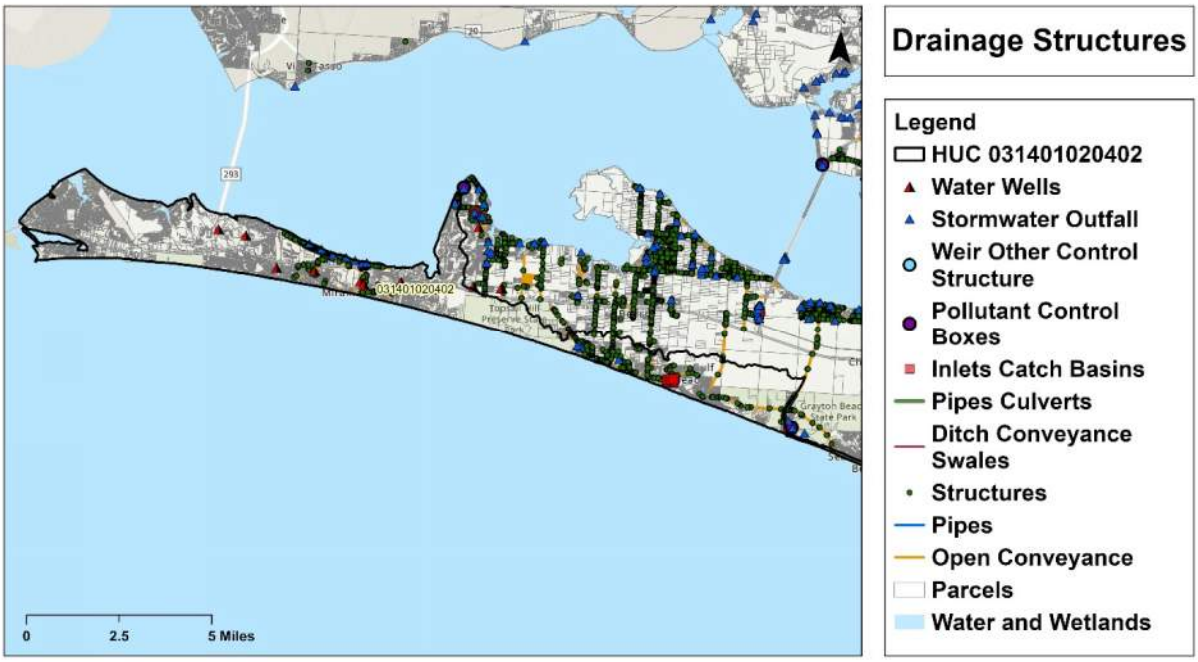

Figure 27. Stormwater Infrastructure for the HUC 031401020402. Processed by FAU.

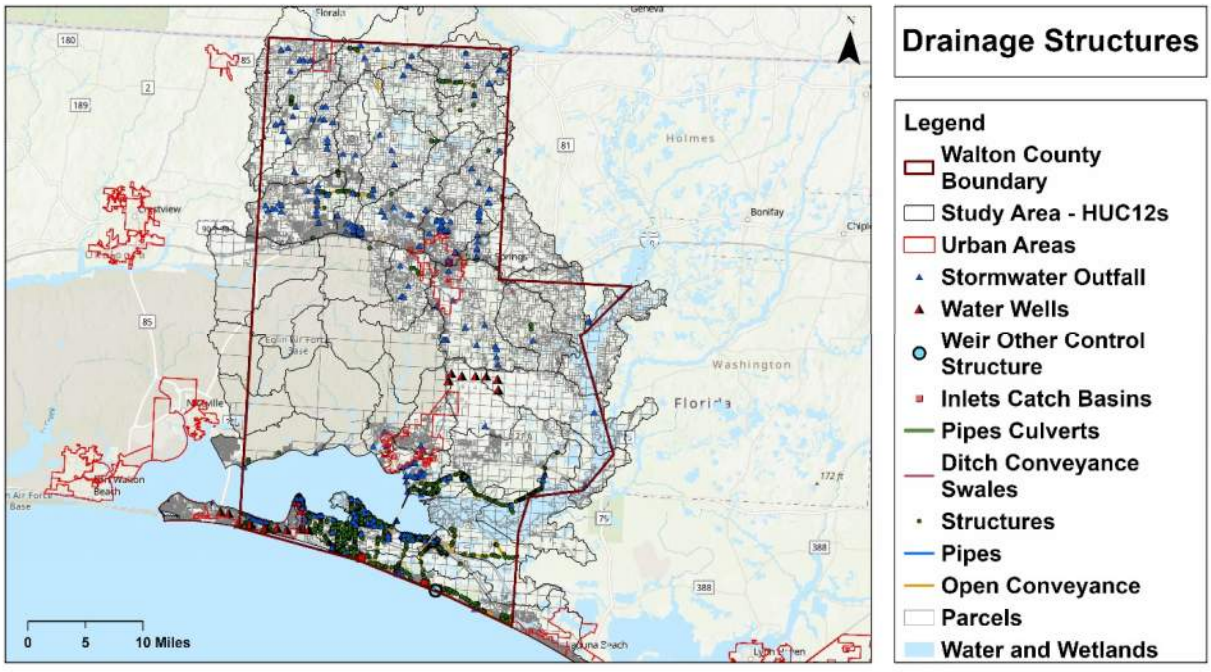

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

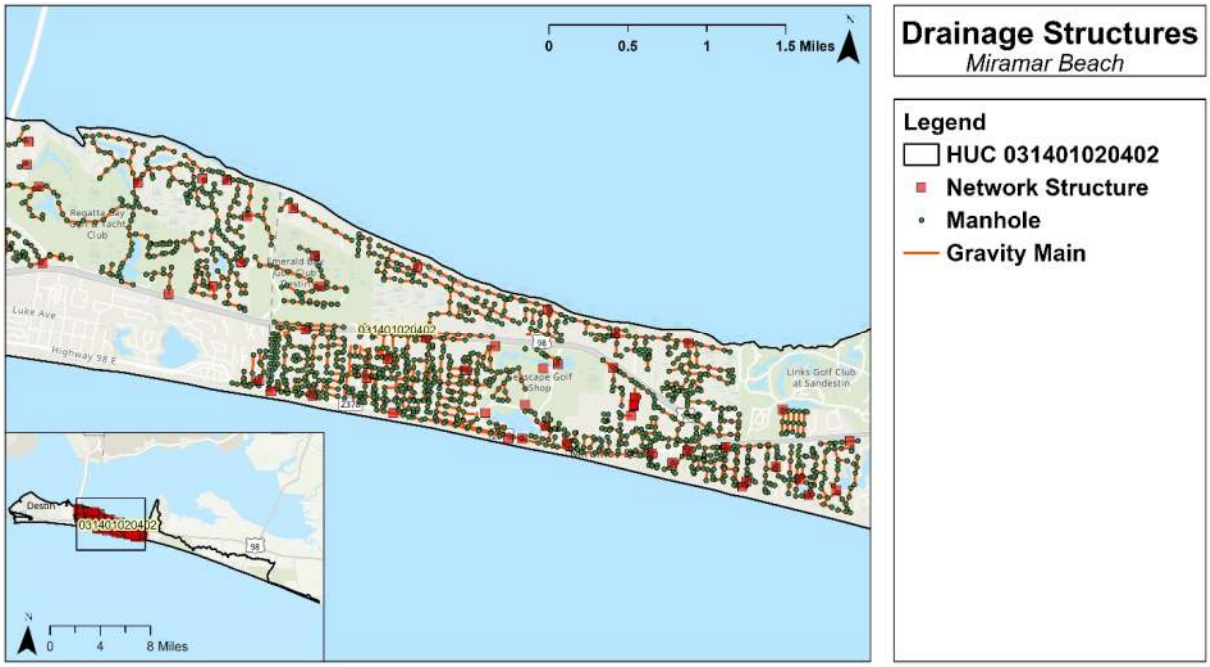

Figure 29. Drainage Structure map for the city of Miramar Beach, processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in Table 5. The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401020402 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. Figure 30 shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

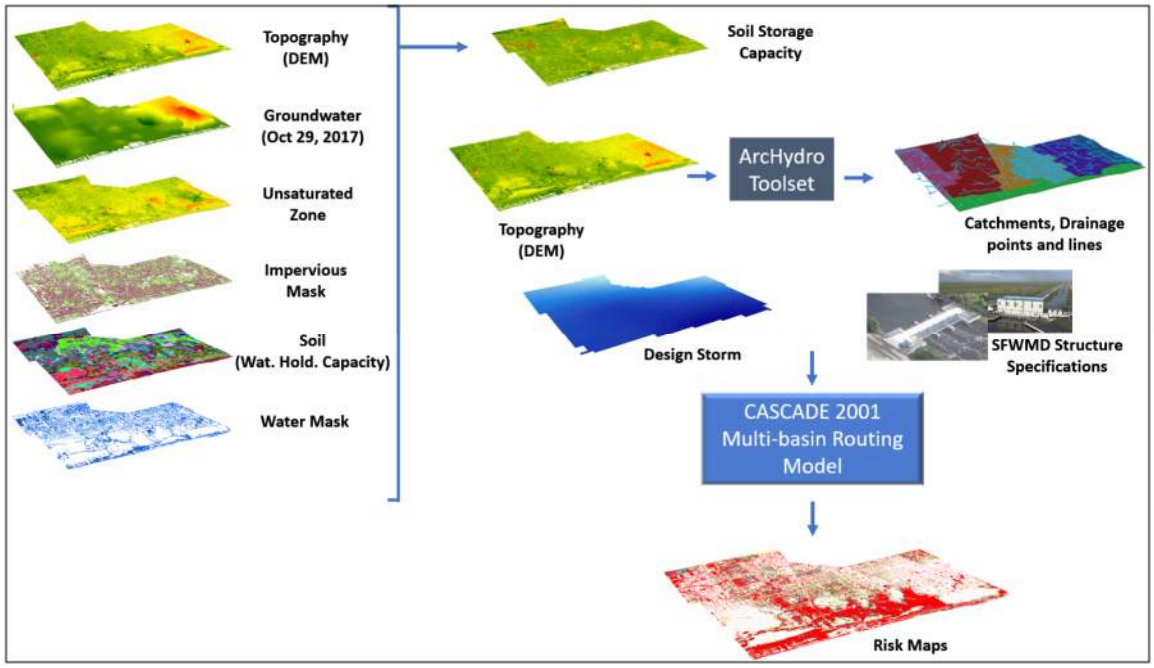

Figure 30. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)

= 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (Figure 31), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

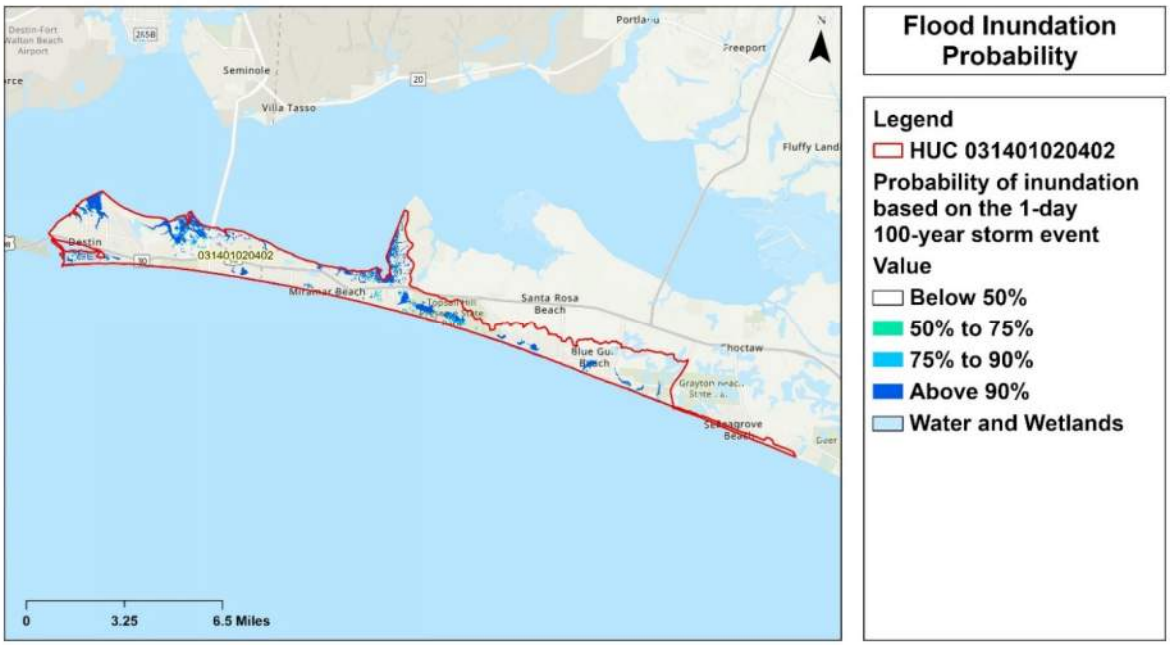

Figure 31. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401020402, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA

will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Future Challenges of Sea Level Rise and Climate Change

Global observations from satellites and long-term data collection have made it possible to document and analyze patterns in the Earth's climate. Scientific analysis of the impact of these changes has helped to improve the understanding of future flood hazard driving forces and long-term impacts on human activities and watershed master planning (http://www.research.noaa.gov/climate/t_observing.html). Examples of impacts are rising global average air and ocean temperatures, increased and earlier snow and ice melt, shorter subtropical rainy seasons, shifted seasons, sea level rise and greater variations in temperature and precipitation (IPCC, 2013; Freas et al., 2008; Marshall et al., 2004; Bloetscher et al., 2010). Marshall et al. (2004) specifically focused on the Florida peninsula to predict changes in rainfall and warmer temperatures but interspersed lower low temperatures due to the potential loss of wetlands.

Future changes in climate will add to the existing impacts, at a time when the population of the state is expected to nearly double by 2030. Additional research and high-resolution climate modeling for the Florida peninsula and local jurisdictions is needed to help guide long-term plans like WMPs. Rainfall appears to be decreasing and temperatures rising (see Figure 32).

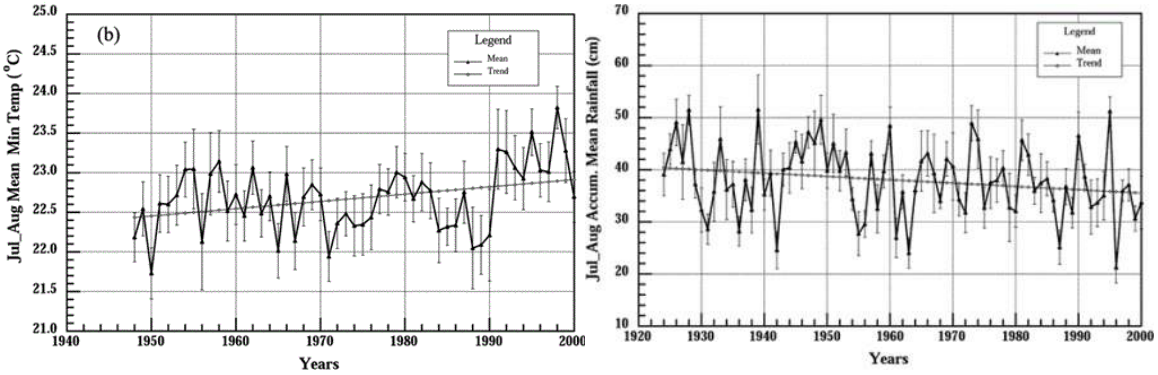

Figure 32. Change in average rainfall and change in average temp 1924 to 2000. Note the reversed trend, which means groundwater input variability is lessened. Source: Marshall et al., 2004.

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3 feet. Accompanying these drivers are potential changes in storm frequency and intensity, desertification, population migration, ocean acidification and coastal flooding (IPCC, 2007), exacerbated by the land cover and land use changes, which are substantially impacted by the fluxes, timing and quality of precipitation (Adrians et al., 2003; Scanlon et al., 2005; Marshall et al., 2004; Salmun and Molod, 2006), and leading to changes in the timing of peak flows and volumes (Richey and Costa-Cabral, 2006).

The results of these climatic changes are likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly An outcome of these climatic patterns is that during the past 140 years, an increase in sea levels has been observed (Bloetscher, 2012), a worrying pattern since sea level rise is a permanent phenomenon, that can be catastrophic to low lying areas in the long-term. The question is how much and how soon? Various studies (Bindoff et al., 2007; Domingues et al., 2008; Edwards, 2007; Gregory, 2008; Vermeer and Rahmstorf, 2009; Jevrejeva, Moore and Grinsted, 2010; Bloetscher, 2010, 2011; IPCC, 2007; Heimlich et al., 2009) indicate large uncertainty in projections of sea level rise by 2100. Gregory et al. (2012) note that during the last two decades, the global rate of sea level rise has been larger than the 20th-century time-mean, and Church et al. (2011) suggested that the cause was increased rates of thermal expansion, glacier mass loss, and ice discharge from icesheets. Gregory et al. (2012) suggested that there may also be increasing contributions to global sea level rise from the effects of groundwater depletion, reservoir impoundment, and loss of storage capacity in surface waters due to siltation. Measurements of Florida's east coast (Maul, 2008) show an average rate of sea level rise of 2.27

± 0.04 mm per year from 1915 to 1992 based on tide gauge readings. Analyzing the tidal gauge readings for Florida shows that:

1. Florida average sea level rise is 2.10 ± 0.49 mm/yr
2. All but one location is within the 95% confidence limit range (the exception is Panama City where there is evidence of submergence and other land-based issues)
3. None of the Florida sea level rise rates differ statistically
4. Average global sea level rise for 1920-2000 was 2.0 mm/yr – within 95% confidence limit for Florida locations

From 1929 to 1992, over eight inches of sea, with another 6 inches added since 1992, which is already having significant impacts on coastal communities where population growth has increased the need for improved flood management strategies (Bloetscher, 2008; Parkinson, 2010; Zhang et al., 2011, 2011a; NFIP, 2011; Schmidt et al., 2011; Warner et al., 2012).

As a result, the SFRCCC (2015) adopted USACE's methodology to derive scenarios of sea level change intermediate to high rates of sea level rise for years 2030 (3" to 7") and 2060 (9" to 24") as the consensus projection to guide future planning. The path keeps increasing – now 14 inches since 1929 (Figure 33) caused by thermal expansion of the ocean and melting ice caps (Jevrejeva et al., 2010; Vermeer and Rahmstorf, 2009). Sea level rise is a major concern in Florida, including Walton County, since the majority of the state's population live on the coast, involving most major commercial, residential, and economic enterprises. Figure 33demonstrate the estimated sea level change for Panama City, considering the predictions of NOAA 2017. For NOAA high scenario SLR change scenario, the estimated level change is higher than 8 ft., while for the intermediate and low scenarios are about 3.9 feet and 1.7 feet respectively.

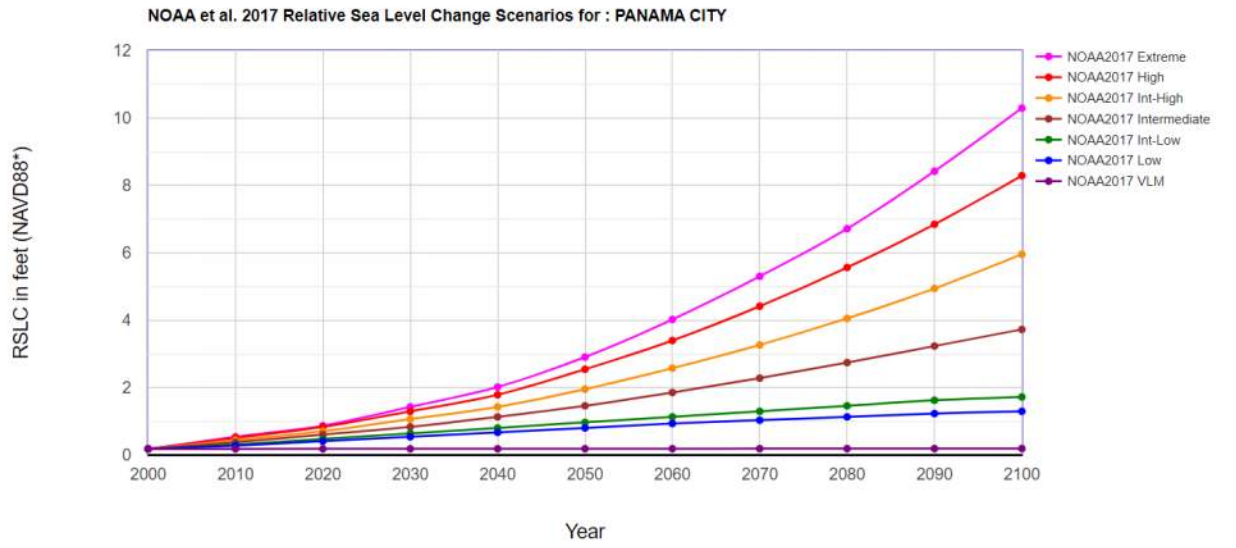

Figure 33. Relative Sea Level Change Scenarios for gauge 8729108, Panama City, FL. Source: NOAA 2017 (https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html)

NOAA (2017) outlines five scenarios for sea level rise. The NFIP proposes the use of the intermediate high projection, which is 1.2 meters or 4 ft globally from current sea level elevations (Figure 34).

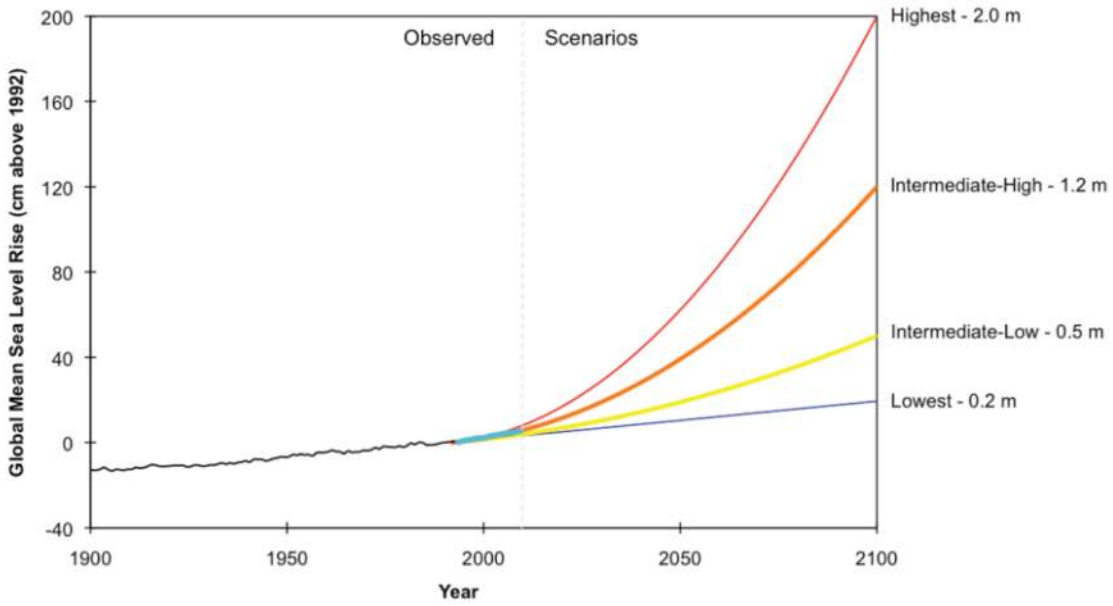

Figure 34. Graphic of global sea level rise projections from NOAA (2017). Source:https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

As sea level rises, access to roads, bridges, rail, and transit could be at risk of flooding, causing the effects of sea level rise to spread indirectly throughout the entire transportation network, affecting the overall system performance. For example, the flooding of a critical road or facility access can cause a shifting of traffic flow causing congested conditions in other roadways that are not actually flooded. Since the roadway network would be unable to carry the traffic demand, the system would experience operational failure; as a result, causing travel times and delays. Moreover, the inundation of a critical access could cause transportation connectivity problems to essential infrastructure like ports or airports. Transportation infrastructure relies on the effectiveness of flood control and stormwater drainage systems for the transportation corridors. Road integrity relies on adequate drainage. The increased risk of severe flooding in Florida's low-lying terrain can adversely affect transportation infrastructure along the coastline; roads can be inundated, and roadway beds can be damaged. Sea level rise will cause increased water table levels (FDOT, 2012), as regional water tables cannot exist naturally below mean high tide (2 feet in Florida). Adding 3 feet of sea level rise on top of groundwater would compound the risk of flooding in low-lying areas. Road bases below 5 feet NVGD would become saturated under this scenario, likely causing premature base failure. As soil storage capacity is diminished due to rising

groundwater elevations associated with sea level rise, the potential for more frequently flooded roadways would likely damage pavements (FDOT, 2012). Hence sea level rise must be accounted for in WMPs in coastal areas. To allow flexibility in the analysis due to the range of increases within the different time periods, an approach that uses incremental increases of 1, 2, and 3 feet of sea level rise is suggested for modeling. The increments can work as threshold values in planning considerations in terms of allowing planners the ability to know ahead of time where the next set of vulnerable areas will be, to allow for a proactive response approach that can be matched to the observed future rates. Sea level rise is a major concern since nearly half the US population lives within 50 miles of the coast, involving most major commercial, residential, and economic enterprises. The effects of 5 ft sea level rise, King tide, and 1-day 100-year storm event are shown in Figure 35.

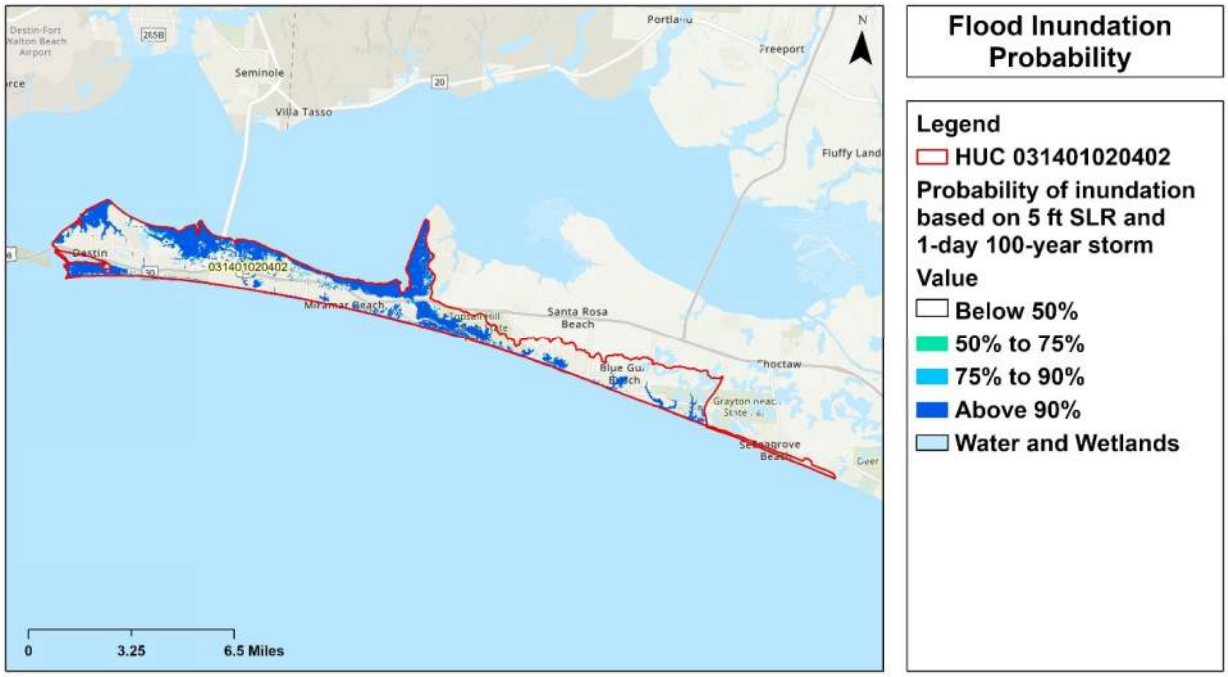

Figure 35. Flood Inundation Probability for a Sea level rise of 5 ft + 1-day 100-year storm event for HUC 031401020402 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Dark blue is area under 5 ft NAVD88 and potentially inundated at the 99th percentile tidal conditions. Processed by FAU.

2.4 Modeling Results

Figures 36-59 are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. **3-day 25-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 36)
2. **1-day 100-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 37)
3. **1-day 10-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 38)
4. **1-day 5-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 39)
5. **Sea level rise of 1 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 40)
6. **Sea level rise of 1 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations storm (Figure 41)
7. **Sea level rise of 1 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 42)
8. **Sea level rise of 1 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 43)
9. **Sea level rise of 2 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 44)
10. **Sea level rise of 2 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 45)
11. **Sea level rise of 2 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 46)
12. **Sea level rise of 2 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 47)
13. **Sea level rise of 3 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 48)
14. **Sea level rise of 3 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 49)

15. **Sea level rise of 3 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 50)
16. **Sea level rise of 3 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 51)
17. **Sea level rise of 4 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 52)
18. **Sea level rise of 4 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 53)
19. **Sea level rise of 4 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 54)
20. **Sea level rise of 4 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 55)
21. **Sea level rise of 5 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 56)
22. **Sea level rise of 5 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 57)
23. **Sea level rise of 5 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 58)
24. **Sea level rise of 5 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 59)

In all scenarios, a considerable amount of flooding is noted along the coast and, following the waterbodies flow path. As this basin connects to the ocean though the Gulf of Mexico and Choctawhatchee Bay, SLR scenarios plays an important hole, implying a considered growth as the projected scenario of rising tides rises.

The design storm simulation determined that approximately 13.8% of the HUC total area or 3.73 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 14.2% of the HUC's total area, or 3.84 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 13.3% of the HUC's total area,

or 3.59 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 13% of the HUC's total area, or 3.51 mi², would be expected to be inundated during the 1-day 5-year storm. Table 7 compares the four storm events.

Table 7. HUC 031401020402 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	23.30	3.73	86.2%	13.8%
1-day 100-year	23.19	3.84	85.8%	14.2%
1-day 10-year	23.44	3.59	86.7%	13.3%
1-day 5-year	23.51	3.51	87.0%	13.0%

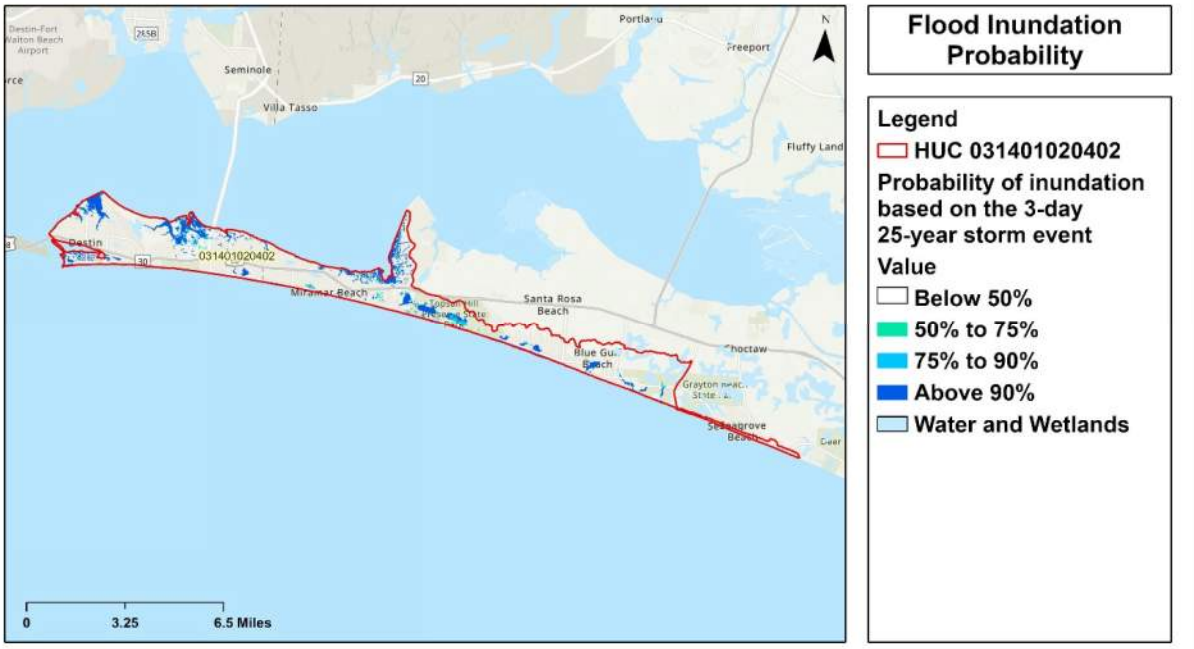

Figure 36. 3-day 25-year storm event for HUC 031401020402 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

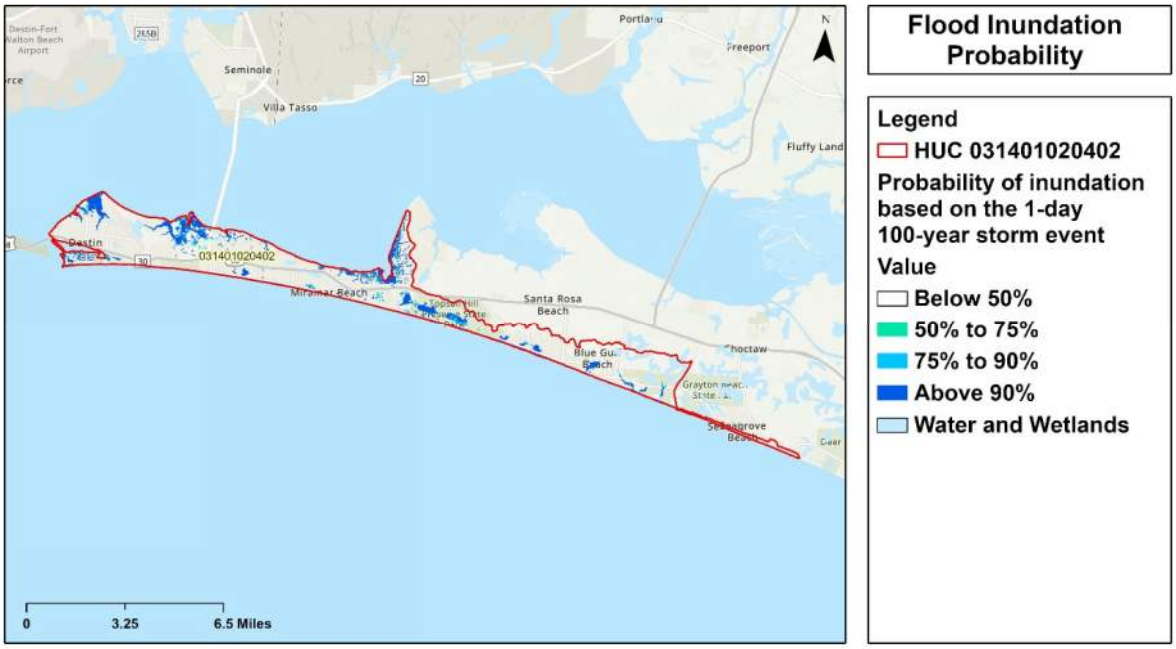

Figure 37. 1-day 100-year storm event for HUC 031401020402 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

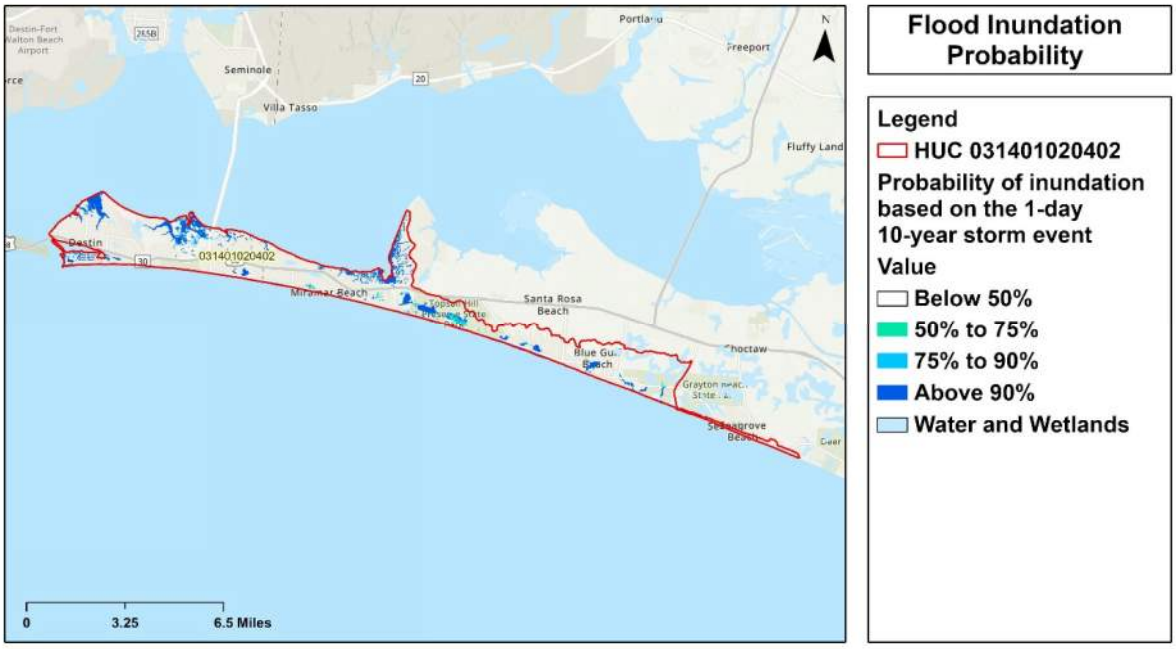

Figure 38. 1-day 10-year storm event for HUC 031401020402 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

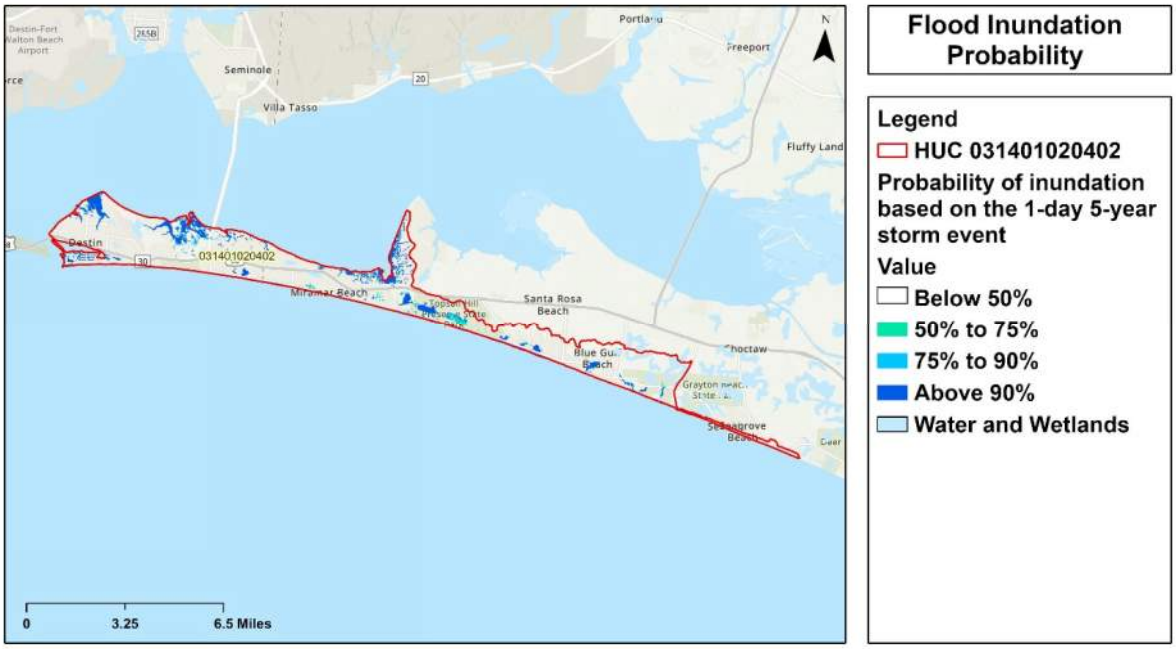

Figure 39. 1-day 5-year storm event for HUC 031401020402 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

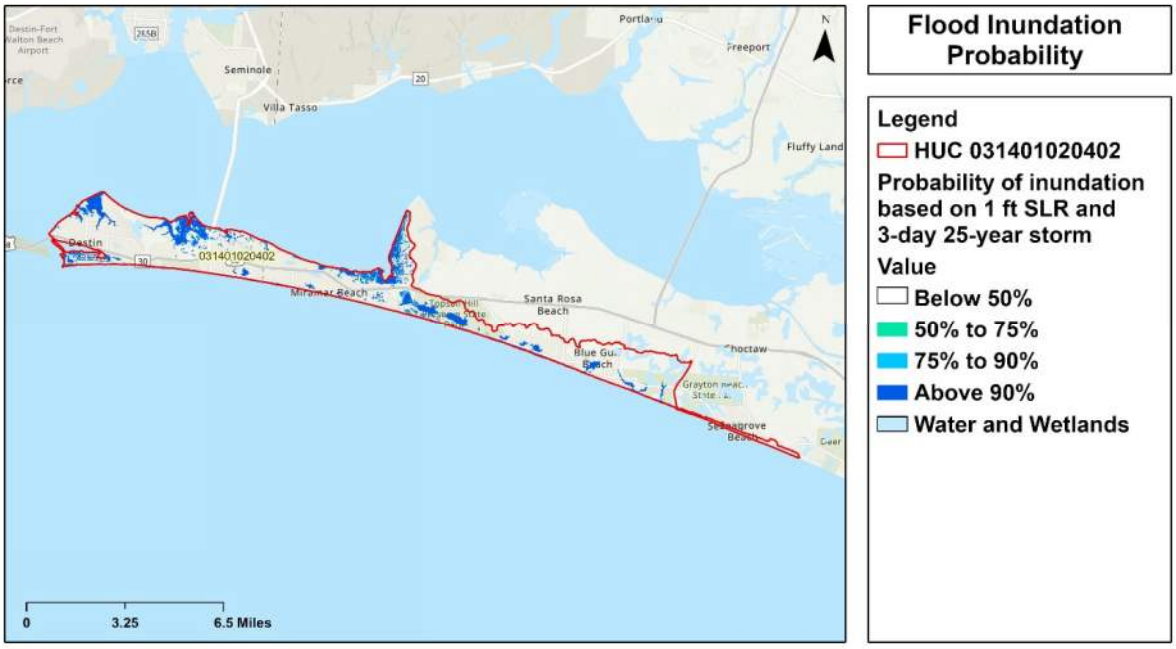

Figure 40. Sea level rise of 1 ft + 3-day 25-year storm for HUC 031401020402 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

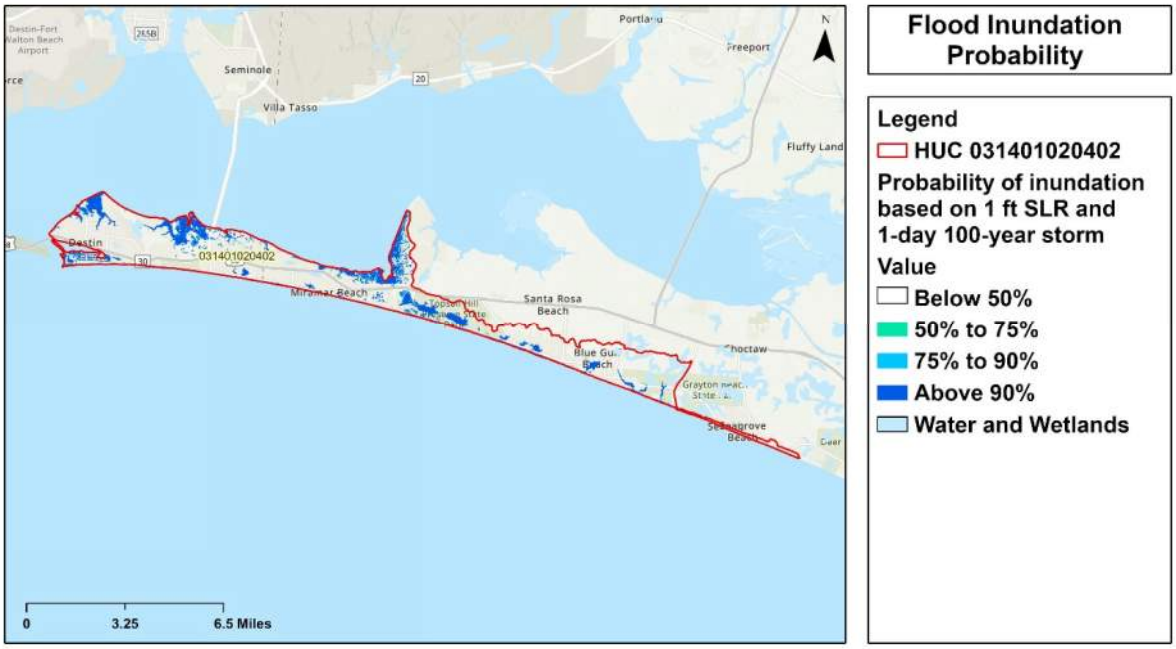

Figure 41. Sea level rise of 1 ft + 1-day 100-year storm for HUC 031401020402 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

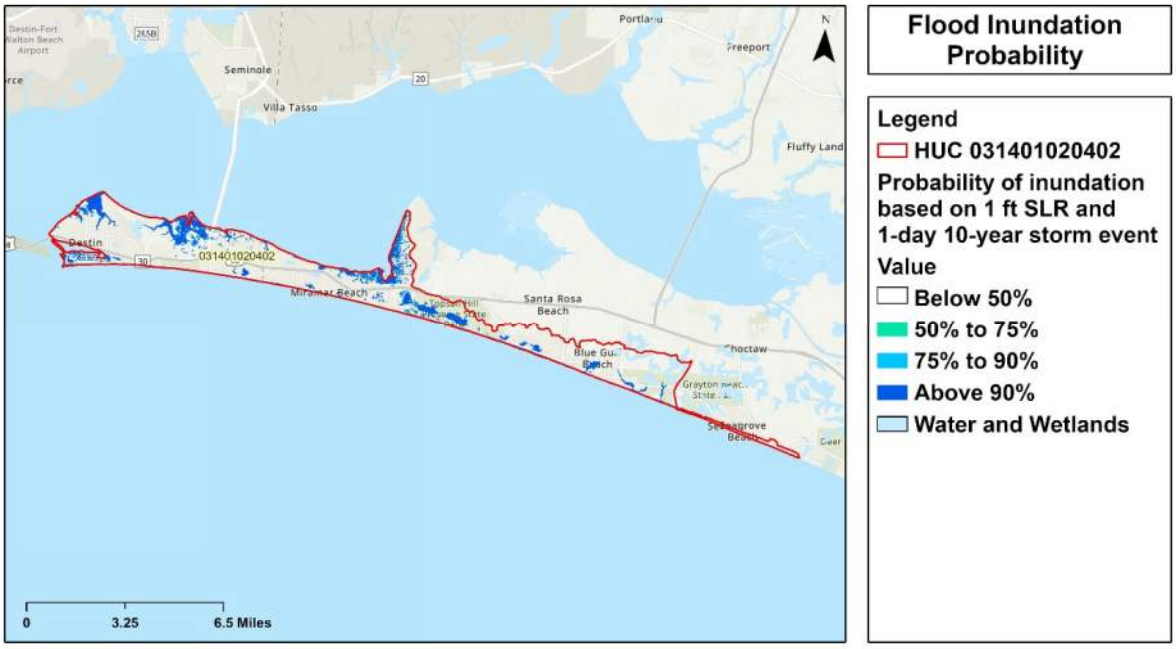

Figure 42. Sea level rise of 1 ft + 1-day 10-year storm for HUC 031401020402 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

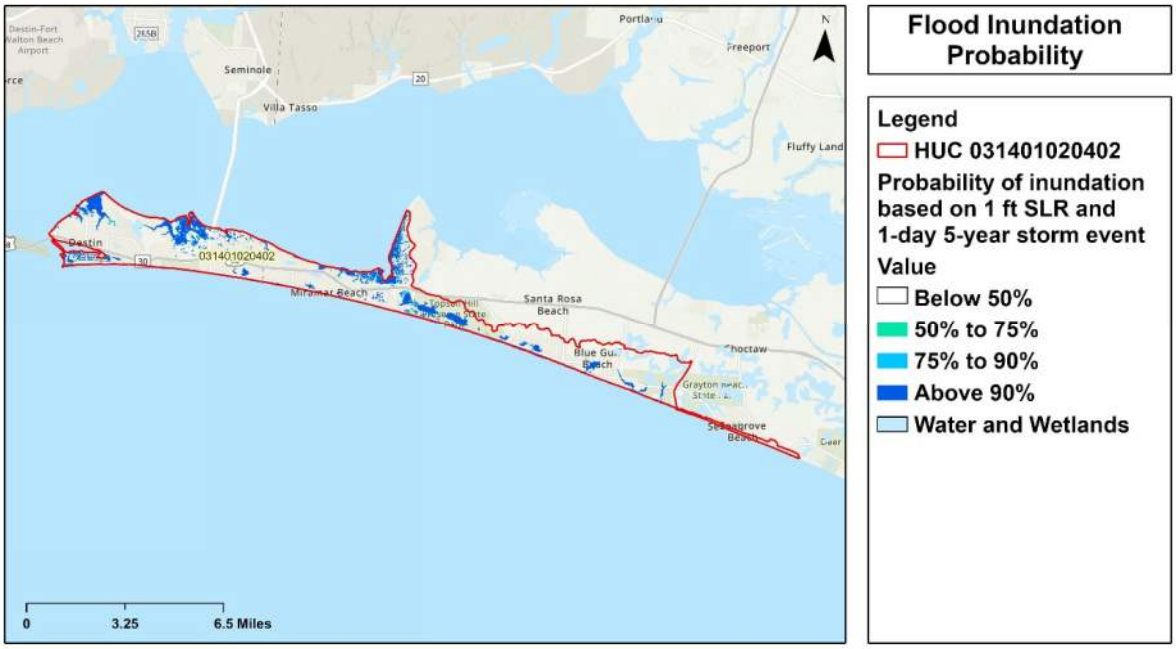

Figure 43. Sea level rise of 1 ft + 1-day 5-year storm for HUC 031401020402 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

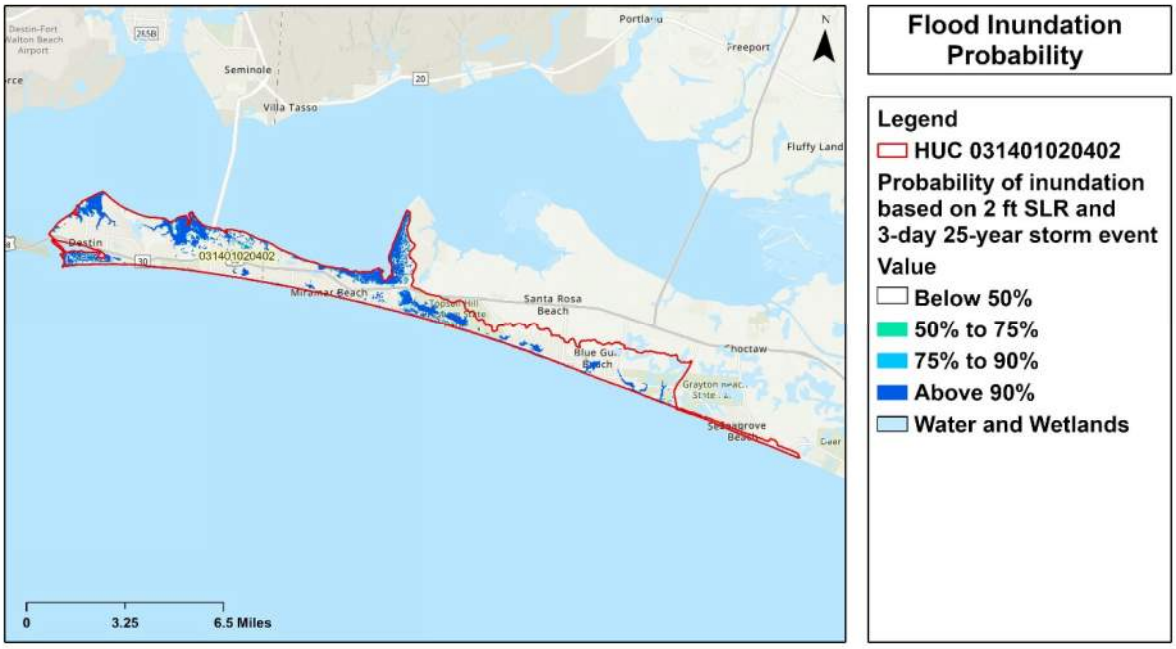

Figure 44. Sea level rise of 2 ft + 3-day 25-year storm for HUC 031401020402 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

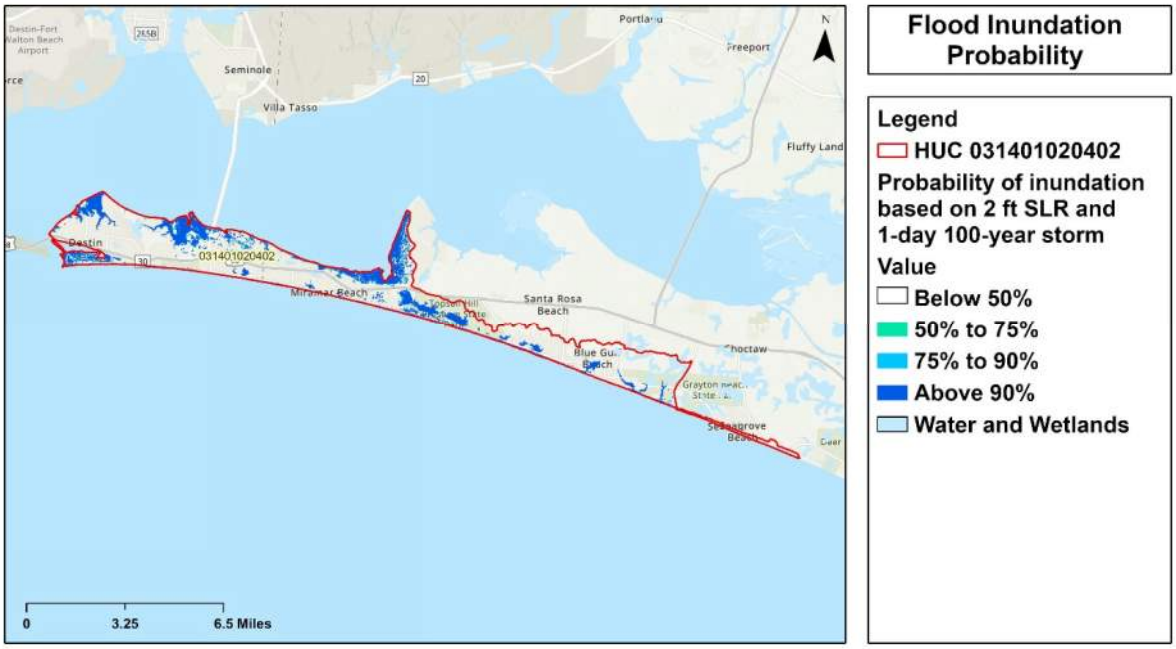

Figure 45. Sea level rise of 2 ft + 1-day 100-year storm for HUC 031401020402 sub-watershed Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

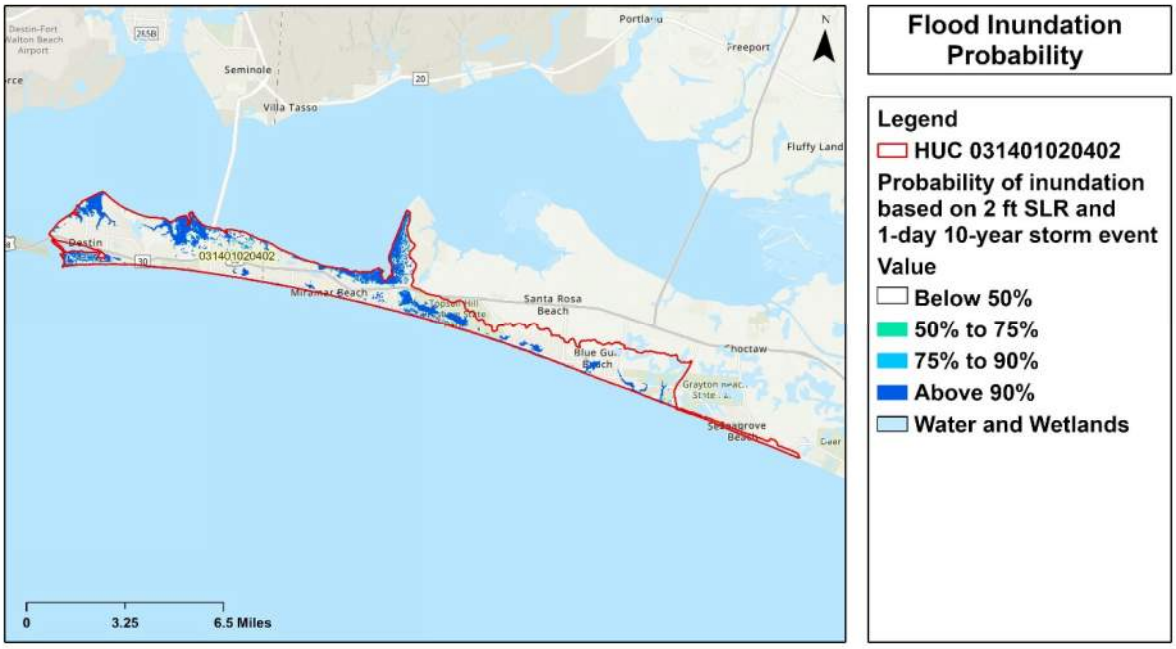

Figure 46. Sea level rise of 2 ft + 1-day 10-year storm for HUC 031401020402 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

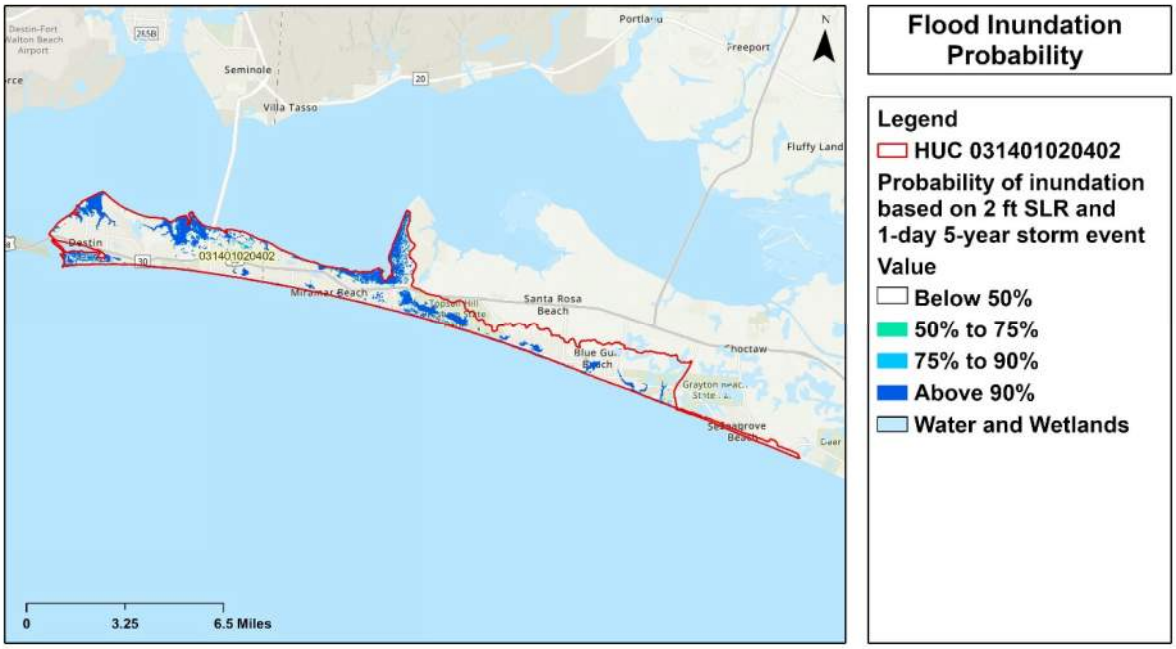

Figure 47. Sea level rise of 2 ft + 1-day 5-year storm for HUC 031401020402 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

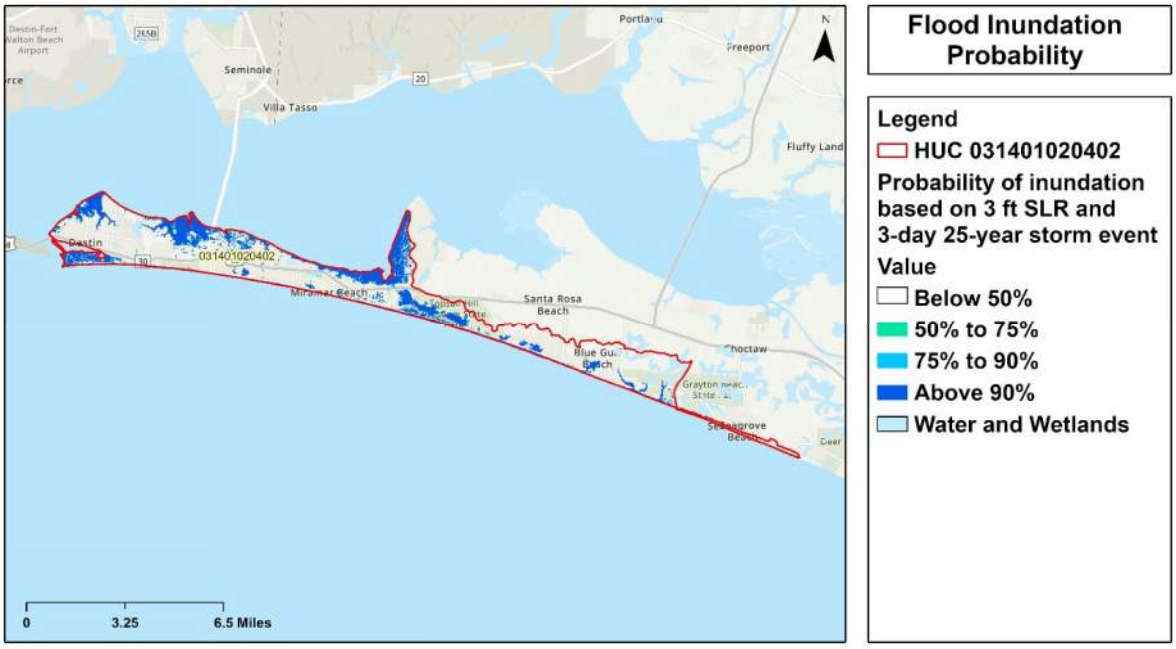

Figure 48. Sea level rise of 3 ft + 3-day 25-year storm for HUC 031401020402 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

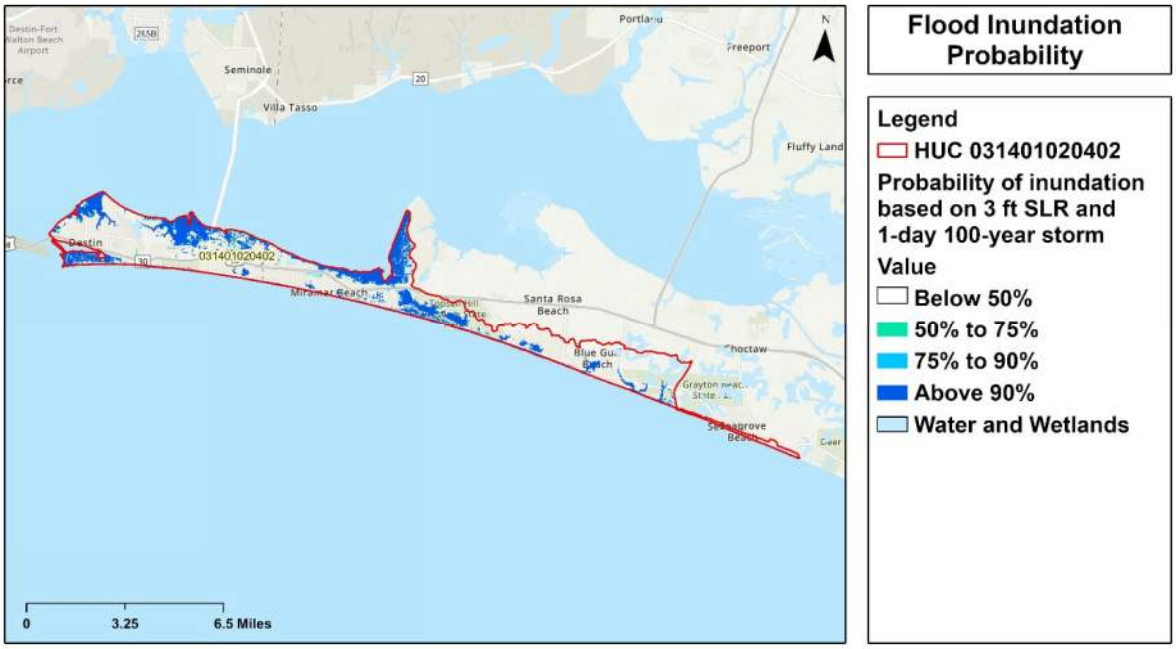

Figure 49. Sea level rise of 3 ft + 1-day 100-year storm for HUC 031401020402 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

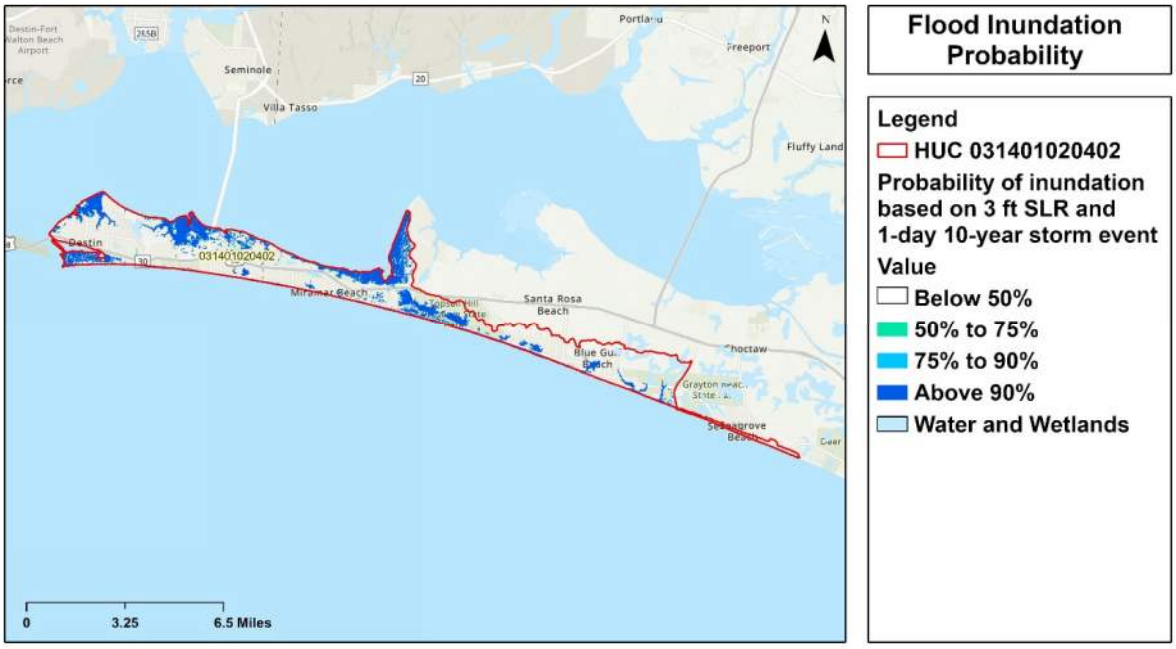

Figure 50. Sea level rise of 3 ft + 1-day 10-year storm for HUC 031401020402 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

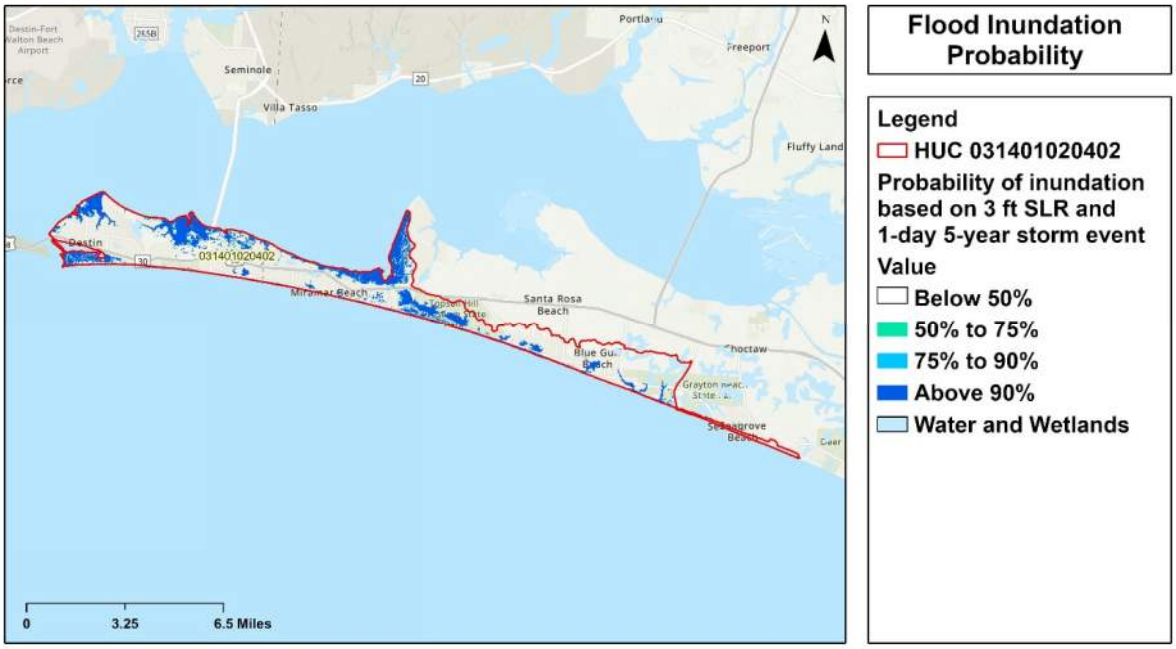

Figure 51. Sea level rise of 3 ft + 1-day 5-year storm for HUC 031401020402 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

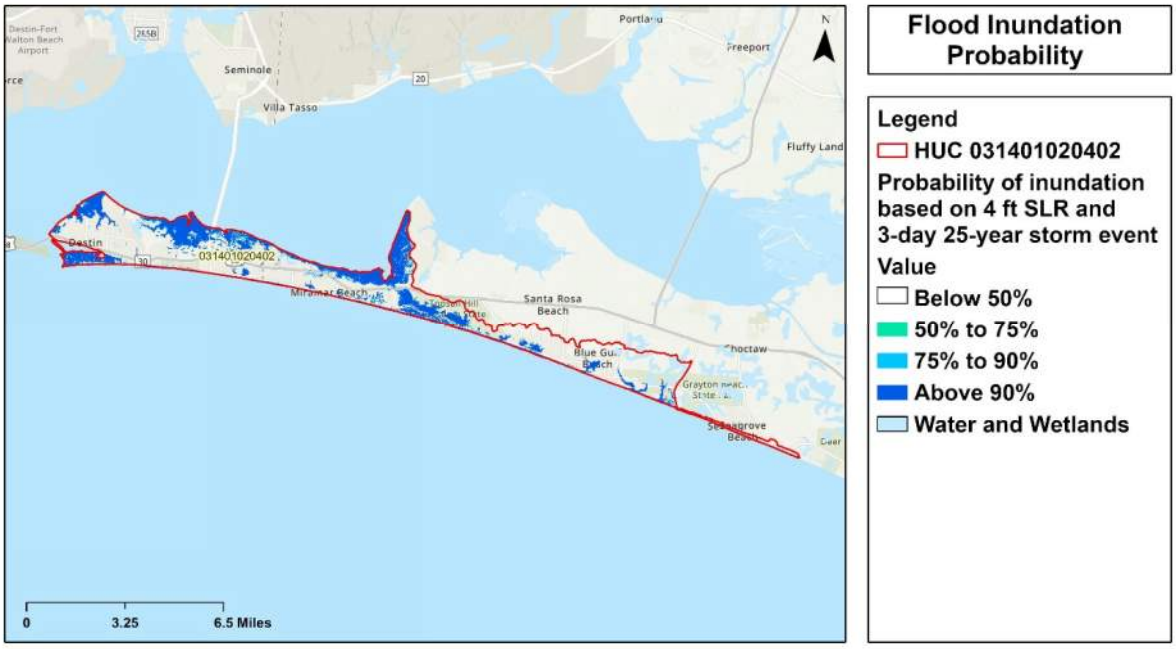

Figure 52. Sea level rise of 4 ft + 3-day 25-year storm for HUC 031401020402 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

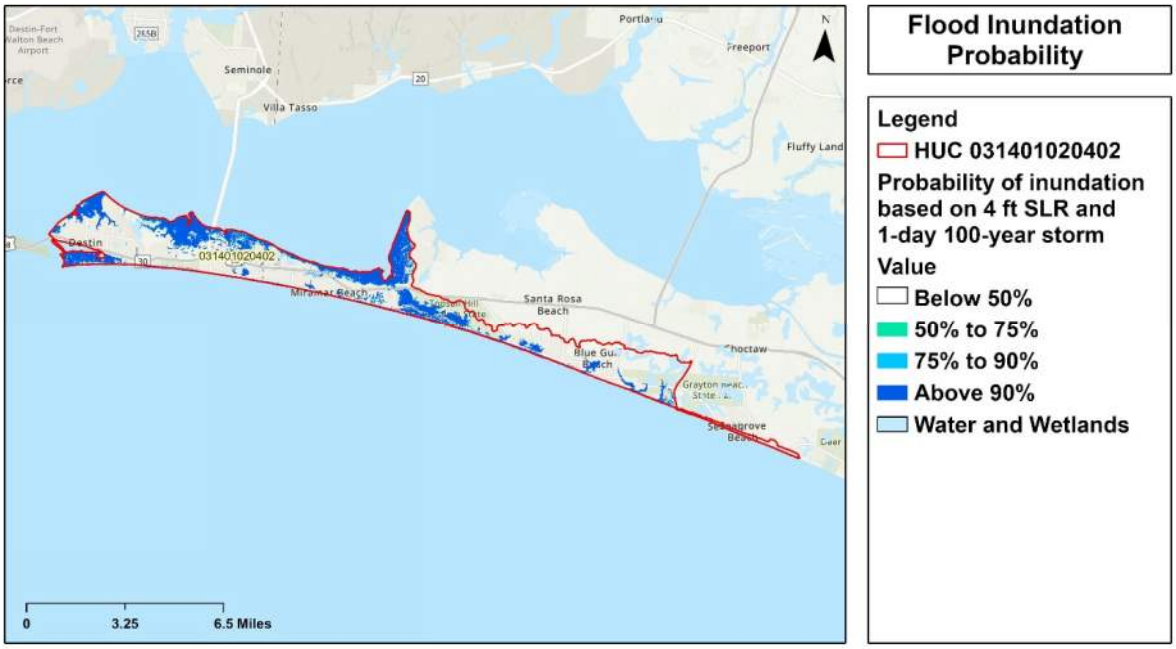

Figure 53. Sea level rise of 4 ft + 1-day 100-year storm for HUC 031401020402 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

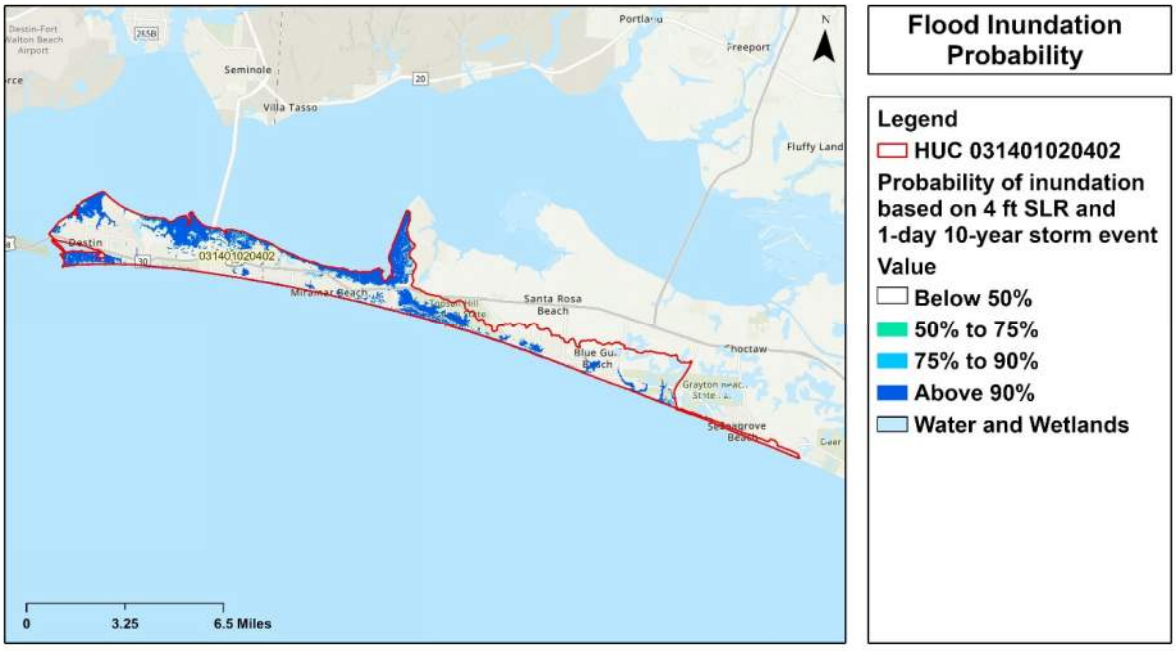

Figure 54. Sea level rise of 4 ft + 1-day 10-year storm for HUC 031401020402 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

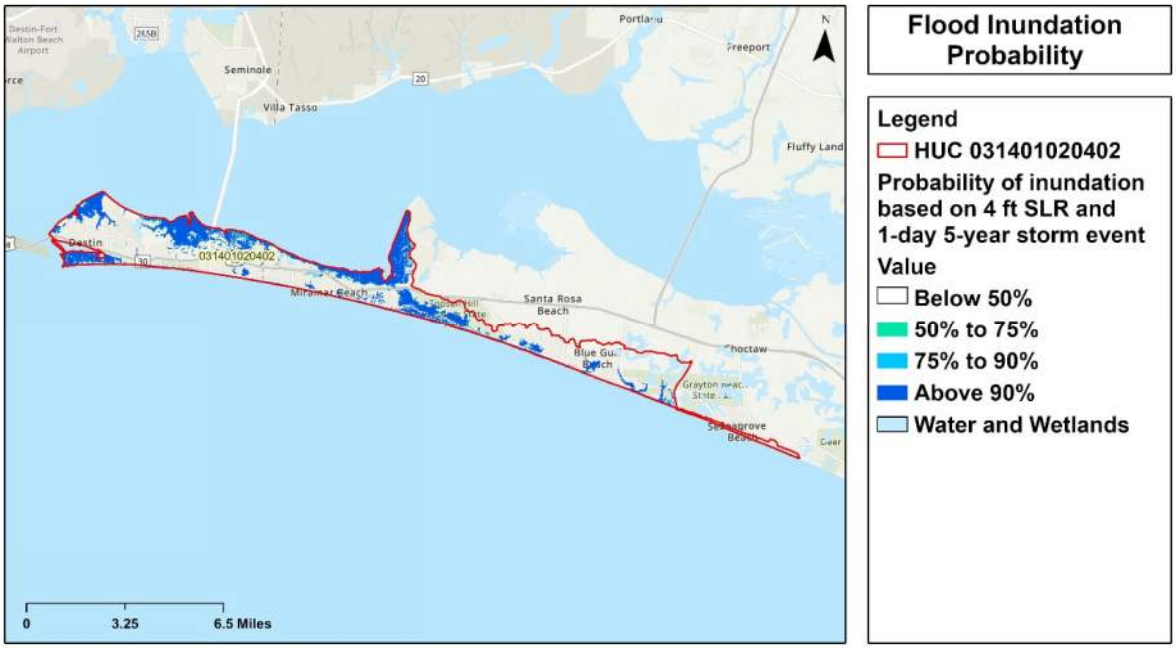

Figure 55. Sea level rise of 4 ft + 1-day 5-year storm for HUC 031401020402 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

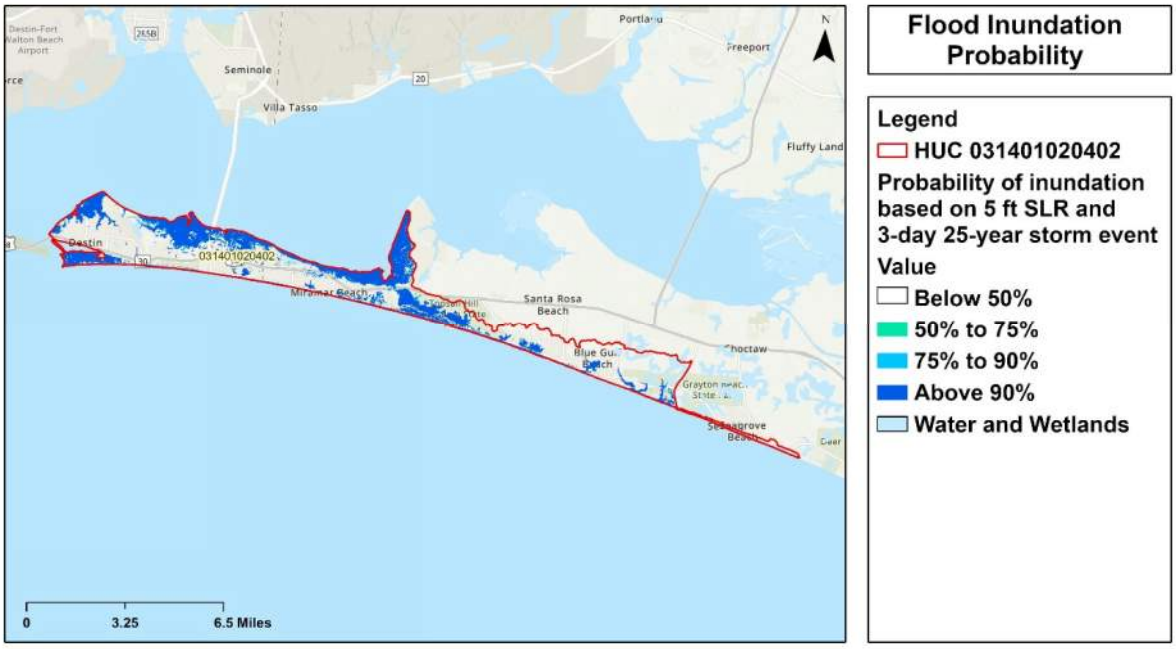

Figure 56. Sea level rise of 5 ft + 3-day 25-year storm for HUC 031401020402 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

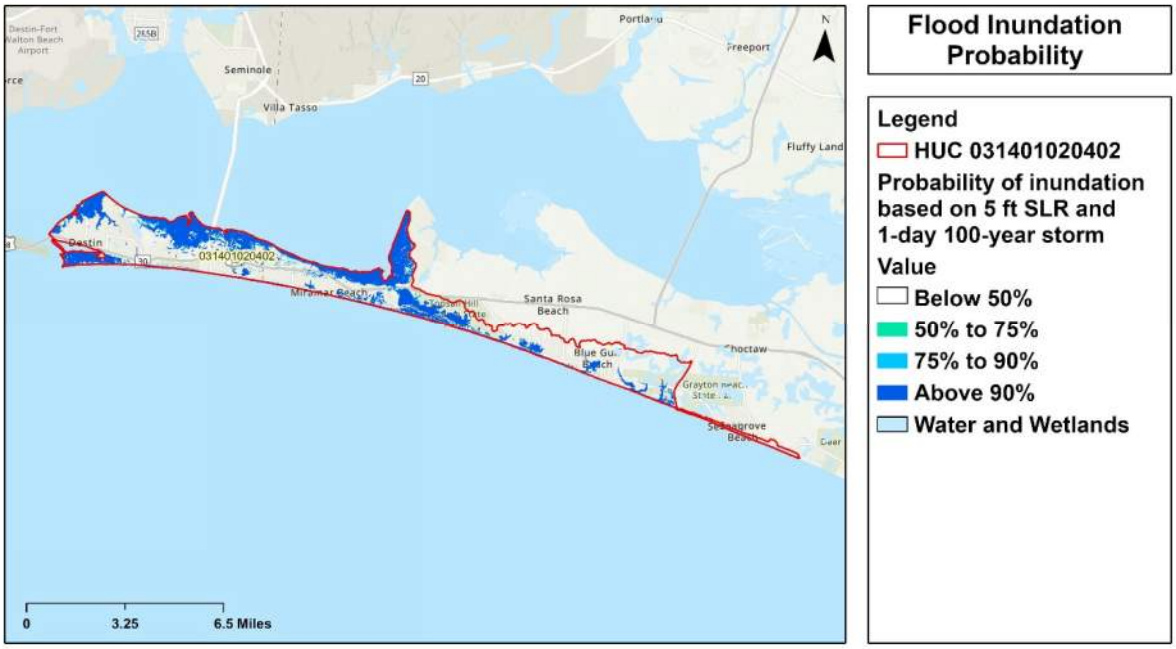

Figure 57. Sea level rise of 5 ft + 1-day 100-year storm for HUC 031401020402 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

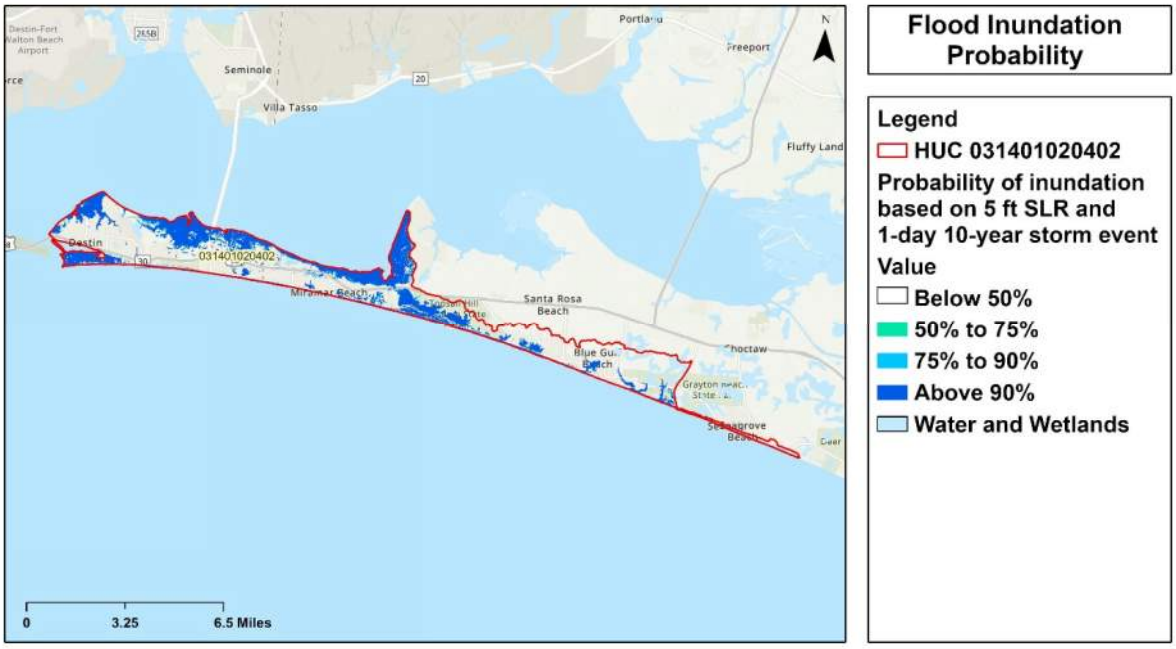

Figure 58. Sea level rise of 5 ft + 1-day 10-year storm for HUC 031401020402 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

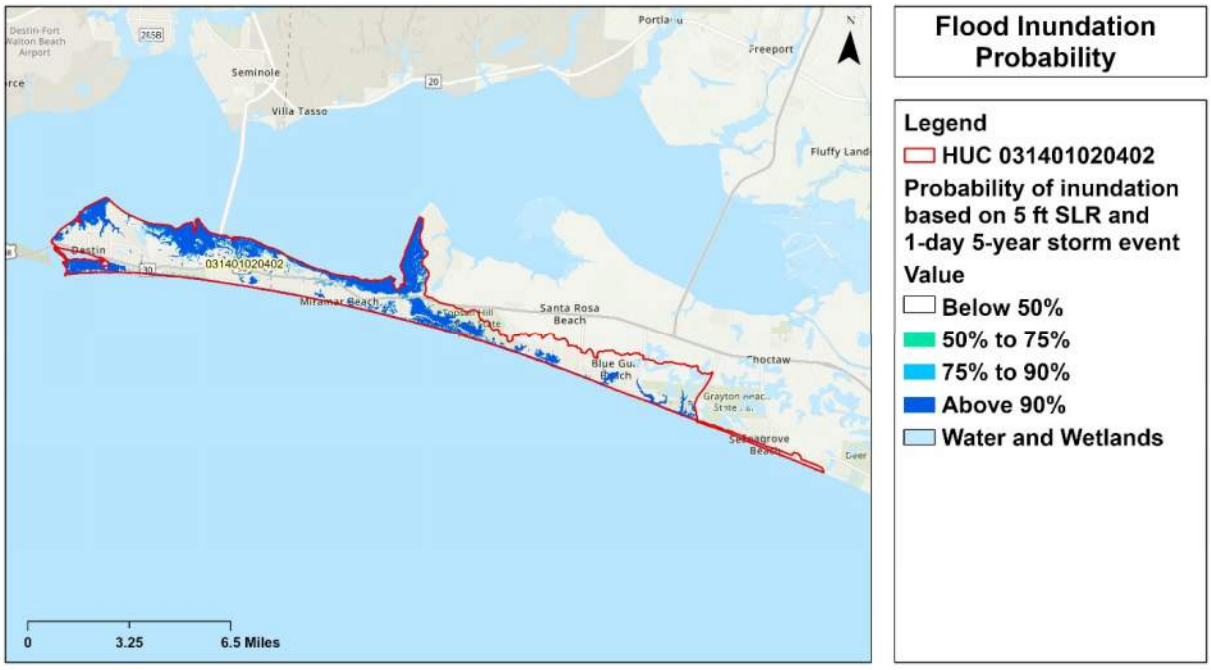

Figure 59. Sea level rise of 5 ft + 1-day 5-year storm for HUC 031401020402 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.5 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older,

poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5

27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6

58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6

94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, as shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.5.1 Results

Figure 60 to Figure 62Figure 62 depict the HUC 031401020402 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (Figure 60) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 61) overlays critical facilities onto the 1-day 100-year storm event scenario, while the third map (Figure 62) represents the same overlay within the context of 5 feet of sea level rise (SLR) combined with the 1-day 100-year storm event. Figure 63 is a mosaic showing critical facilities overlaid in the 5 feet SLR + 1-day 100-year storm event for the whole county.

Additionally, Figure 64 and illustrate the composite score for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Figure 65 represents the calculation for composite score based on 1-day 100-year storm event, while **Error! Reference source not found.** shows the calculation for composite score for the same storm event, but including a 5 feet of Sea Level Rise scenario. Figure 66 shows the same area zoomed out.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

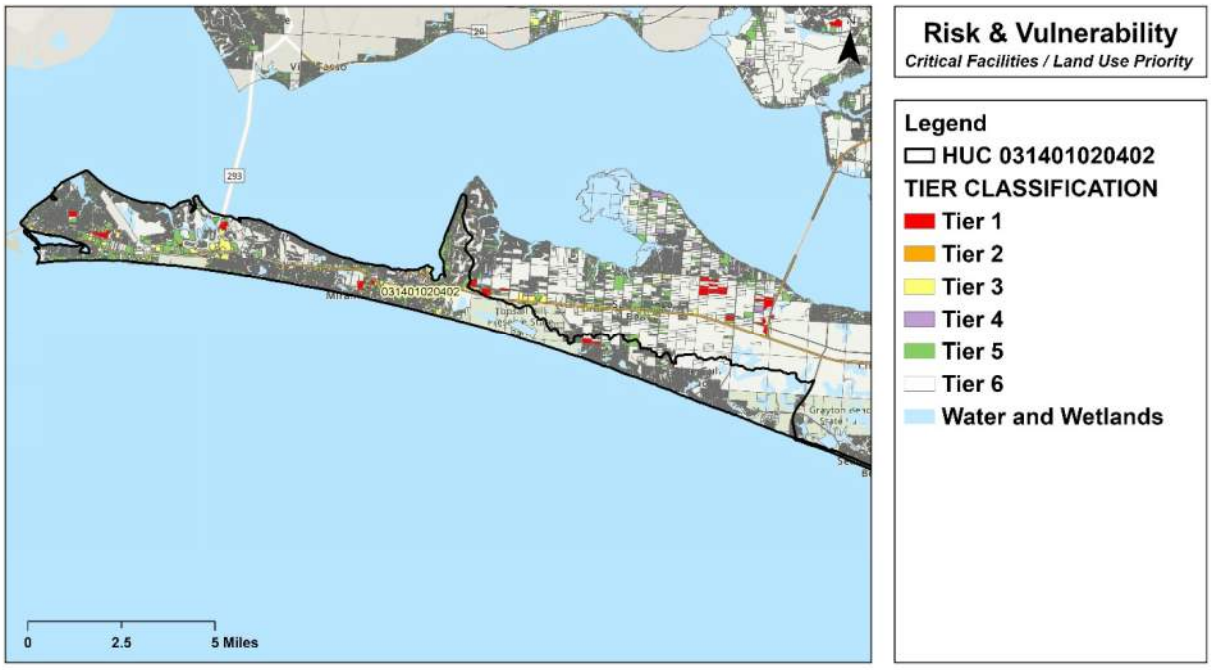

Figure 60. HUC 031401020402 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

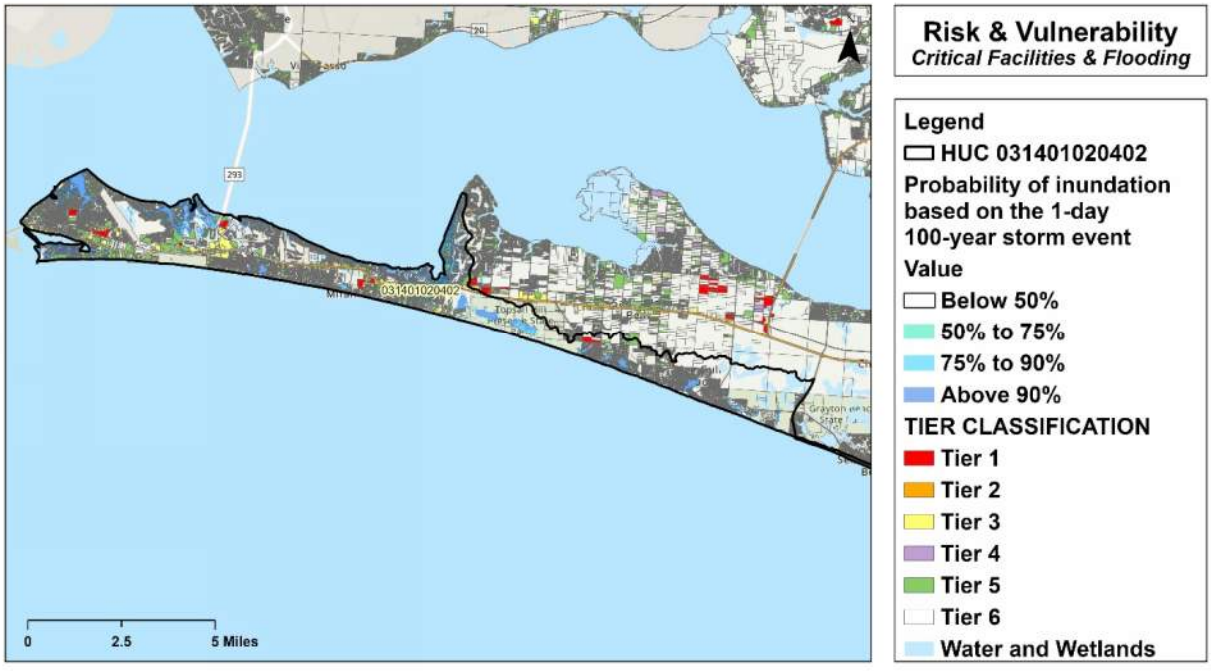

Figure 61. HUC 031401020402 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

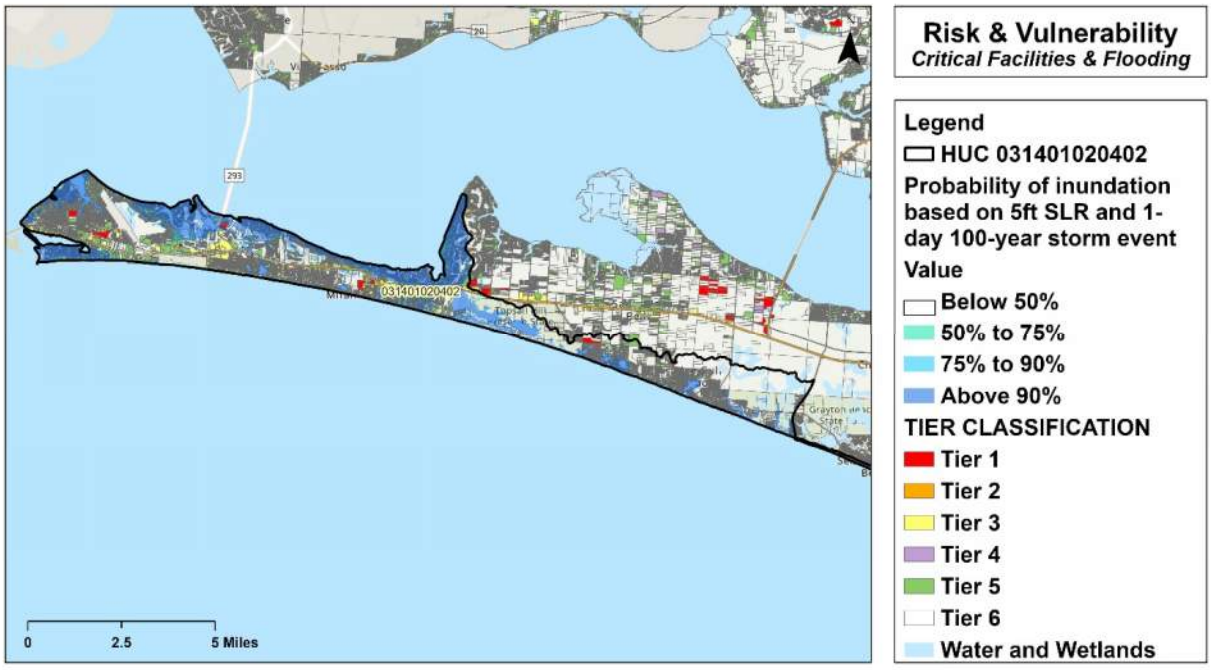

Figure 62. HUC 031401020402 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

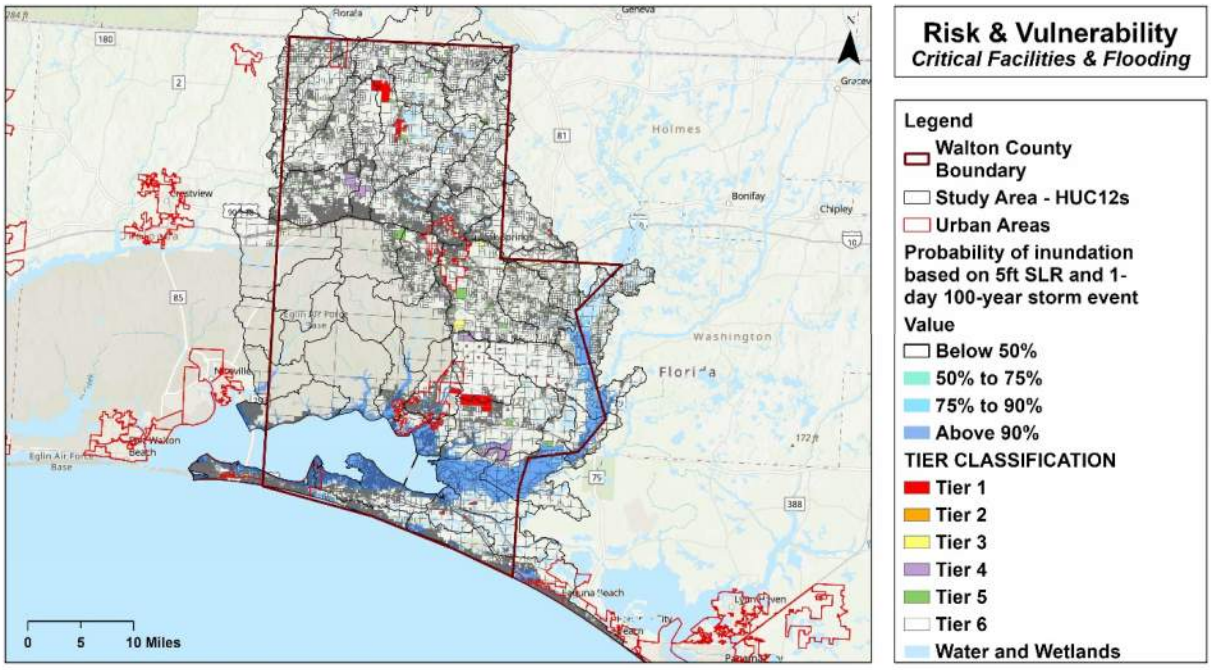

Figure 63. Walton County (mosaic) - Critical Facilities (priority of land uses) map, overlaid on the 1-day 100-year storm event + 5 ft. SLR probability of inundation for Walton County. Processed by FAU.

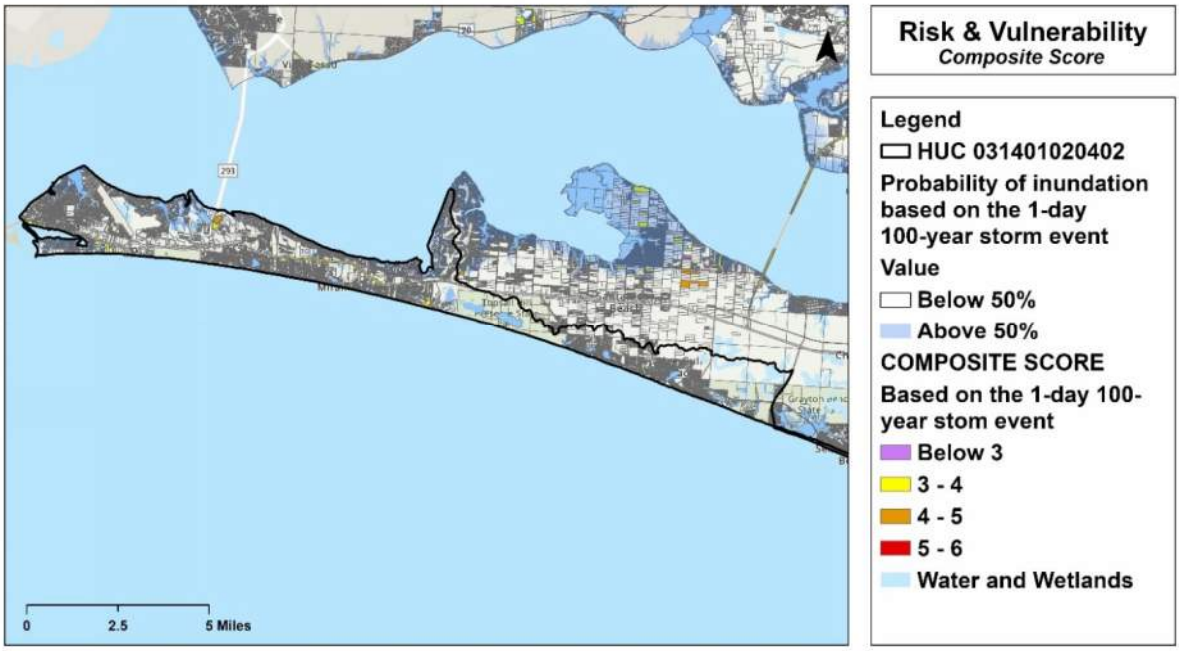

Figure 64. HUC 031401020402 sub-watershed Composite Score Risk map based on the 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation. Processed by FAU.

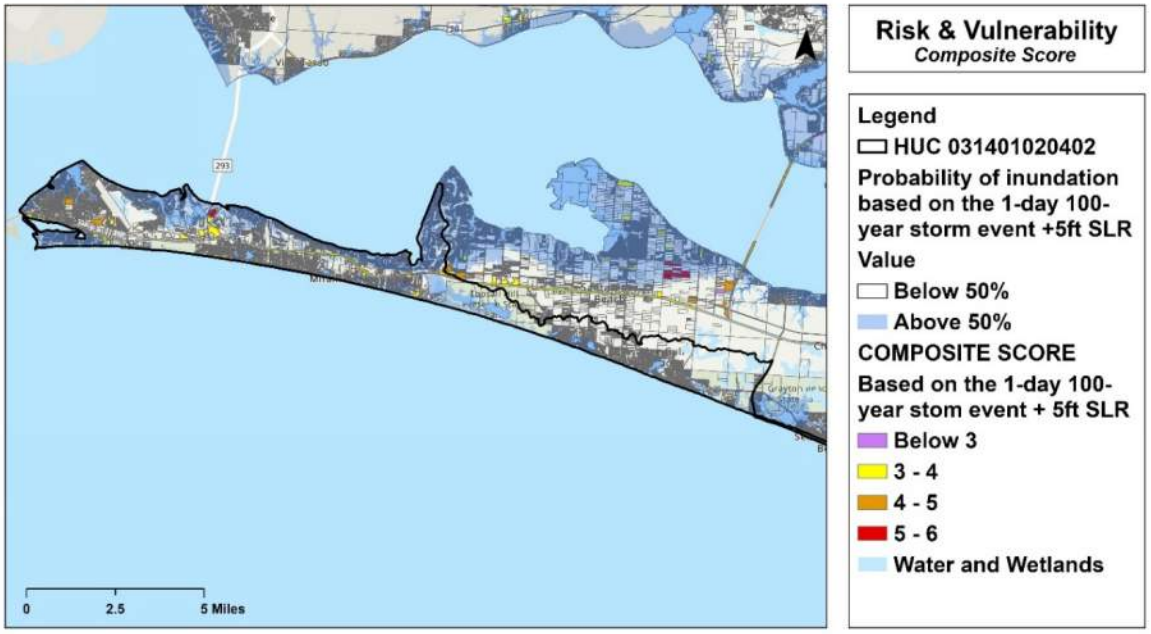

Figure 65. HUC 031401020402 sub-watershed Composite Score Risk map based on 1-day 100-year storm event + 5 ft. SRL, overlaid on the 1-day 100-year + 5 ft. SLR probability of inundation. Processed by FAU.

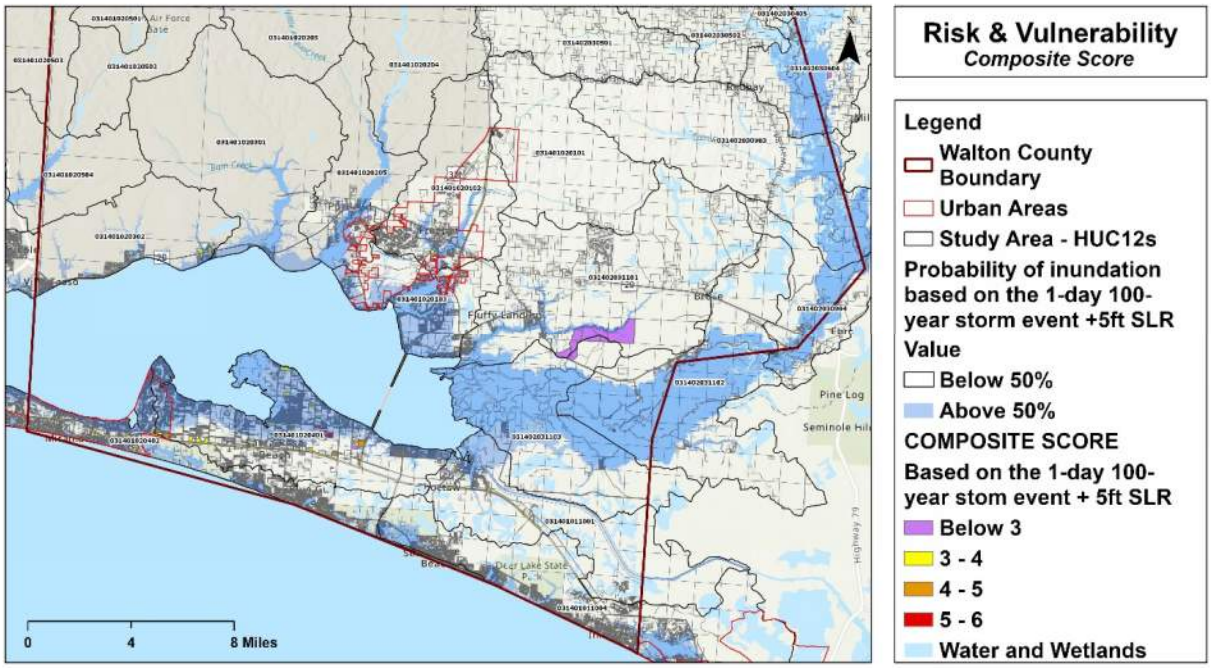

Figure 66. Coastal Area of Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

2.5.2 Drill-down – Miramar Beach and Sacred Oaks

For enhanced visualization of the urban areas within this HUC 031401020402, the following maps illustrate the same results for critical facilities (land use priorities) and composite scores, but on a reduced scale, which better facilitates the examination of finer details within the urban area (Miramar Beach and Sacred Oaks). These maps cover both the 1-day 100-year scenario and the 1-day 100-year + 5 feet SLR scenario. Figure 67 to Figure 81 show drilldowns into the community – starting with priority of land uses, composite scores and flooding (in set of 3).

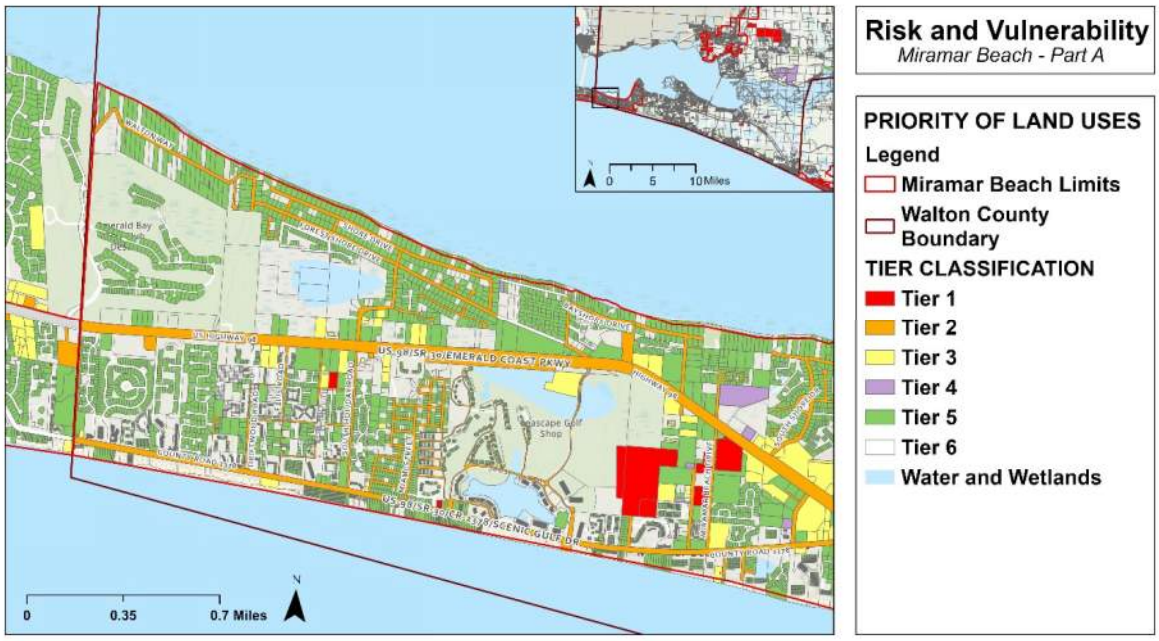

Figure 67. Critical Facilities (priority of land uses) map for Miramar Beach (part A). Processed by FAU.

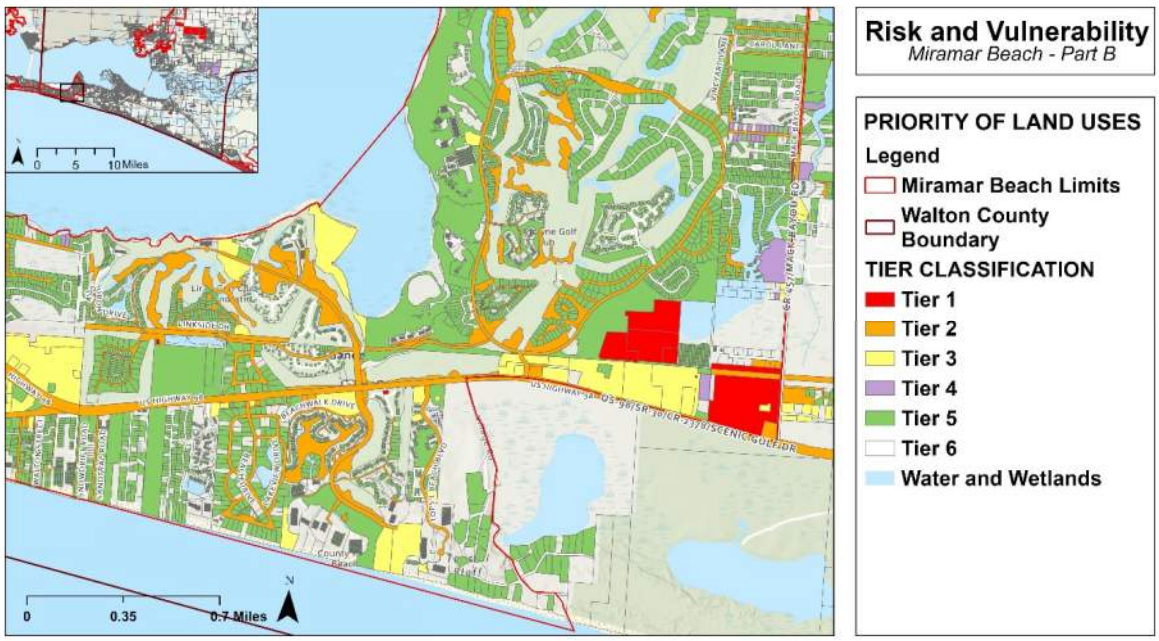

Figure 68. Critical Facilities (priority of land uses) map for Miramar Beach (part B). Processed by FAU.

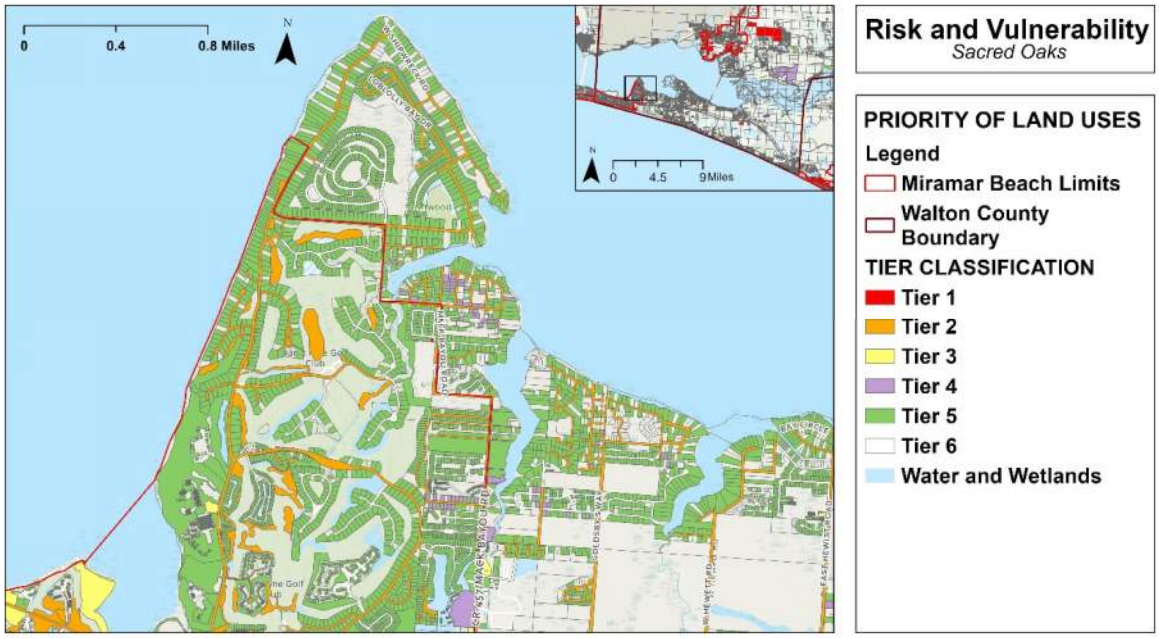

Figure 69. Critical Facilities (priority of land uses) map for Sacred Oaks. Processed by FAU.

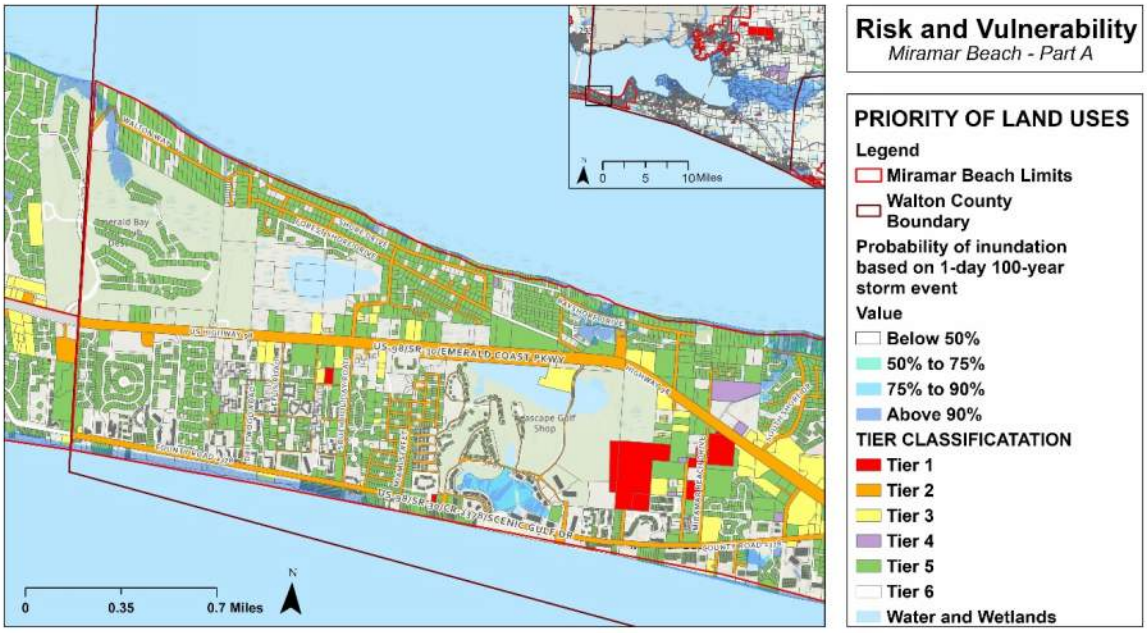

Figure 70. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event for Miramar Beach (part A). Processed by FAU.

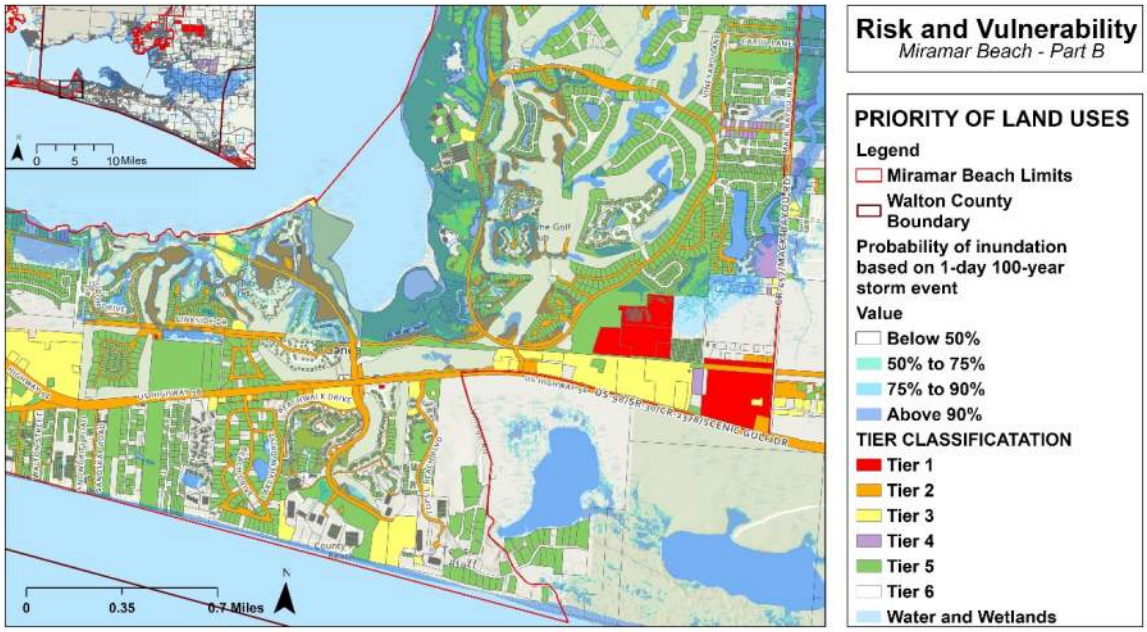

Figure 71. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event for Miramar Beach (part B). Processed by FAU.

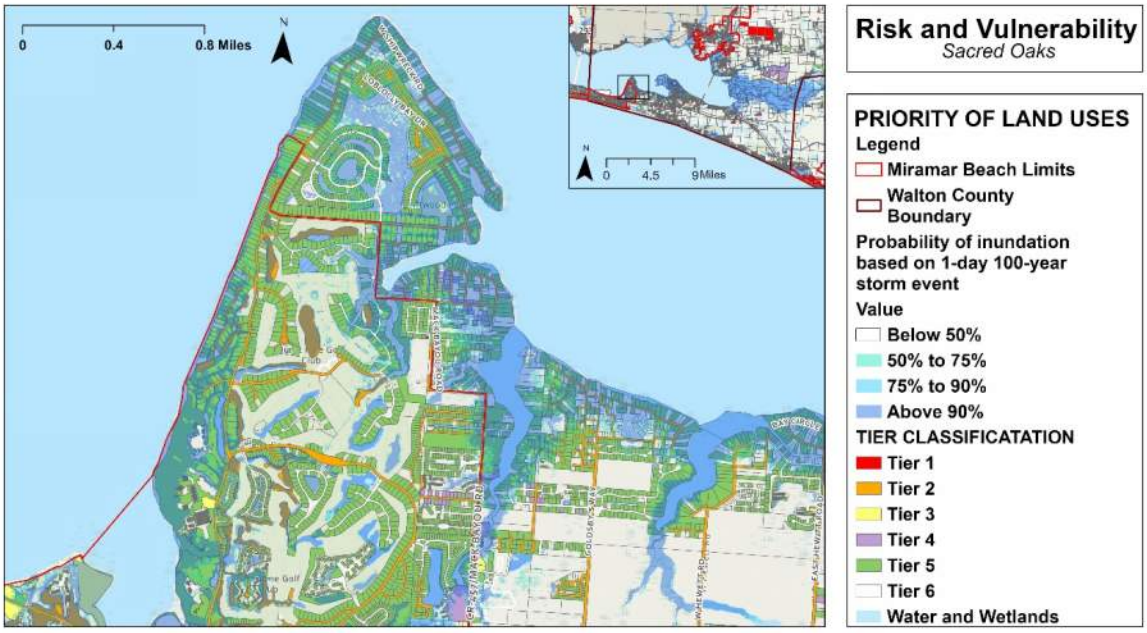

Figure 72. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event for Sacred Oaks. Processed by FAU.

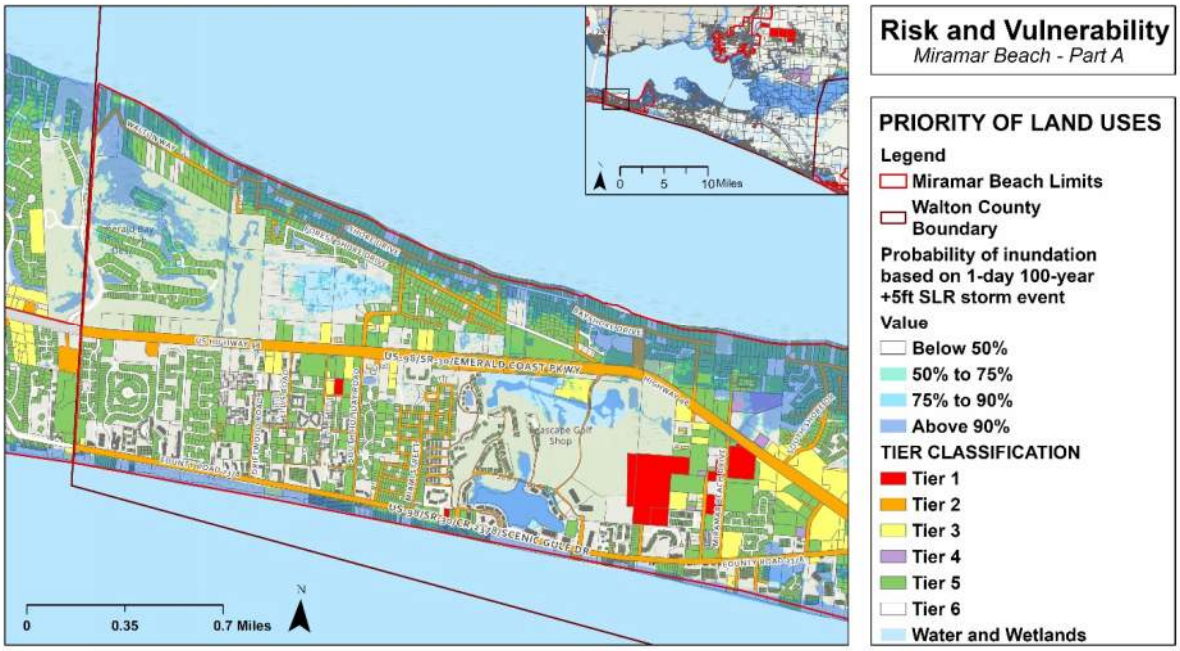

Figure 73. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event + 5 feet SLR for Miramar Beach (part A). Processed by FAU.

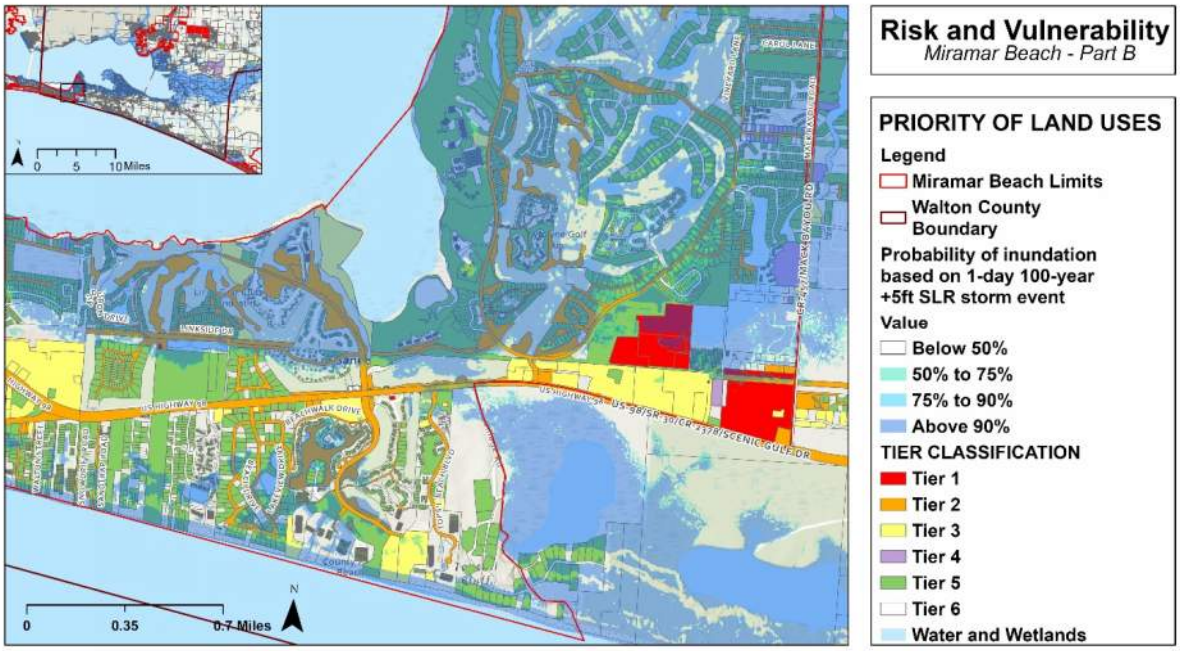

Figure 74. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event + 5 feet SLR for Miramar Beach (part B). Processed by FAU.

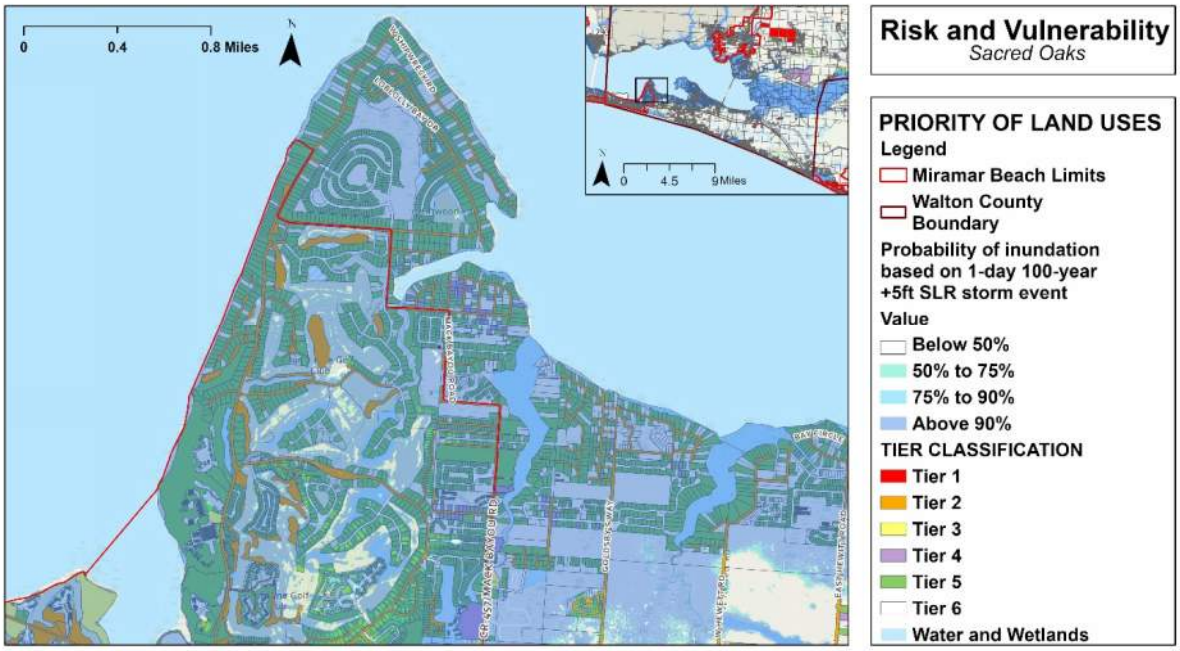

Figure 75. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event + 5 feet SLR for Sacred Oaks. Processed by FAU.

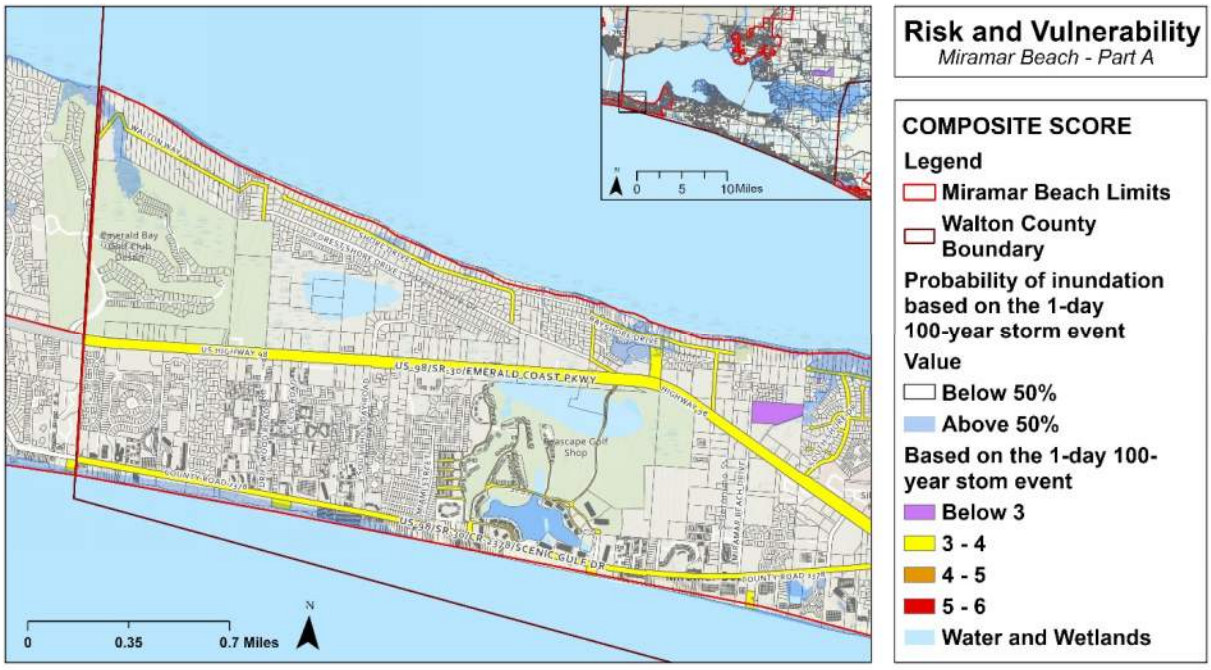

Figure 76. Composite Score map based on 1-day 100-year storm event, overlaid in flooding layer for Miramar Beach (part A). Processed by FAU.

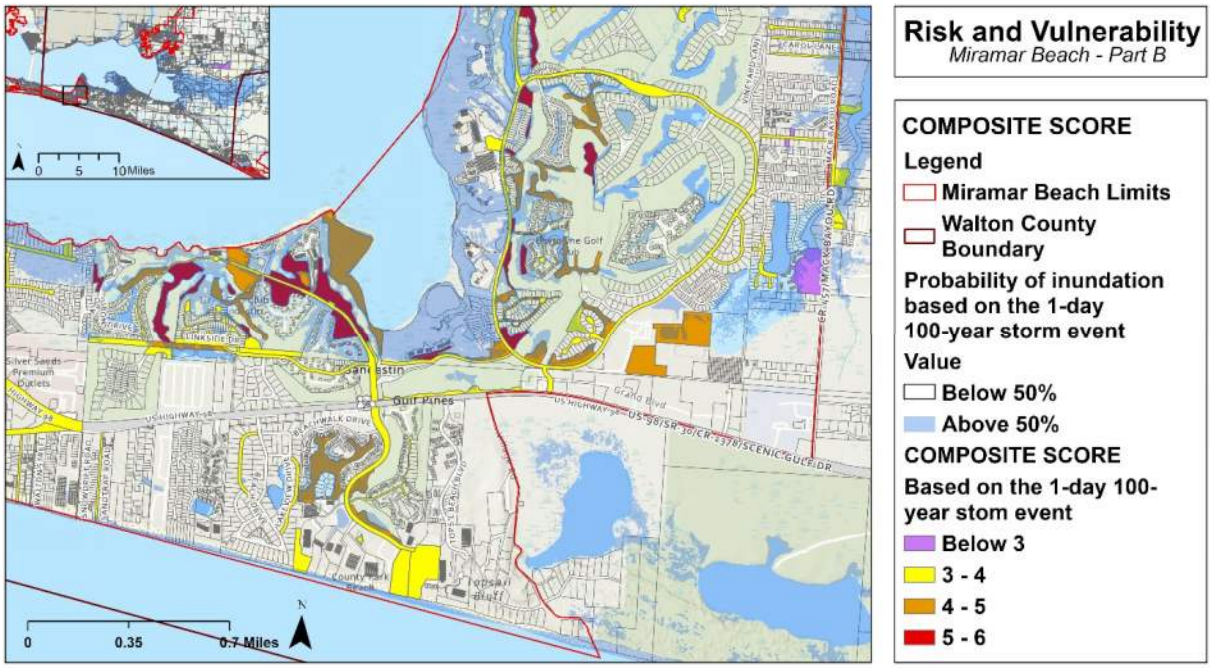

Figure 77. Composite Score map based on 1-day 100-year storm event, overlaid in flooding layer for Miramar Beach (part B). Processed by FAU.

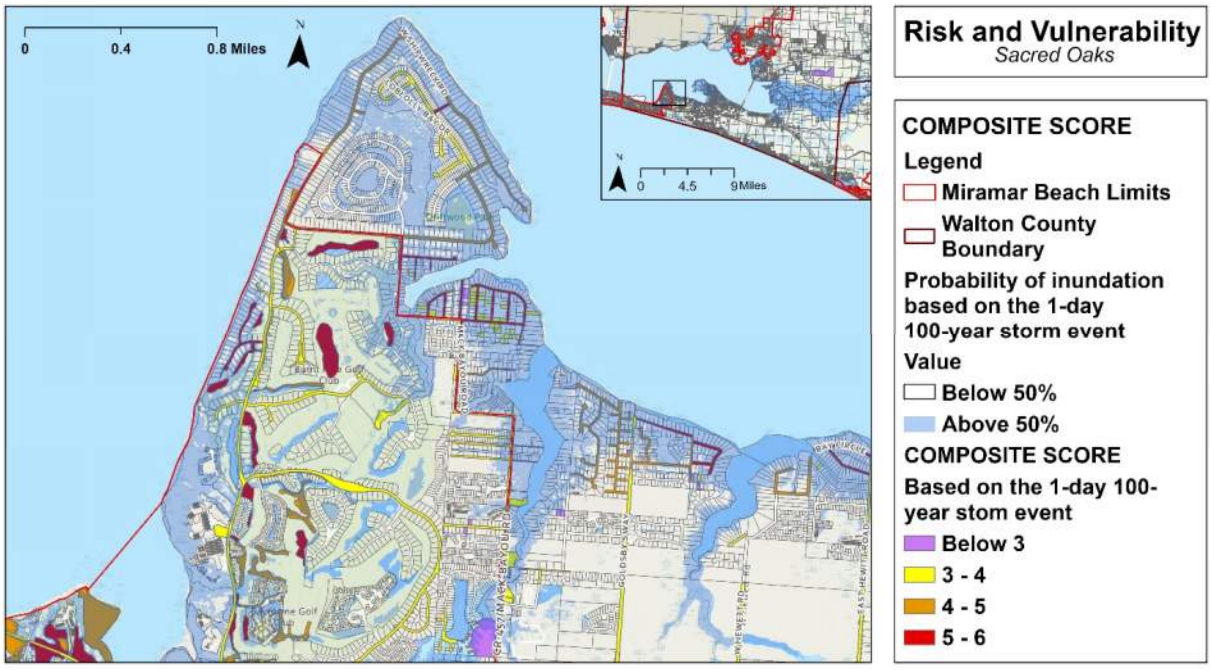

Figure 78. Composite Score map based on 1-day 100-year storm event, overlaid in flooding layer for Sacred Oaks. Processed by FAU.

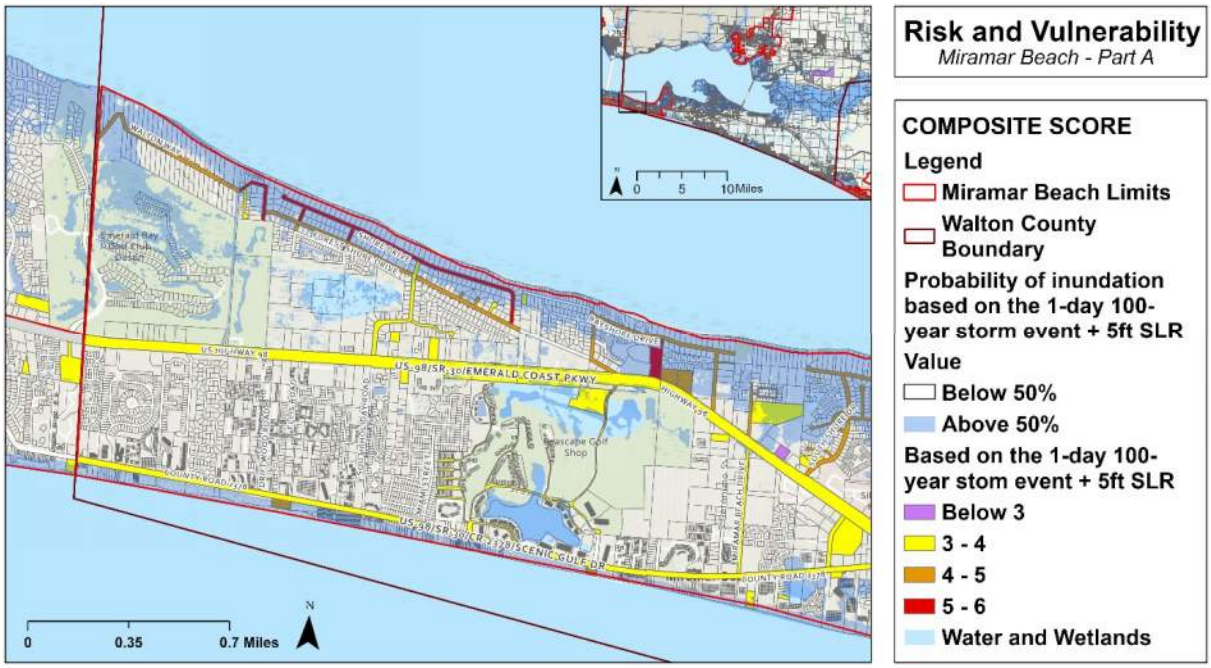

Figure 79. Composite Score map based on 1-day 100-year storm event + 5 feet SLR, overlaid in flooding layer for Miramar Beach (part A). Processed by FAU.

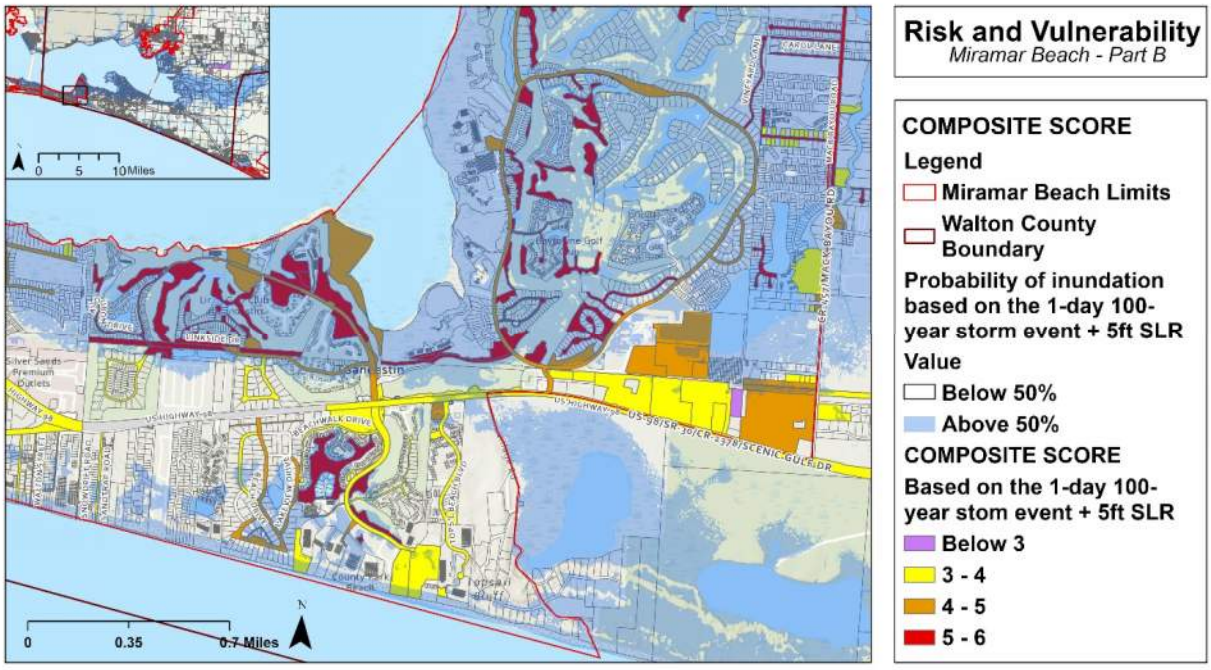

Figure 80. Composite Score map based on 1-day 100-year storm event + 5 feet SLR, overlaid in flooding layer for Miramar Beach (part B). Processed by FAU.

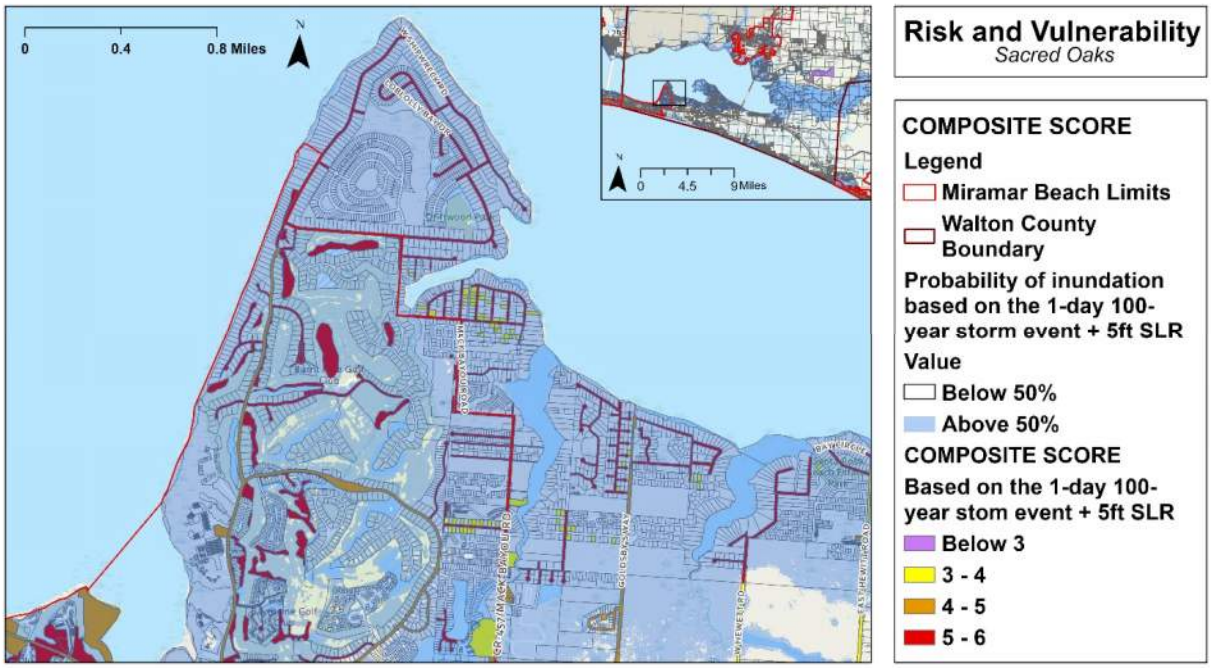

Figure 81. Composite Score map based on 1-day 100-year storm event + 5 feet SLR, overlaid in flooding layer for Sacred Oaks. Processed by FAU.

2.5.3 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401020402. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.5.4 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It is important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401020402. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401020402	17299.39
All of the 1-day 100-year storm event inundation	**2457.96**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	465.76
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	176.24
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	1992.20
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	1815.96

2.5.5 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. Figure 82 indicates the results

from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

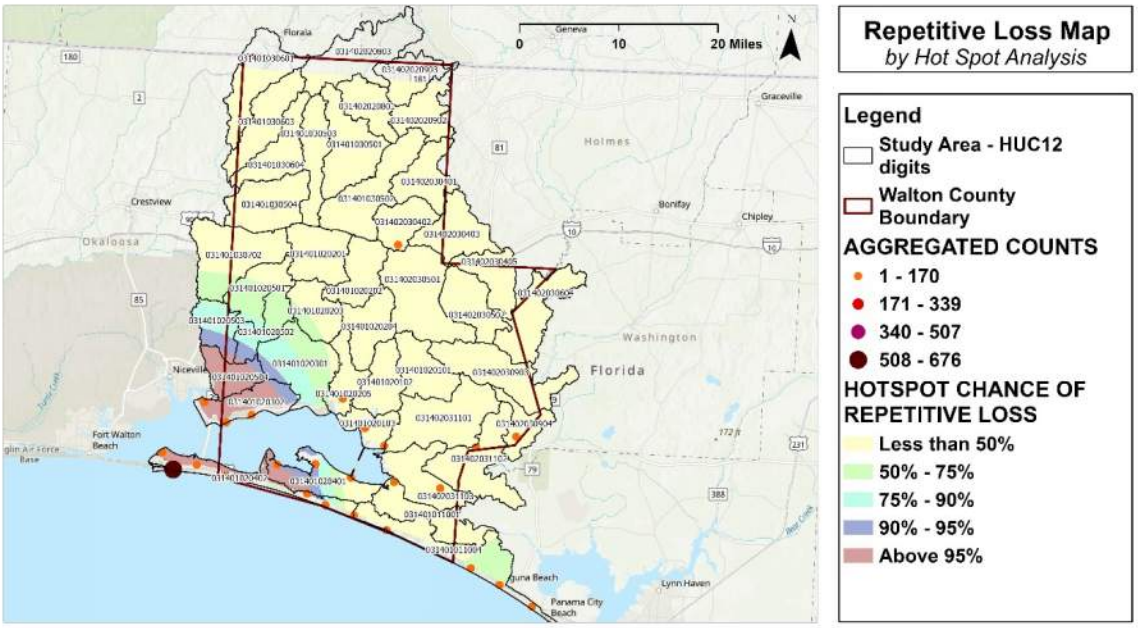

Figure 82. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.5.6 Priority Projects

The basin encompasses Miramar Beach, the most densely populated area in the county, characterized by medium-to-high development. Unfortunately, a significant portion of this community faces a severe flooding risk, particularly during a 1-day 100-year storm event + 5 ft. SRL scenario. The basin's coastal location, resembling a peninsula, renders all sides vulnerable to rising tides and sea-level increases. The alarming frequency of flooding in both scenarios highlights the urgent need for intervention.

Regarding land use priority, numerous critical facilities fall within the flood zone, including 51 parcels classified as tier 1. However, not all of these tier 1 parcels are within the flood-prone areas. The basin displays a diverse range of land use priorities, covering tiers 2 to 6, totaling 35,600 parcels. A substantial proportion of these parcels are affected by flooding, particularly when considering the 5 feet of sea-level rise scenario.

An in-depth analysis of the composite score offers a detailed view of parcels within the flood zone. A total of 341 parcels face the impact of the 1-day 100-year storm event + 5 ft. SRL scenario, with 184 parcels affected solely by the 1-day 100-year storm event.

In the most critical scenario (1-day 100-year storm event + 5 ft. SRL), 105 parcels fall within the score range of 5-6, signifying the highest priority for intervention. These include three utility parcels, two public schools, one college, one financial institution, and all the remaining parcels are roads, such as W Shipwreck Rd, Shore Drive, Linkside Dr, Prestwick Pl, North Geronimo Street, Burnt Pine Ln, Walton Way, Audubon Drive, Sandestin Blvd West, Lake Point Drive, and Del Mar Ct.

Within the score range of 4-5, 48 parcels are identified, encompassing a community shopping center, seven office buildings, eight restaurants/cafeterias, two hotels, one light manufacturing facility, one public school, one hospital, seven utility parcels, and the rest are roads, including County Highway 30a, South Shore Dr, Forest Shore Drive, Beach Drive, Walton Way, Bayshore Drive, Lakeview Drive, Thompson Drive, Open Gulf Street, and Stallworth Blvd.

The score range of 3-4 encompasses 182 parcels, featuring 23 mobile homes, five regional shopping centers, 13 community shopping centers, 32 office buildings, four professional service buildings, 25 restaurants/cafeterias, two repair service shops, two auto sales/auto repair facilities, 11 hotels, one light manufacturing facility, one private school, two privately owned hospitals, one homes for the aged, one orphanage, and all remaining parcels are roads, including portions of County Highway 30a, US Highway 98, Allen Loop Road, County Road 2378, Eastern Lake Road, Overlook Drive, Sandtrap Road, and Tops'l Beach Blvd.

Lastly, seven parcels receive a score "below 3" based on the composite score classification. These comprise five mobile homes and two orphanages or other non-profit organizations.

APPENDIX P

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401020501

EXLINE CREEK

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401020501) is highlighted among all the HUCs to help identifying its location. (Figure 3).

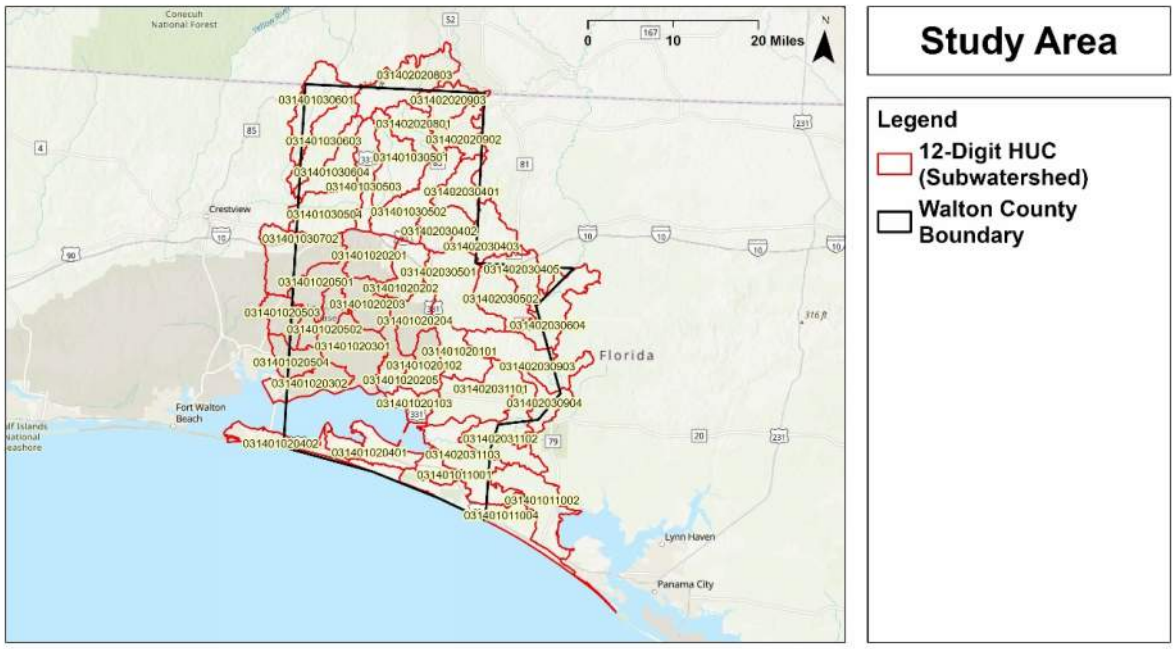

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

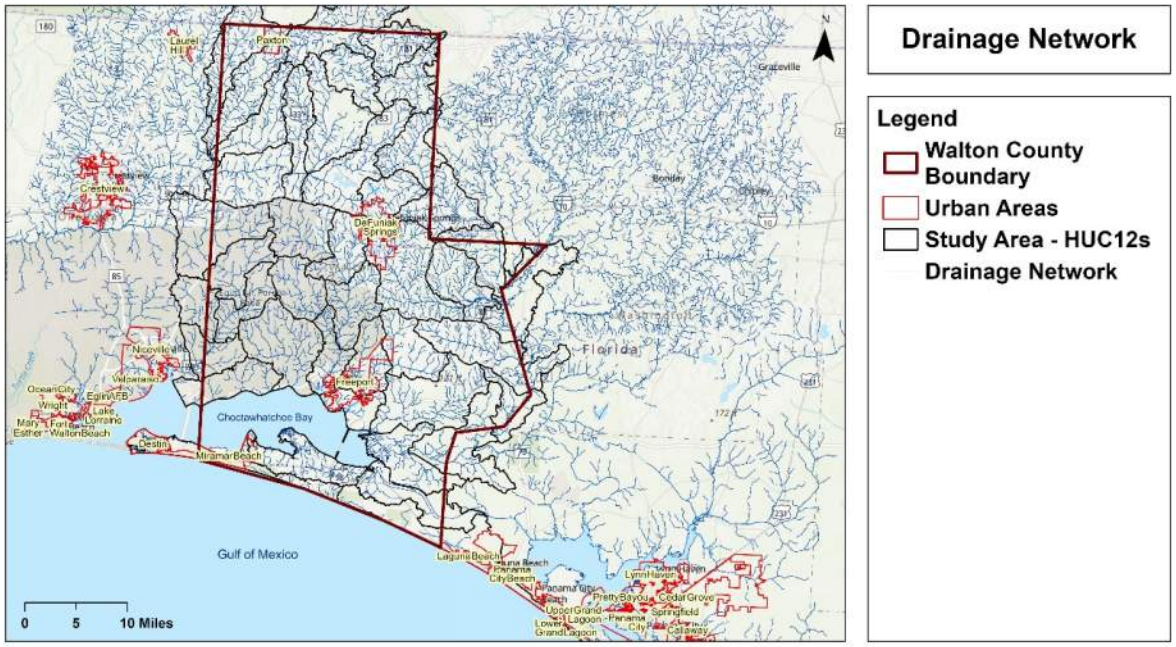

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

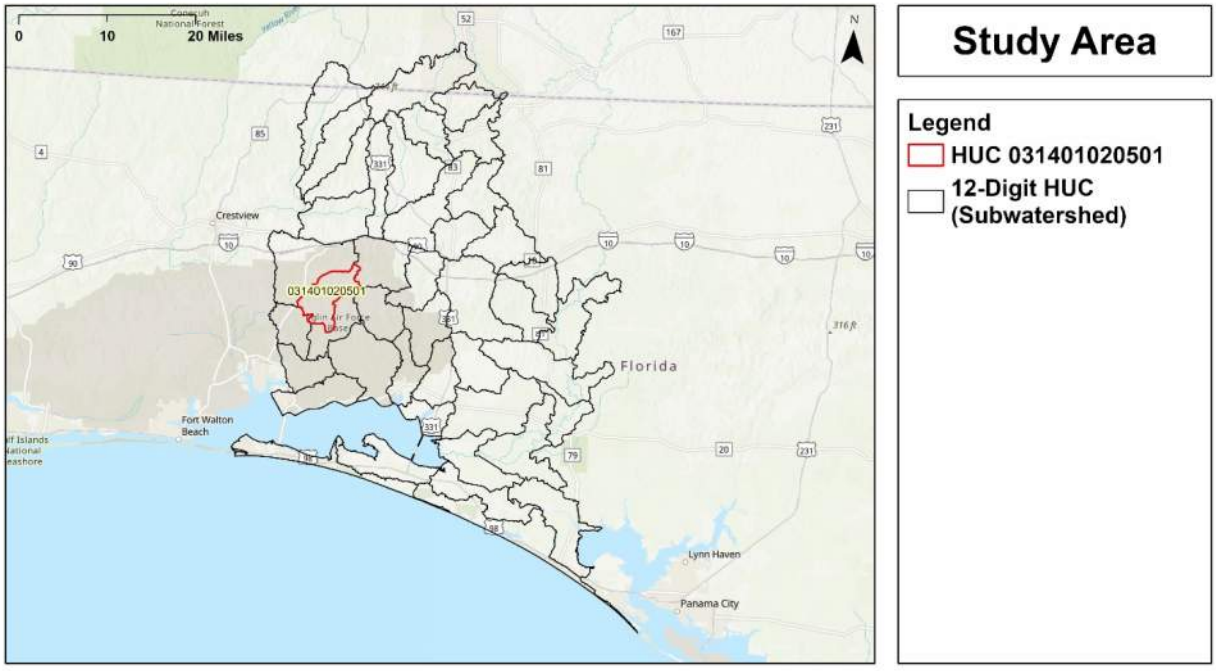

Figure 3. HUC 031401020501 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development, tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

Figures 12 and 13 in the county-wide report show the current and projected land use for the County. Based on the 2017 future land use map for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL))

Level 1 Land Use-Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 1.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

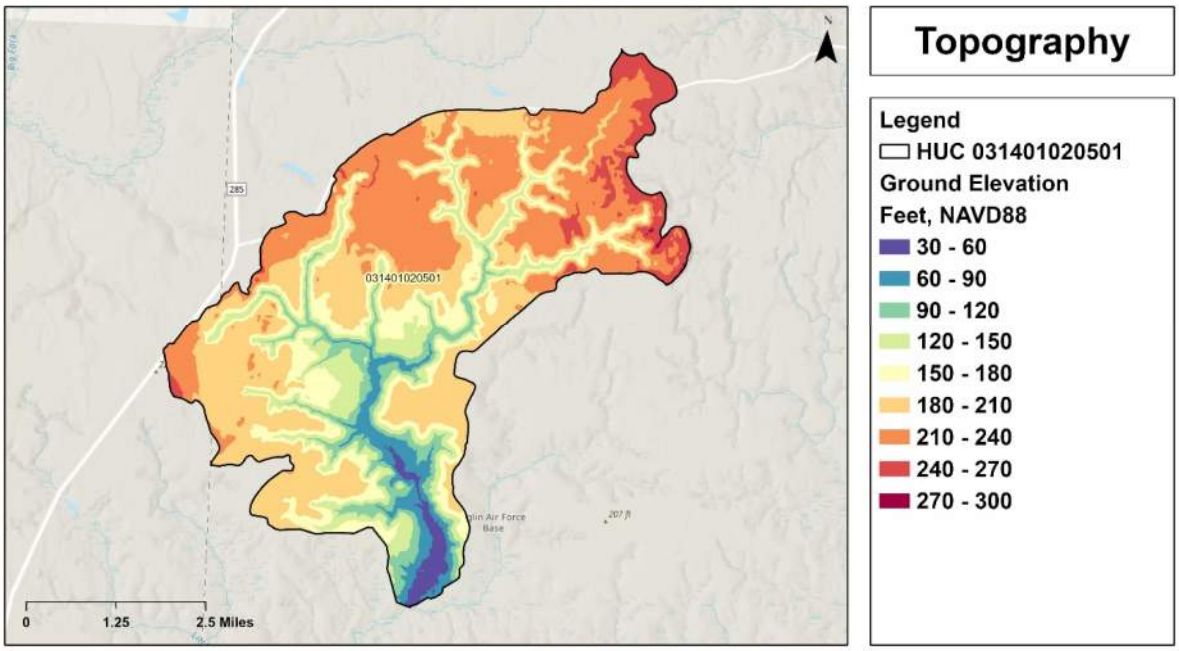

Figure 4. Topographic map of the HUC 031401020501 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401020501 sub-watershed is shown in **Error! Reference source not found.**.

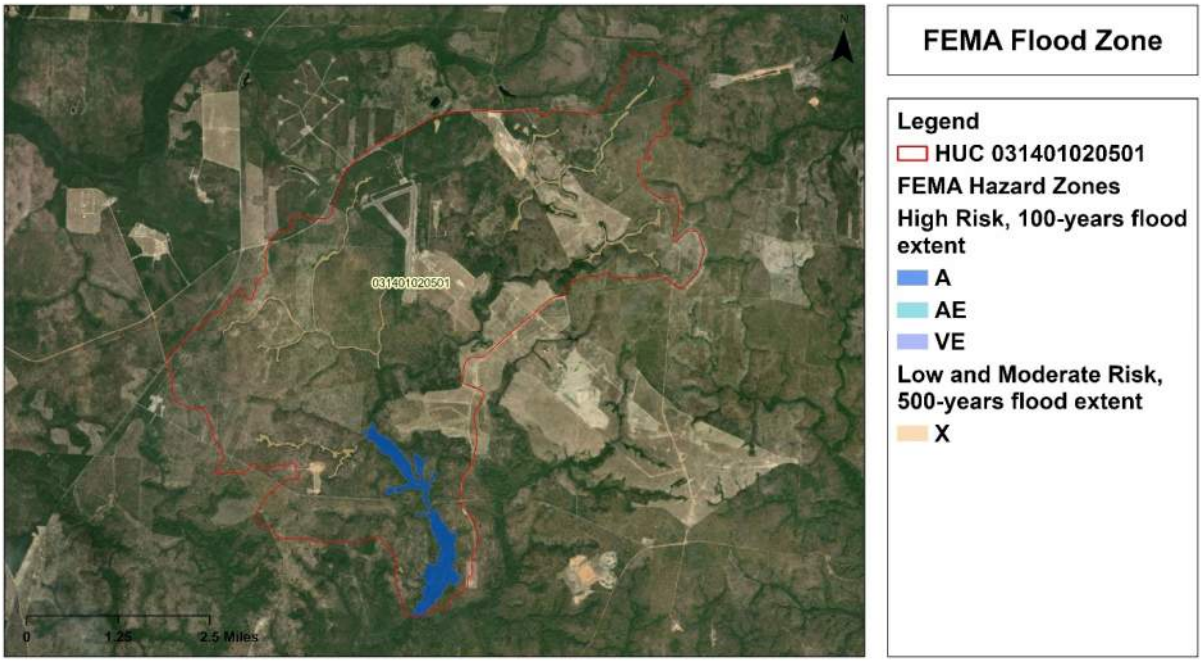

Figure 5. FEMA Flood Zone map (2020) for HUC 031401020501 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401020501 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

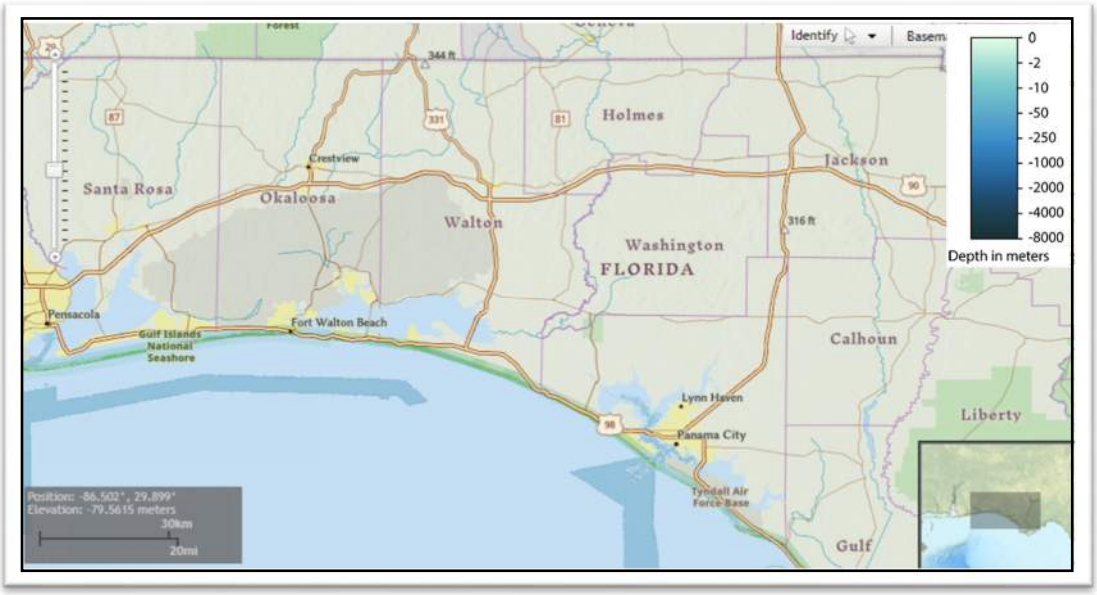

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

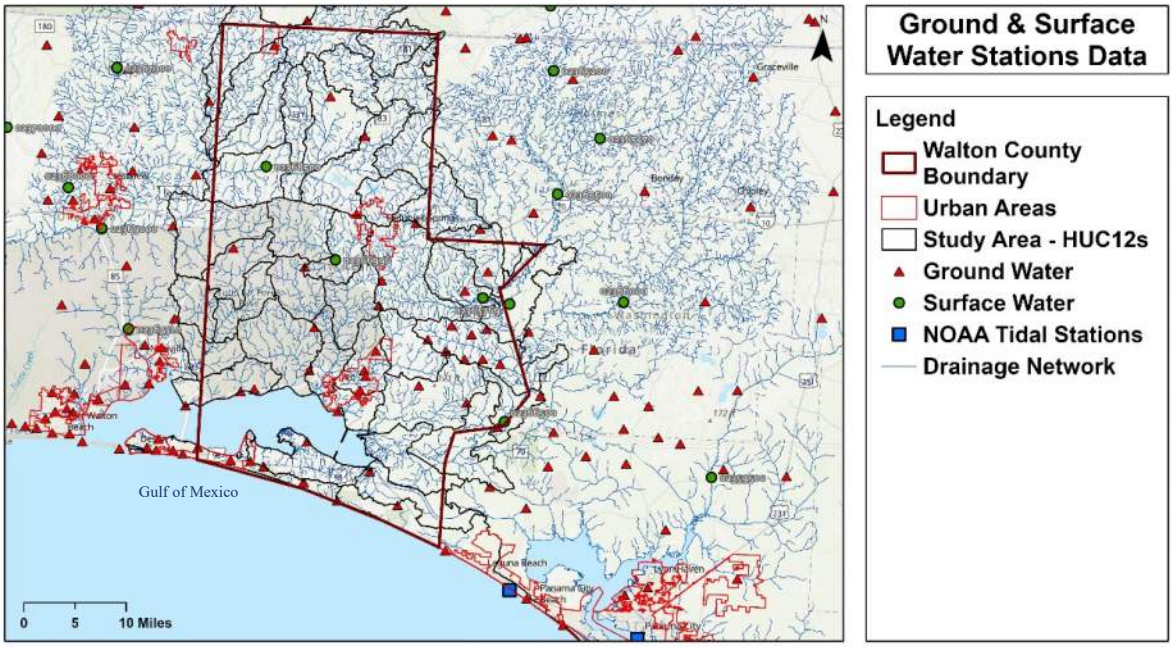

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031401020501 has no major rivers and canals, but creeks include:

- Rocky Creek
- Wildcat Creek
- Bear Branch
- Green Head Branch

- Exline Creek
- Mount Sinai Branch

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366996. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401020501, which is USGS 02366996 Alaqua Creek Near Pleasant Ridge, FL

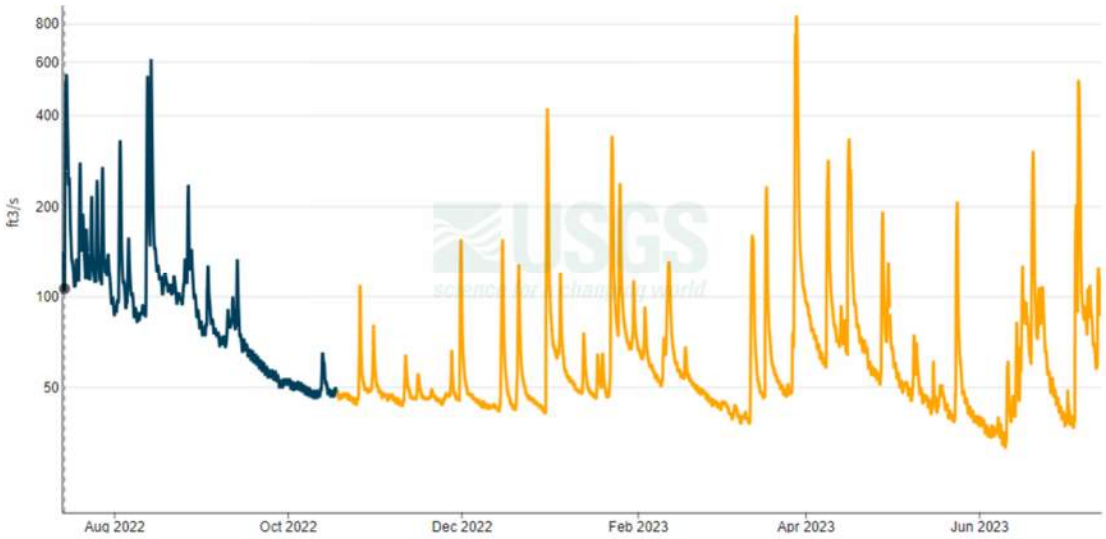

Figure 8. Average streamflow for Alaqua Creek Near Pleasant Ridge, FL (USGS 02366996 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366996/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station

(or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401020501 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031401020501 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

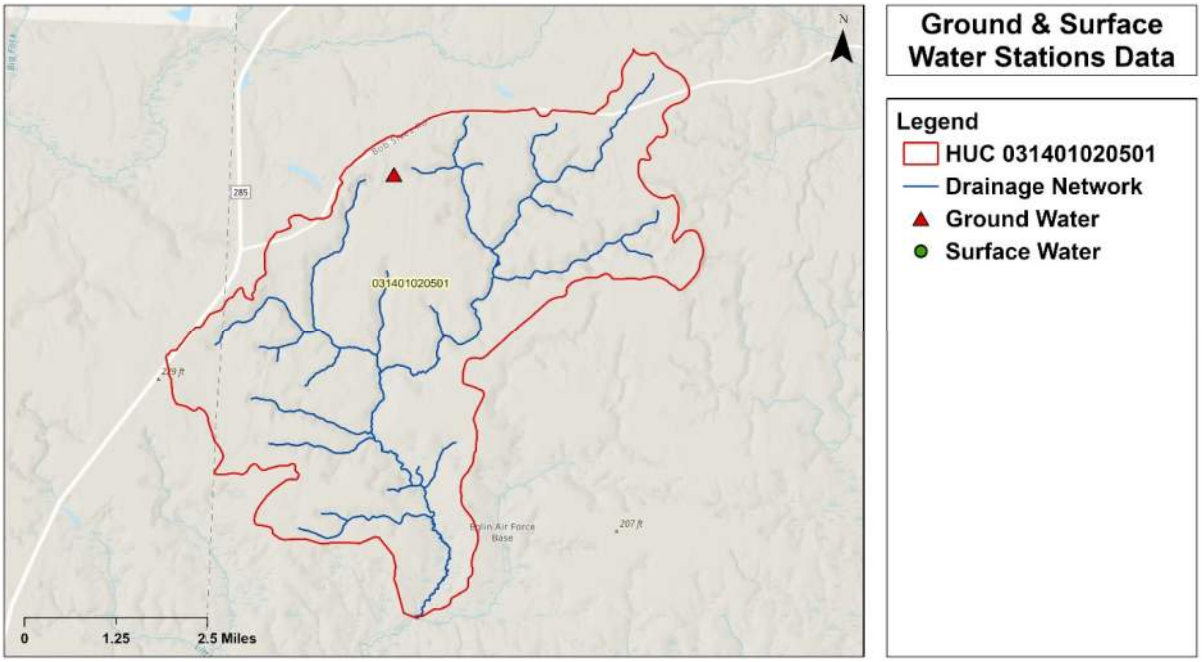

Figure 9. Ground and Surface Water Stations in the HUC 031401020501 sub-watershed, processed by FAU.

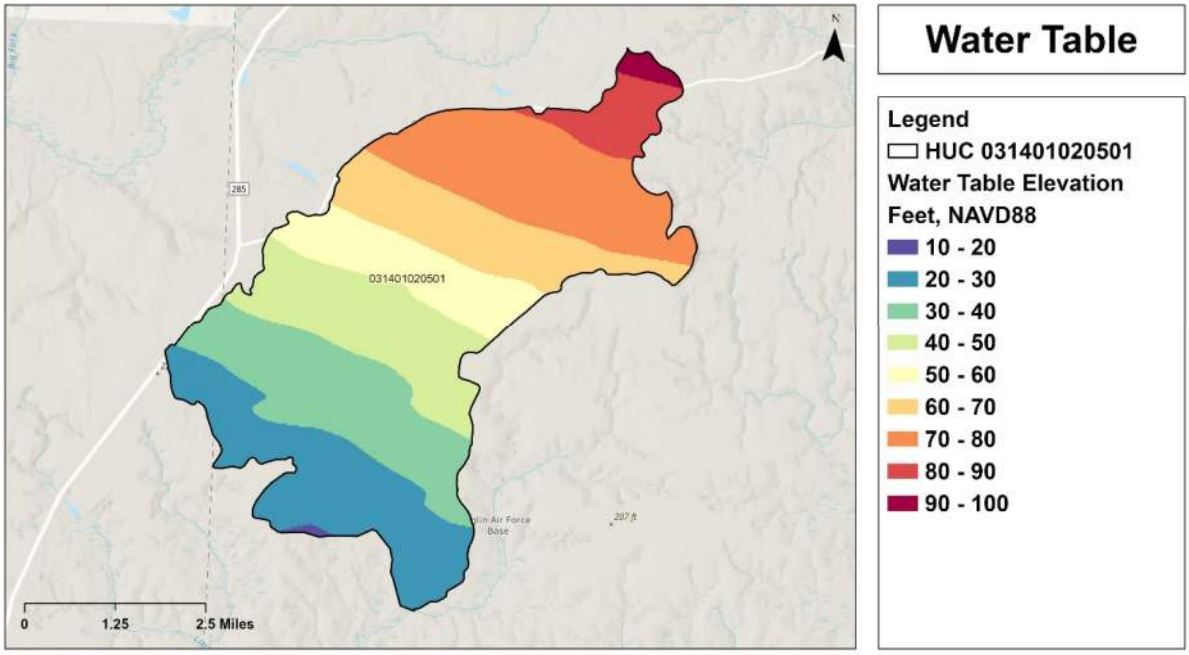

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401020501 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

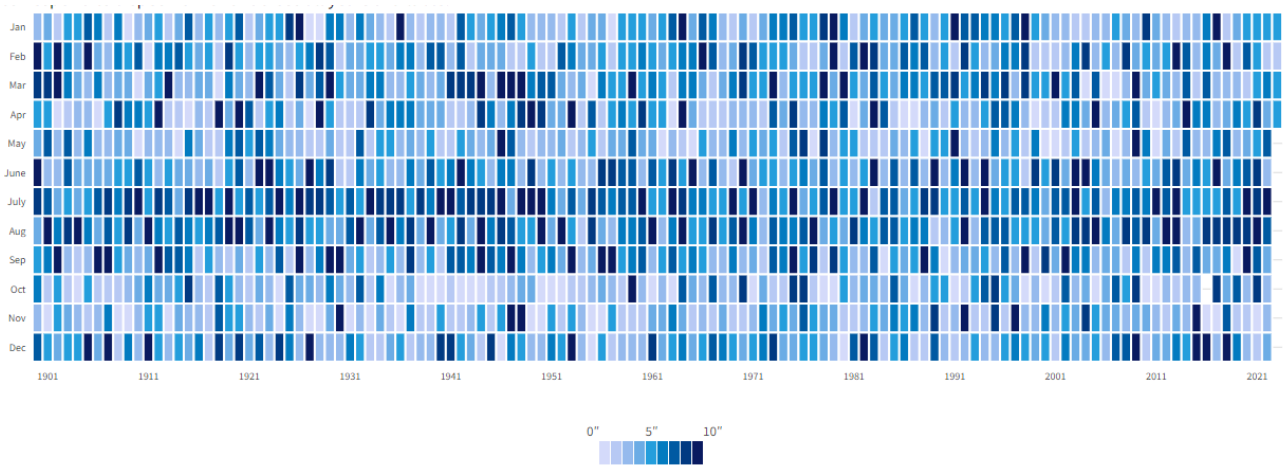

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/).

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

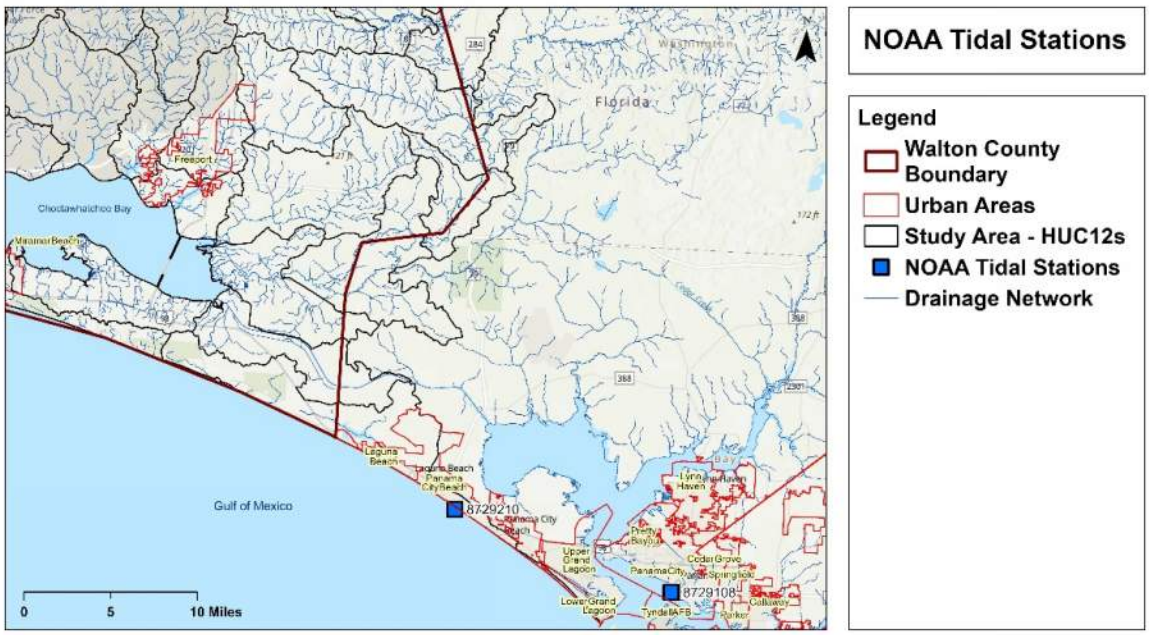

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

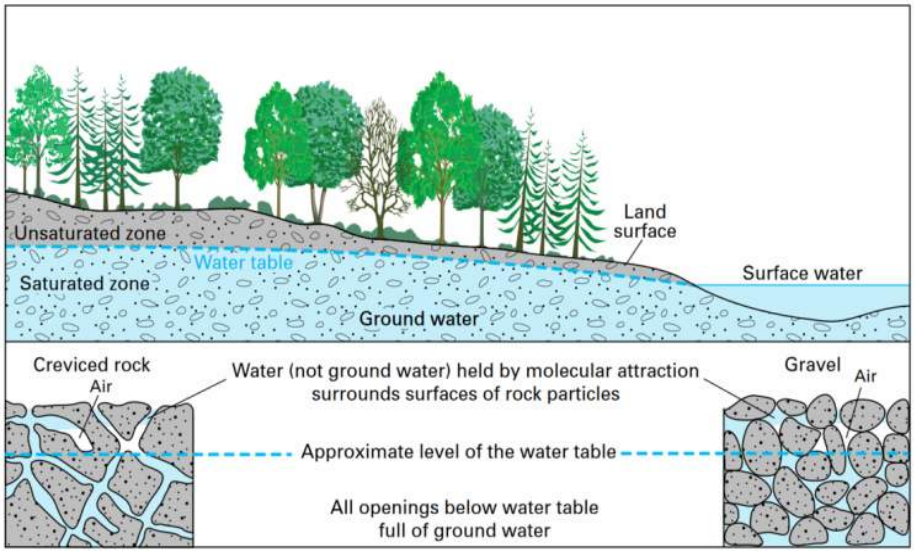

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

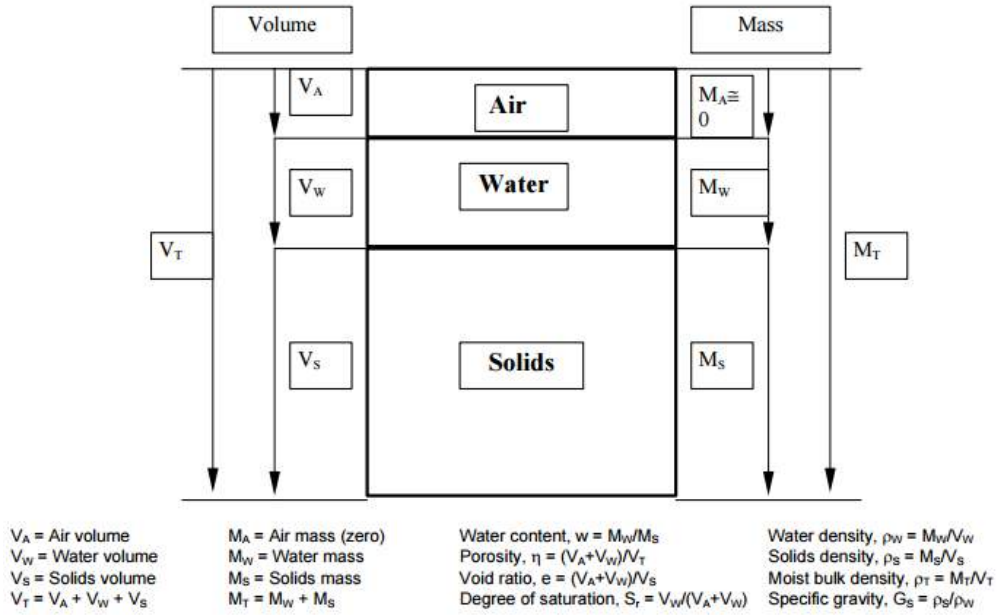

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

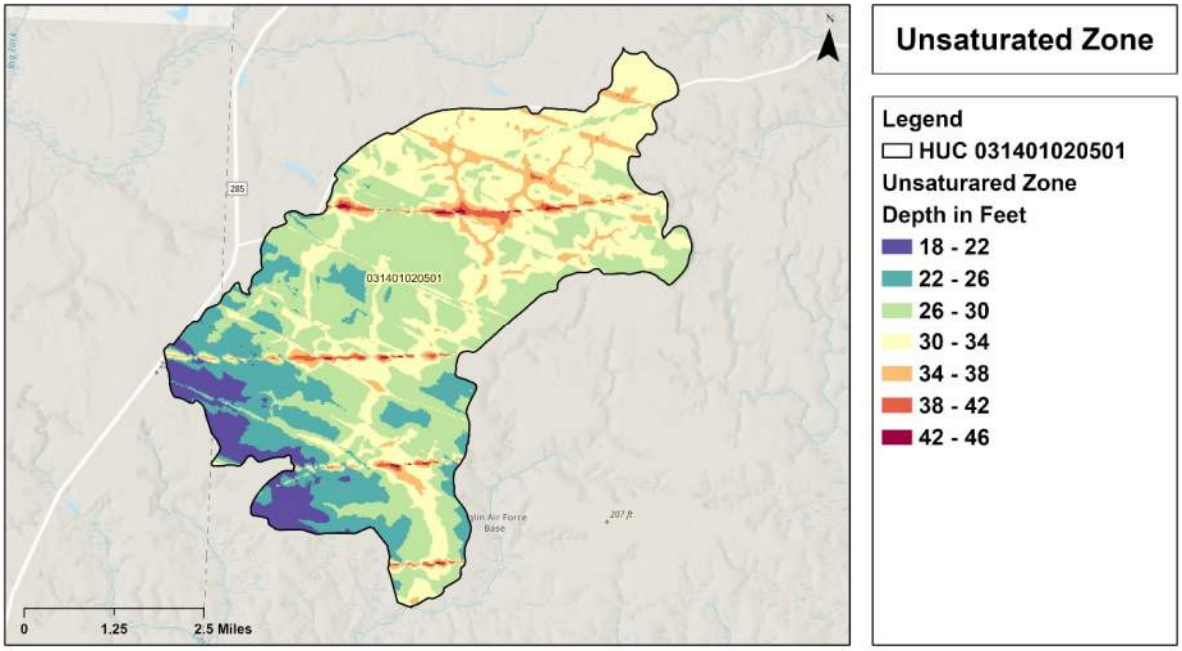

Figure 15. Unsaturated zone map for HUC 031401020501, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately to limited soil storage capacity, falling within the range of 18 to 34 feet of remaining capacity.

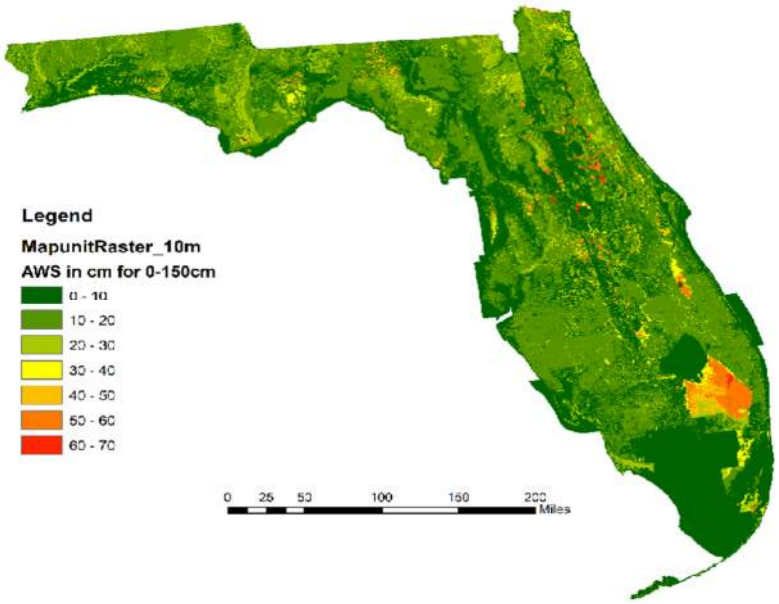

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

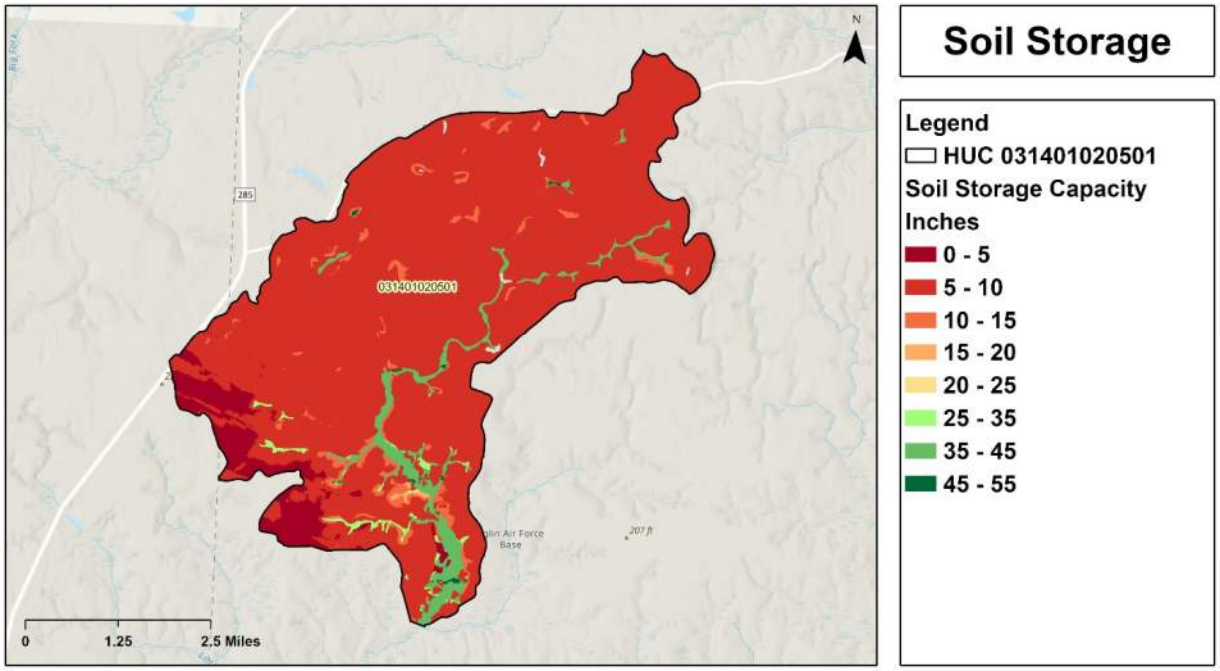

Figure 17. Water storage capacity of soil for the HUC 031401020501 (inches), processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

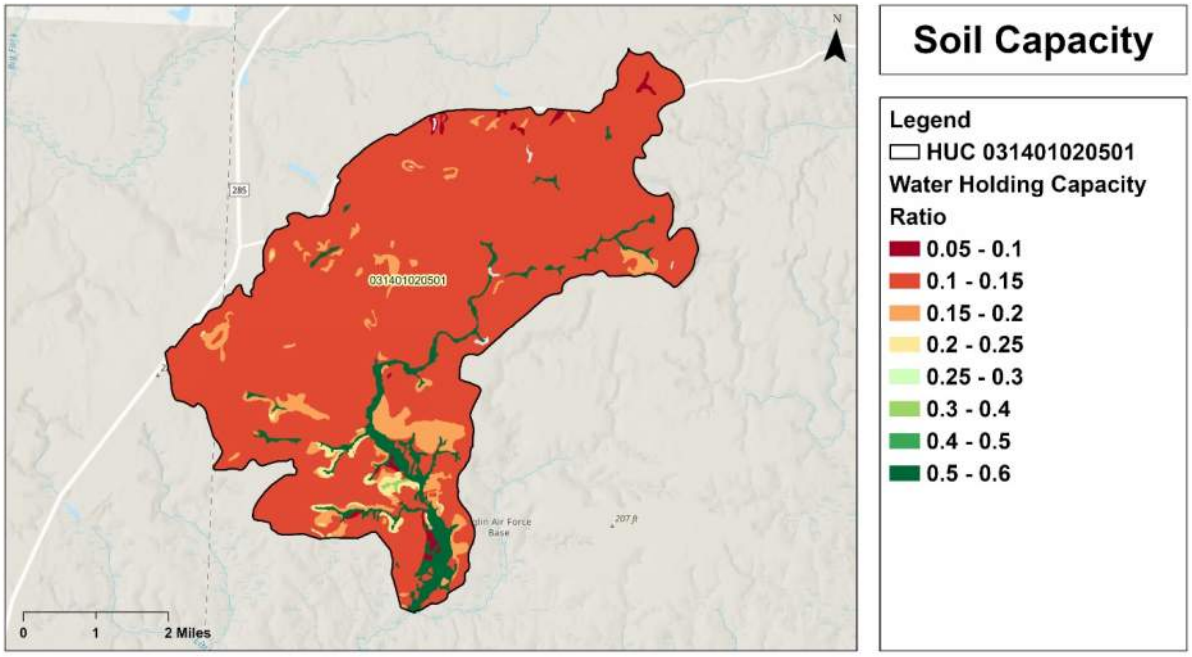

Figure 18. Water Holding Capacity (ratio) for the HUC 031401020501, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

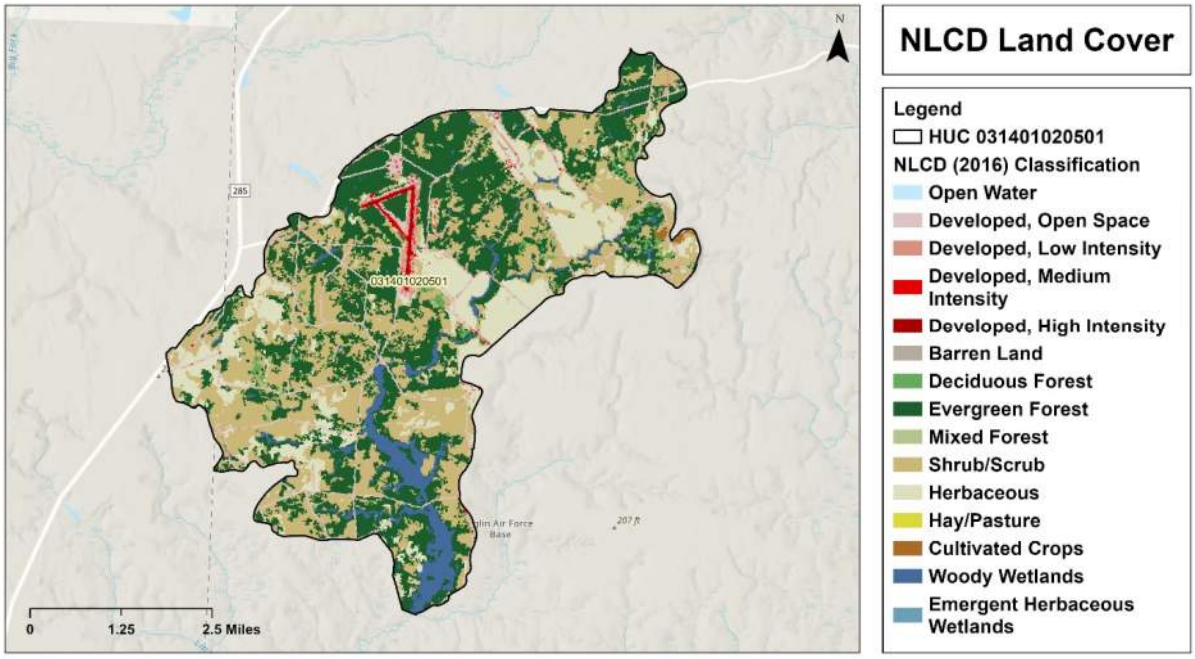

Figure 19. Land use in the HUC 031401020501 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

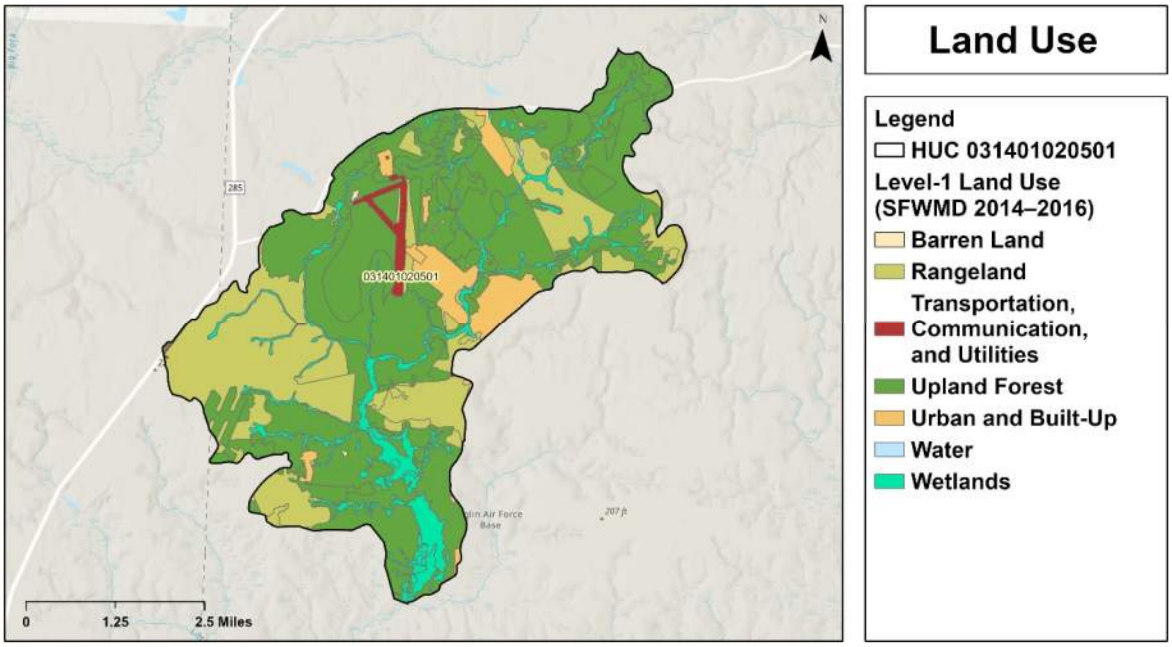

Figure 20. Land use in the HUC 031401020501 (from the (2023 Florida Geographic Data Library (FGDL)), processed by FAU.

In the HUC 031401020501 sub-watershed, the predominant land cover is upland forest, accounting for 57.79% of the area. Rangeland comes in second at 21.58%, followed by Transportation, Communication, and Utilities at 10.90%. Developed land constitutes a minor portion, with only 4.23% categorized as urban and built-up, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031401020501 subwatershed (2023 Florida Geographic Data Library (FGDL))

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	0.00	0.00%
Barren Land	120.59	0.44%
Rangeland	5897.74	21.58%
Transportation, Communication, and Utilities	2979.47	10.90%
Upland Forest	15790.21	57.79%
Urban and Built-Up	1155.95	4.23%
Water	5.28	0.02%
Wetlands	1375.11	5.03%
Grand Total:	**27324.36**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

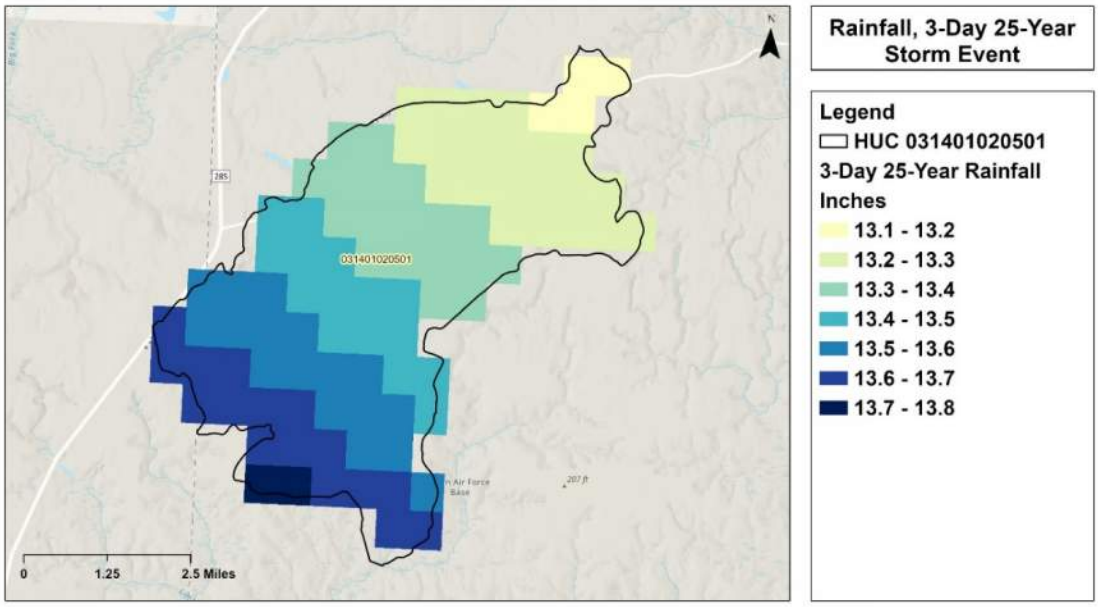

Figure 21. Rainfall distribution map across HUC 031401020501 sub-watershed, for 3-day 25-year storm event, processed by FAU.

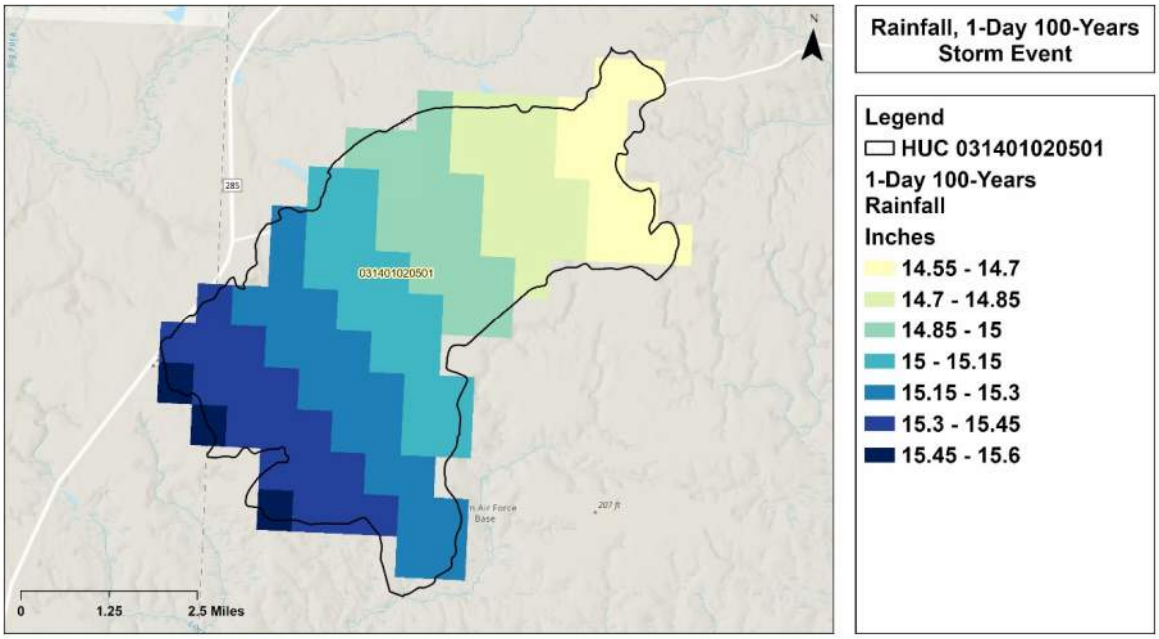

Figure 22. Rainfall distribution map across HUC 031401020501 sub-watershed, for 1-day 100-year storm event, processed by FAU.

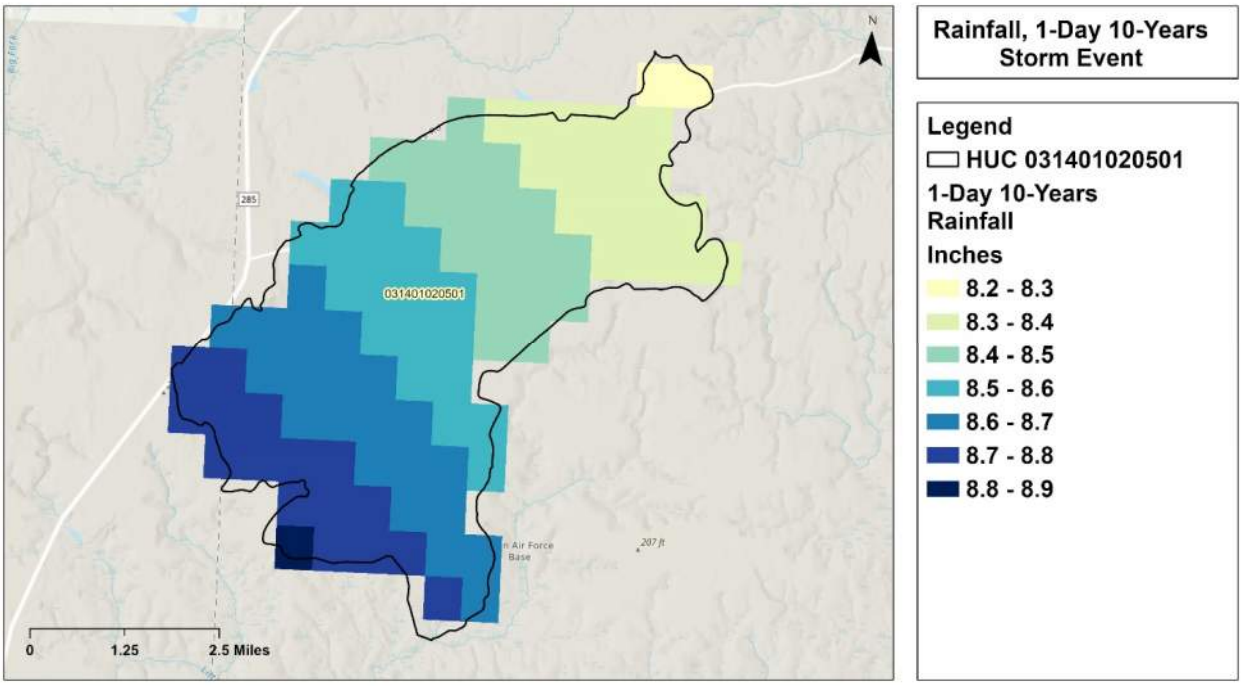

Figure 23. Rainfall distribution map across HUC 031401020501 sub-watershed, for 1-day 10-year storm event, processed by FAU.

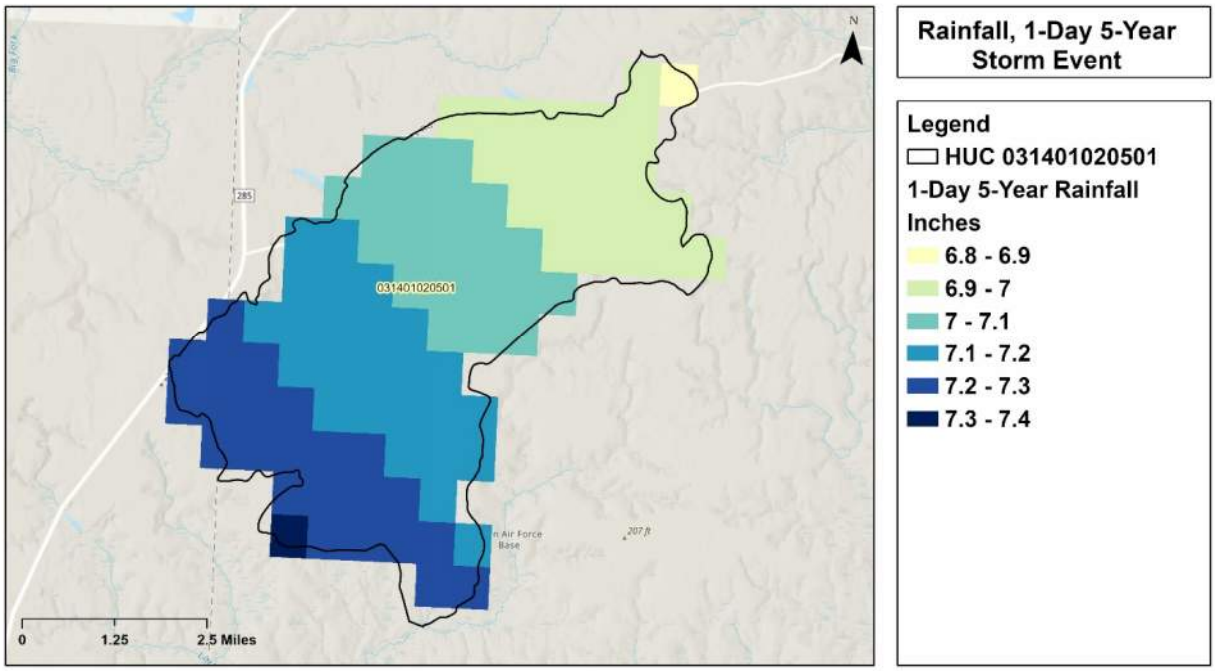

Figure 24. Rainfall distribution map across HUC 031401020501 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer

was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

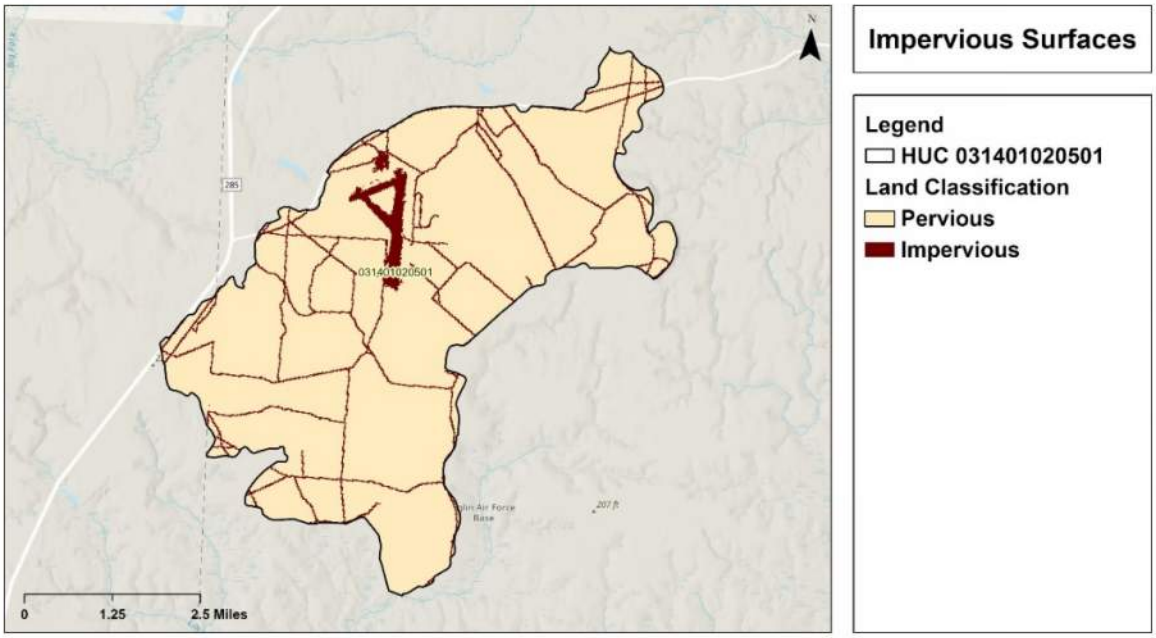

Figure 25. Impervious area map for the HUC 031401020501 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

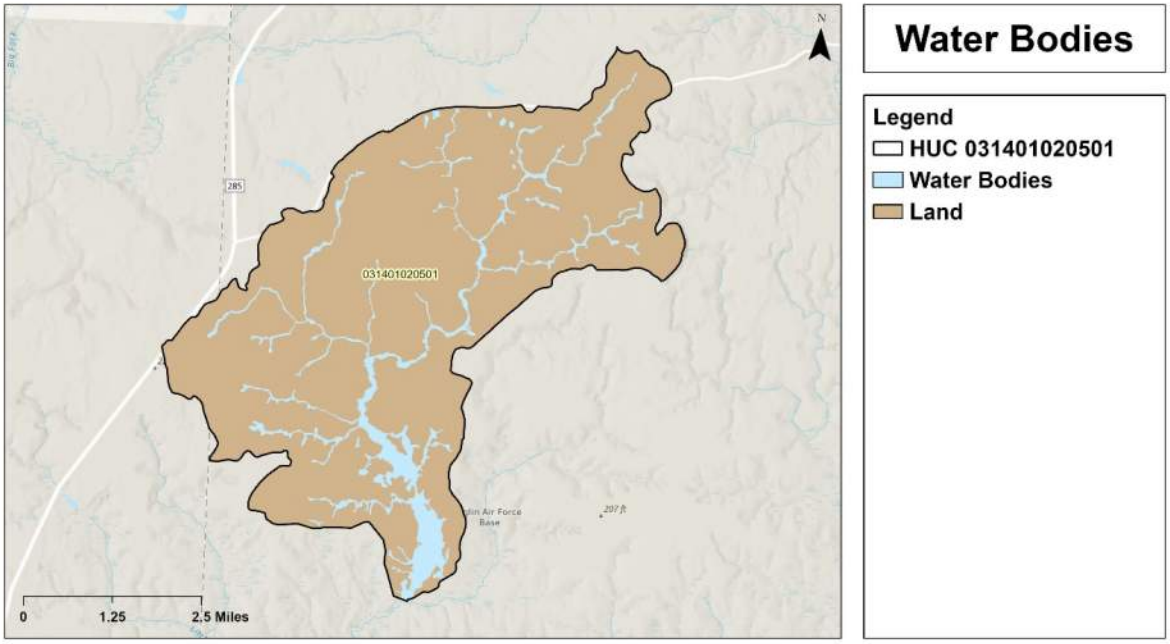

Figure 26. Water bodies map for the HUC 031401020501 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

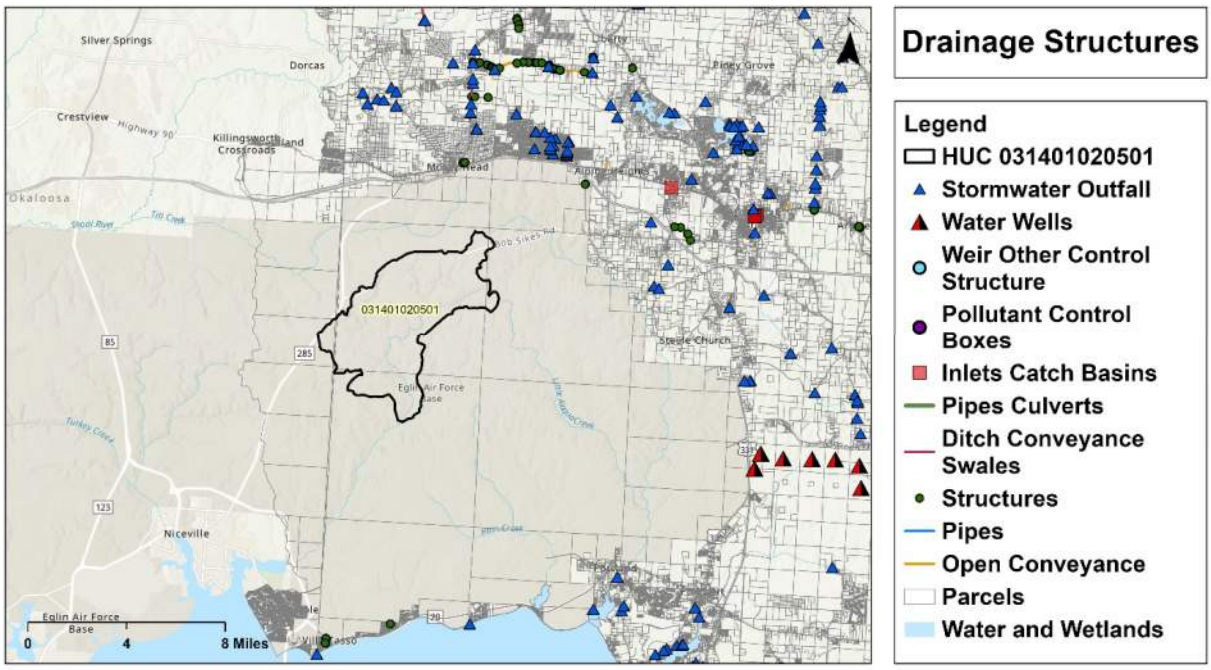

Figure 27. Stormwater Infrastructure for the HUC 031401020501. Processed by FAU.

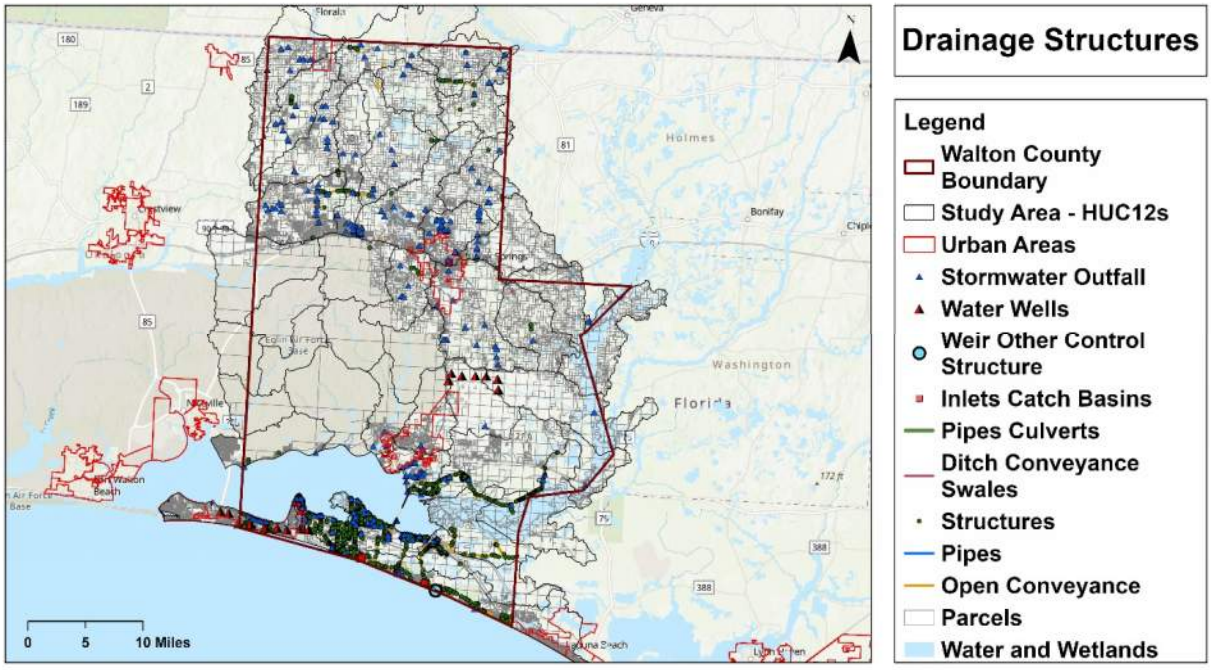

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401020501 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the

coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

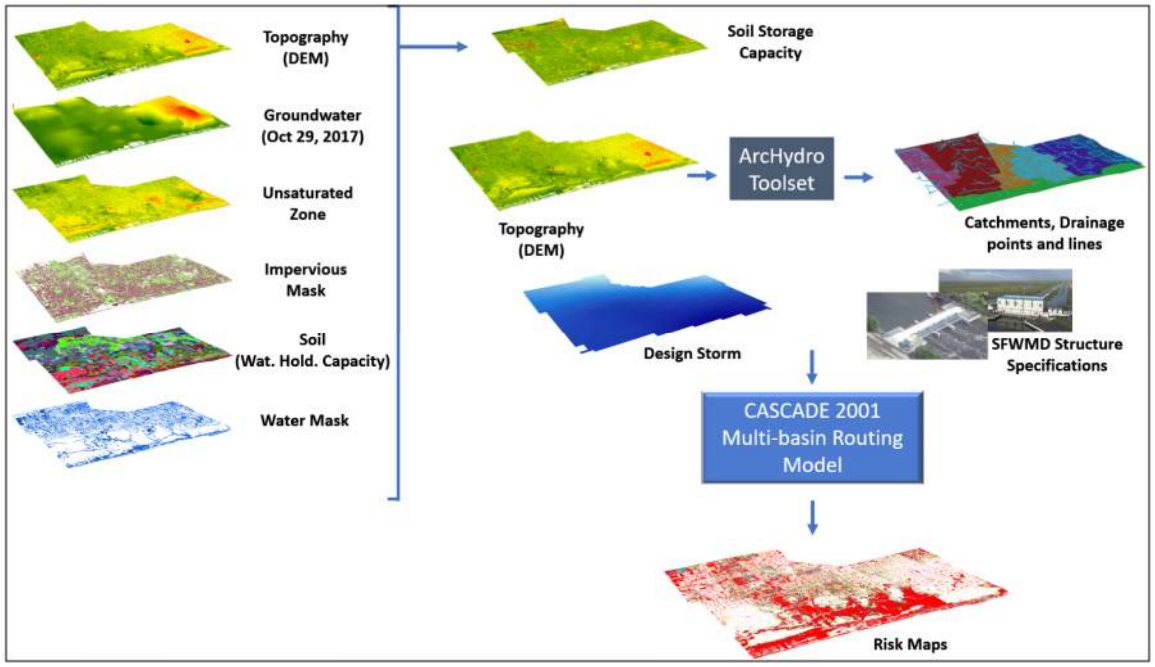

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are

critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

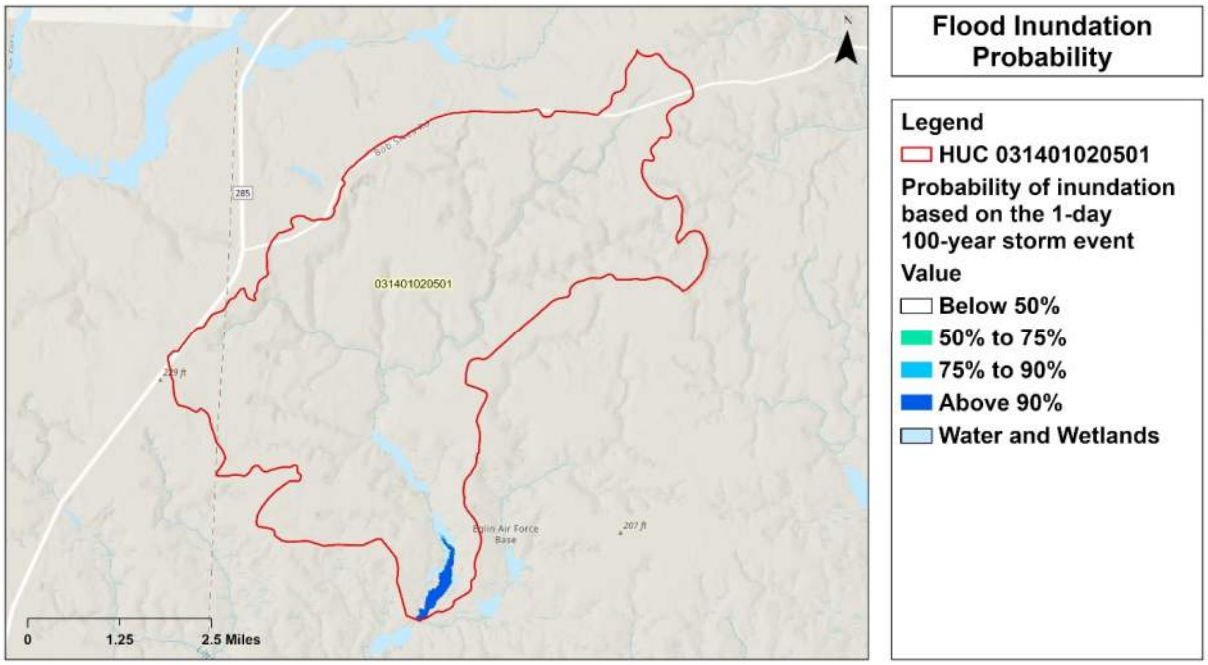

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401020501, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate

the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not

eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a small portion of flooding is noted at the entrance to the creek into the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, sea level rise should not impact the HUC, therefore SLR scenarios were not calculated.

The design storm simulation determined that approximately 0.6% of the HUC total area or 0.15 mi² has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 0.6% of the HUC's total area, or 0.15 mi² would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.5% of the HUC's total area, or 0.11 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0.4% of the HUC's total area, or 0.09 mi², would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401020501 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	25.02	0.15	99.4%	0.6%
1-day 100-year	25.02	0.15	99.4%	0.6%
1-day 10-year	25.05	0.11	99.5%	0.5%
1-day 5-year	25.07	0.09	99.6%	0.4%

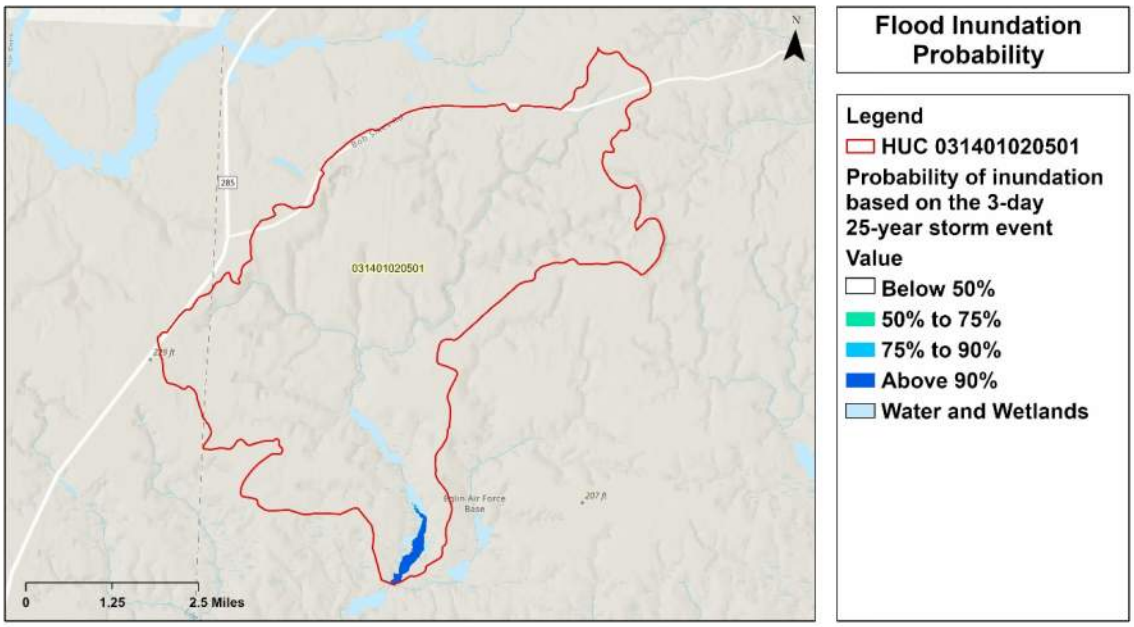

Figure 31. 3-day 25-year storm event for HUC 031401020501 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

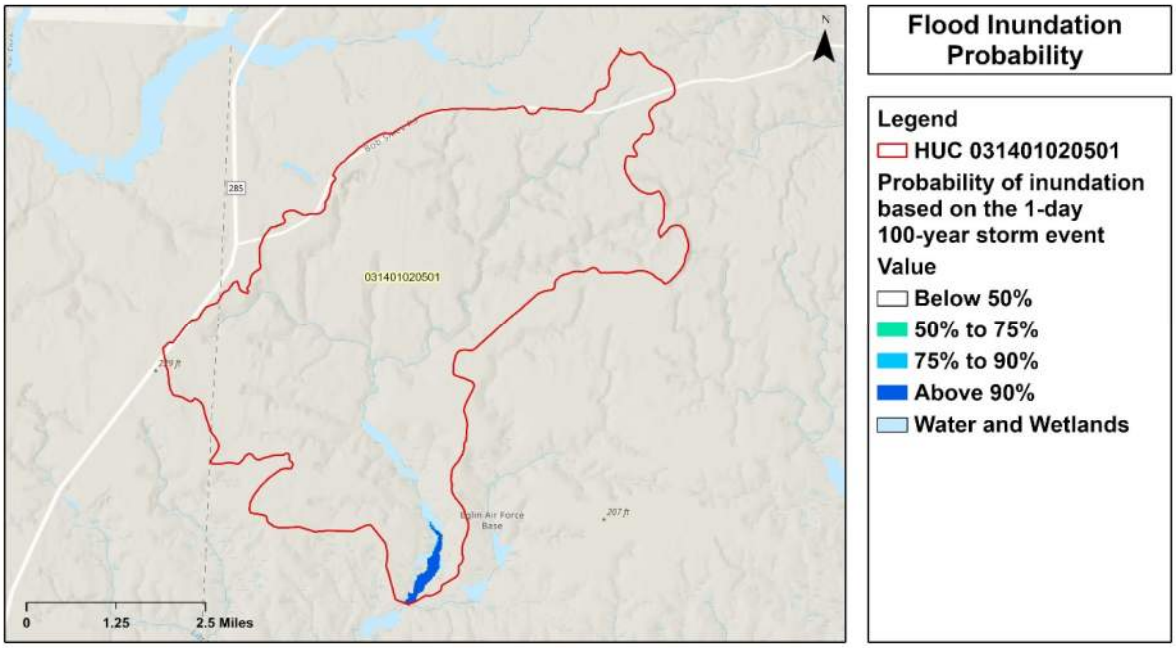

Figure 32. 1-day 100-year storm event for HUC 031401020501 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

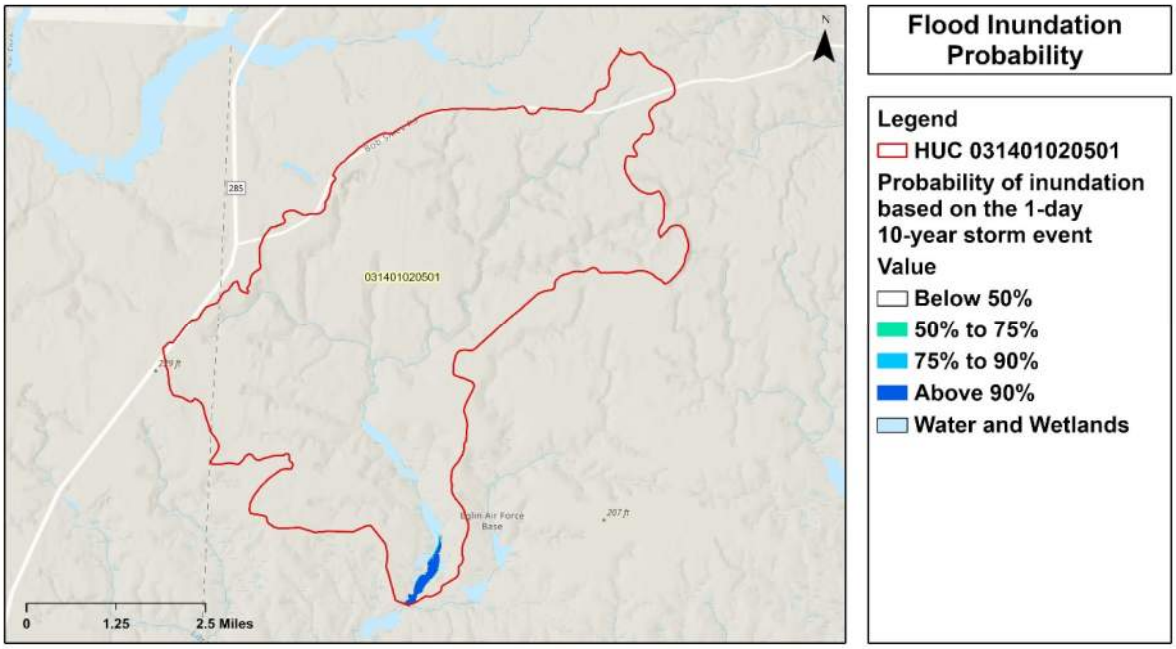

Figure 33. 1-day 10-year storm event for HUC 031401020501 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

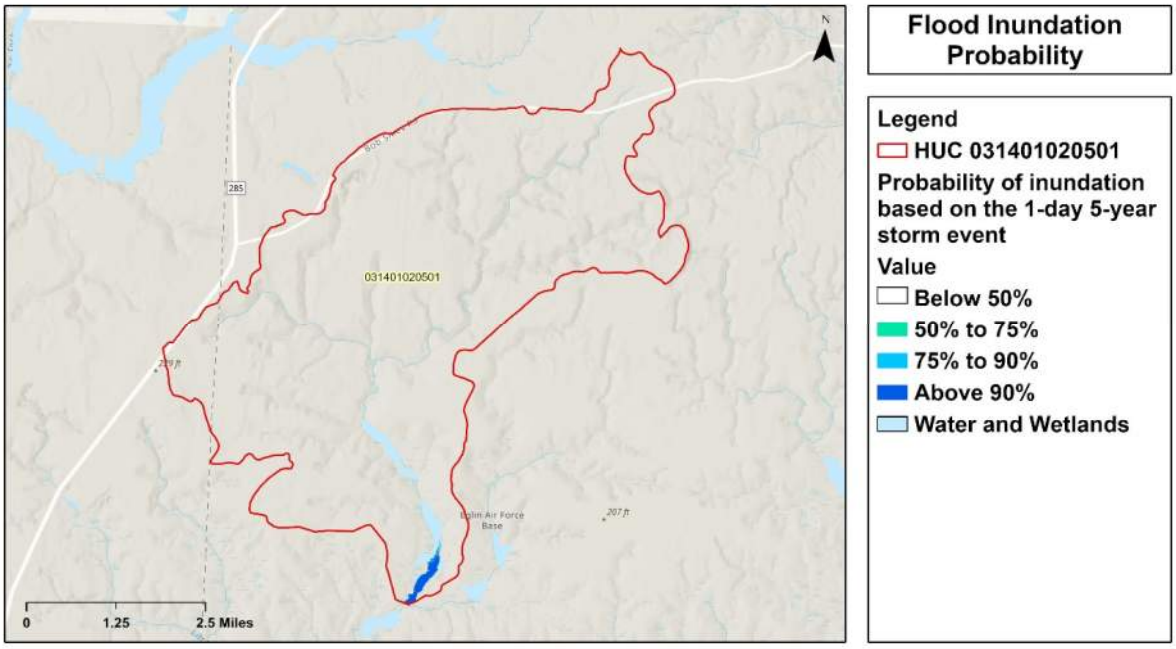

Figure 34. 1-day 5-year storm event for HUC 031401020501 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6

11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5

36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6

60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1

92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4

60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031401020501 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

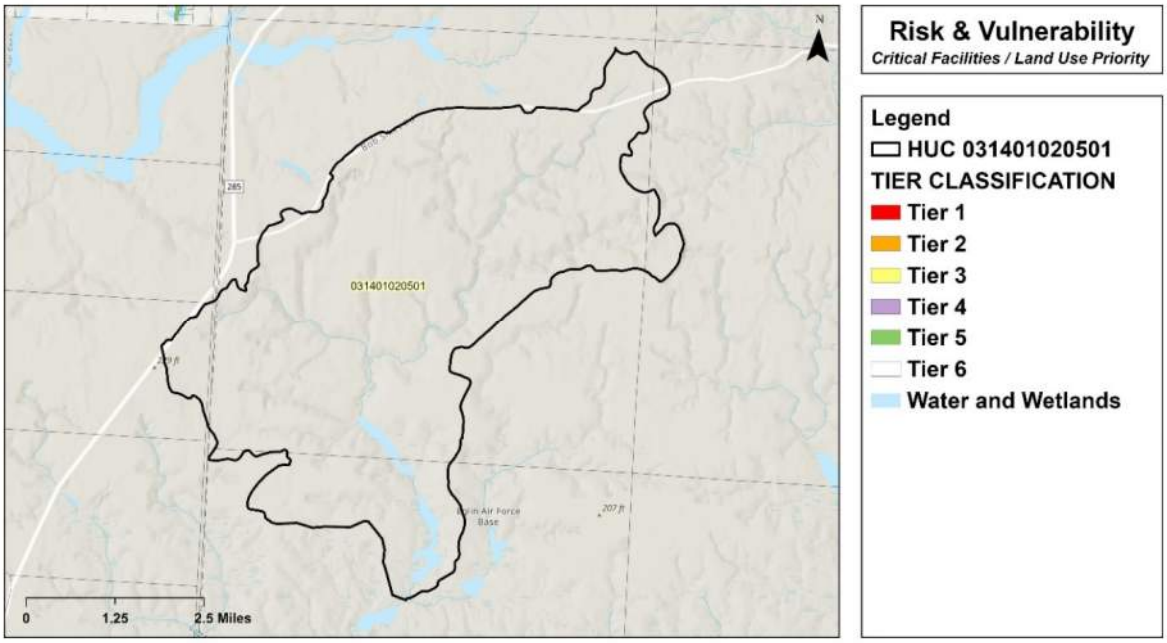

Figure 35. HUC 031401020501 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

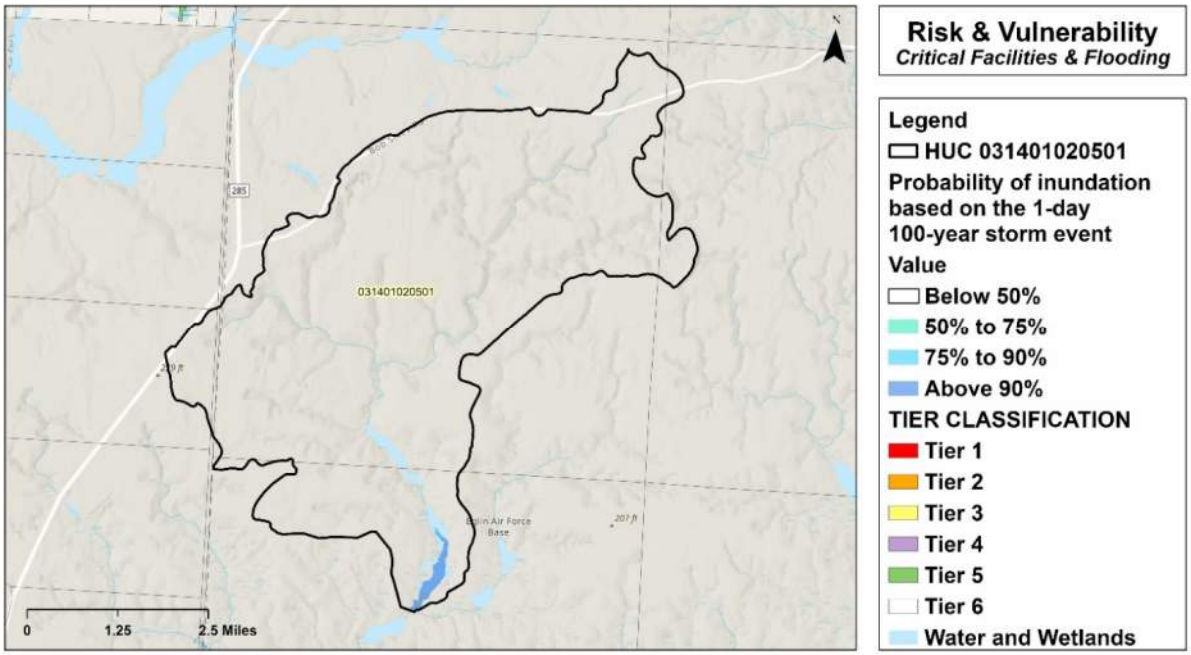

Figure 36. HUC 031401020501 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

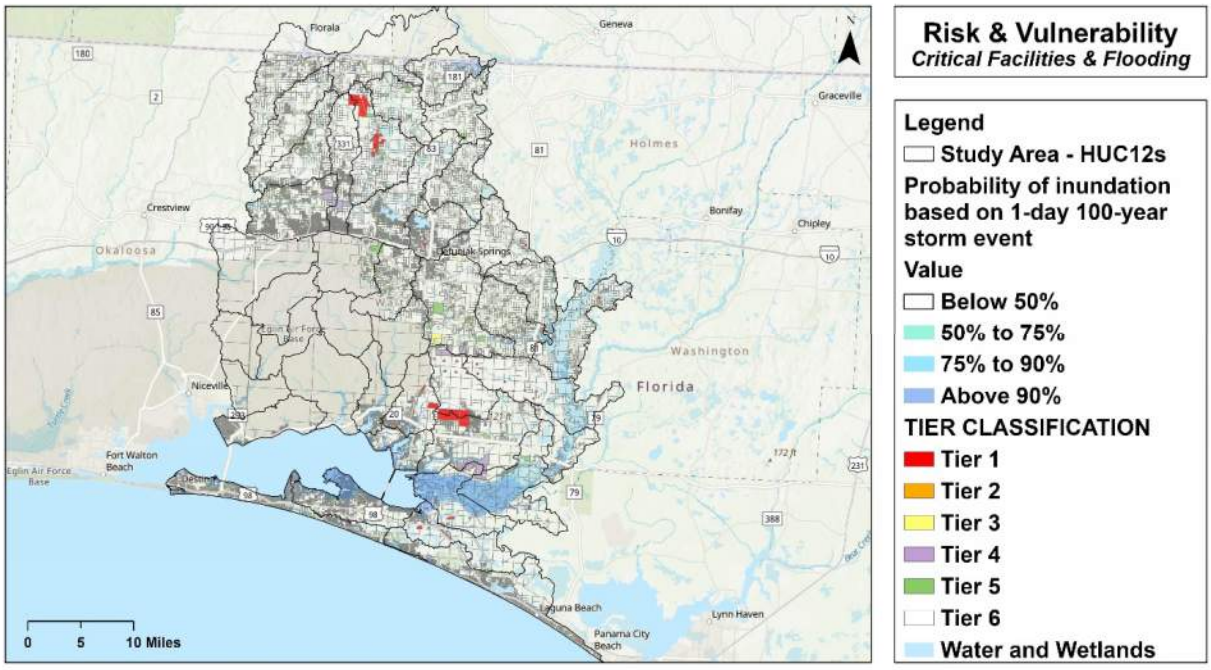

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

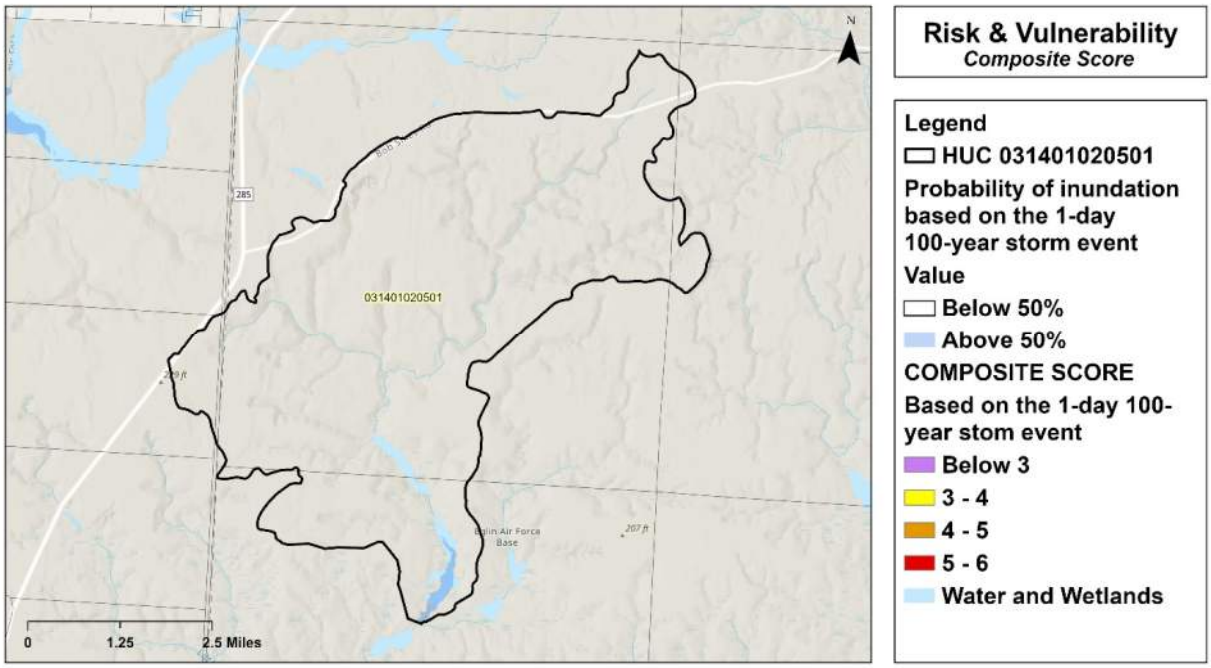

Figure 38. HUC 031401020501 sub-watershed Composite Score Risk map, with calculation based on 1-day 100-year storm event. Processed by FAU.

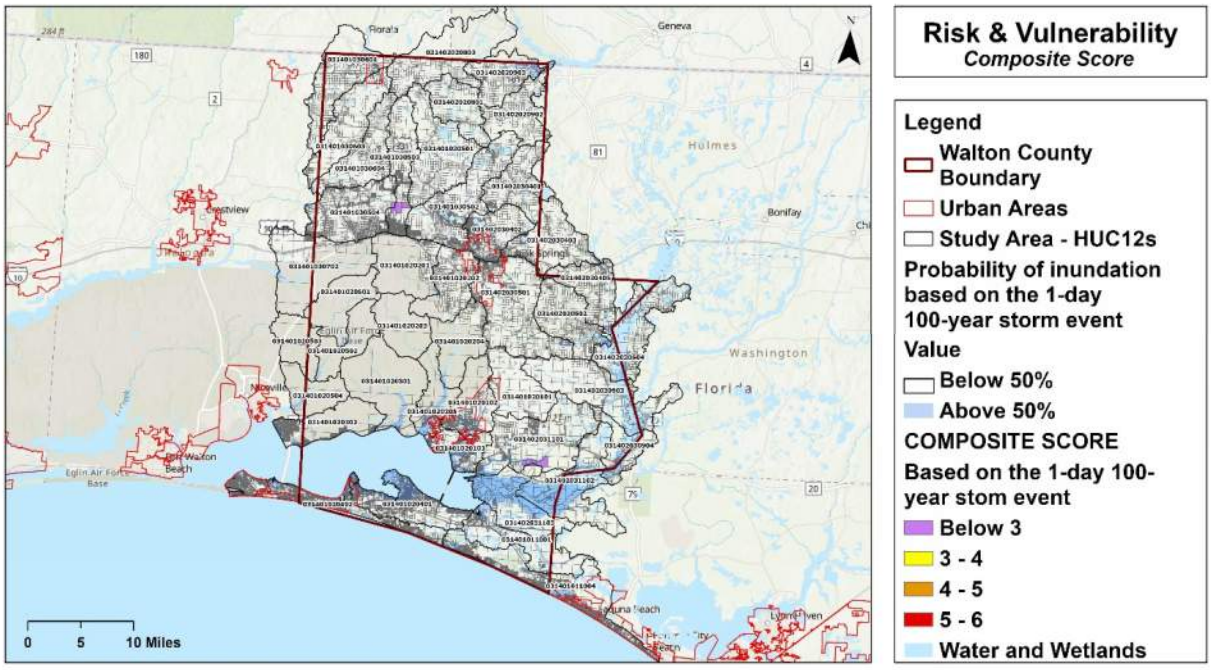

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401020501. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands: This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands: In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401020501. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401020501	16106.26
All of the 1-day 100-year storm event inundation	**93.40**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	57.92
B. Federal Land in 1-day 100-year inundation > 10 acres	35.48
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	0.00
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	0.00

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

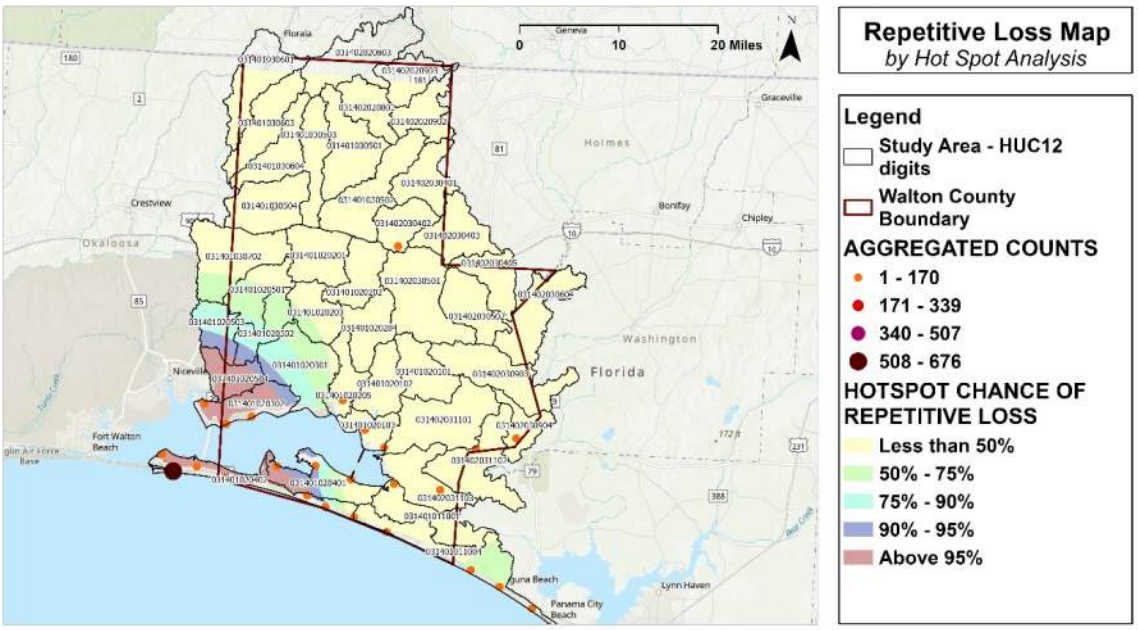

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5. Priority Projects

The entire HUC area is undeveloped and non-coastal. As a result, there are no critical facilities or other land uses that require priority intervention. The minor flooding and null composite score indicate that the HUC is not significantly affected by flooding, and there are no pressing priorities for interventions to address inundation impacts.

APPENDIX Q

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401020502

PAINTER HEAD BRANCH

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Research Assistant: Leticia Sabio

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401020502) is highlighted among all the HUCs to help identifying its location. (Figure 3).

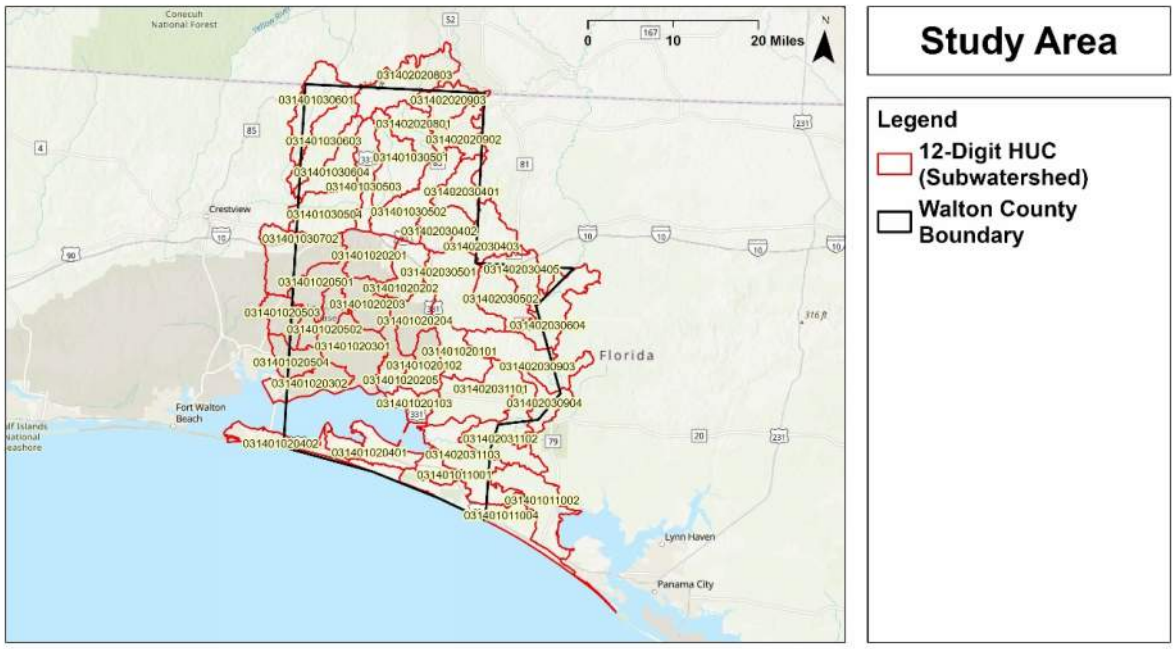

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

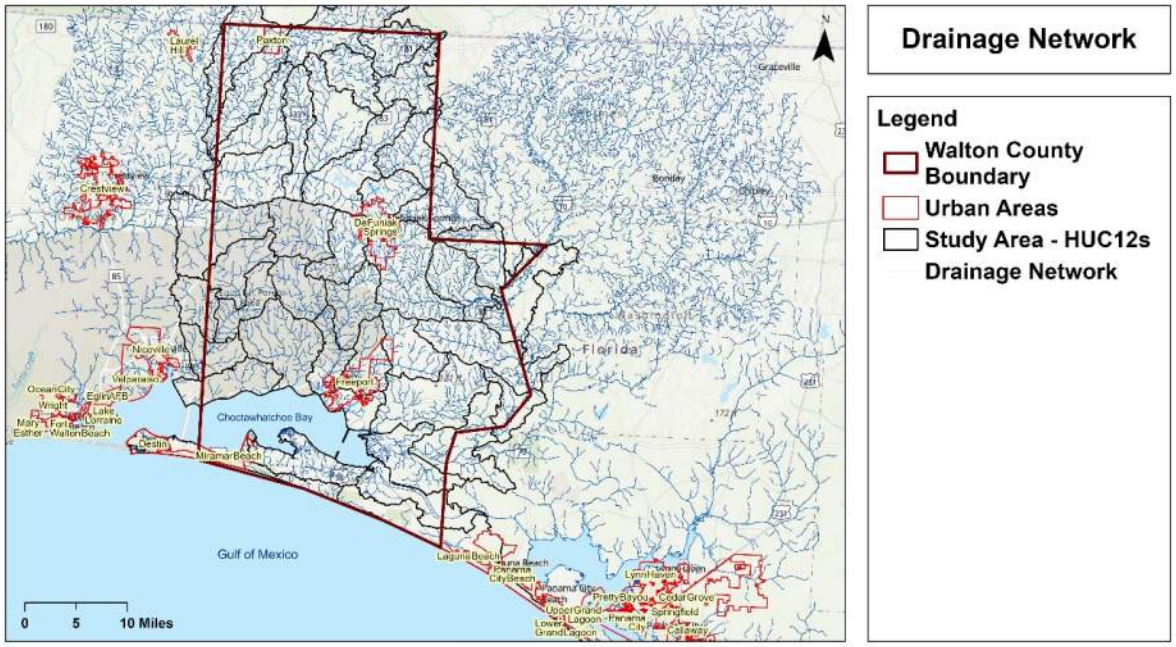

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

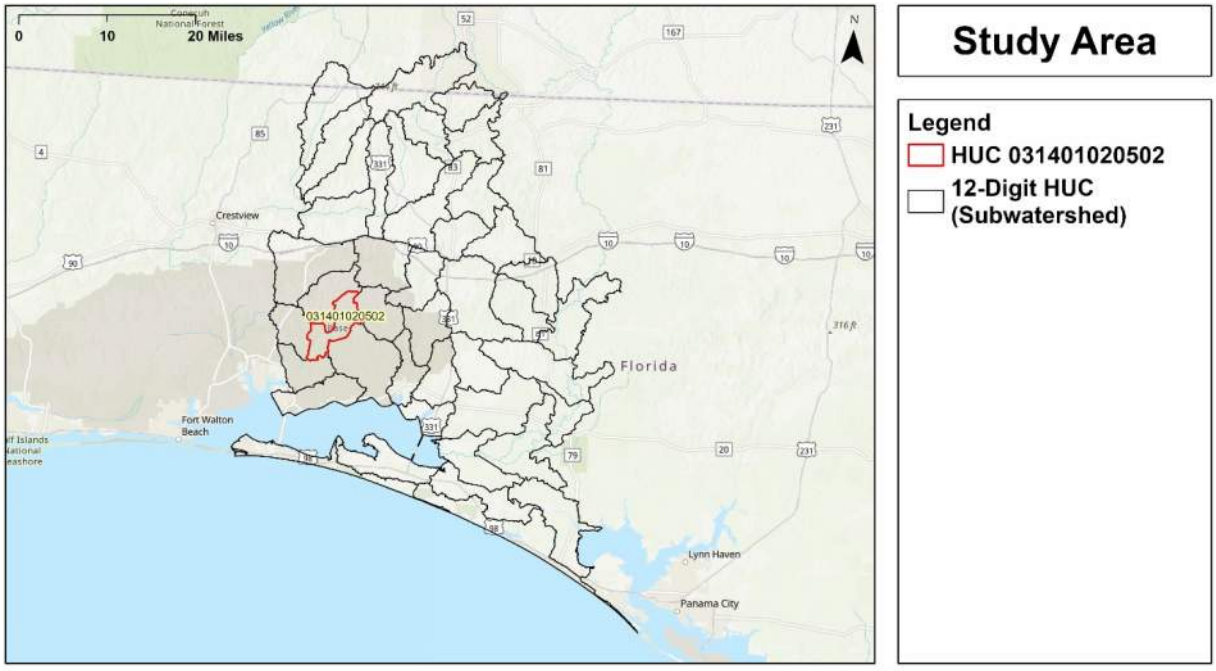

Figure 3. HUC 031401020502 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development, tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

Figures 12 and 13 in the county-wide report show the current and projected land use for the County. Based on the 2017 future land use map for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL))

Level 1 Land Use-Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 1.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.

- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

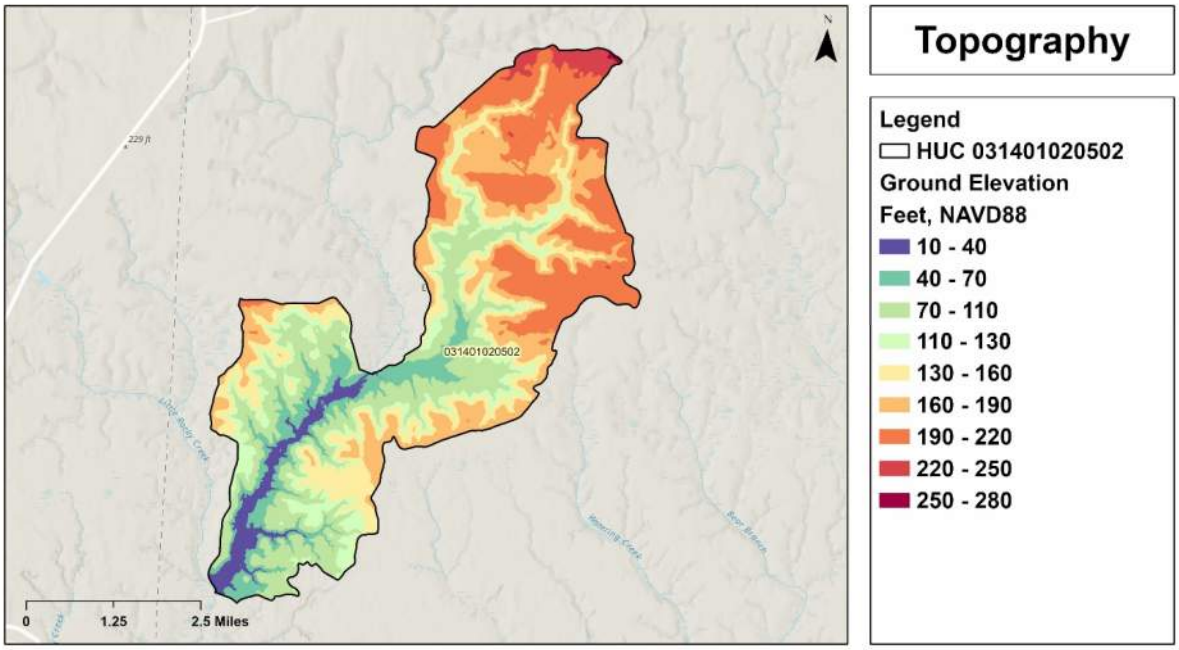

Figure 4. Topographic map of the HUC 031401020502 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401020502 sub-watershed is shown in **Error! Reference source not found.**.

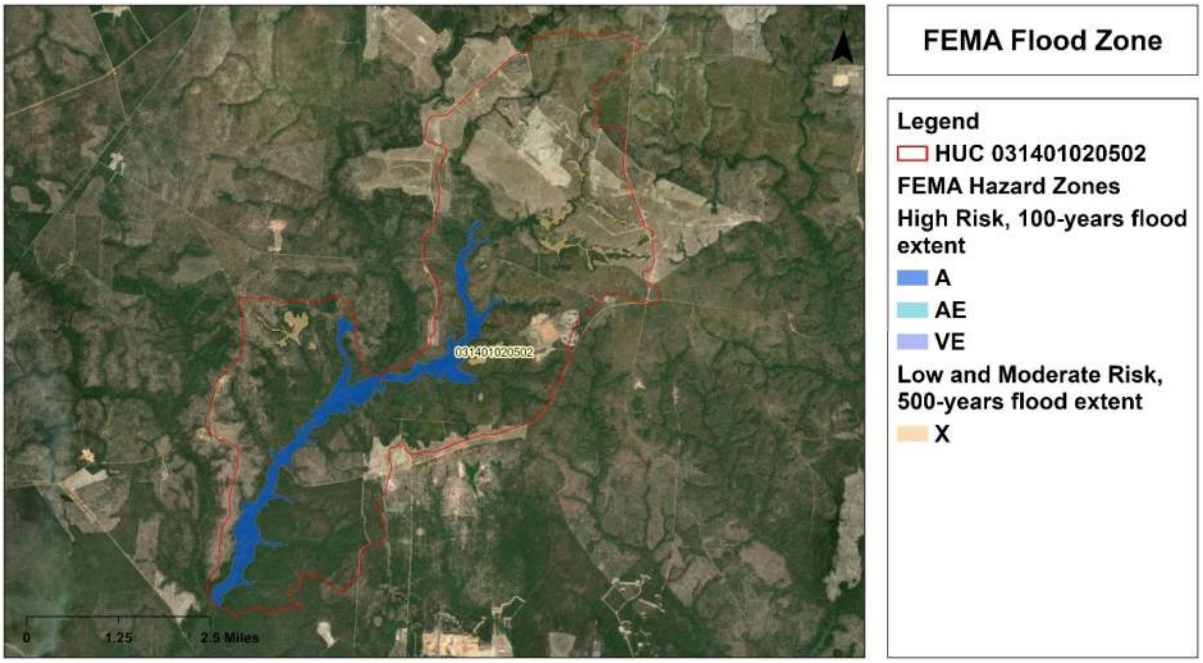

Figure 5. FEMA Flood Zone map (2020) for HUC 031401020502 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401020502 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing.

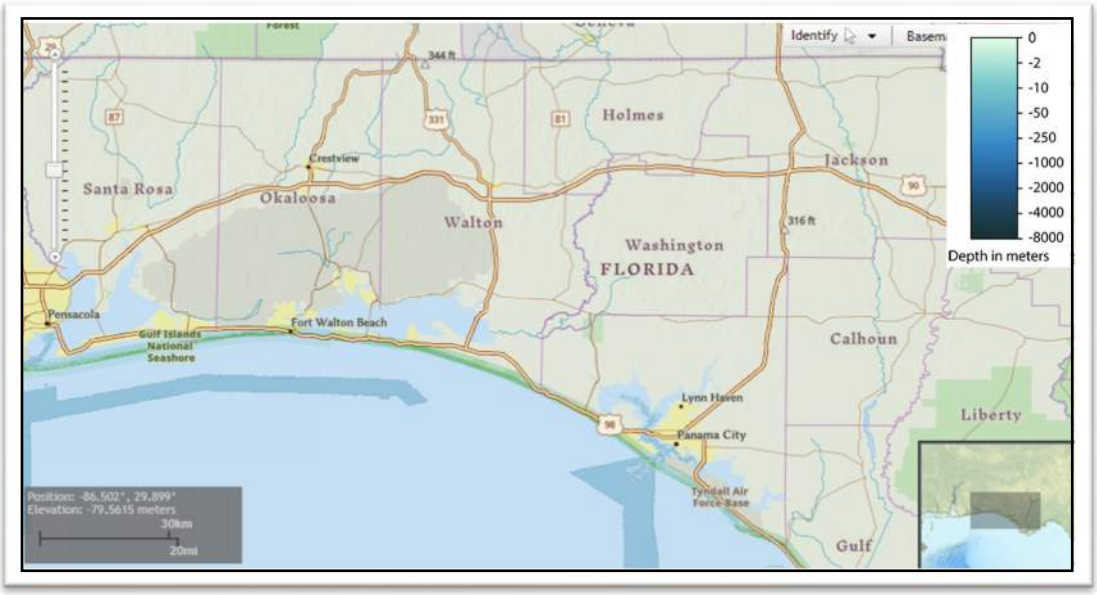

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

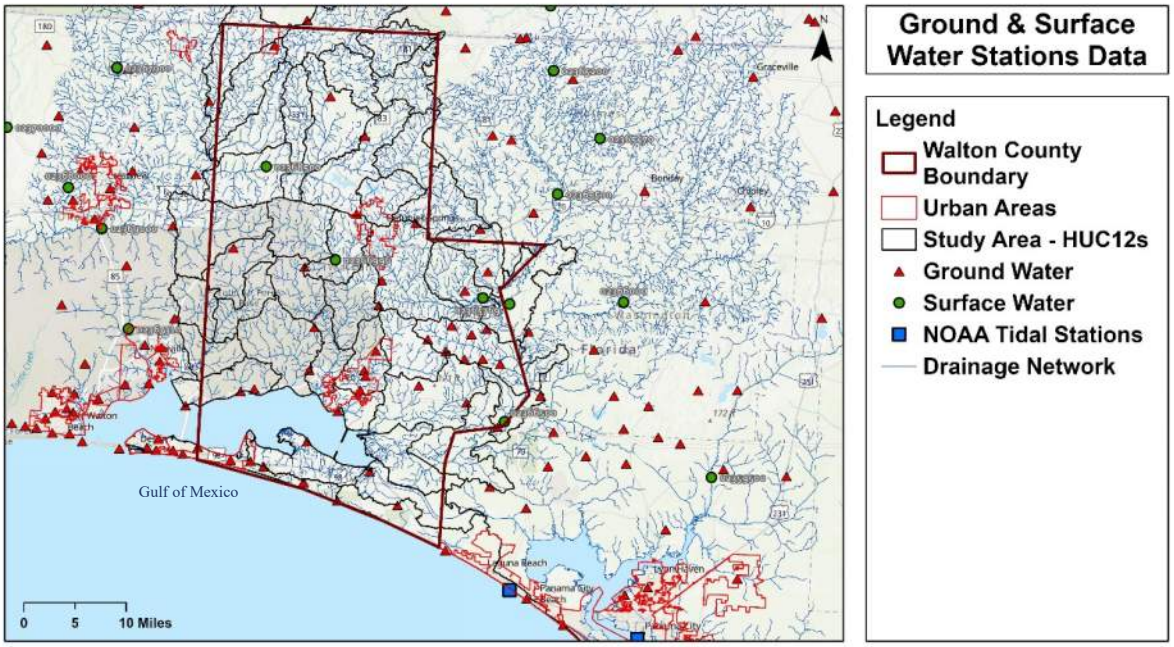

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031401020502 has no major rivers and canals, but creeks and branches include:

- Cedar Head Branch
- Rocky Creek
- Fox Branch
- Old Peg Branch

- Schoolhouse Branch
- East Rocky Creek
- Open Branch

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366996. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401020502, which is USGS 02366996 Alaqua Creek Near Pleasant Ridge, FL.

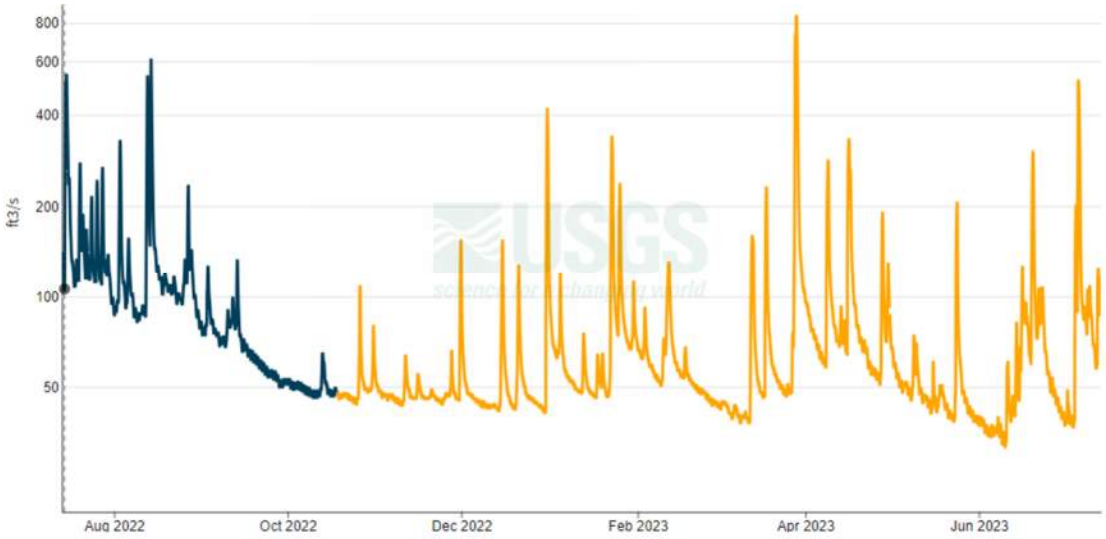

Figure 8. Average streamflow for Alaqua Creek Near Pleasant Ridge, FL (USGS 02366996 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366996/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station

(or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401020502 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031401020502 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

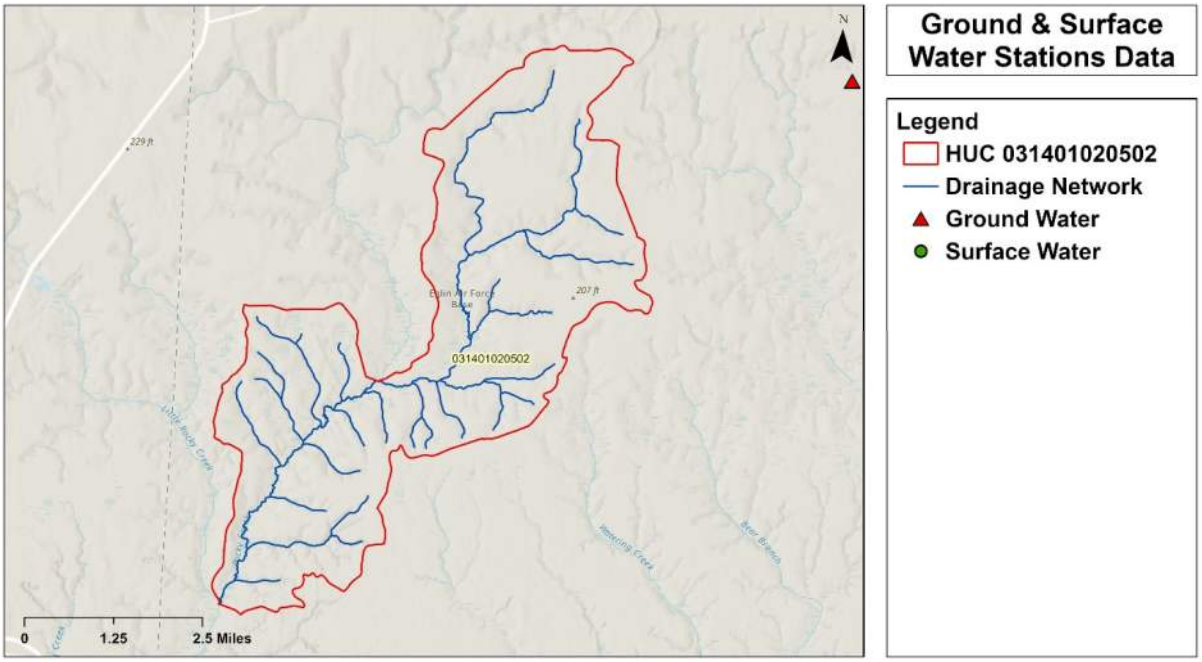

Figure 9. Ground and Surface Water Stations in the HUC 031401020502 sub-watershed, processed by FAU.

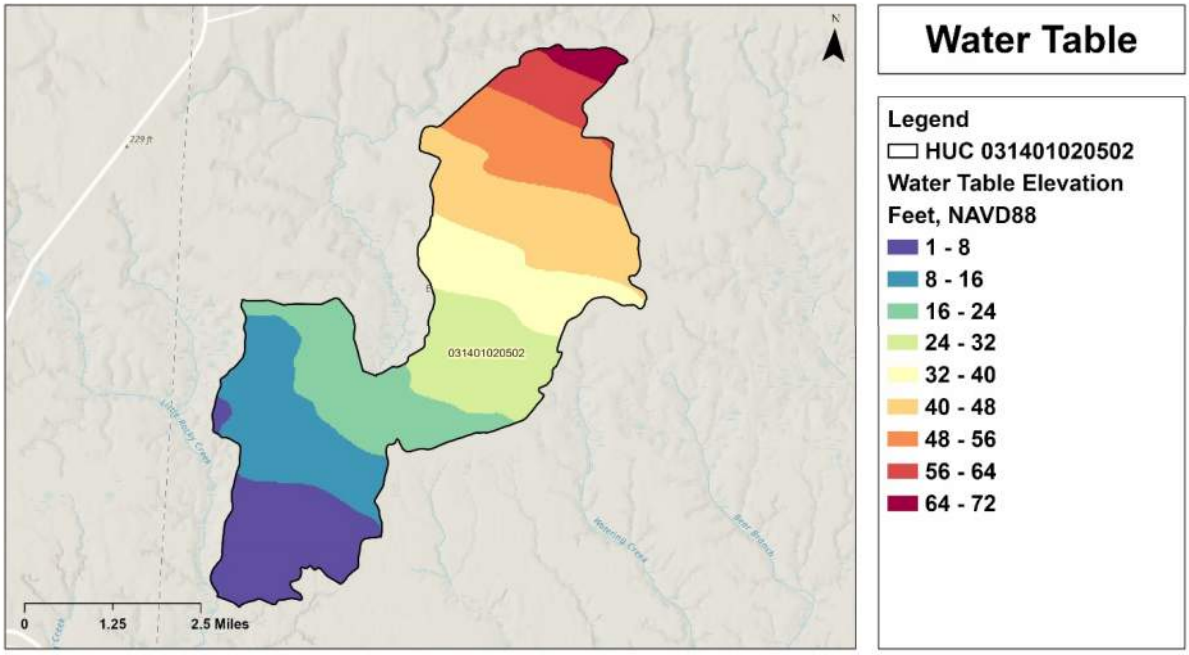

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401020502 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

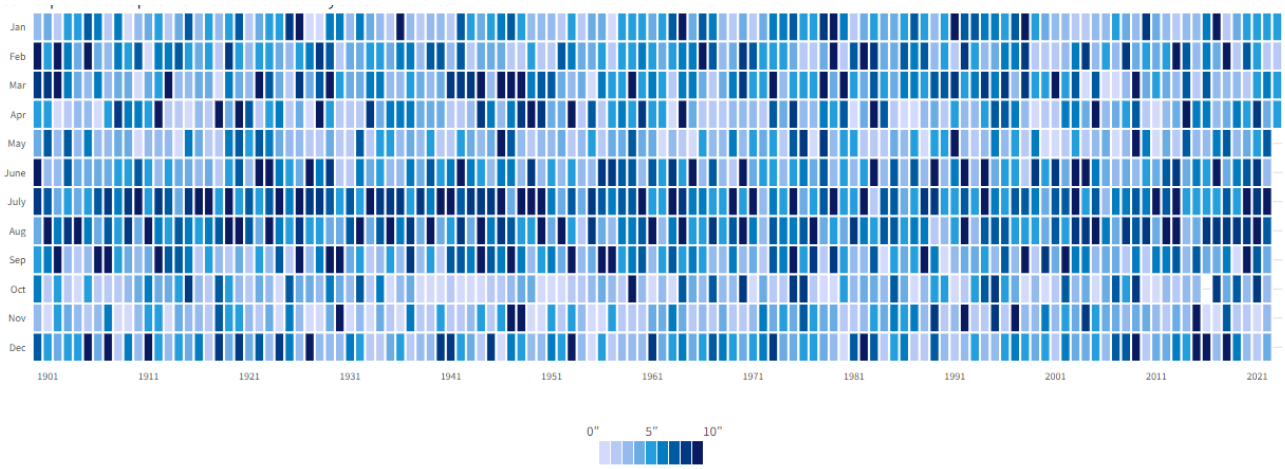

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/).

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

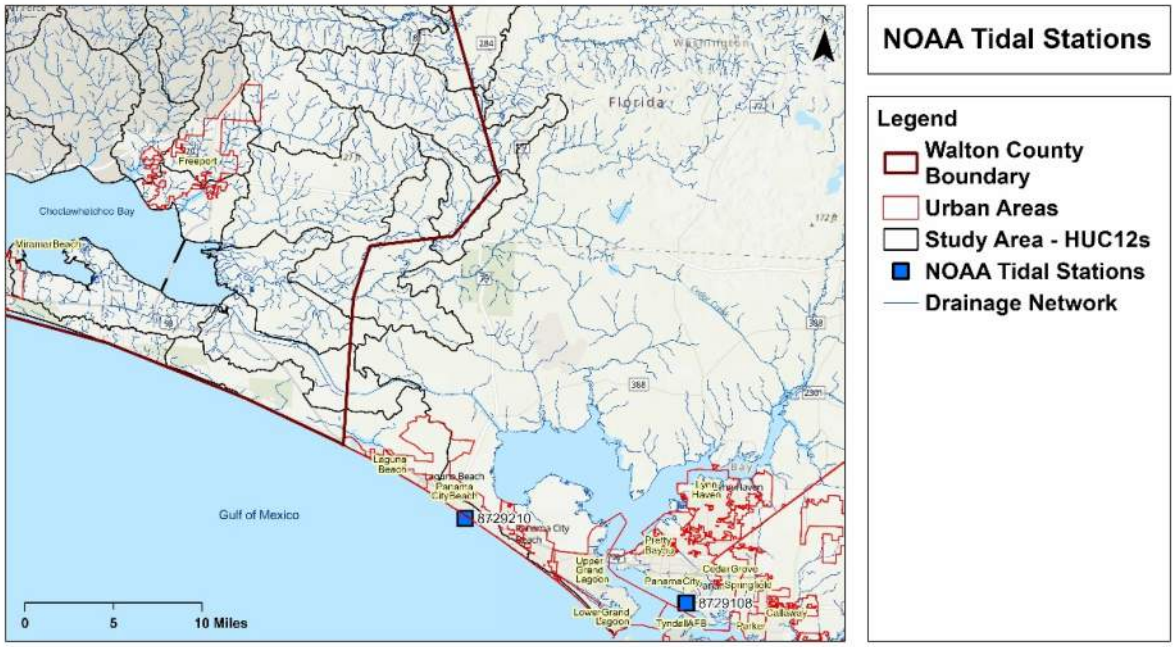

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

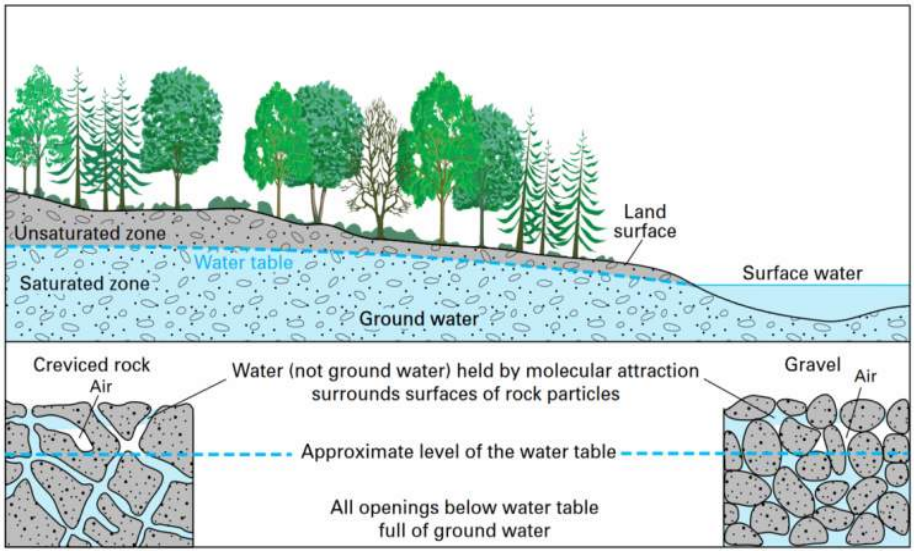

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

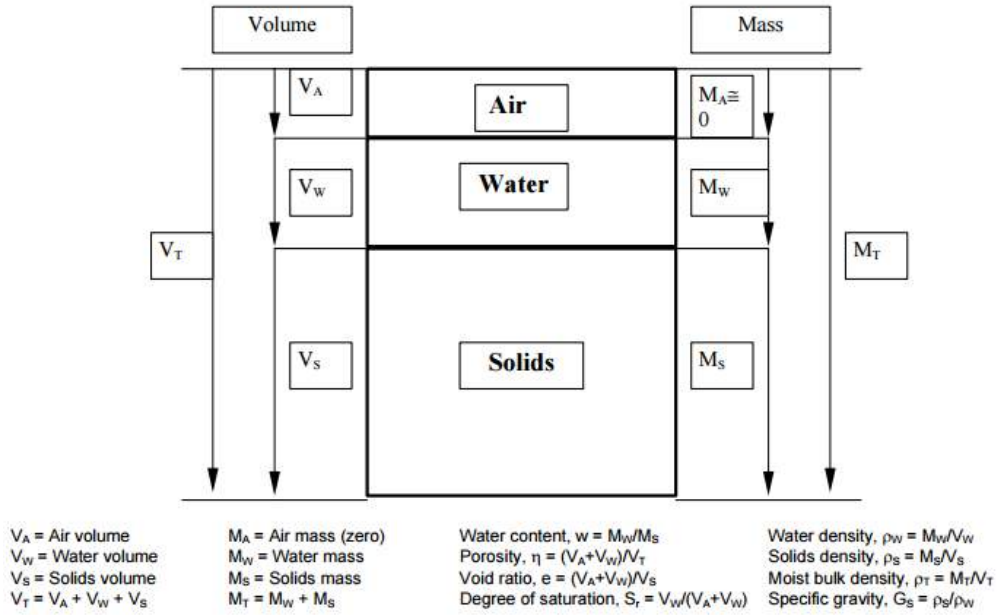

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

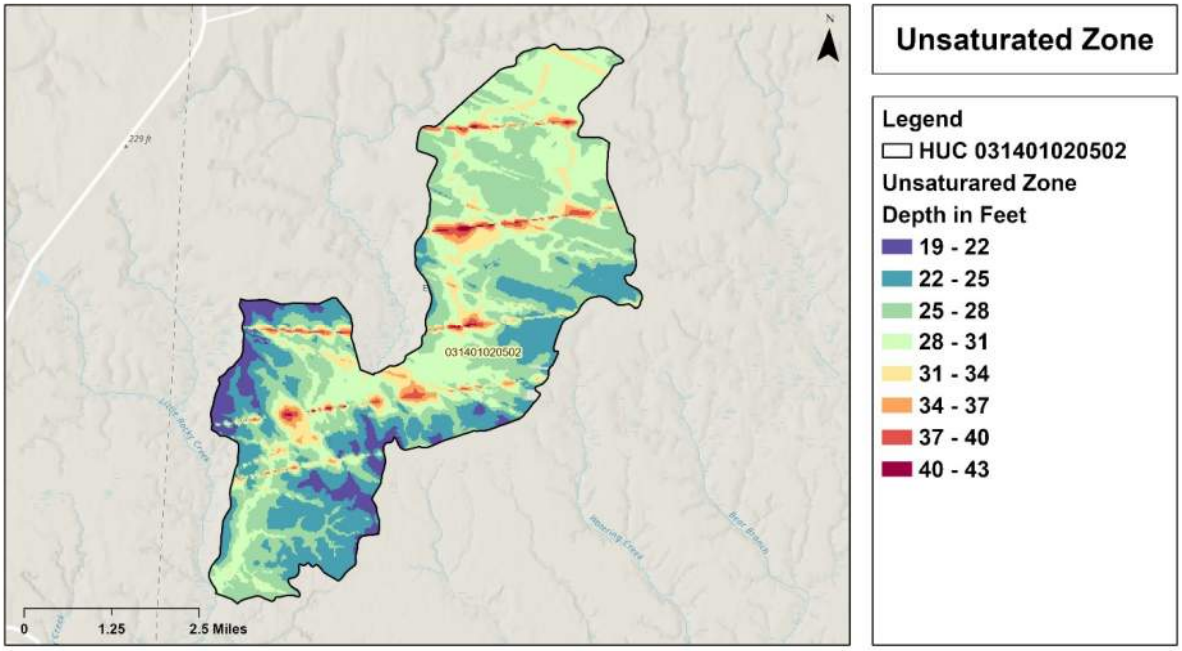

Figure 15. Unsaturated zone map for HUC 031401020502, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately favorable soil storage capacity, falling within the range of 22 to 34 feet of remaining capacity.

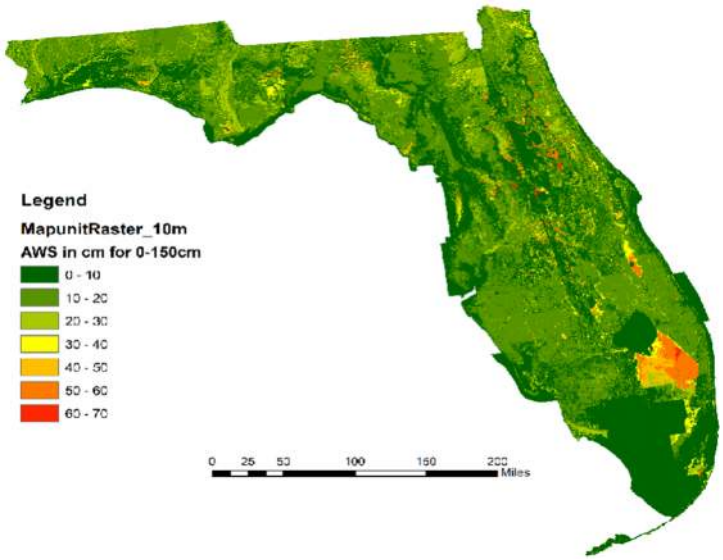

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

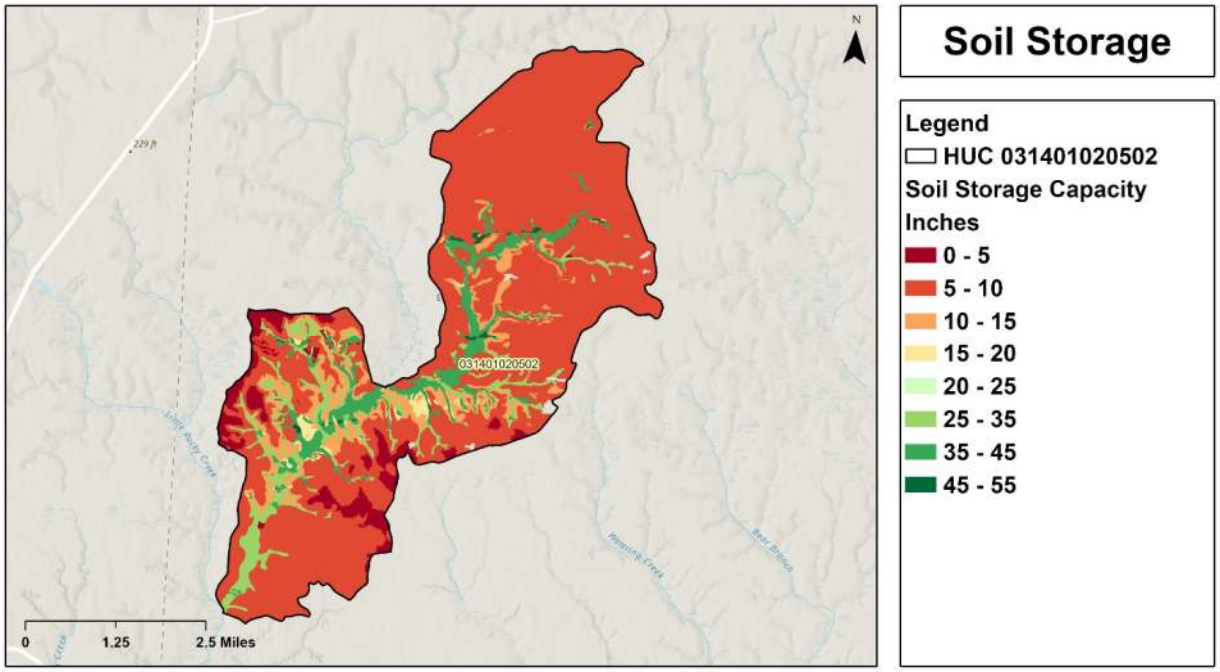

Figure 17. Water storage capacity of soil for the HUC 031401020502, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

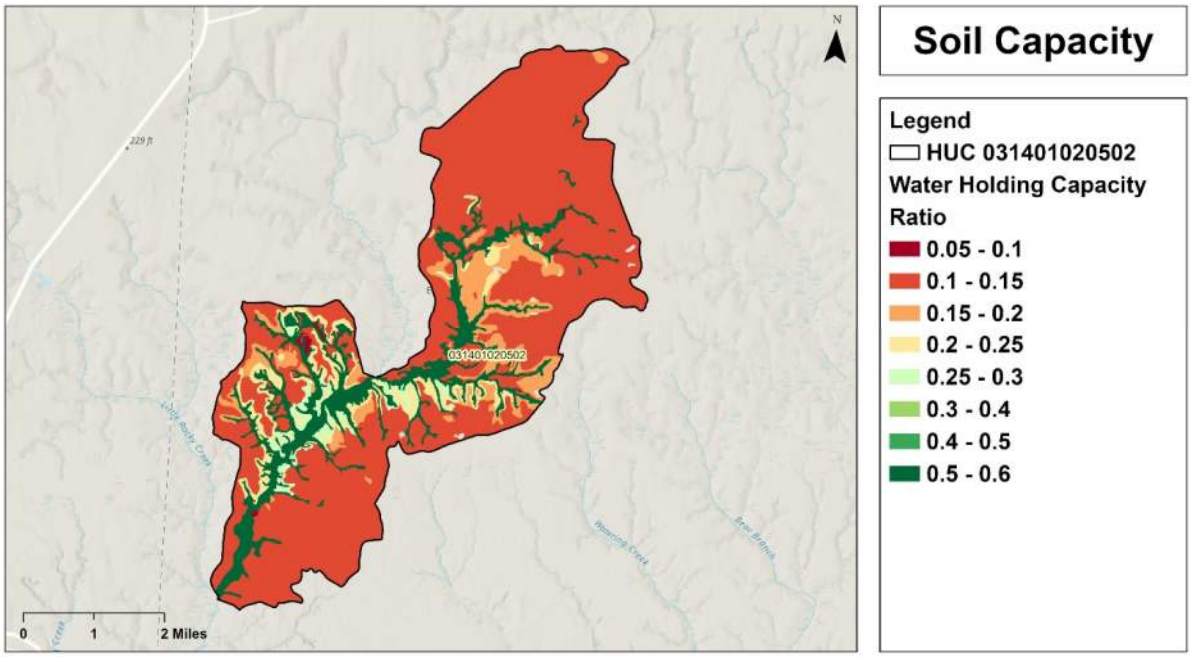

Figure 18. Water Holding Capacity (ratio) for the HUC 031401020502, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

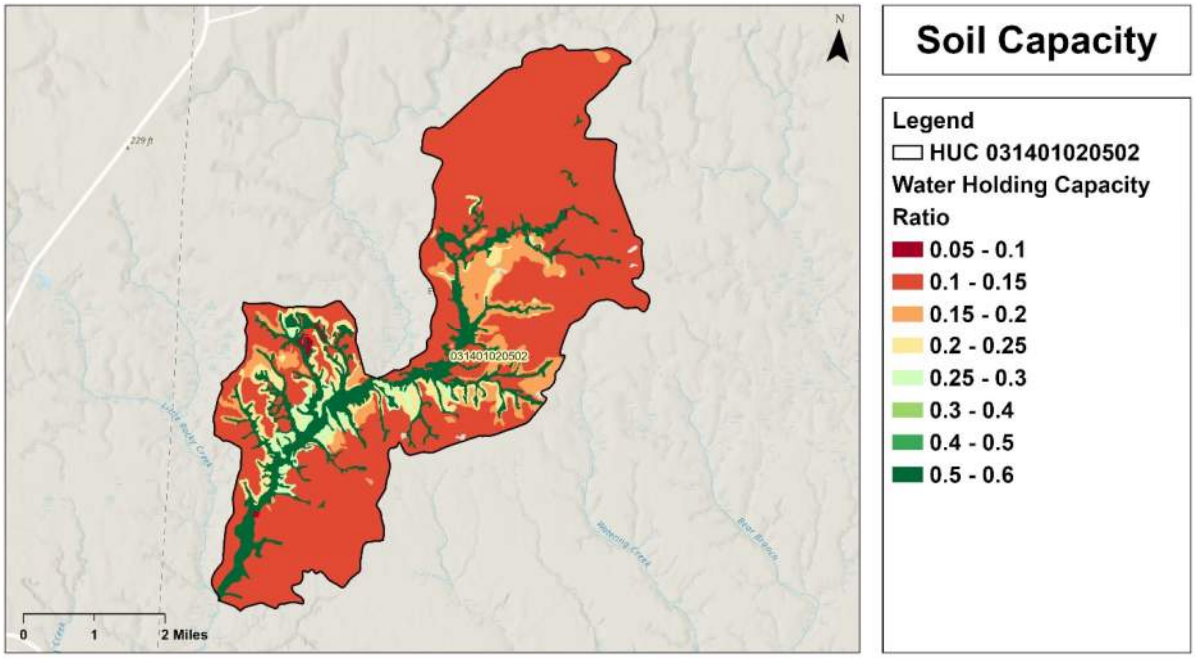

Figure 19. Land use in the HUC 031401020502 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

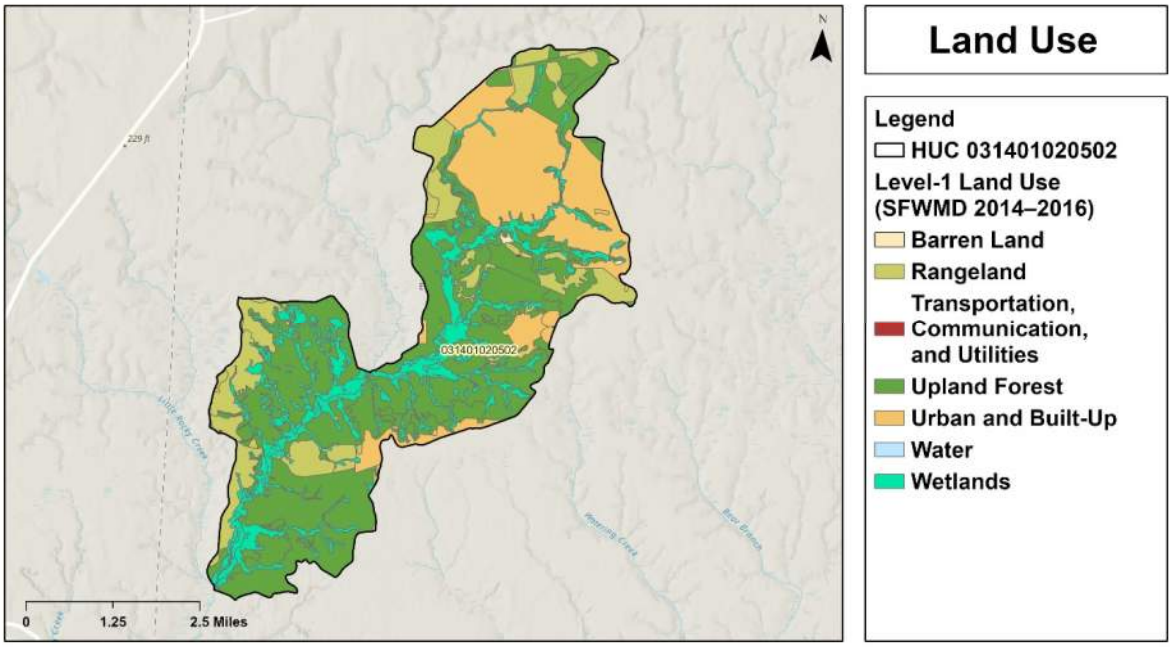

Figure 20. Land use in the HUC 031401020502 (from the (2023 Florida Geographic Data Library (FGDL)), processed by FAU.

In the HUC 031401020502 sub-watershed, the predominant land cover is upland forest, accounting for 54.06% of the area. Urban and built-up comes in second at 17.60%, followed by rangeland at 17.53%, and wetlands at 10.52%, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031401020502 subwatershed (2023 Florida Geographic Data Library (FGDL))

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	0.00	0.00%
Barren Land	26.46	0.12%
Rangeland	3994.12	17.53%
Transportation, Communication, and Utilities	3.42	0.01%
Upland Forest	12313.66	54.06%
Urban and Built-Up	4008.33	17.60%
Water	37.96	0.17%
Wetlands	2395.47	10.52%
Grand Total:	**22779.43**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

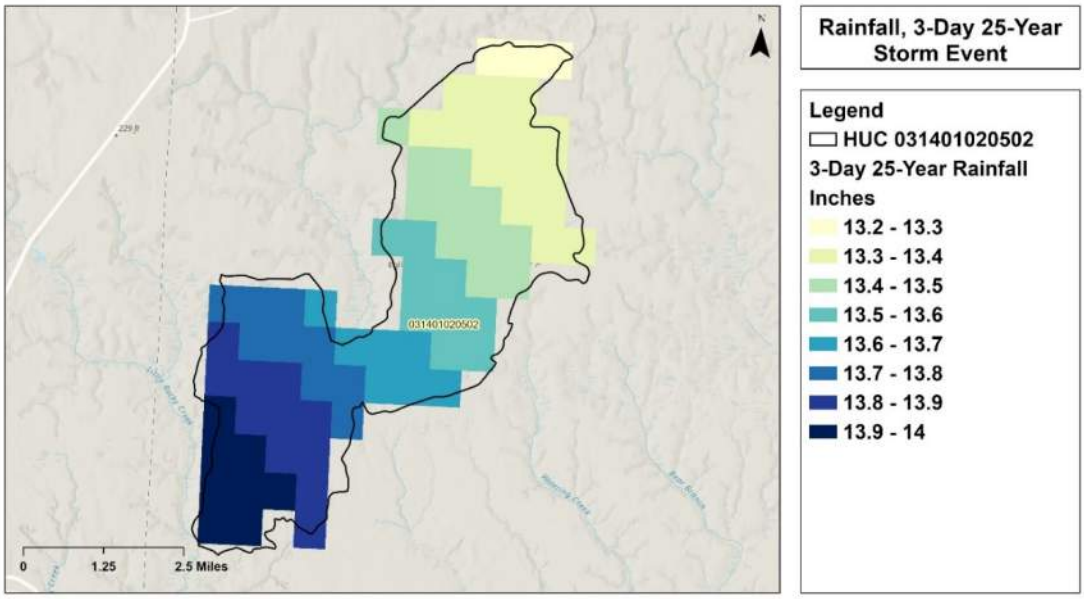

Figure 21. Rainfall distribution map across HUC 031401020502 sub-watershed, for 3-day 25-year storm event, processed by FAU.

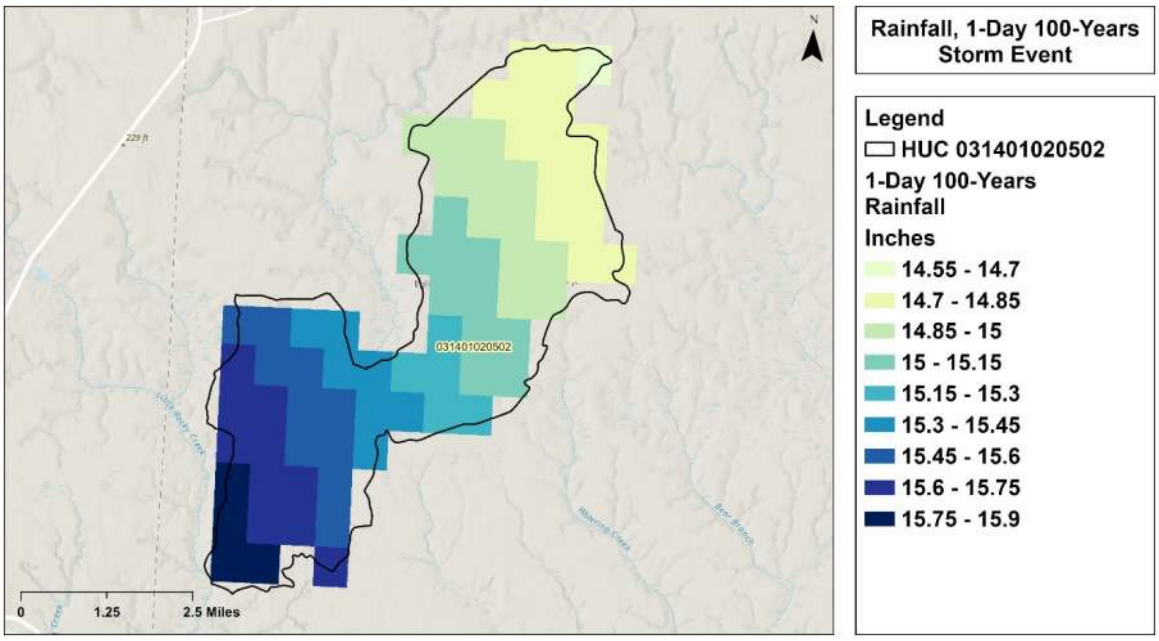

Figure 22. Rainfall distribution map across HUC 031401020502 sub-watershed, for 1-day 100-year storm event, processed by FAU.

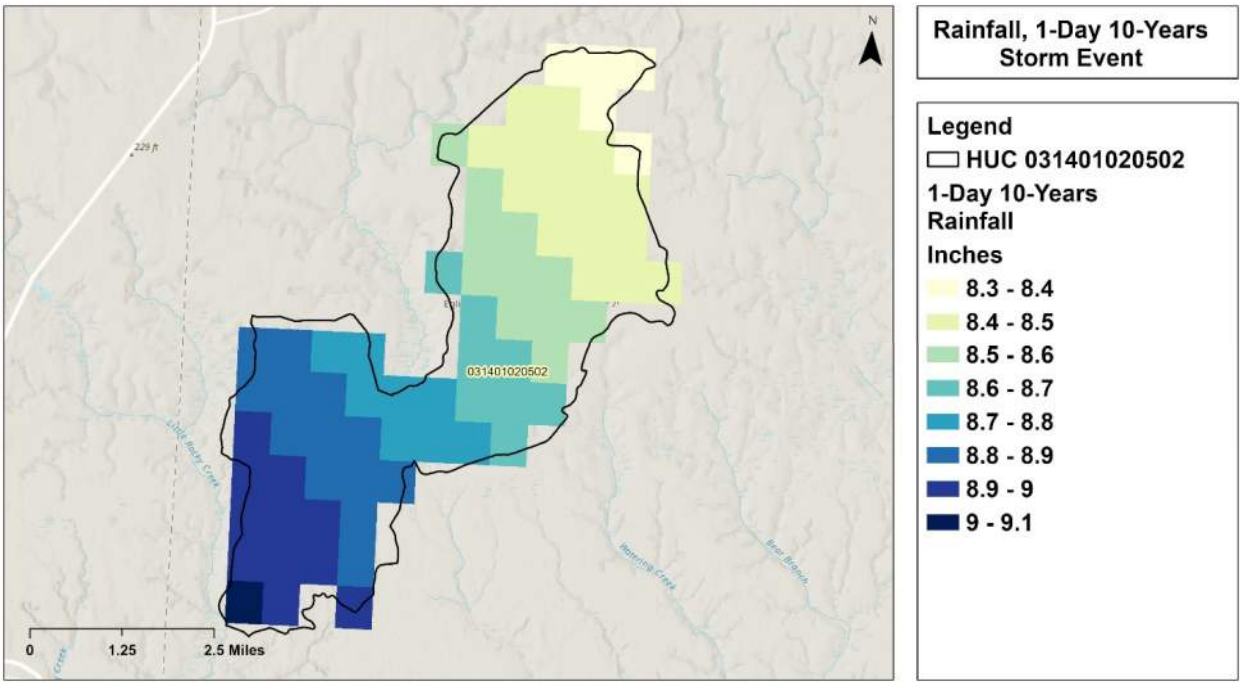

Figure 23. Rainfall distribution map across HUC 031401020502 sub-watershed, for 1-day 10-year storm event, processed by FAU.

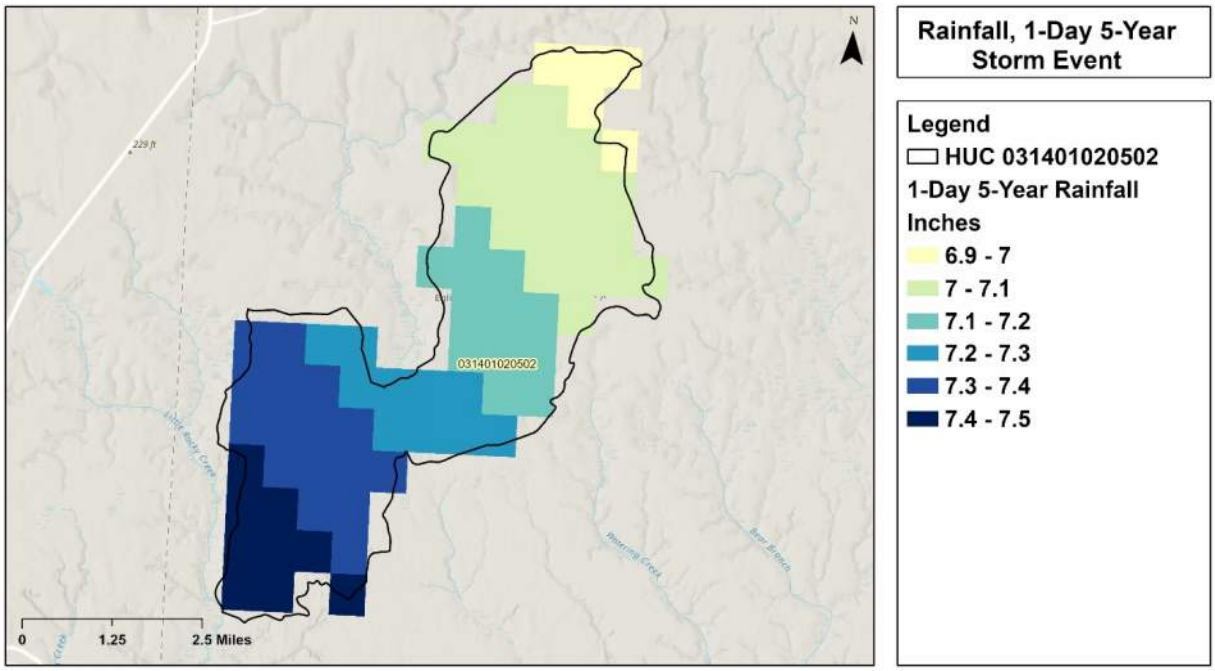

Figure 24. Rainfall distribution map across HUC 031401020502 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer

was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

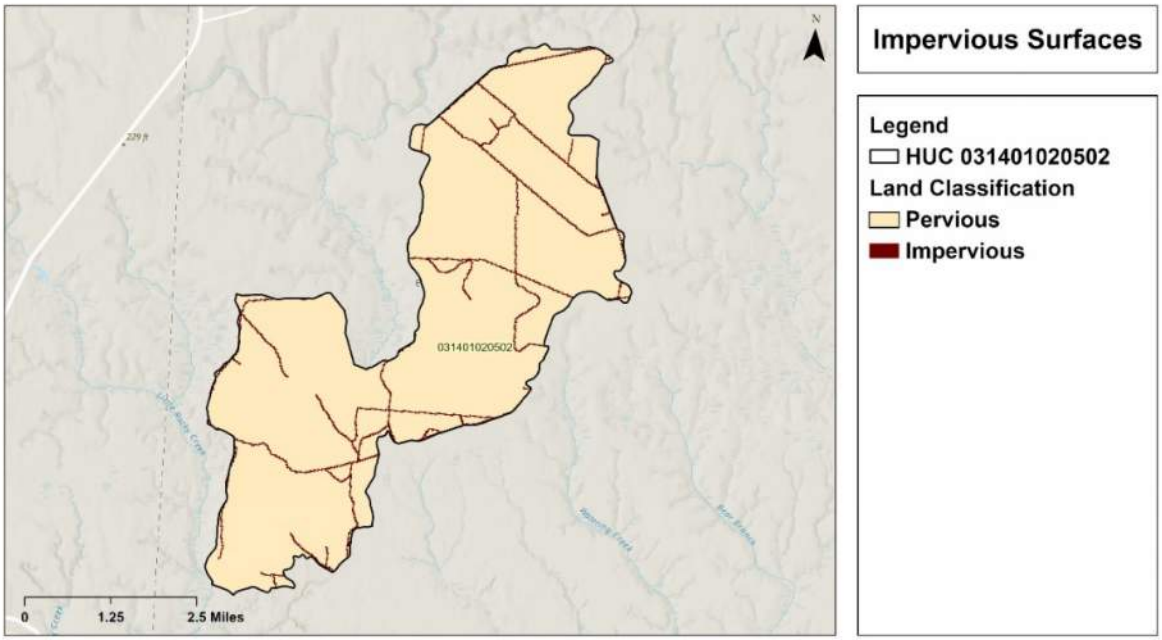

Figure 25. Impervious area map for the HUC 031401020502 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

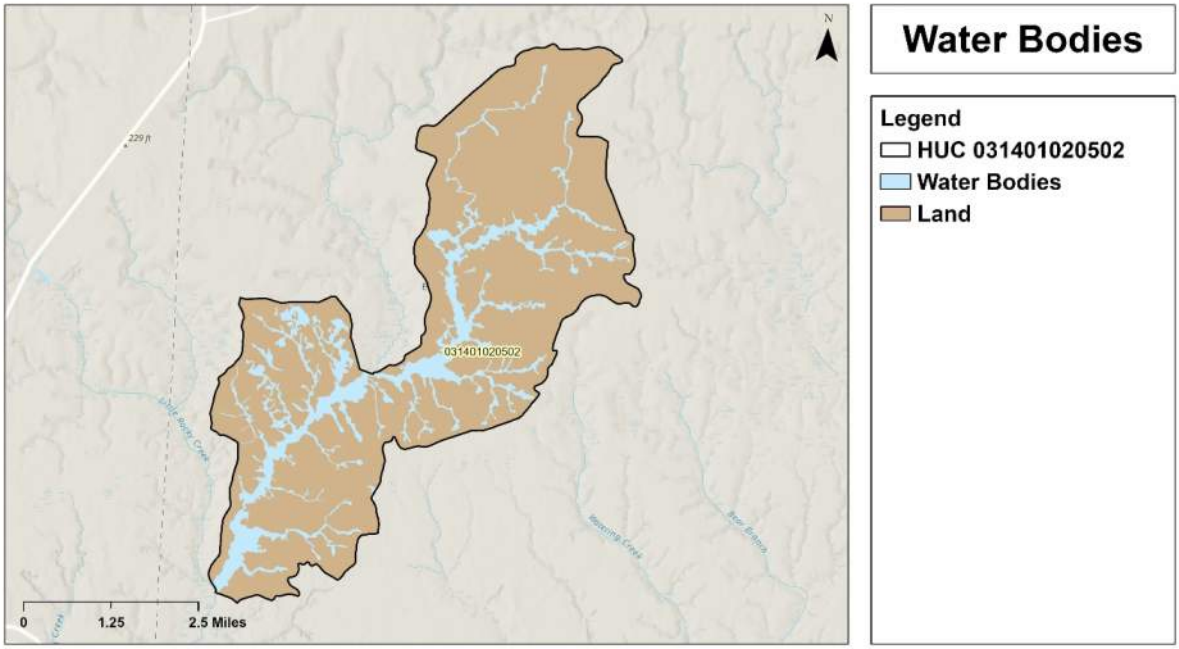

Figure 26. Water bodies map for the HUC 031401020502 sub-watershed, processed by FAU.

1.10. Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

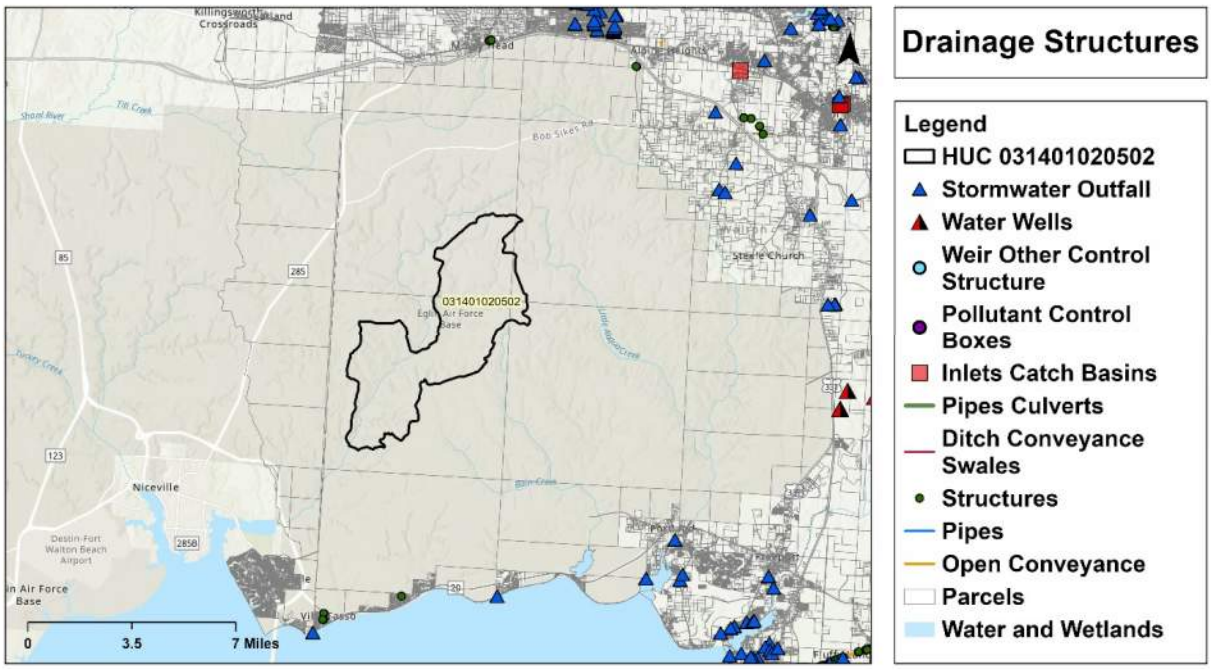

Figure 27. Stormwater Infrastructure for the HUC 031401020502. Processed by FAU.

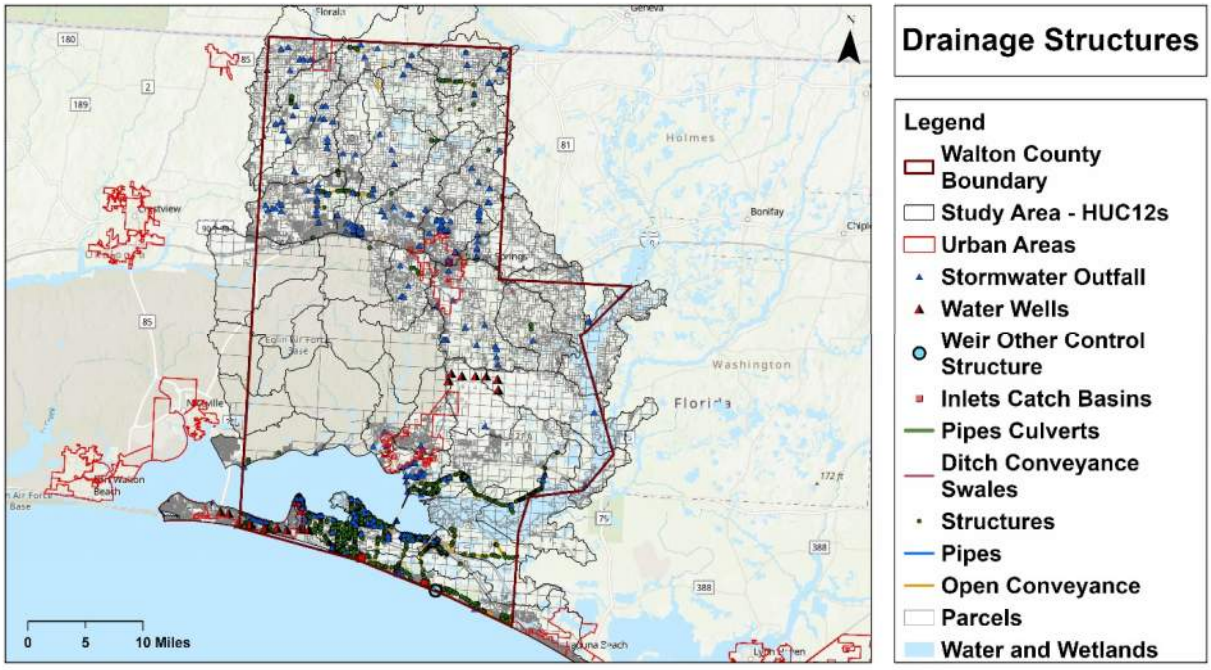

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**.. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401020502 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species

while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

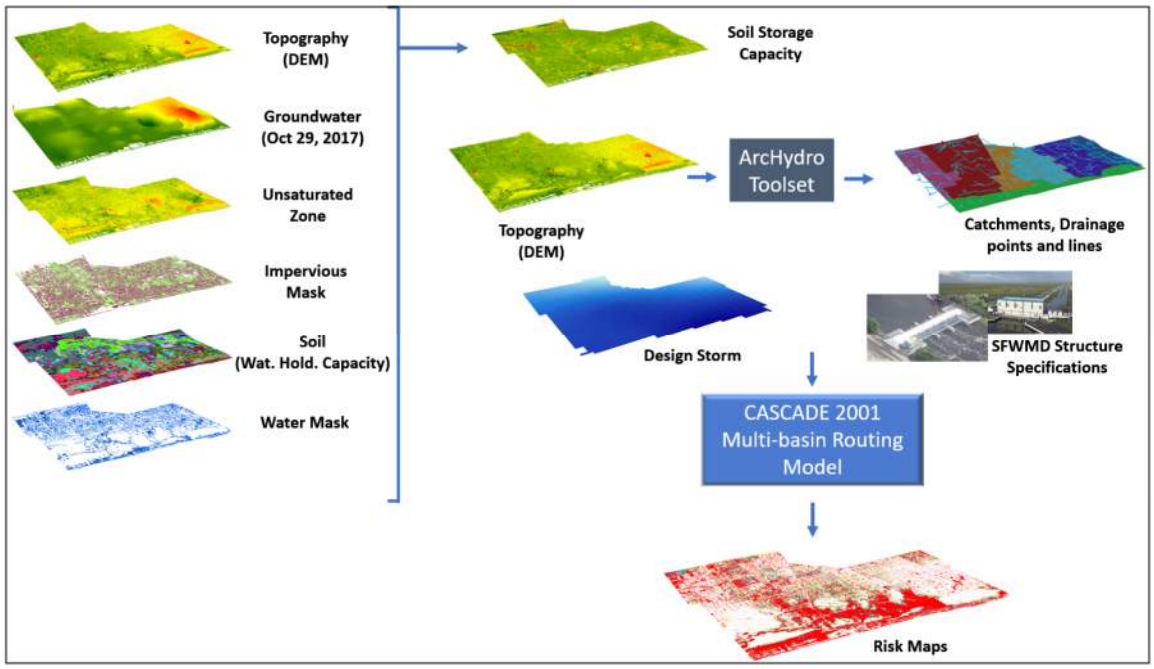

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are

critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

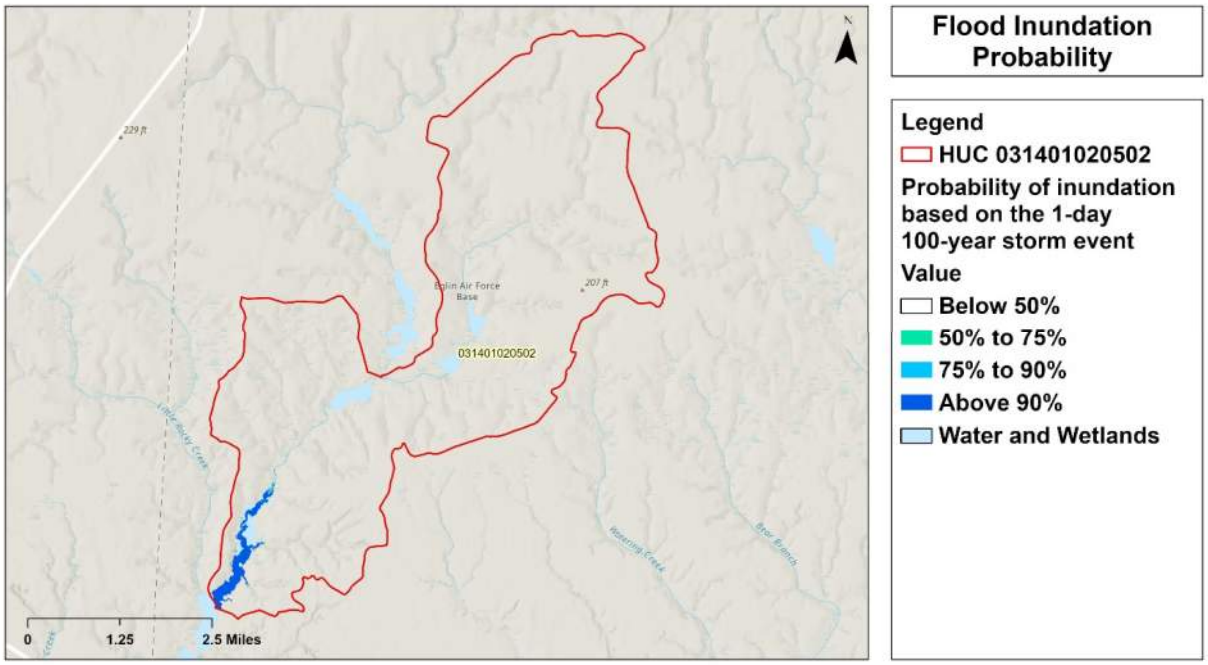

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401020502, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate

the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not

eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a small portion of flooding is noted at the entrance to the creek into the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, sea level rise should not impact the HUC, therefore SLR scenarios were not calculated.

The design storm simulation determined that approximately 0.9% of the HUC total area or 0.19 mi² has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 1% of the HUC's total area, or 0.22 mi² would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.5% of the HUC's total area, or 0.12 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0.5% of the HUC's total area, or 0.11 mi², would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401020502 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	20.78	0.19	99.1%	0.9%
1-day 100-year	20.76	0.22	99.0%	1.0%
1-day 10-year	20.86	0.12	99.5%	0.5%
1-day 5-year	20.86	0.11	99.5%	0.5%

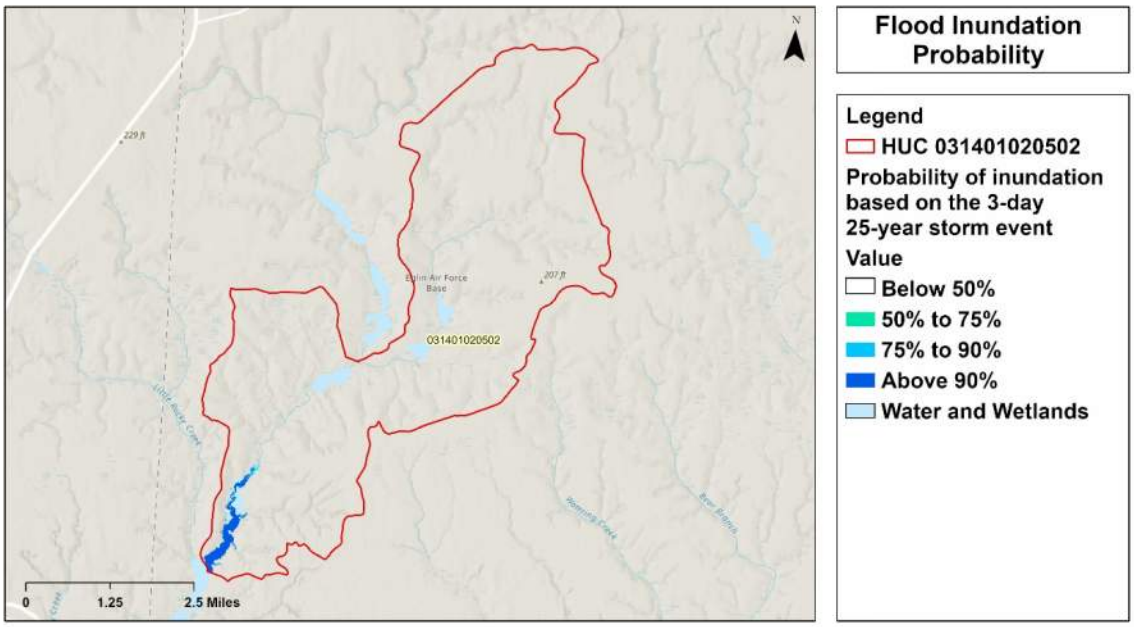

Figure 31. 3-day 25-year storm event for HUC 031401020502 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

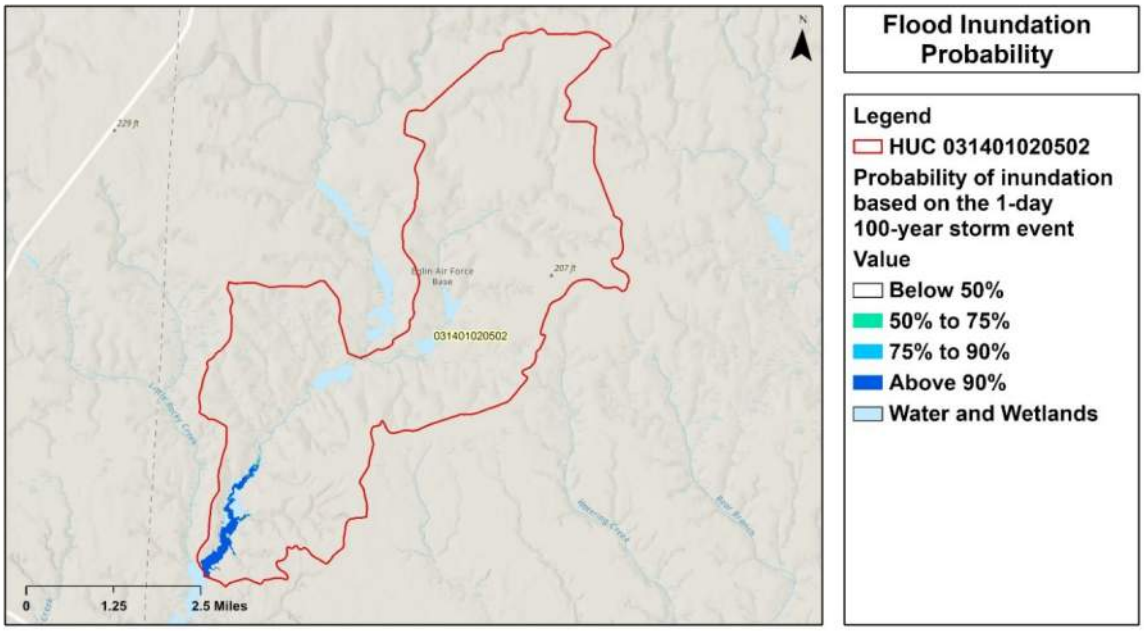

Figure 32. 1-day 100-year storm event for HUC 031401020502 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

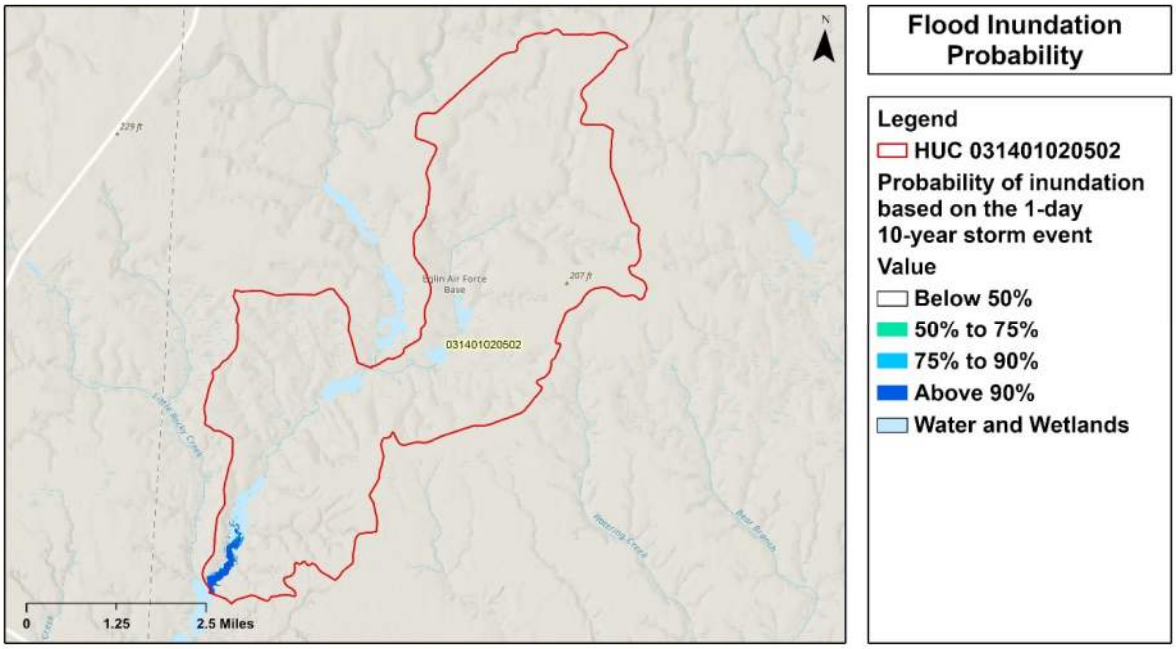

Figure 33. 1-day 10-year storm event for HUC 031401020502 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

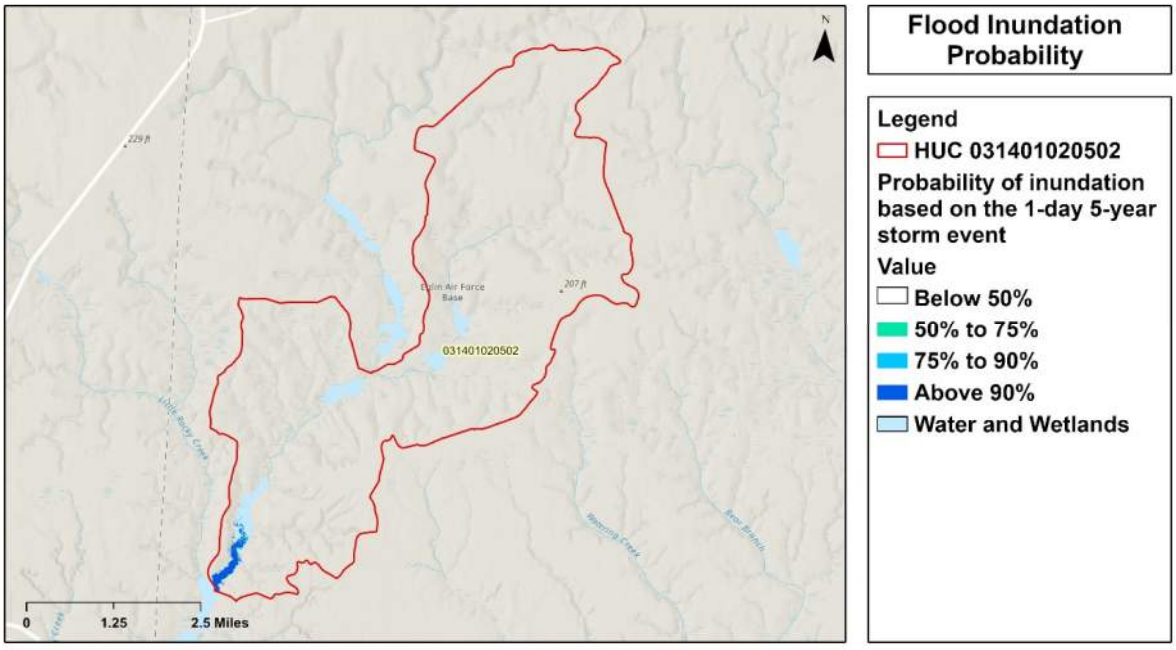

Figure 34. 1-day 5-year storm event for HUC 031401020502 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6

11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6

37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6

60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1

92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5

70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031401020502 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

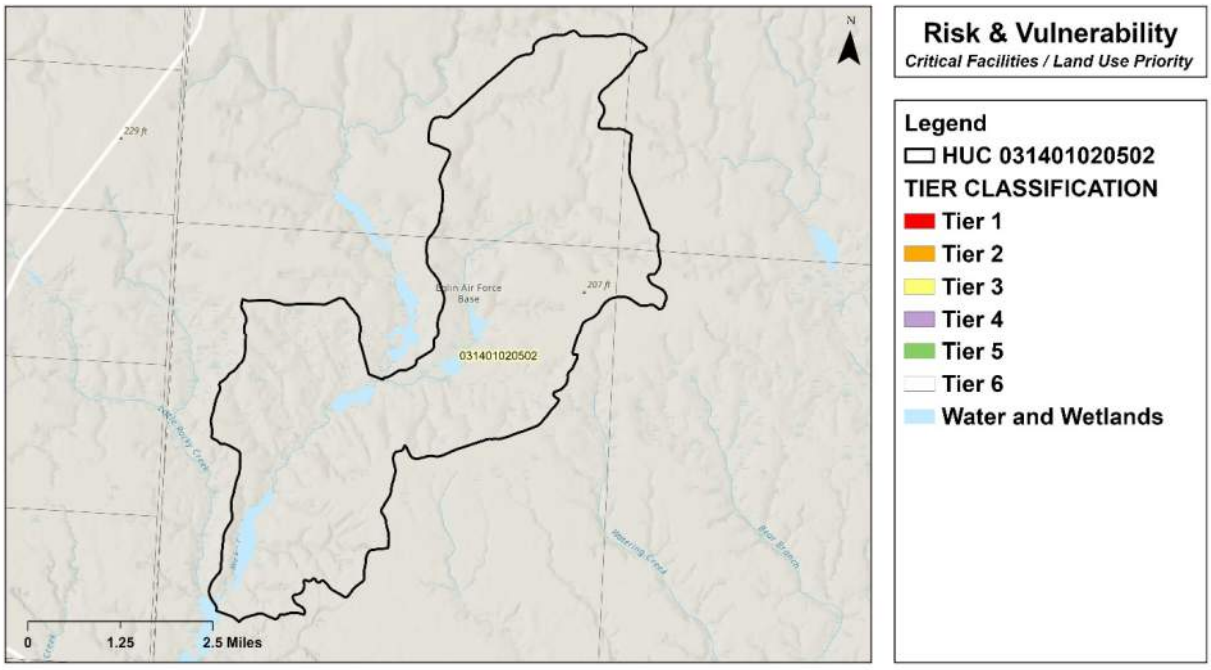

Figure 35. HUC 031401020502 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

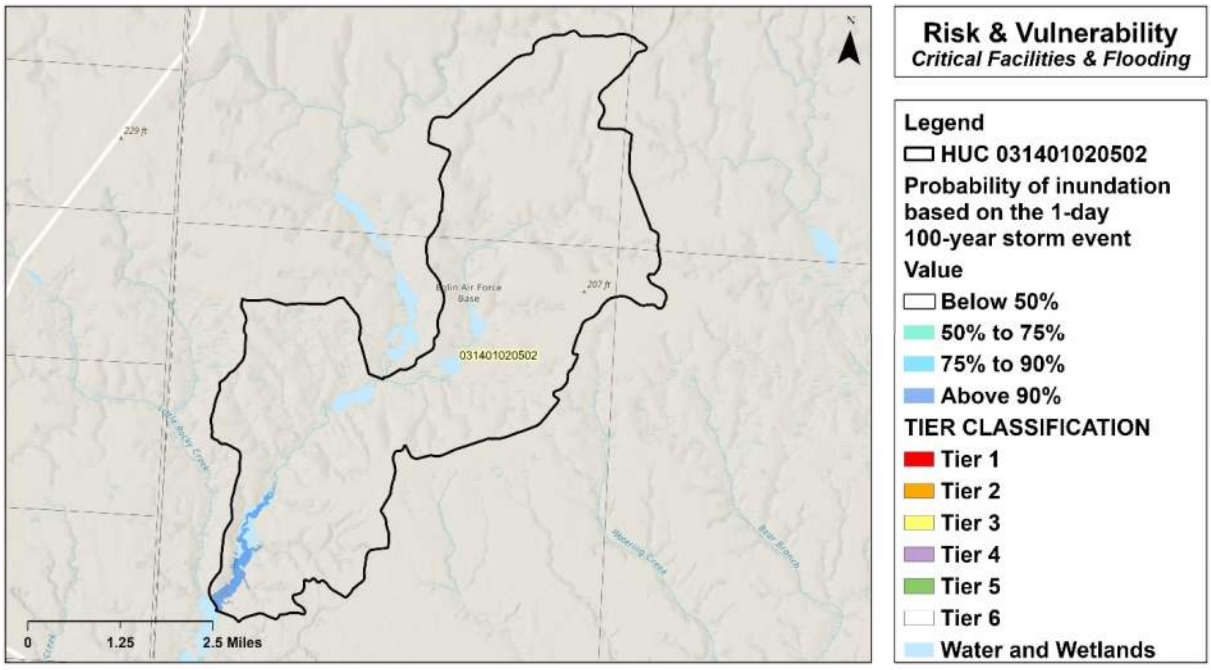

Figure 36. HUC 031401020502 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

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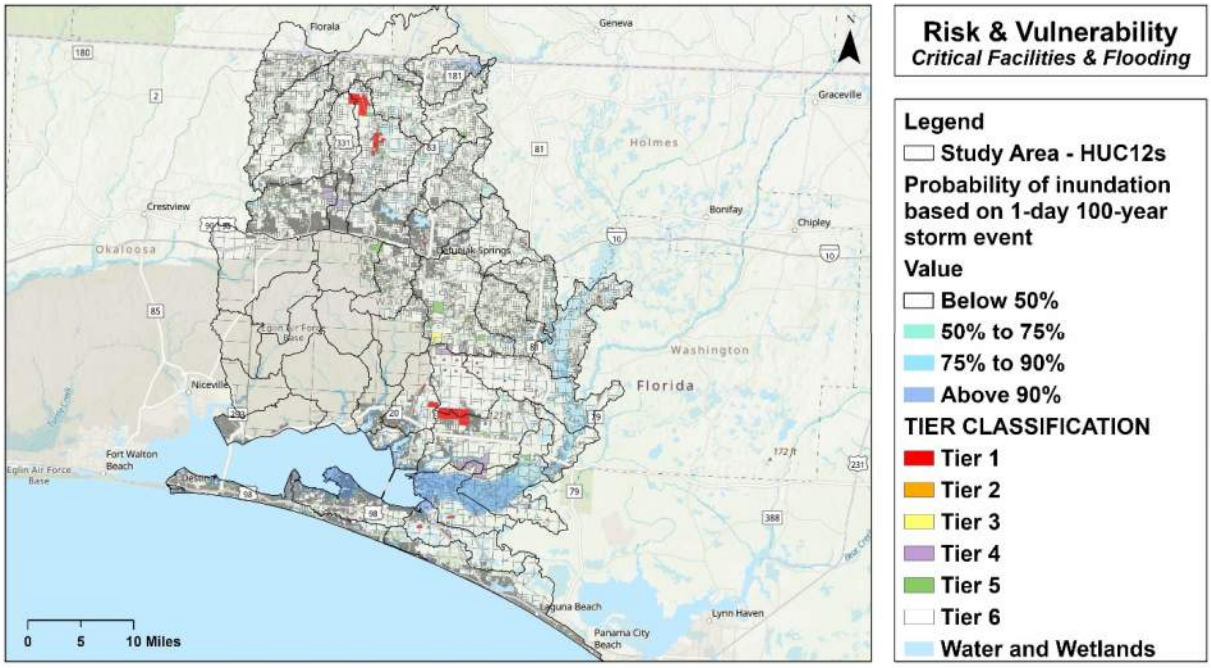

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

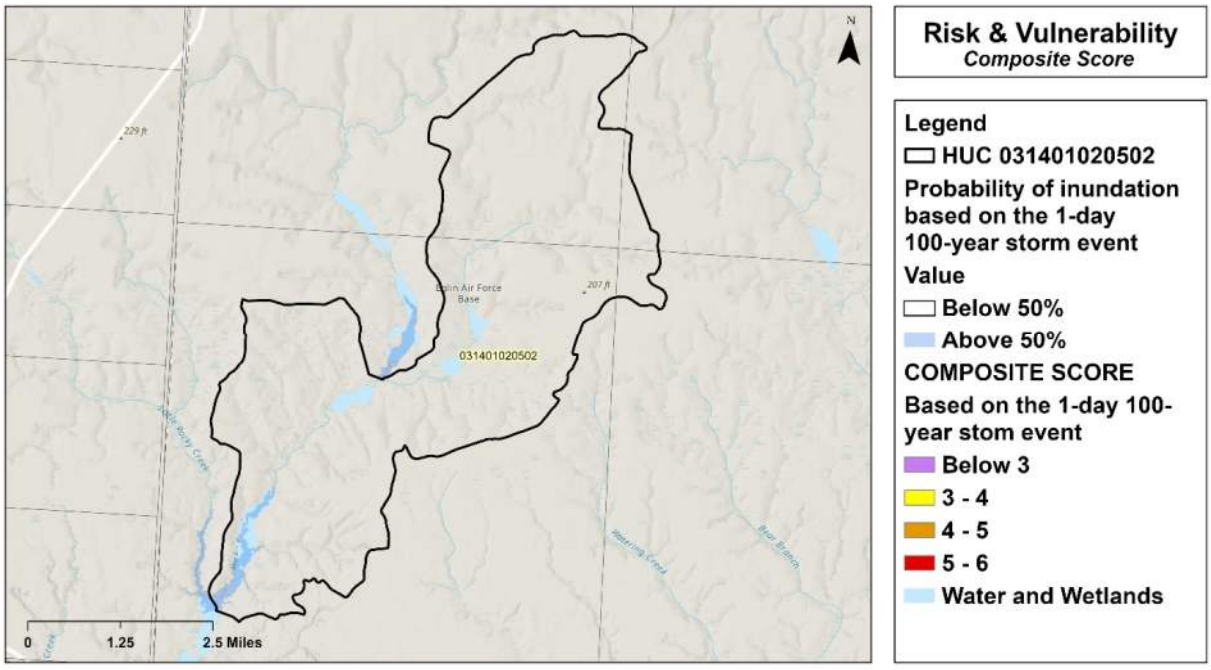

Figure 38. HUC 031401020502 sub-watershed Composite Score Risk map, calculation based on 1-day 100-year storm event. Processed by FAU.

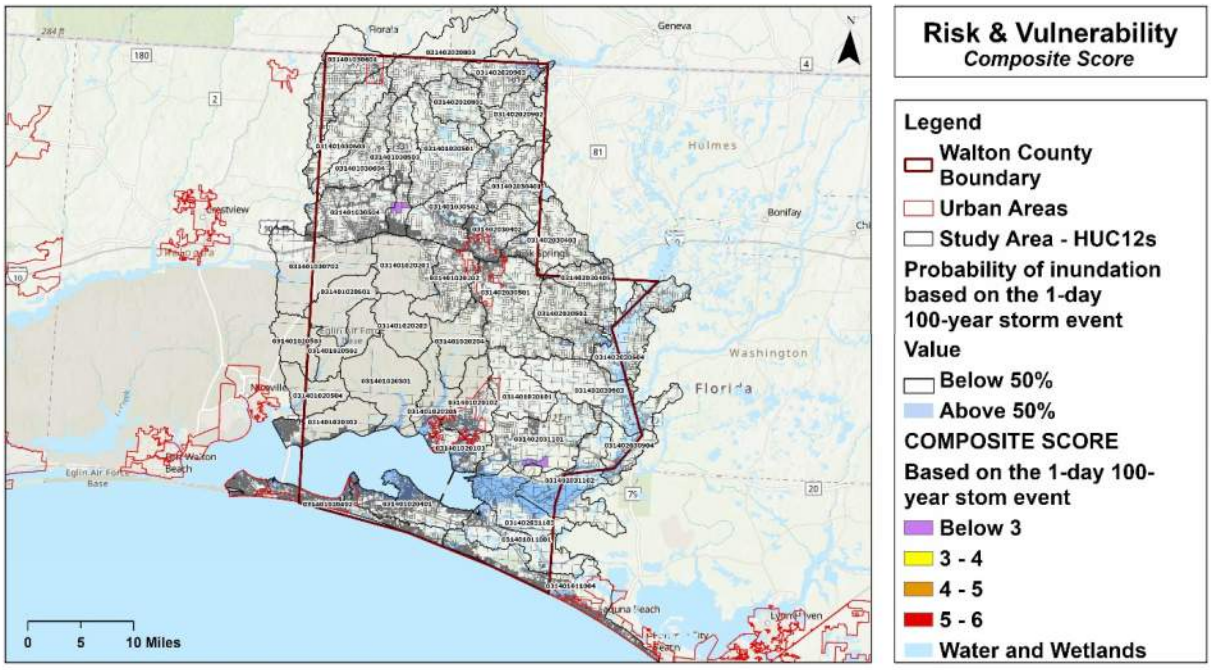

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401020502. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands: This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands: In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401020502. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401020502	13421.71
All of the 1-day 100-year storm event inundation	**138.04**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	85.11
B. Federal Land in 1-day 100-year inundation > 10 acres	52.92
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	0.00
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	0.00

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that

have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

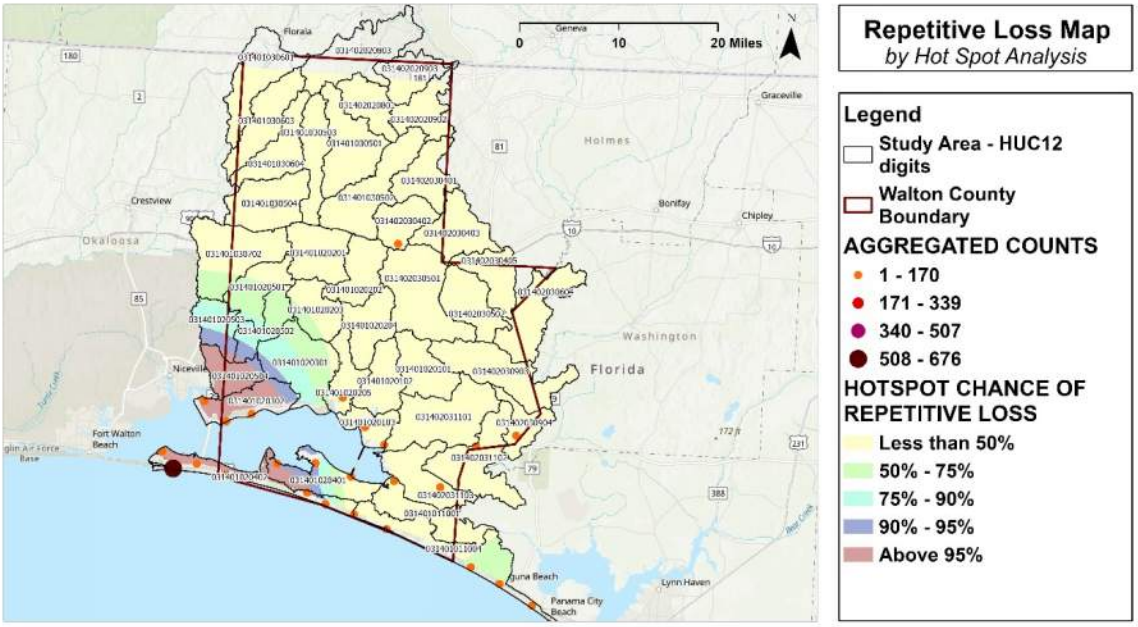

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5 Priority Projects

The entire HUC area is undeveloped and non-coastal. As a result, there are no critical facilities or other land uses that require priority intervention. The minor flooding and null composite score indicate that the HUC is not significantly affected by flooding, and there are no pressing priorities for interventions to address inundation impacts.

APPENDIX R

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401020503

LITTLE ROCKY CREEK

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401020503) is highlighted among all the HUCs to help identifying its location. (Figure 3).

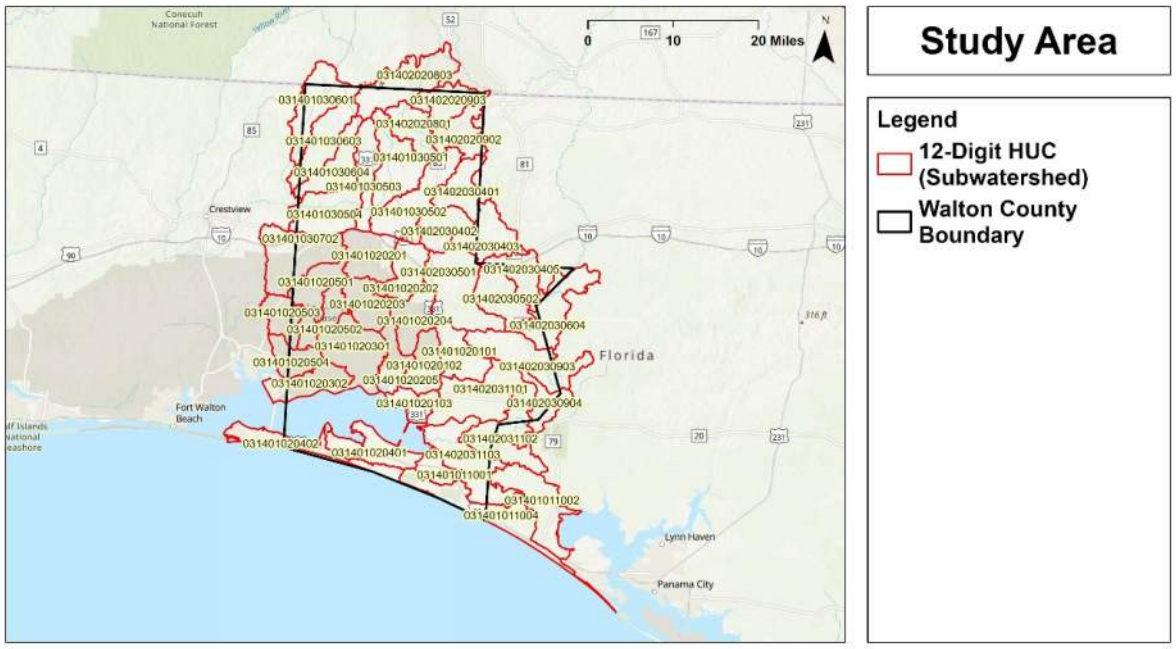

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

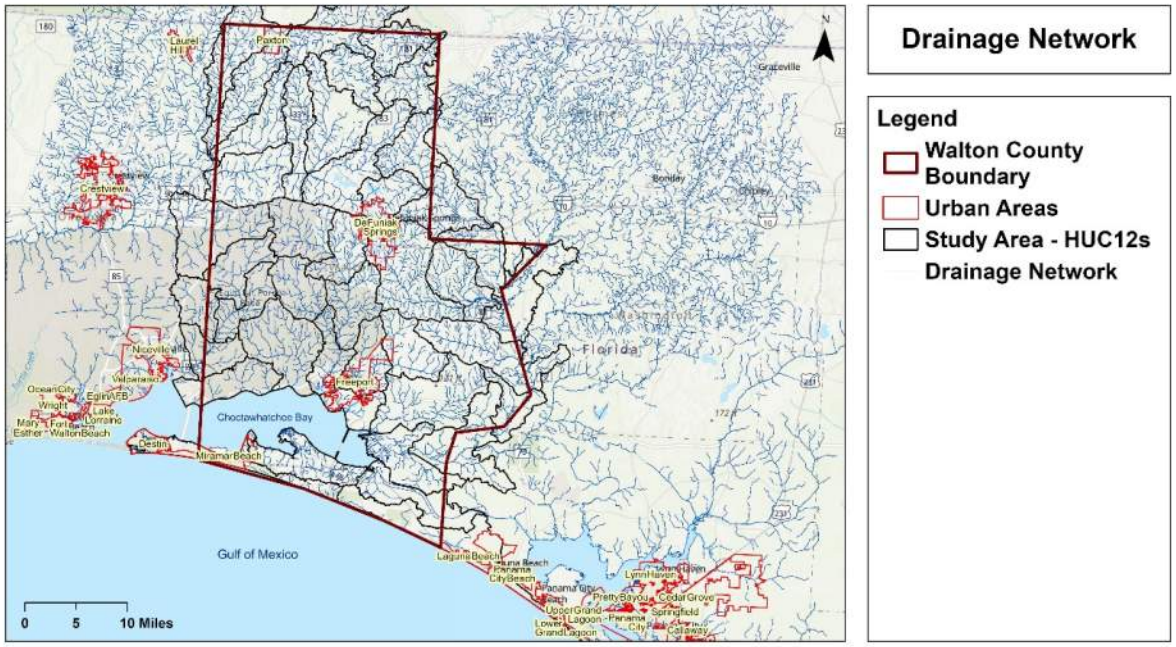

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

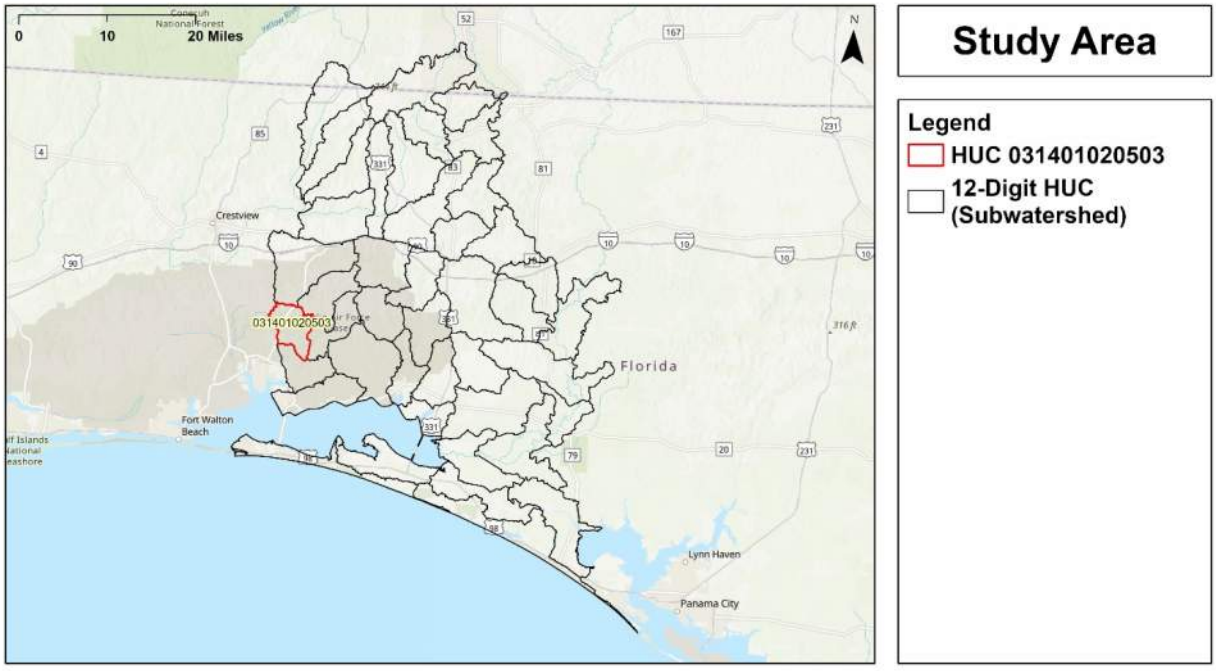

Figure 3. HUC 031401020503 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Based on the 2014-2016 SFWMD Level 1 land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with

high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

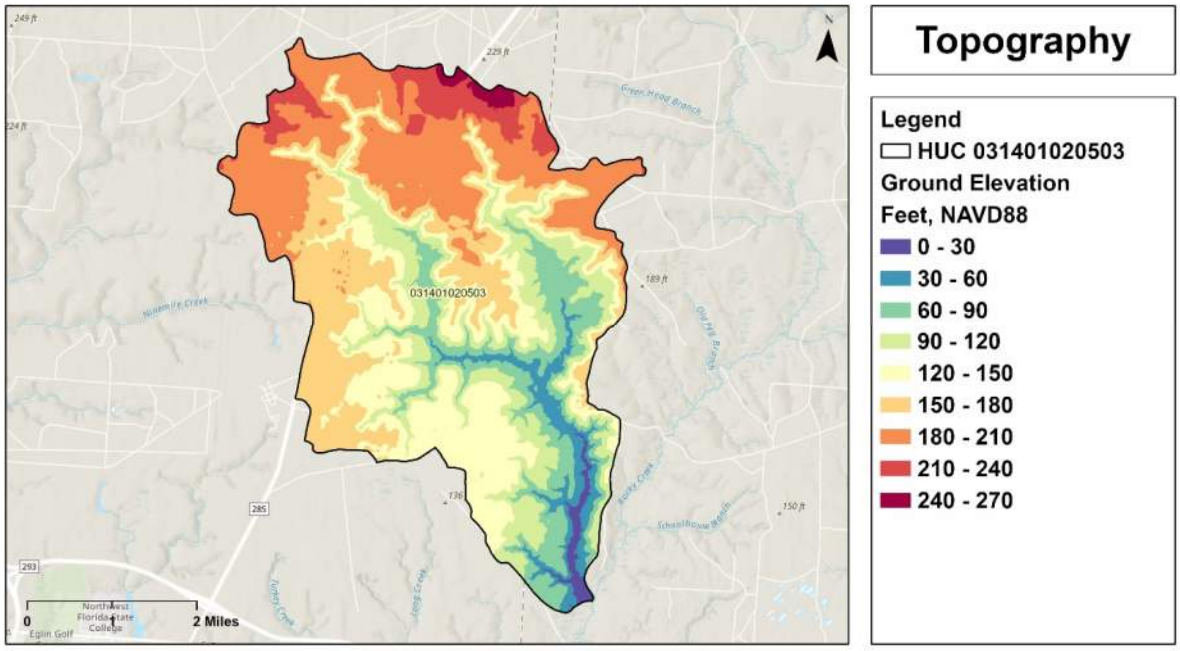

Figure 4. Topographic map of the HUC 031401020503 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology.

Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401020503 sub-watershed is shown in **Error! Reference source not found.**.

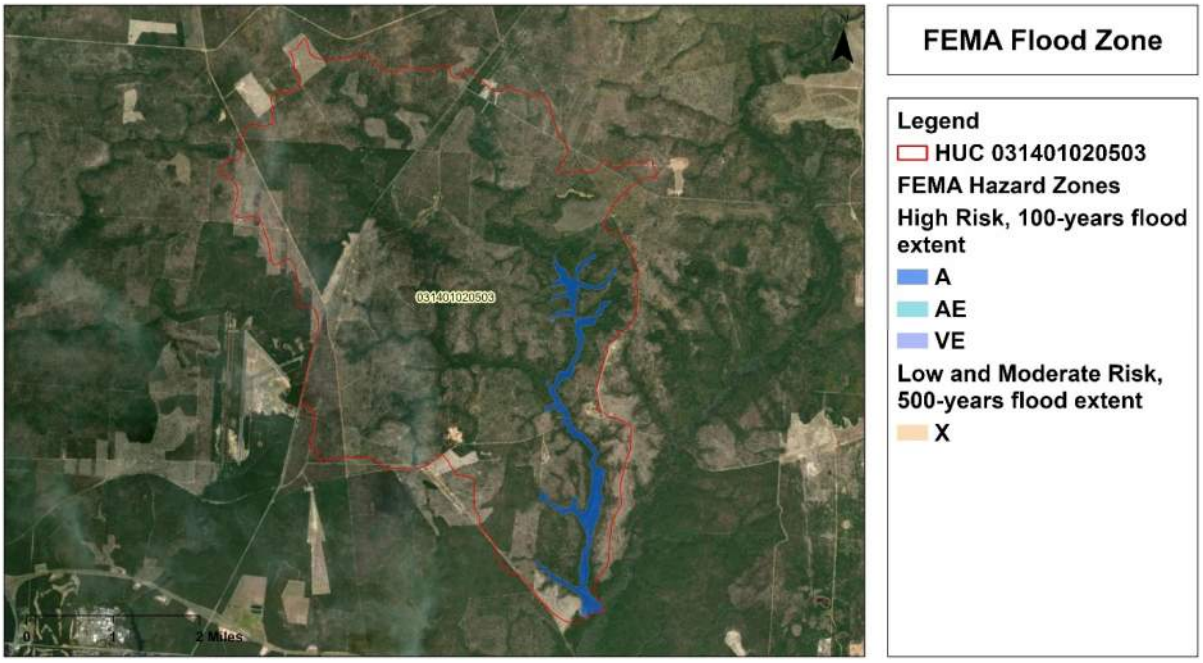

Figure 5. FEMA Flood Zone map (2020) for HUC 031401020503 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination

between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401020503 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

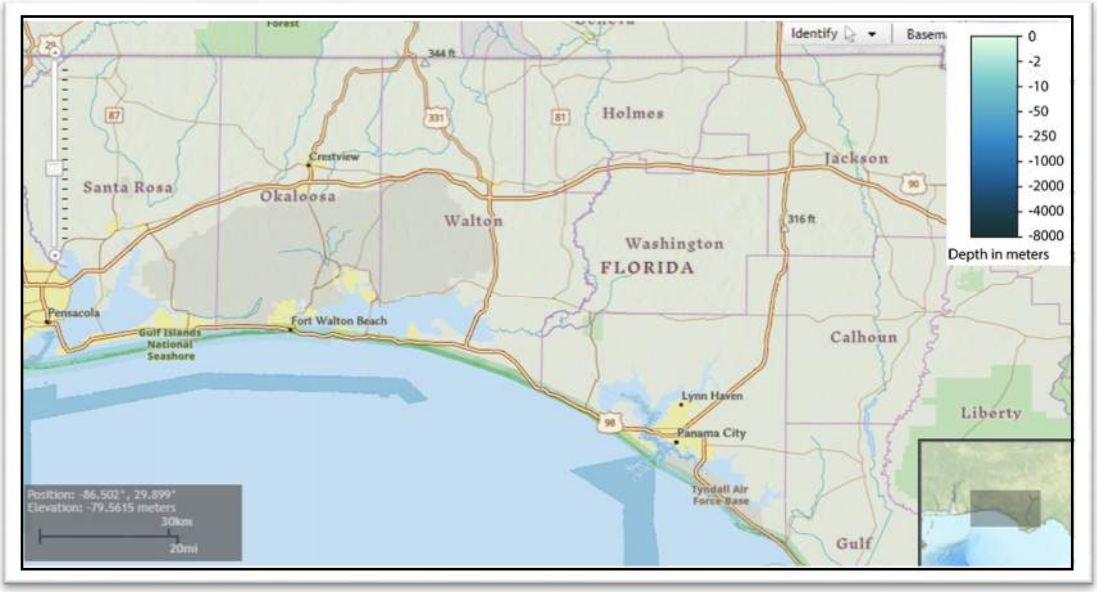

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological

conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

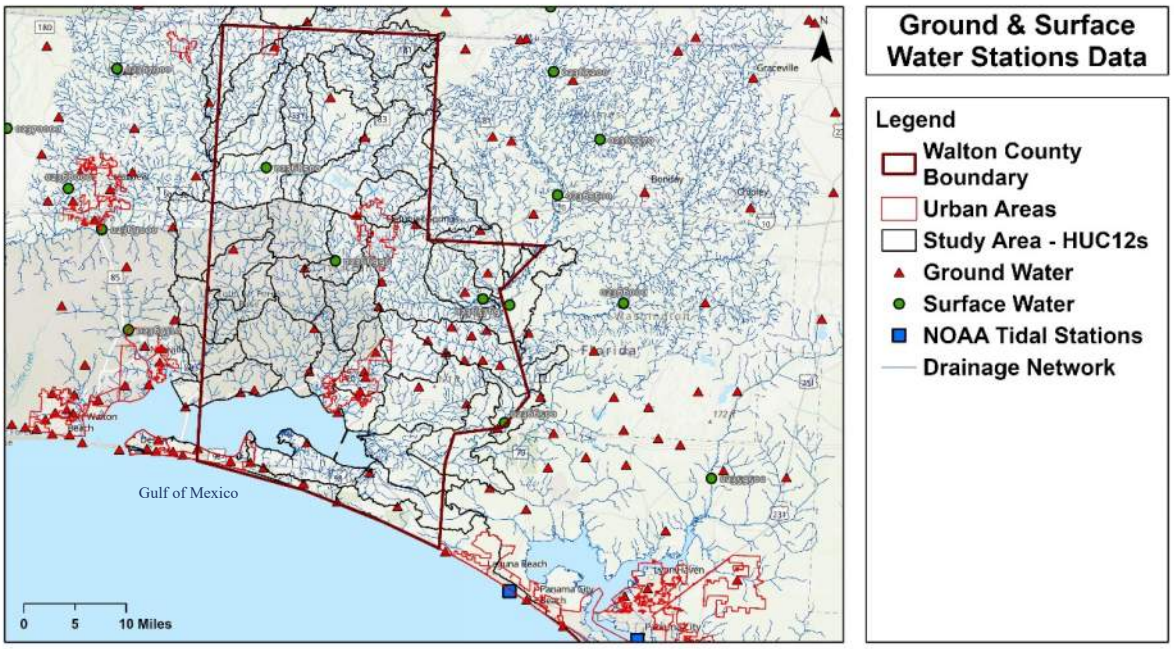

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031401020503 has no major rivers and canals, but creeks and a branch, include:

- Little Rocky Creek
- Smith Branch
- Middle Rocky Creek

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366996. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401020503, which is USGS 02366996 Alaqua Creek Near Pleasant Ridge, FL.

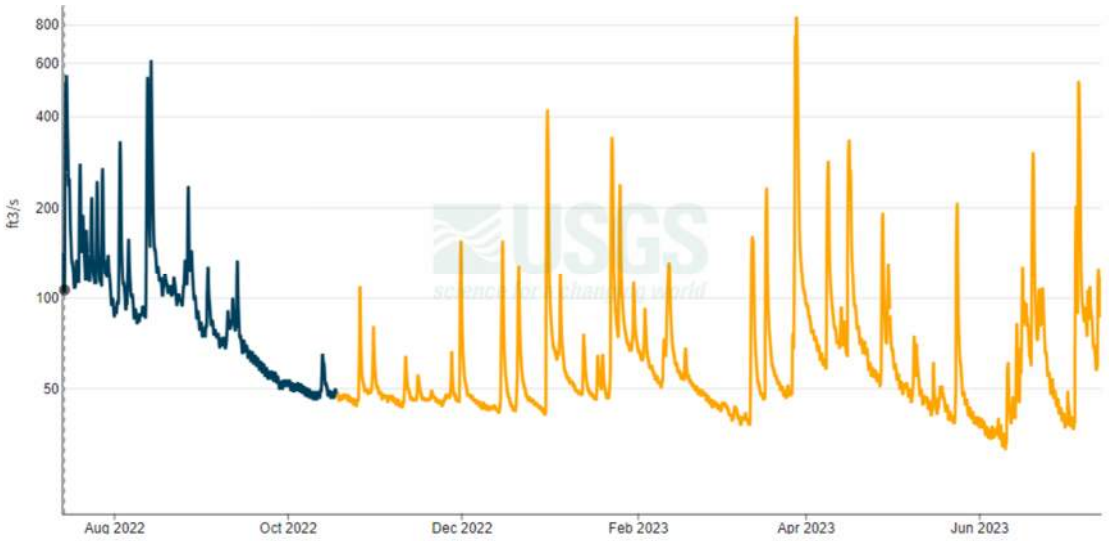

Figure 8. Average streamflow for Alaqua Creek Near Pleasant Ridge, FL (USGS 02366996 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366996/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99^{th}- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98^{th} - 100^{th} percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station

(or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data is obtained from the SFWMD DBHYDRO site for surface waters (https://www.sfwmd.gov/science-data/dbhydro) and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401020503 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031401020503 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

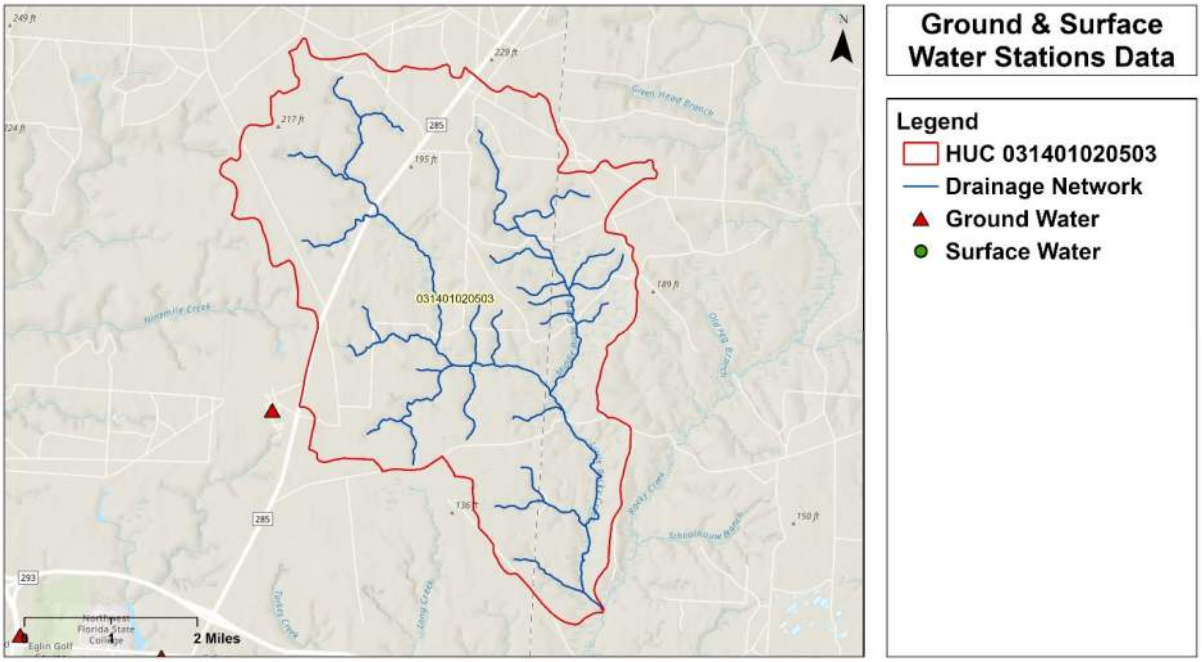

Figure 9. Ground and Surface Water Stations in the HUC 031401020503 sub-watershed, processed by FAU.

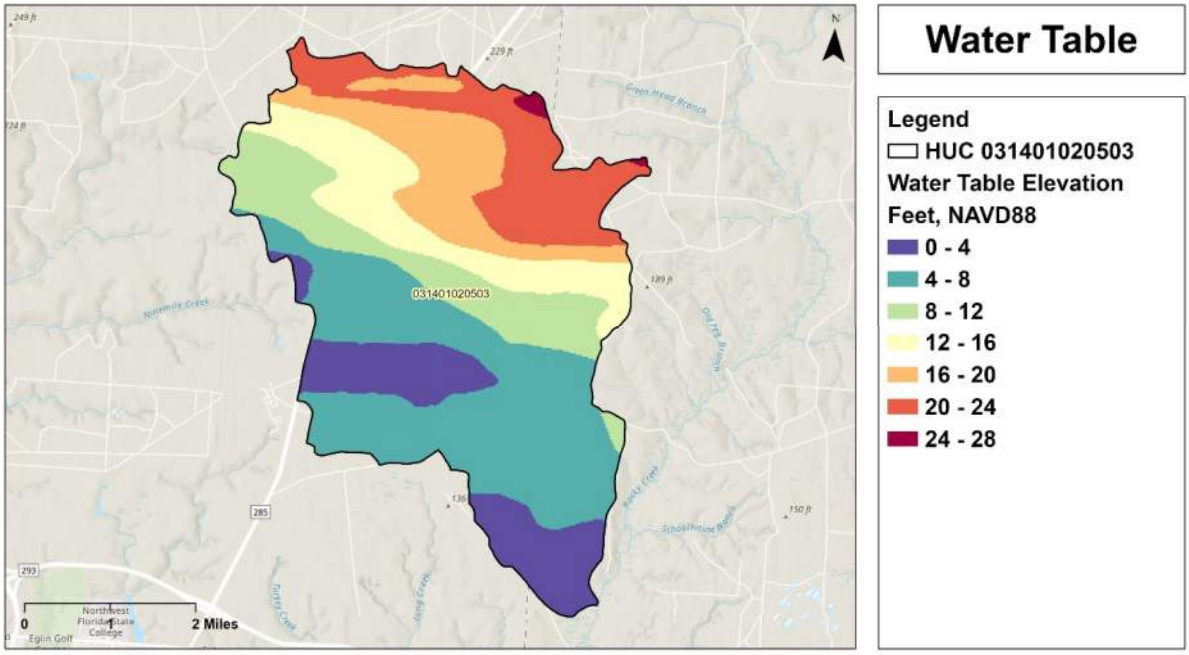

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401020503 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

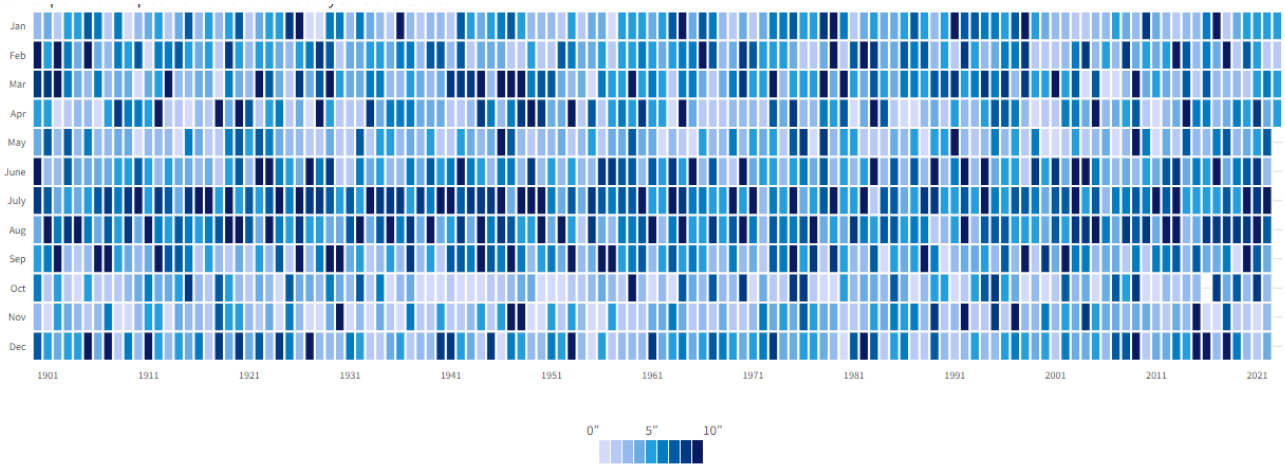

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/).

While the topography (Section 2.1) and native soil (Section 2.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there are no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

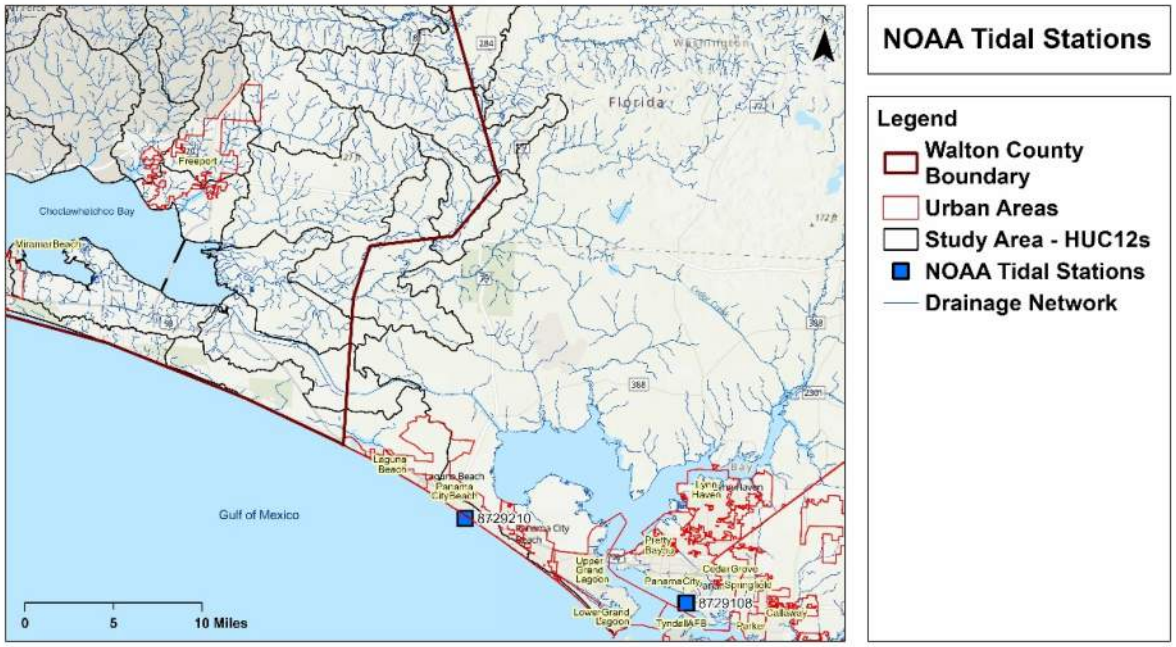

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

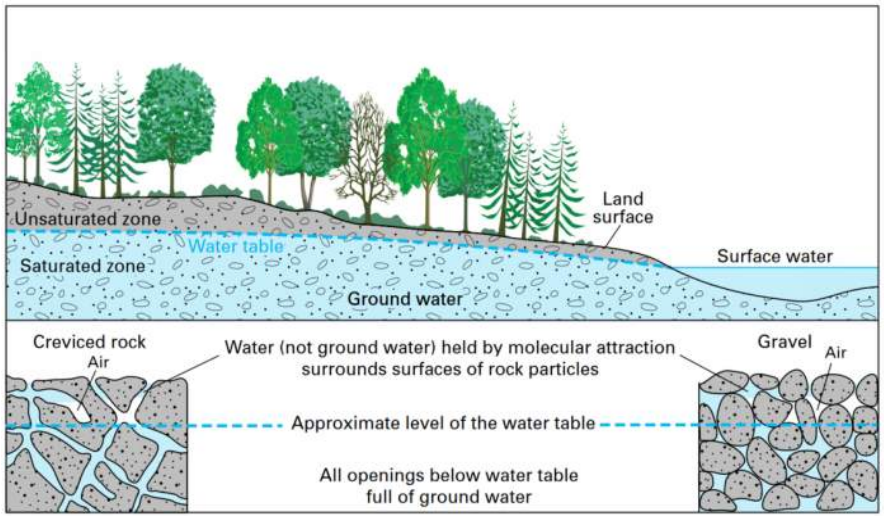

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

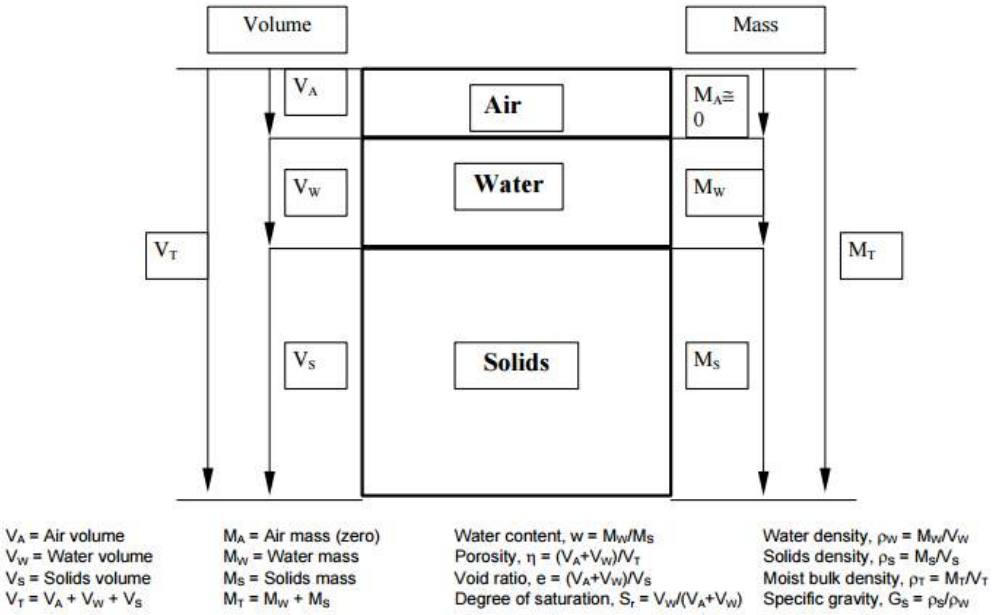

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

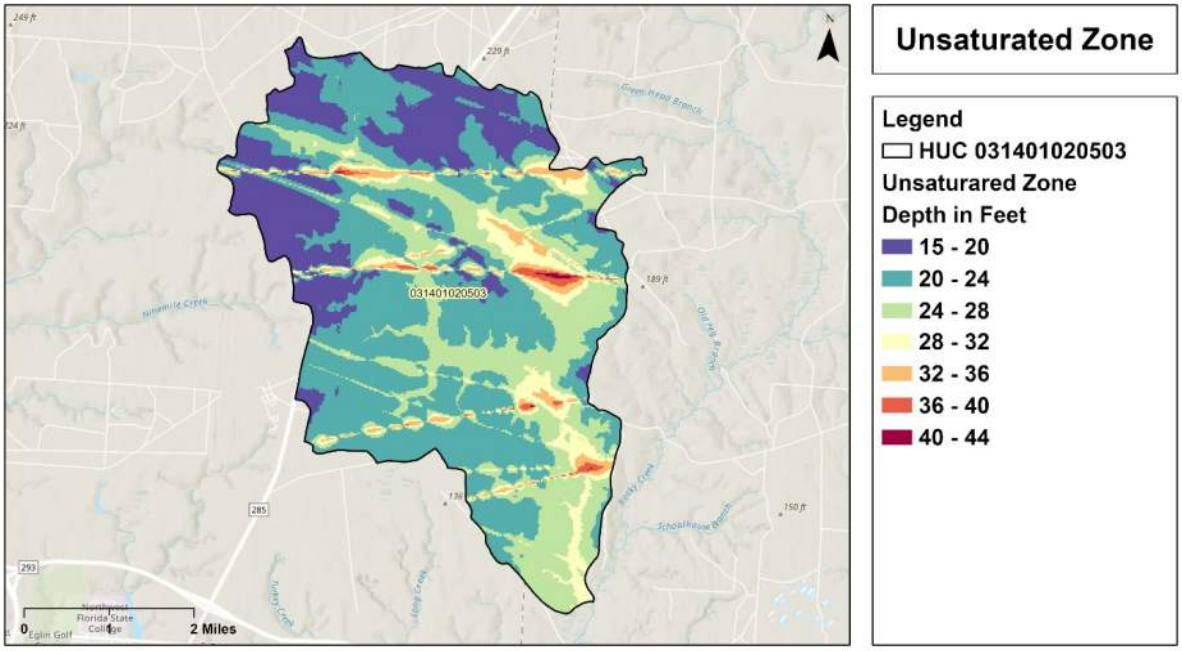

Figure 15. Unsaturated zone map for HUC 031401020503, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a limited to moderate soil storage capacity, falling within the range of 15 to 32 feet of remaining capacity.

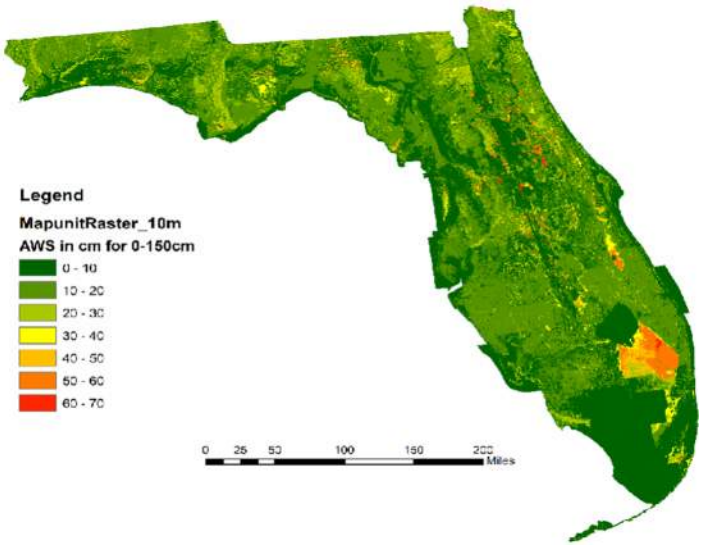

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

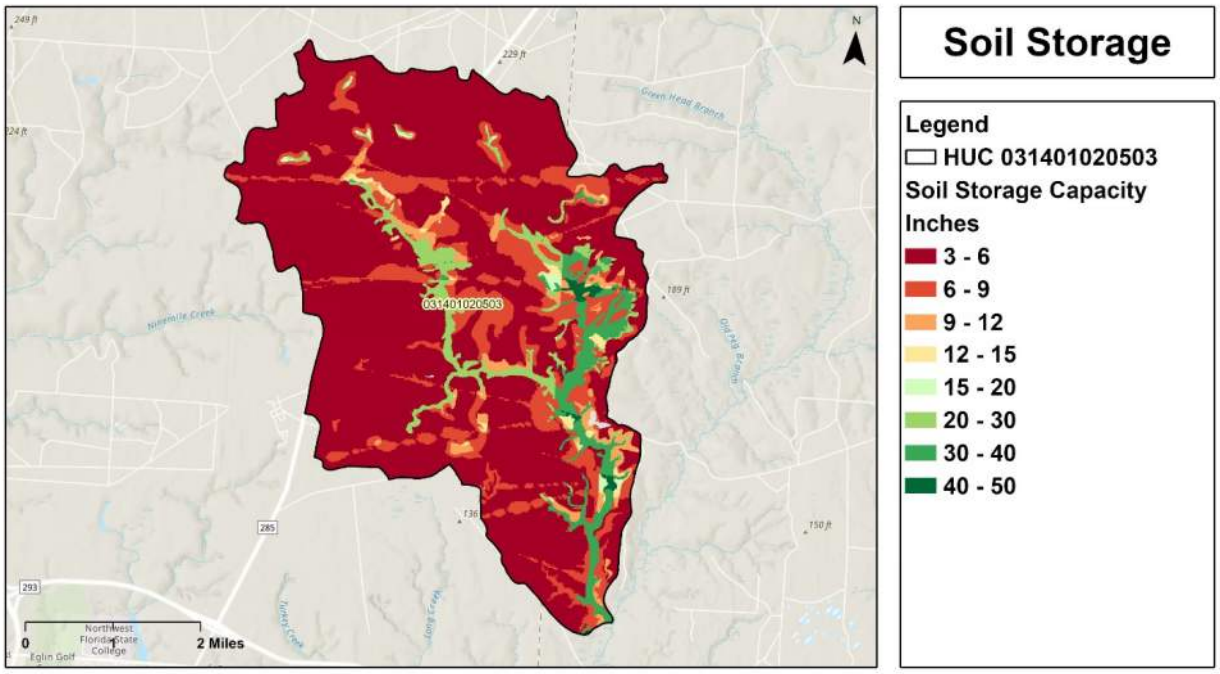

Figure 17. Water storage capacity of soil for the HUC 031401020503, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

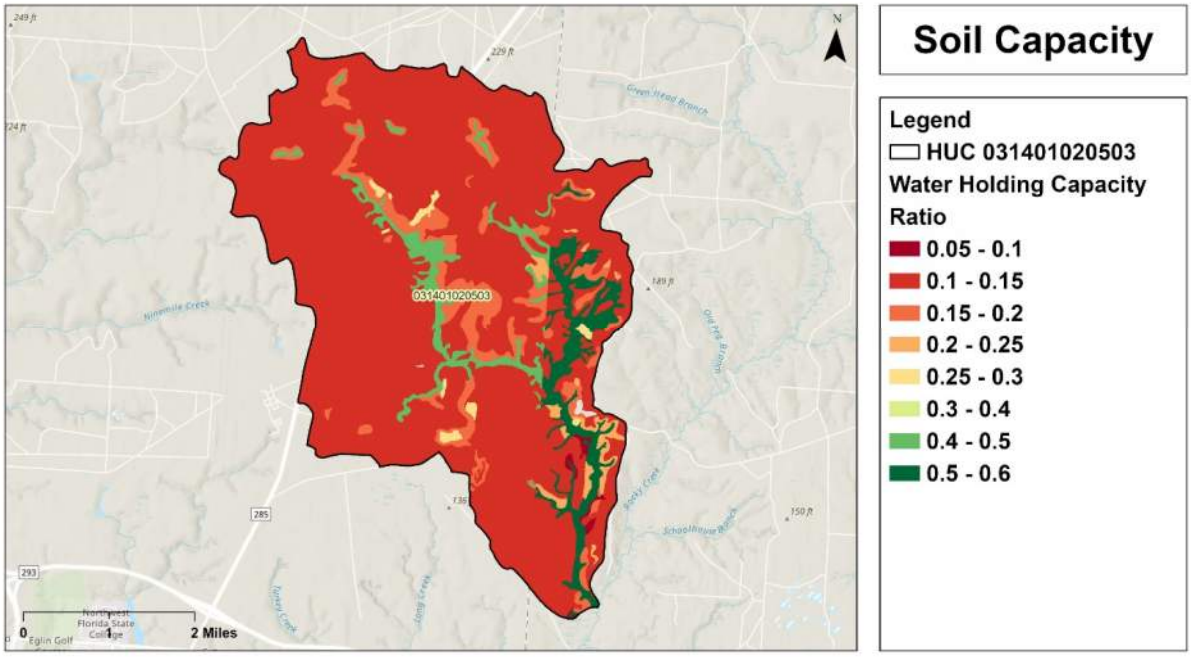

Figure 18. Water Holding Capacity (ratio) for the HUC 031401020503, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

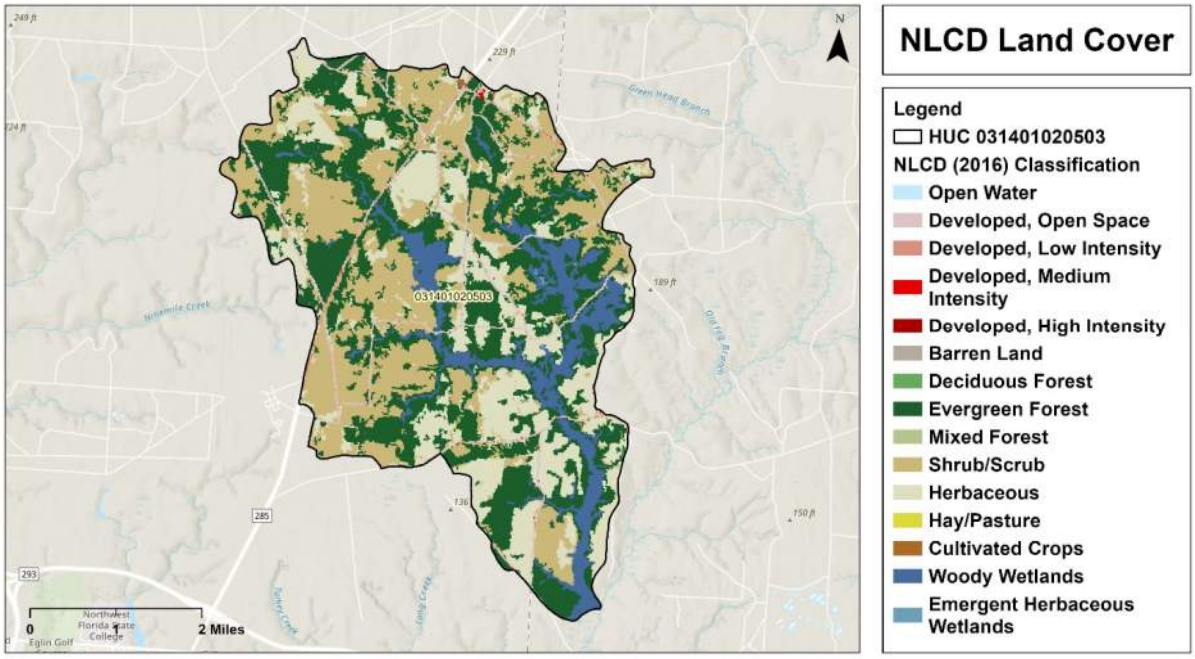

Figure 19. Land use in the HUC 031401020503 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

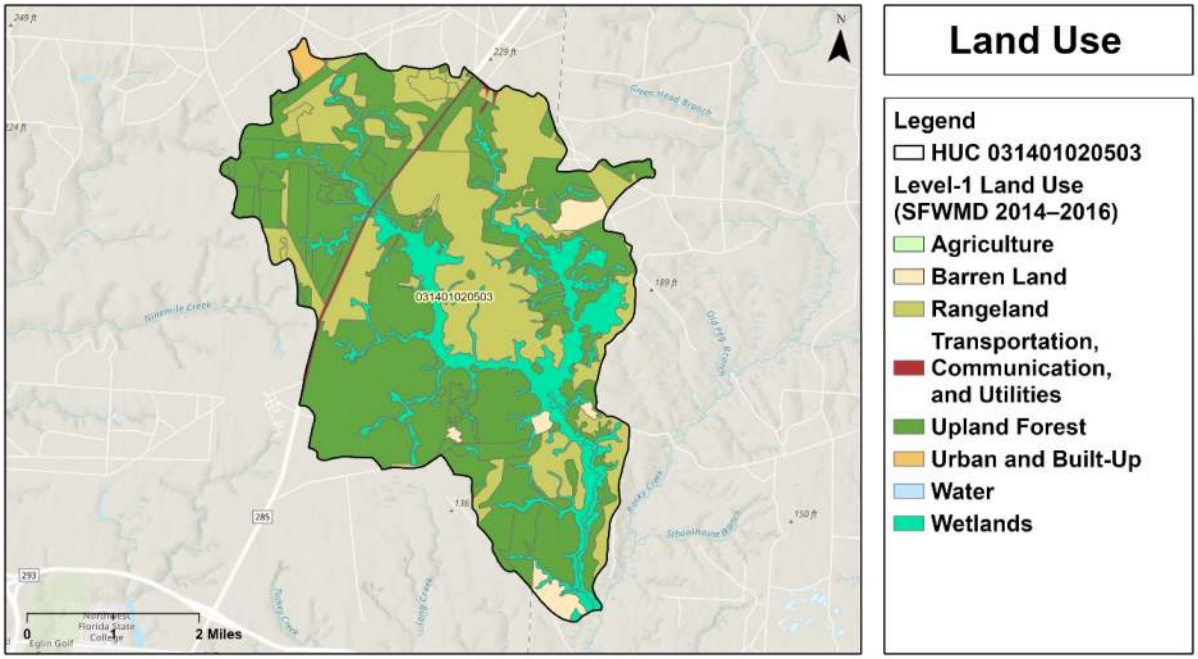

Figure 20. Land use in the HUC 031401020503 (SFWMD 2014-2016), processed by FAU.

In the HUC 031401020503 sub-watershed, the predominant land cover is upland forest, accounting for 45.19% of the area. Rangelands comes in second at 32.56%, followed by Transportation, Communication, and Utilities at 11.44%, and wetlands at 9.10%. Developed land constitutes a minor portion, with only 0.39% categorized as urban and built-up, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031401020503 subwatershed (SFWMD 2014-2016).

Level 1 Land Use Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	0.00	0.00%
Barren Land	323.67	1.32%
Rangeland	7972.54	32.56%
Transportation, Communication, and Utilities	2801.00	11.44%
Upland Forest	11063.25	45.19%
Urban and Built-Up	95.52	0.39%
Water	0.00	0.00%
Wetlands	2228.30	9.10%
Grand Total:	**24484.27**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

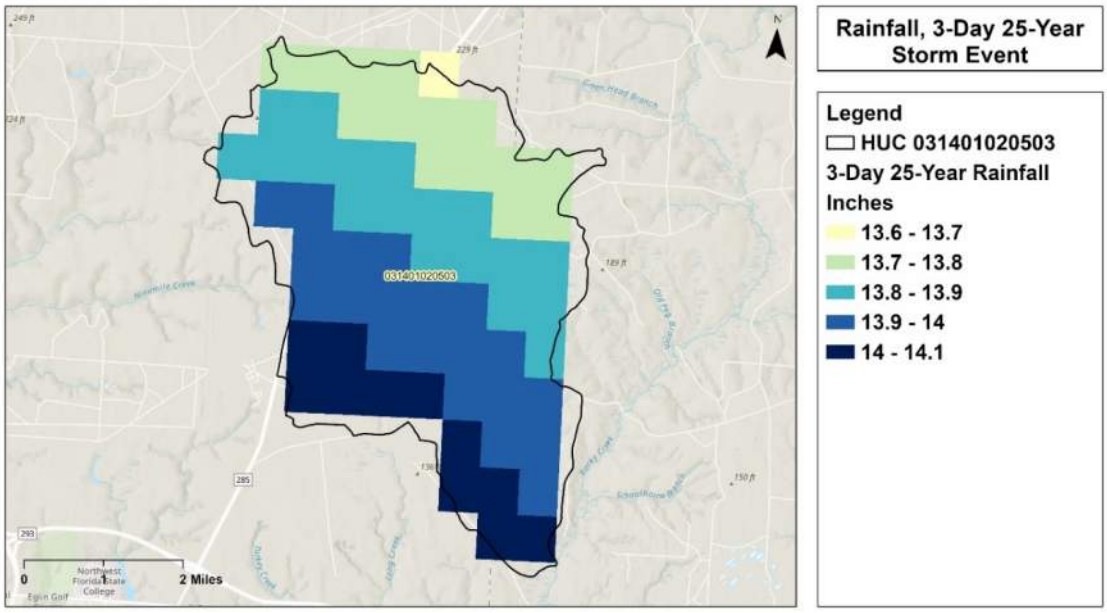

Figure 21. Rainfall distribution map across HUC 031401020503 sub-watershed, for 3-day 25-year storm event, processed by FAU.

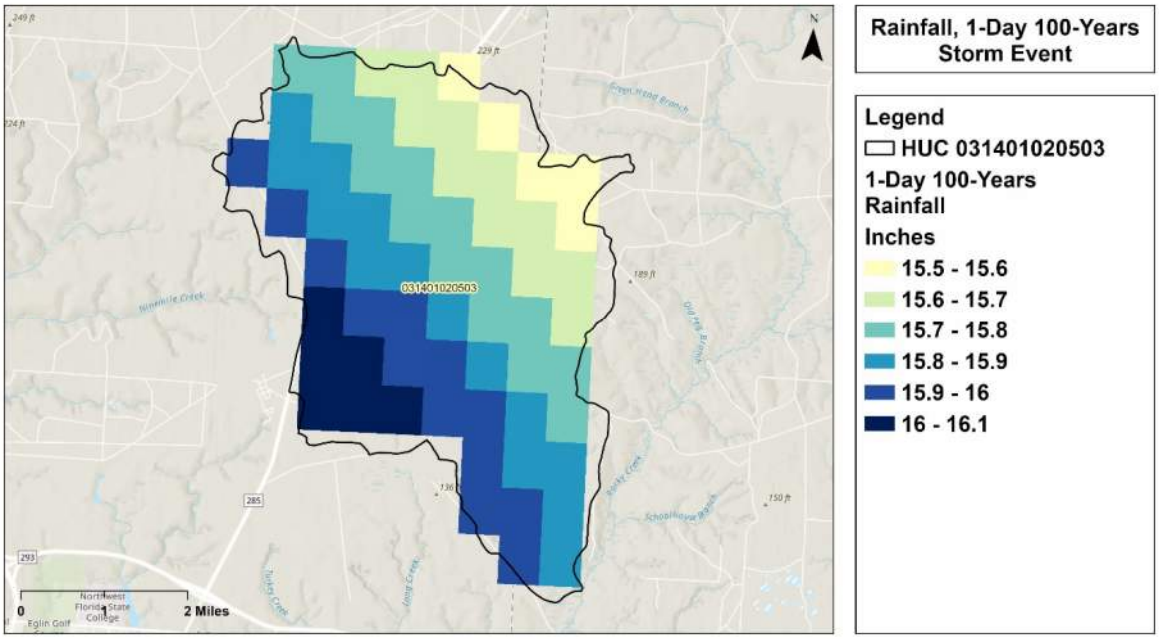

Figure 22. Rainfall distribution map across HUC 031401020503 sub-watershed, for 1-day 100-year storm event, processed by FAU.

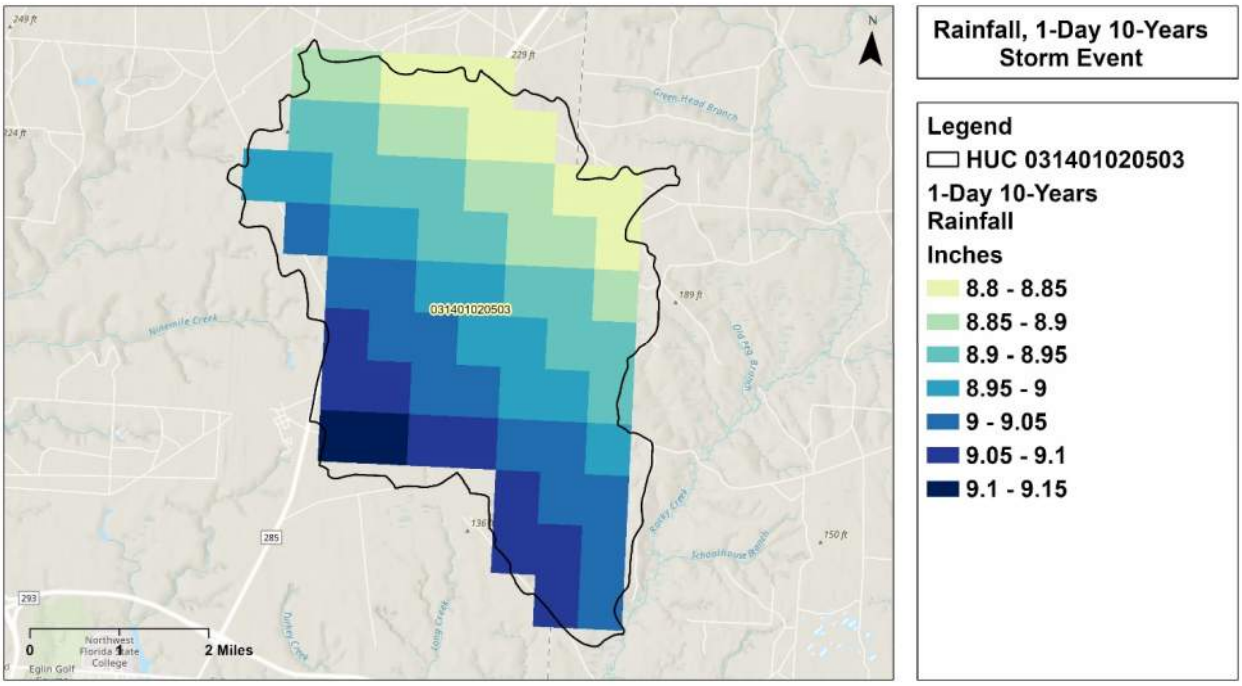

Figure 23. Rainfall distribution map across HUC 031401020503 sub-watershed, for 1-day 10-year storm event, processed by FAU.

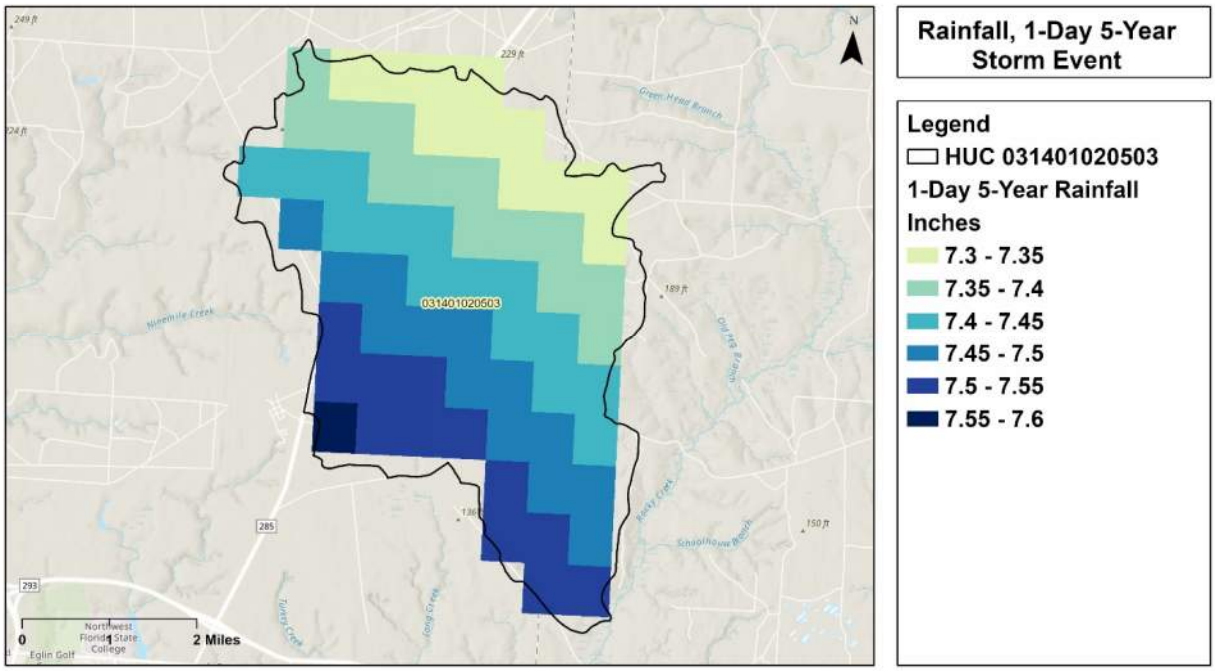

Figure 24. Rainfall distribution map across HUC 031401020503 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer

was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

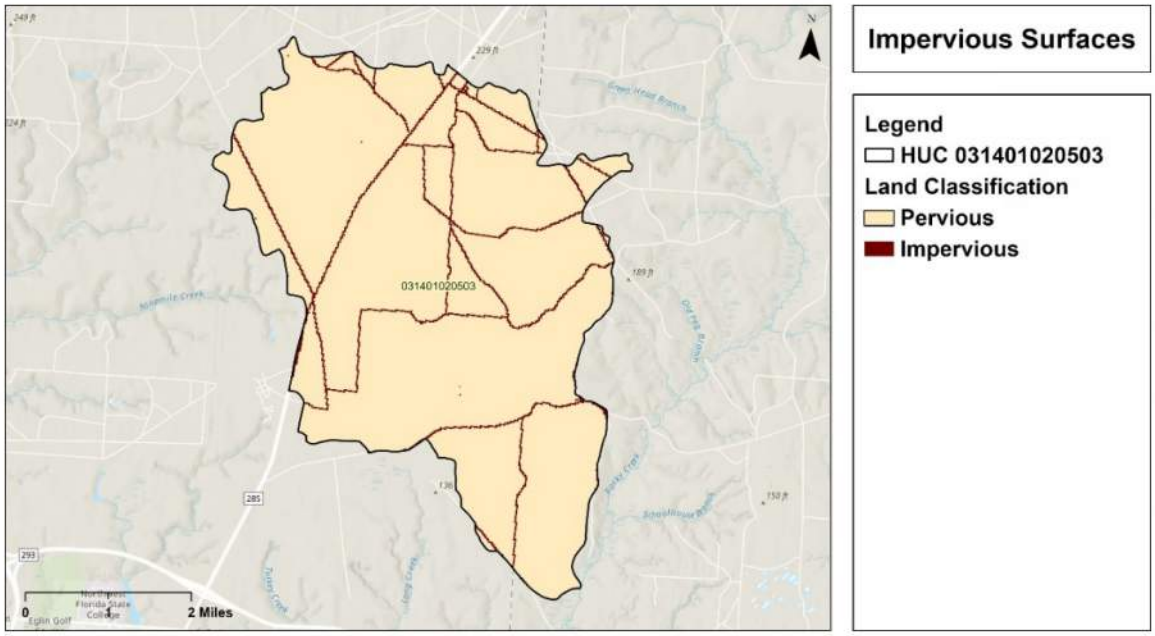

Figure 25. Impervious area map for the HUC 031401020503 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

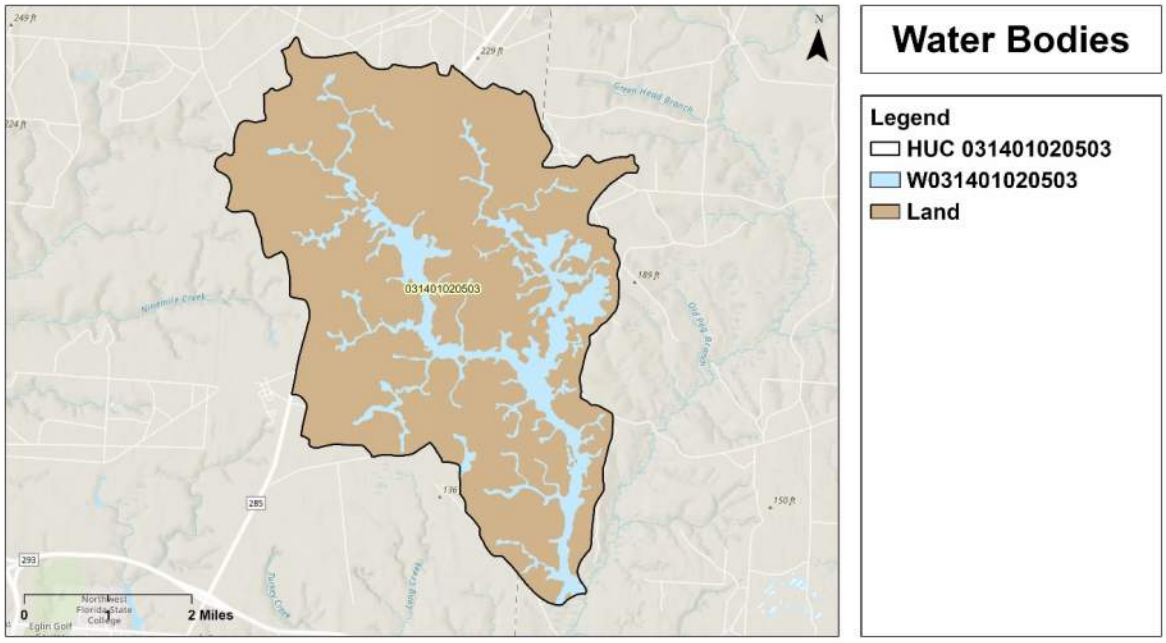

Figure 26. Water bodies map for the HUC 031401020503 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, , such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

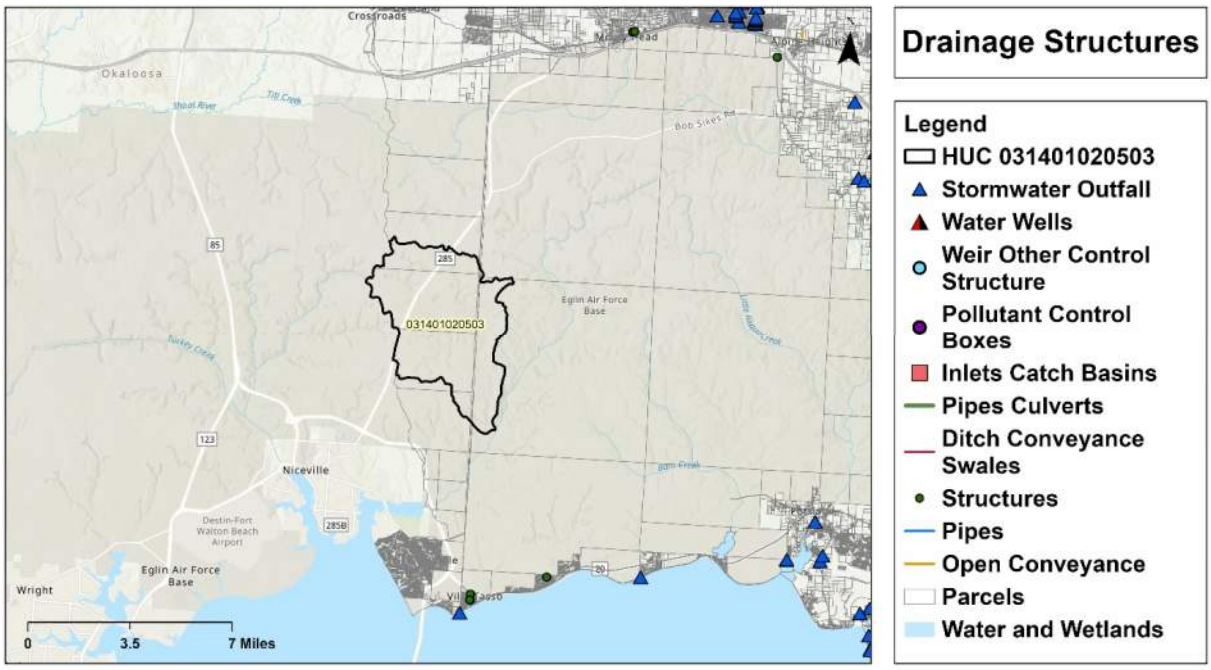

Figure 27. Stormwater Infrastructure for the HUC 031401020503. Processed by FAU.

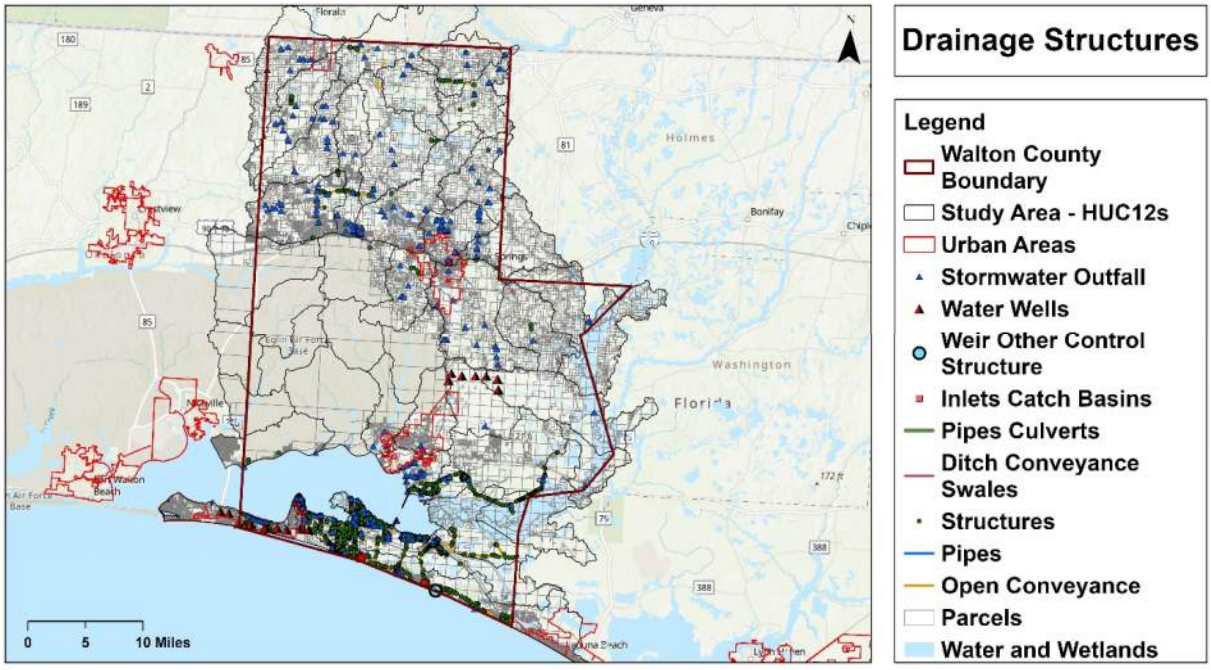

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**.. The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401020503 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the SFWMD DBHYDRO website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

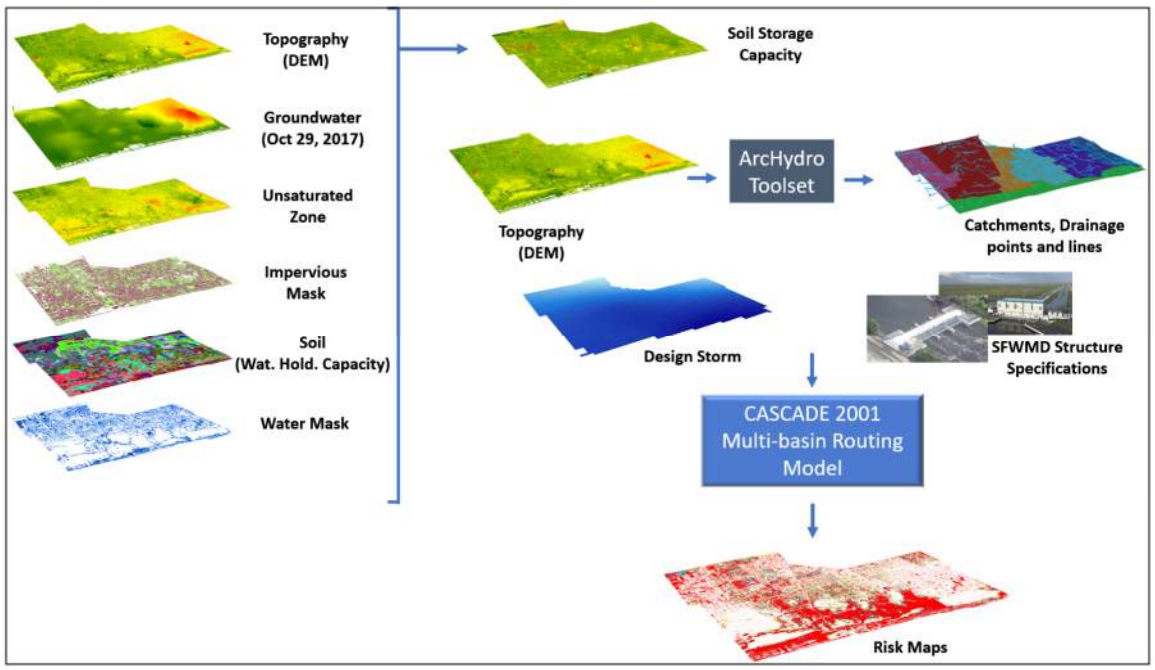

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)

= 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

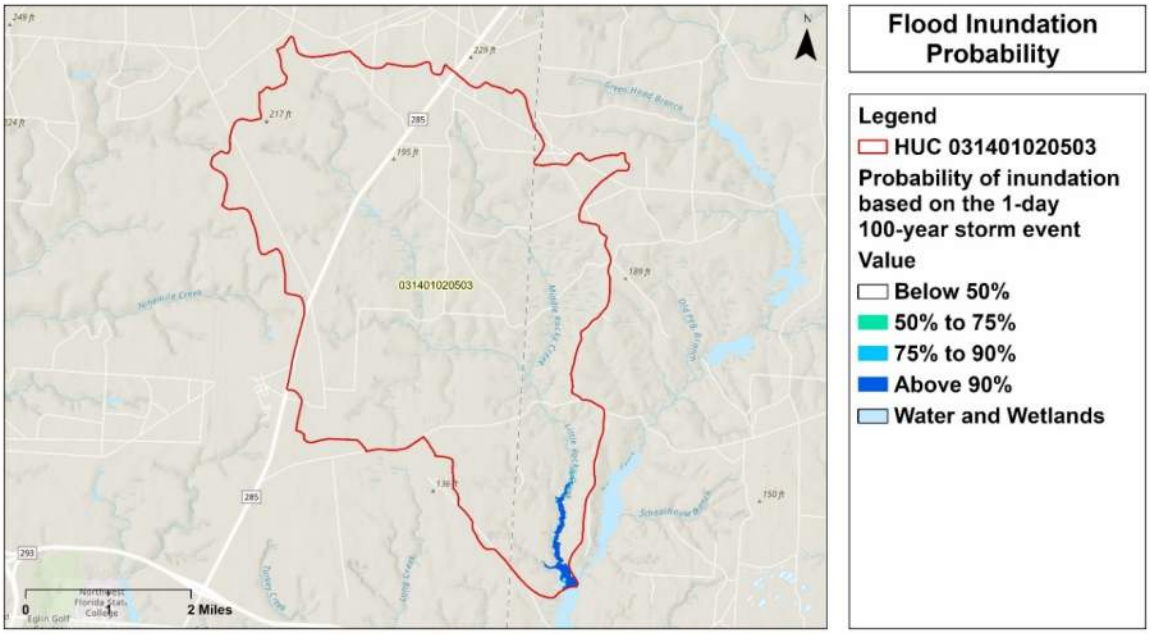

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401020503, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees

and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a small portion of flooding is noted at the entrance to the creek into the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, sea level rise should not impact the HUC, therefore SLR scenarios were not calculated.

The design storm simulation determined that approximately 0.6% of the HUC total area or 0.11 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 0.6% of the HUC's total area, or 0.12 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.4% of the HUC's total area, or 0.08 mi^2, would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0.3% of the HUC's total area, or 0.07 mi^2, would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401020503 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	19.15	0.11	99.4%	0.6%
1-day 100-year	19.14	0.12	99.4%	0.6%
1-day 10-year	19.18	0.08	99.6%	0.4%
1-day 5-year	19.19	0.07	99.7%	0.3%

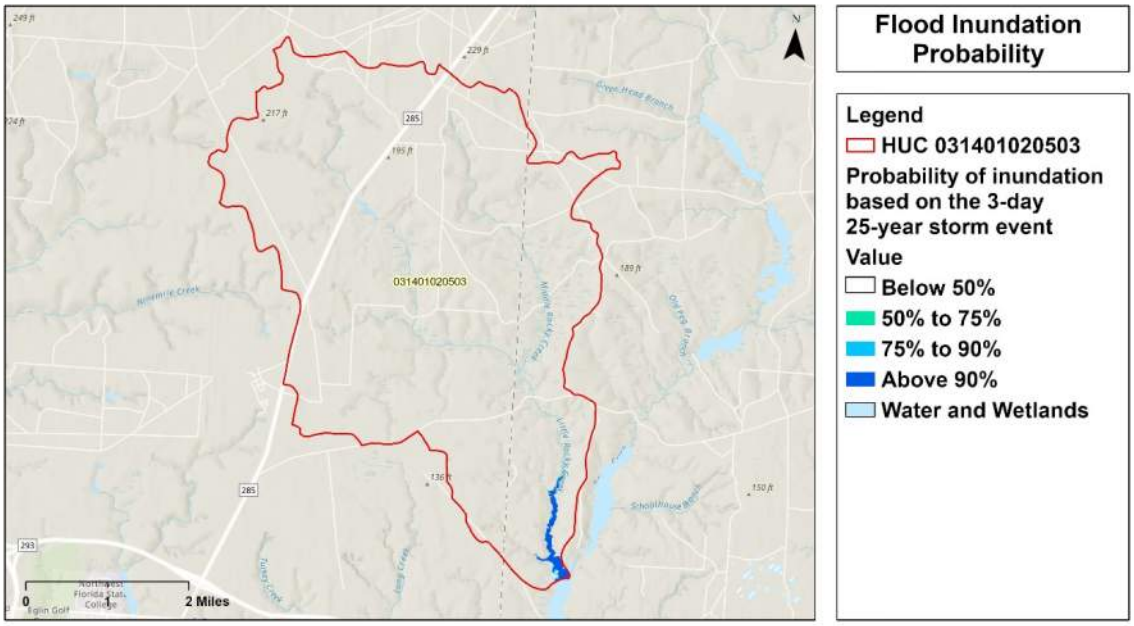

Figure 31. 3-day 25-year storm event for HUC 031401020503 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

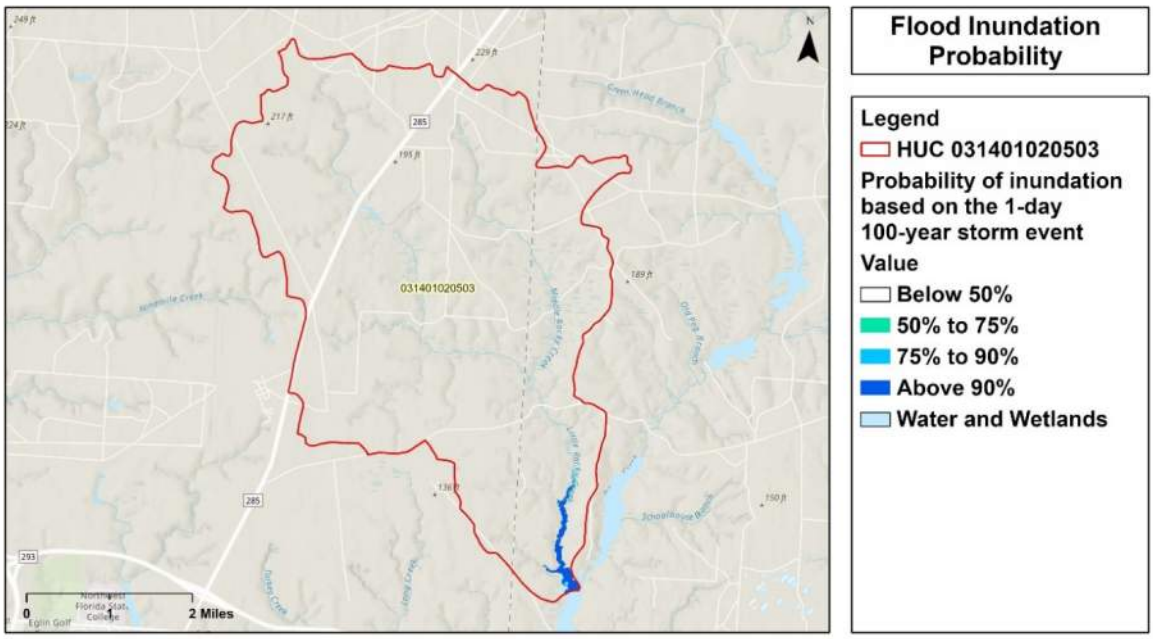

Figure 32. 1-day 100-year storm event for HUC 031401020503 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

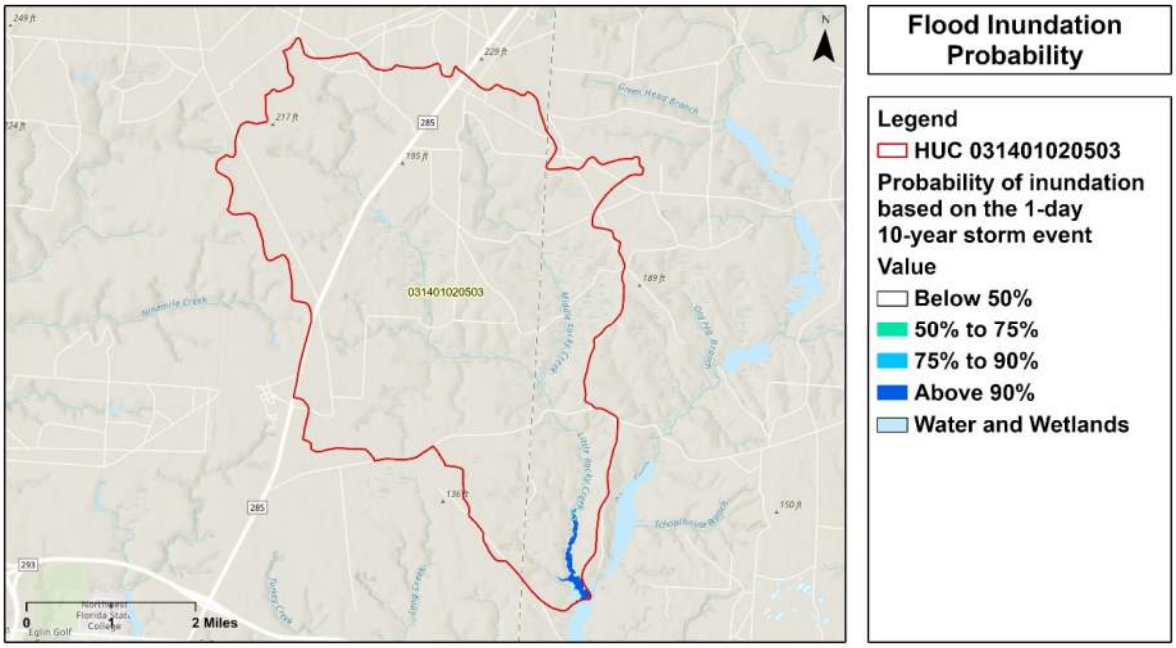

Figure 33. 1-day 10-year storm event for HUC 031401020503 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

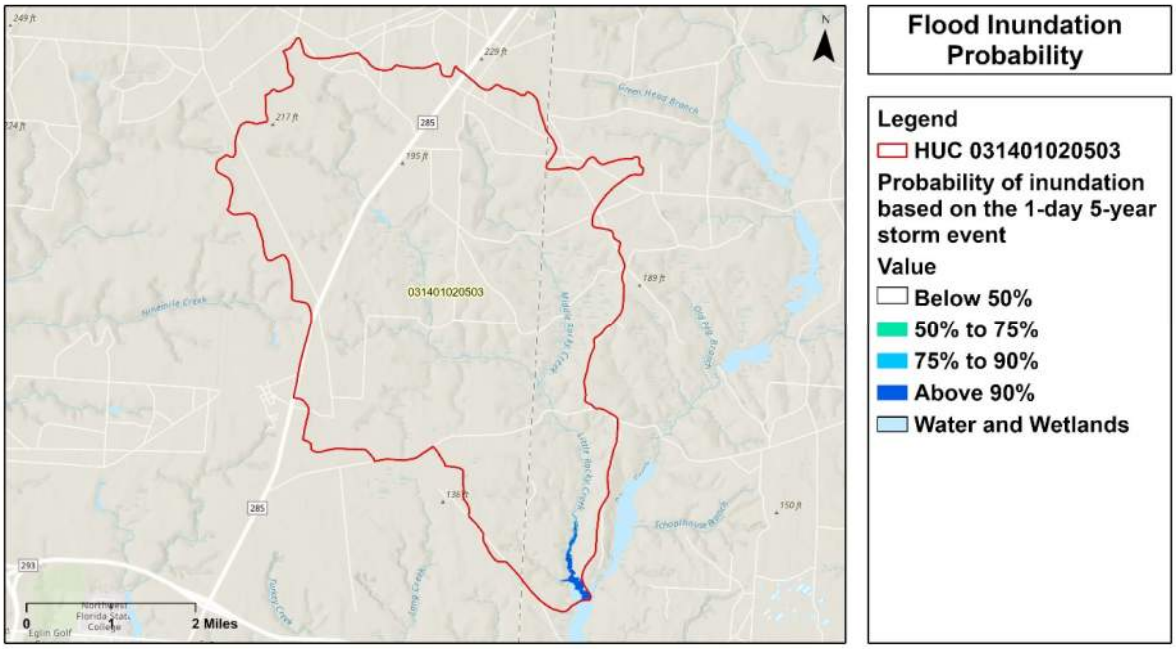

Figure 34. 1-day 5-year storm event for HUC 031401020503 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. The major regional issues in the greater watershed are the C43 reservoir and capital projects associated with the SFWMD plans for controlling discharges that impact the ecosystem in the west end of the watershed. Hence regional water management districts and USACE projects have higher priority due the larger area served. All other improvements are distinctly local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	Description	TIER (Priority of Land Use)
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5

23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories,	5

	Bakeries, Potato Chip Factories	
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2

74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6

101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, as shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.**depict the HUC 031401020503 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

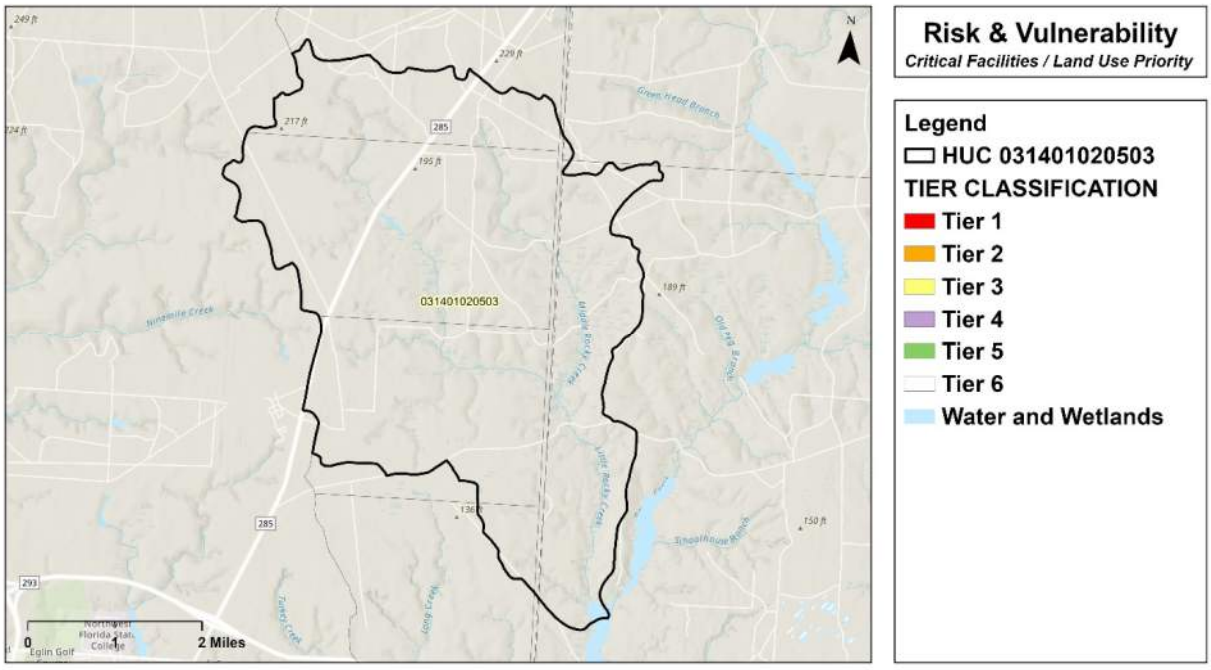

Figure 35. HUC 031401020503 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

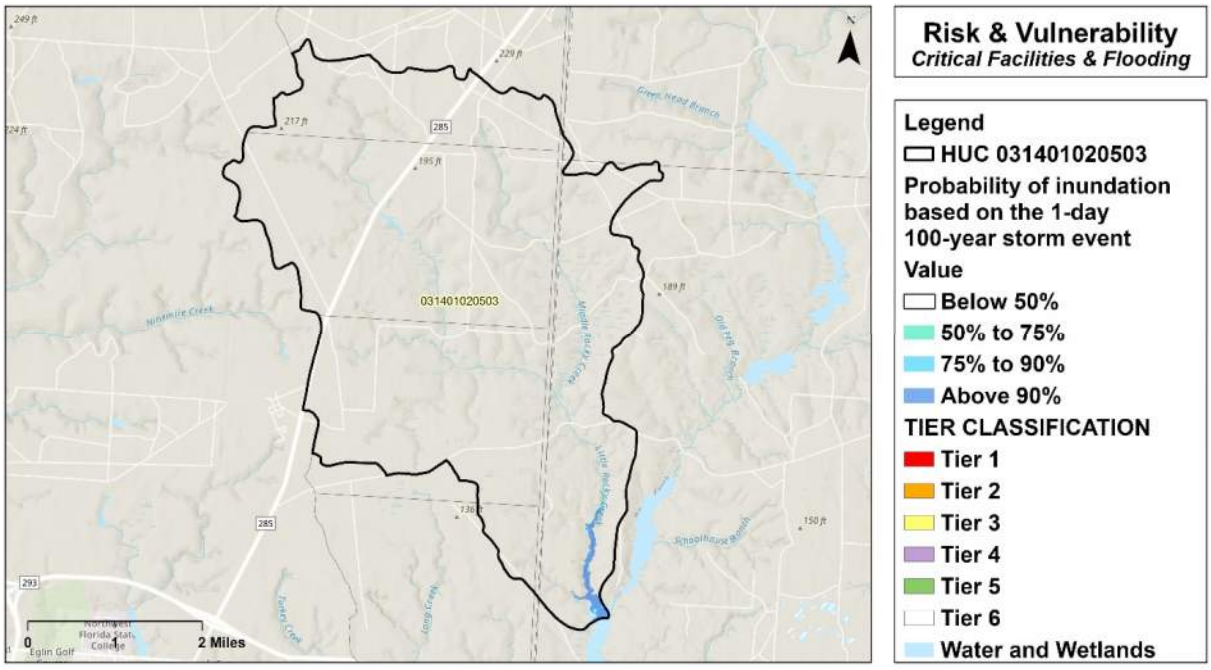

Figure 36. HUC 031401020503 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

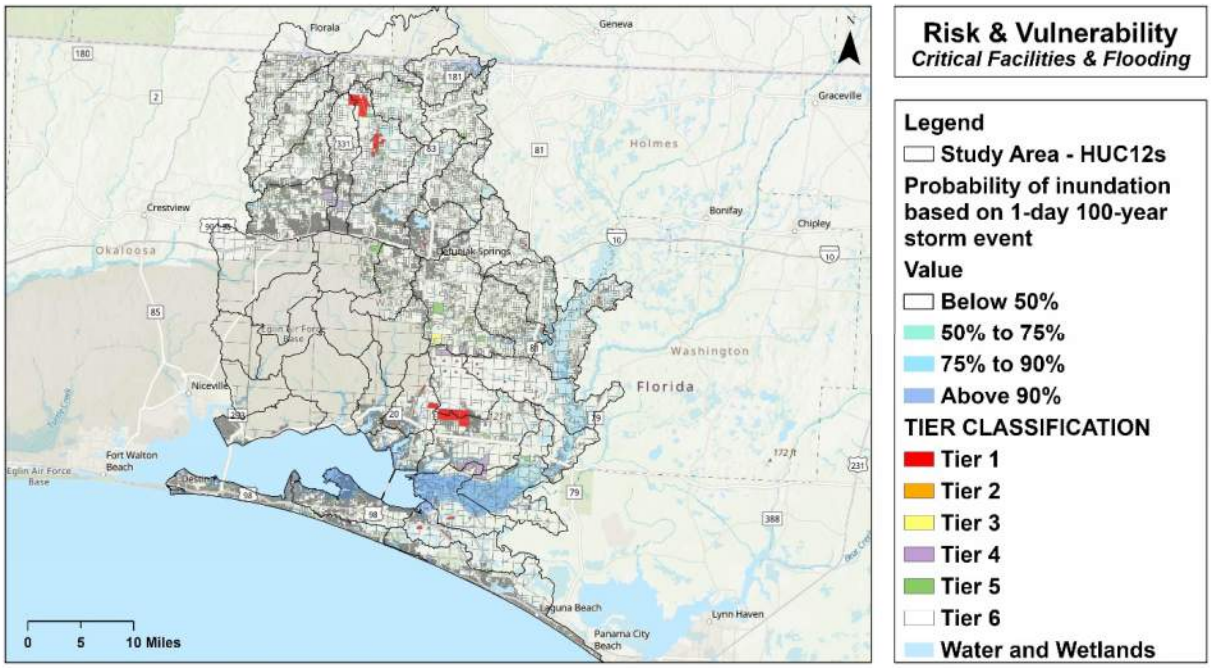

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

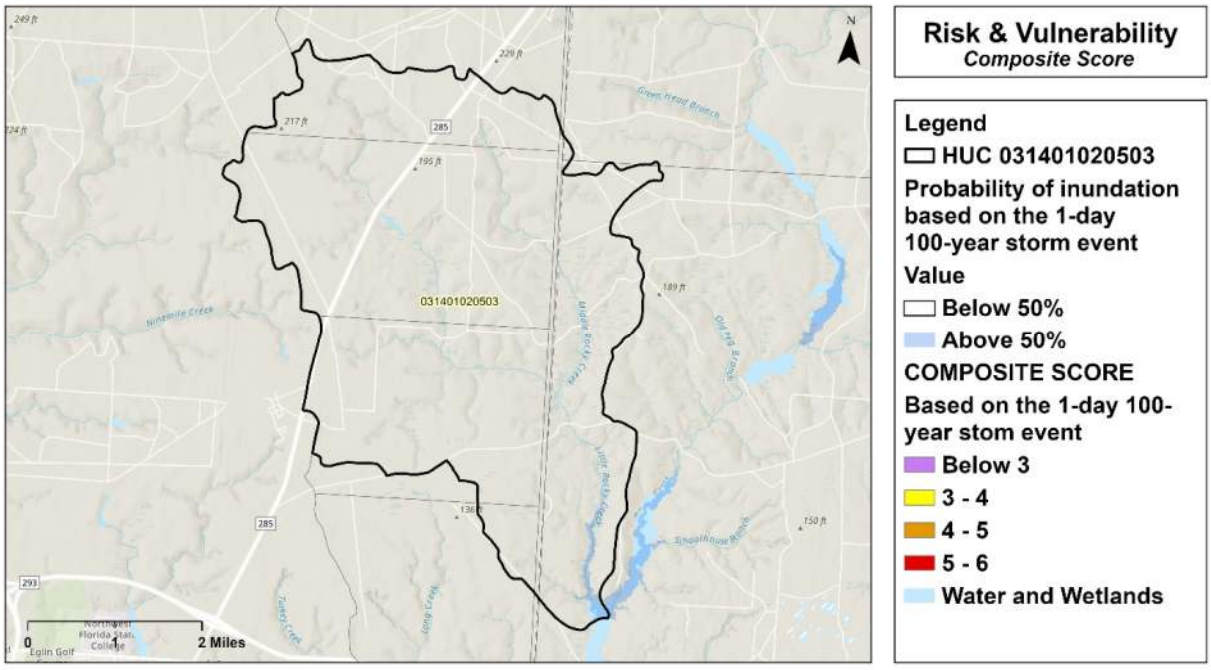

Figure 38. HUC 031401020503 sub-watershed Composite Score Risk map, calculation based on 1-day 100-year storm event. Processed by FAU.

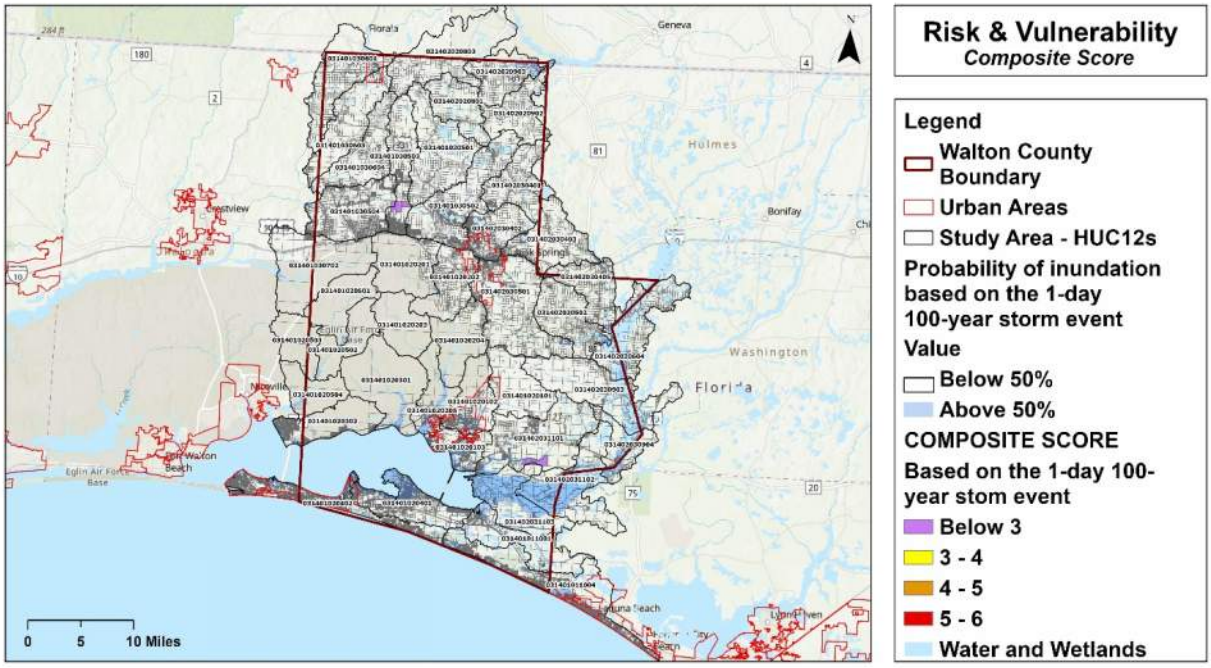

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

Please note that due to the scale of the map, the composite score layer is not properly visible in this map.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401020503. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It is important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evalu

ation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands: This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands: In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401020503. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401020503	12325.27
All of the 1-day 100-year storm event inundation	**74.27**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	18.36
B. Federal Land in 1-day 100-year inundation > 10 acres	55.91
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	0.00
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	0.00

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. Figure 40 indicates the results

from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

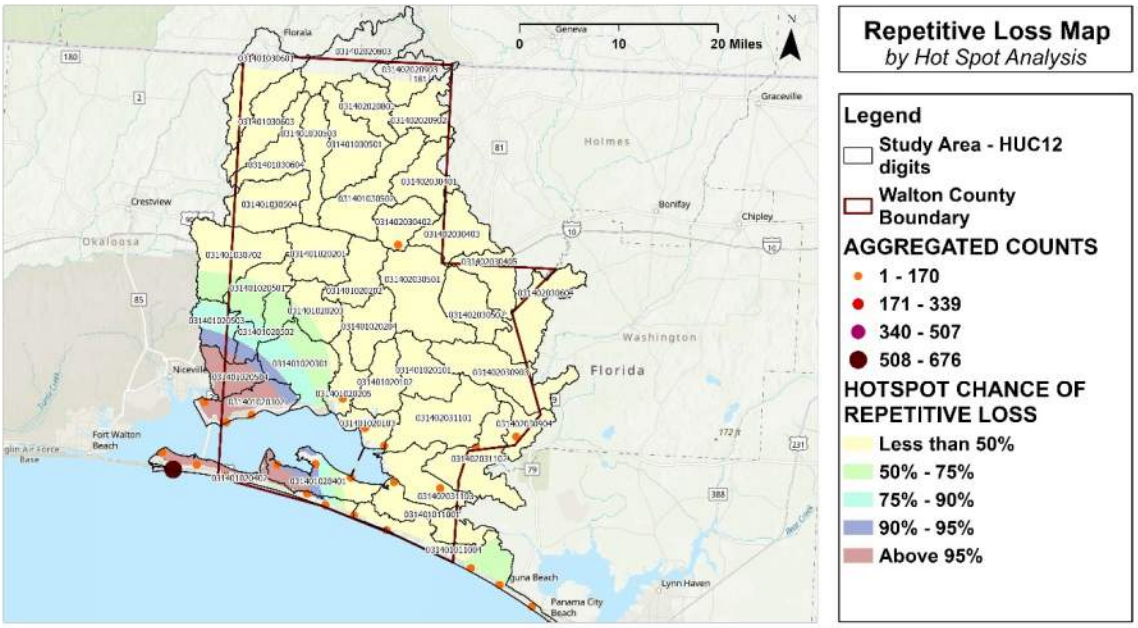

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5. Priority Projects

The entire HUC area is undeveloped and non-coastal. As a result, there are no critical facilities or other land uses that require priority intervention. The minor flooding and null composite score indicate that the HUC is not significantly affected by flooding, and there are no pressing priorities for interventions to address inundation impacts.

APPENDIX S

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401020504

LOWER ROCKY CREEK-ROCKY BAYOU

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Co-Principal Investigators: Weibo Liu, Ph.D., Daniel Meeroff, Ph.D., Diana Mitsova, Ph.D., S. Nagarajan, Ph.D., Hongbo Su, Ph.D., Ramesh Teegavarapu, Ph.D., Zhixiao Xie, Ph.D., Yan Yong, Ph.D., and Caiyun Zhang, Ph.D., Ahmet Urusan, Ph.D., Shannon Egger, Eva Suarez, Ph.D.

Research Assistant: Leticia Sabio

This resource was funded in part, through a grant agreement from the Florida Division of Emergency Management's (FDEM) Bureau of Mitigation, by a grant provided by through the Hazard Mitigation Grant Program (HMGP) DR-4337-004-P, as approved by FDEM and the Federal Emergency Management Agency (FEMA) to create and update Watershed Master Plans (WMP) throughout the state of Florida. The views, statements, findings, conclusions, and recommendations expressed herein are those of the authors and do not necessarily reflect the views of the State of Florida, FEMA, or any of their sub-agencies.

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 sub-watershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds ((**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401020504) is highlighted among all the HUCs to help identifying its location. (Figure 3).

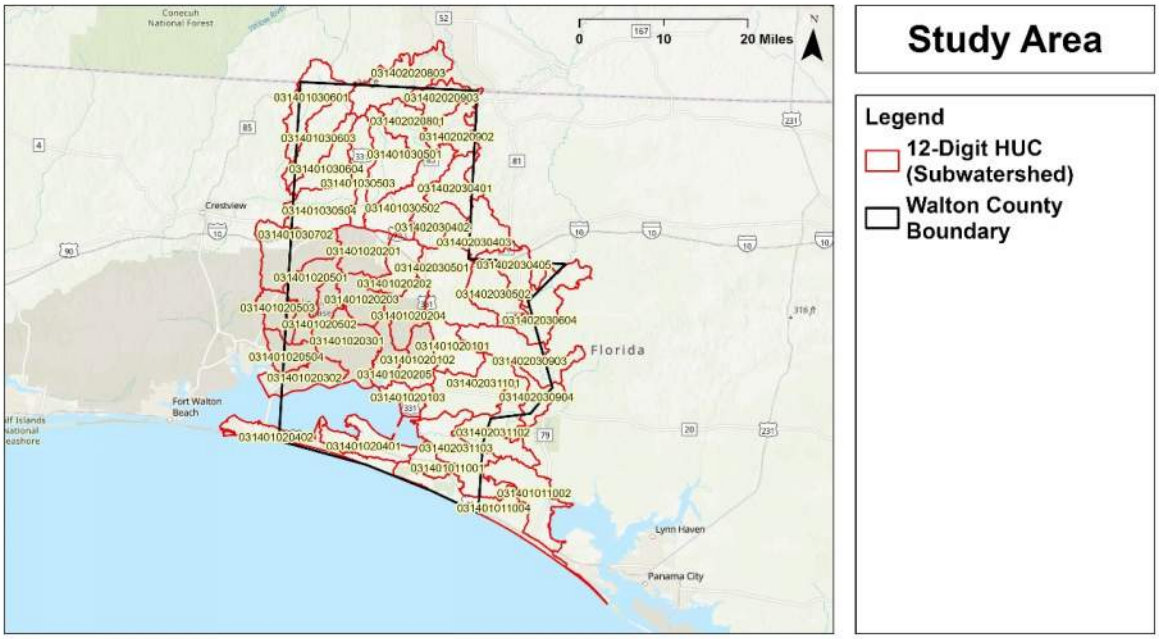

Figure 1. Walton County and all HUCs 12-digit sub-watershed, processed by FAU.

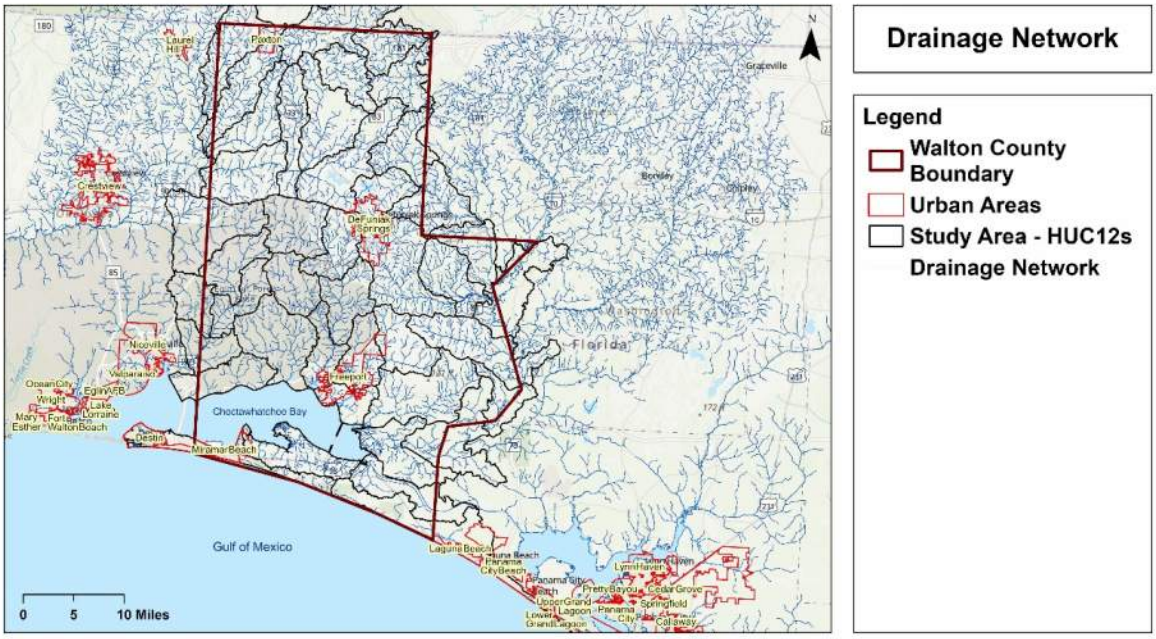

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

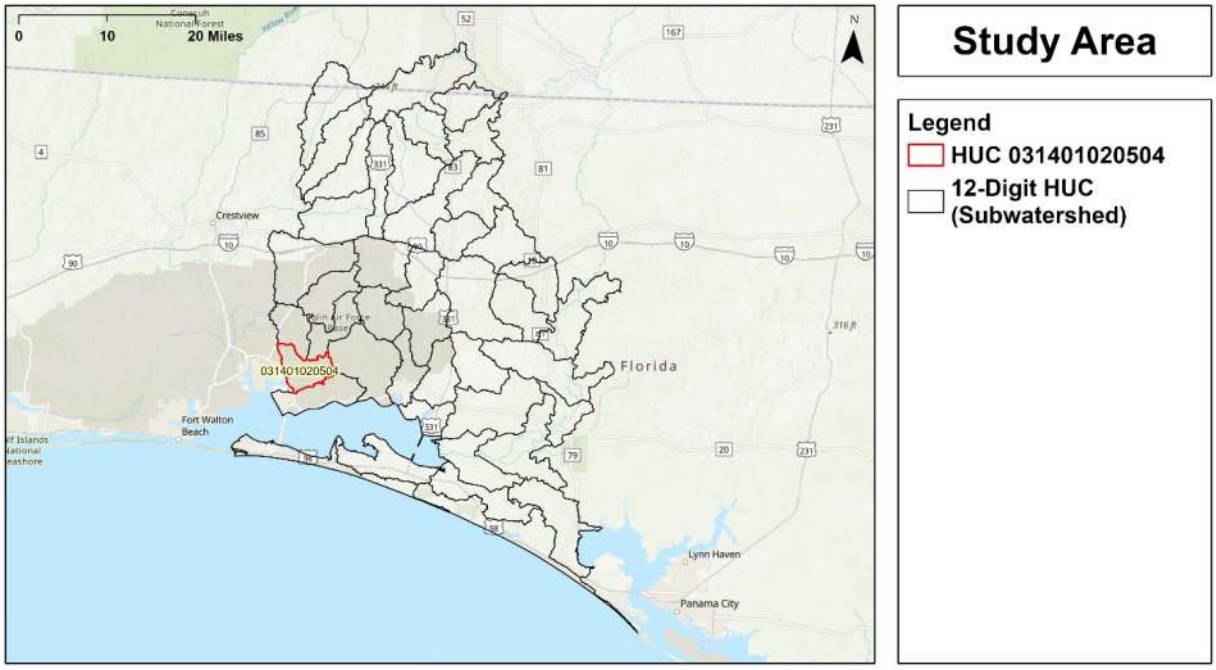

Figure 3. HUC 031401020504 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Based on the future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with

high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

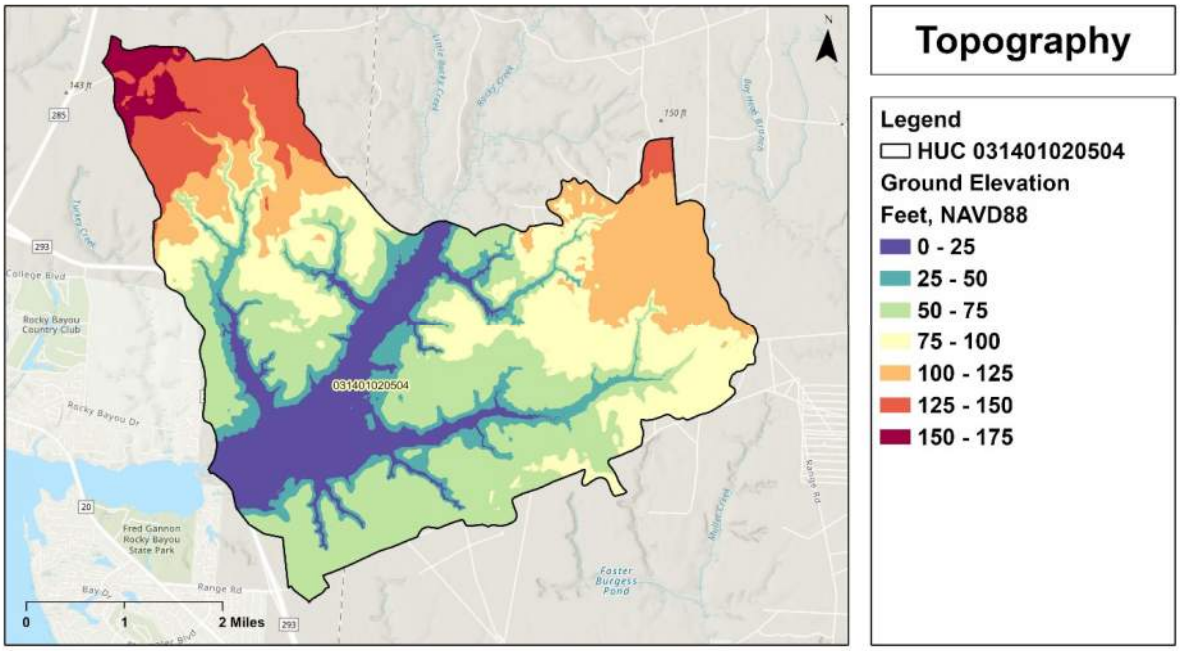

Figure 4. Topographic map of the HUC 031401020504 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of

wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401020504 sub-watershed is shown in Figure 5.

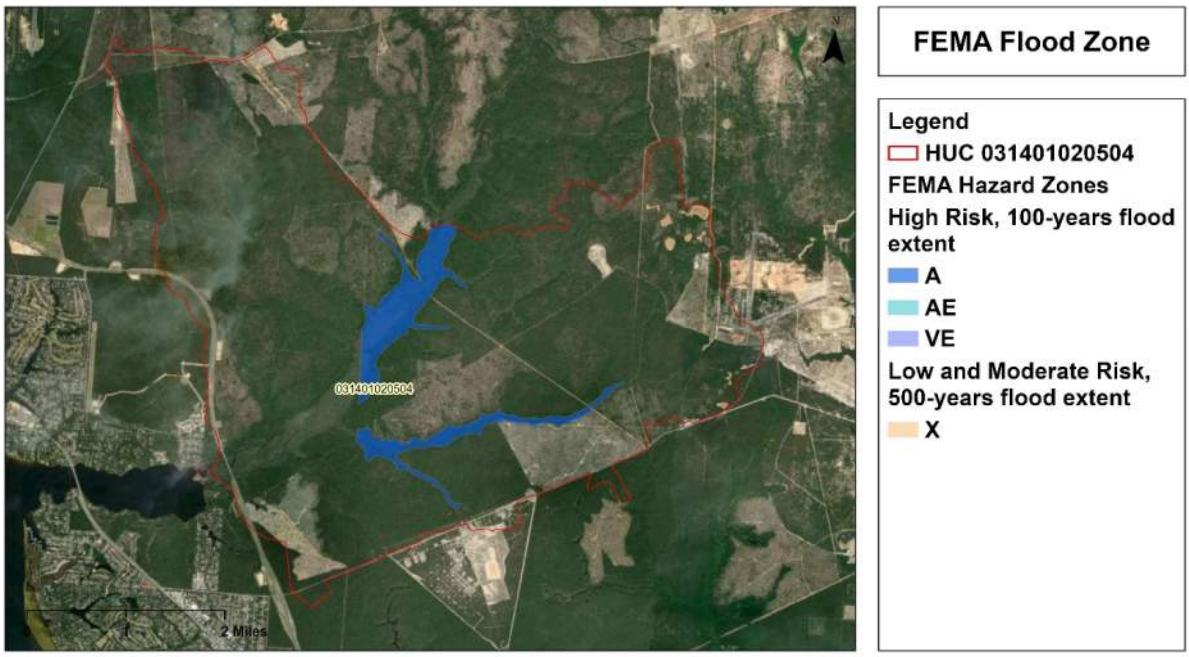

Figure 5. FEMA Flood Zone map (2020) for HUC 031401020504 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal

area, including the sub-watershed 031401020504 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

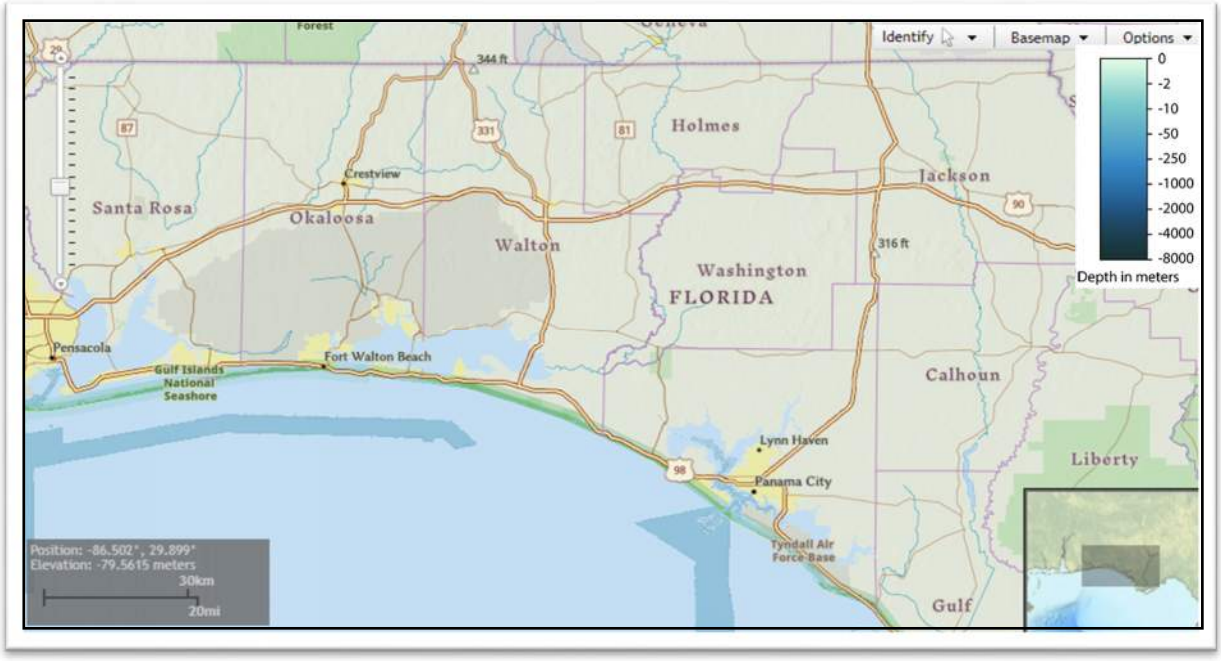

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological

conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

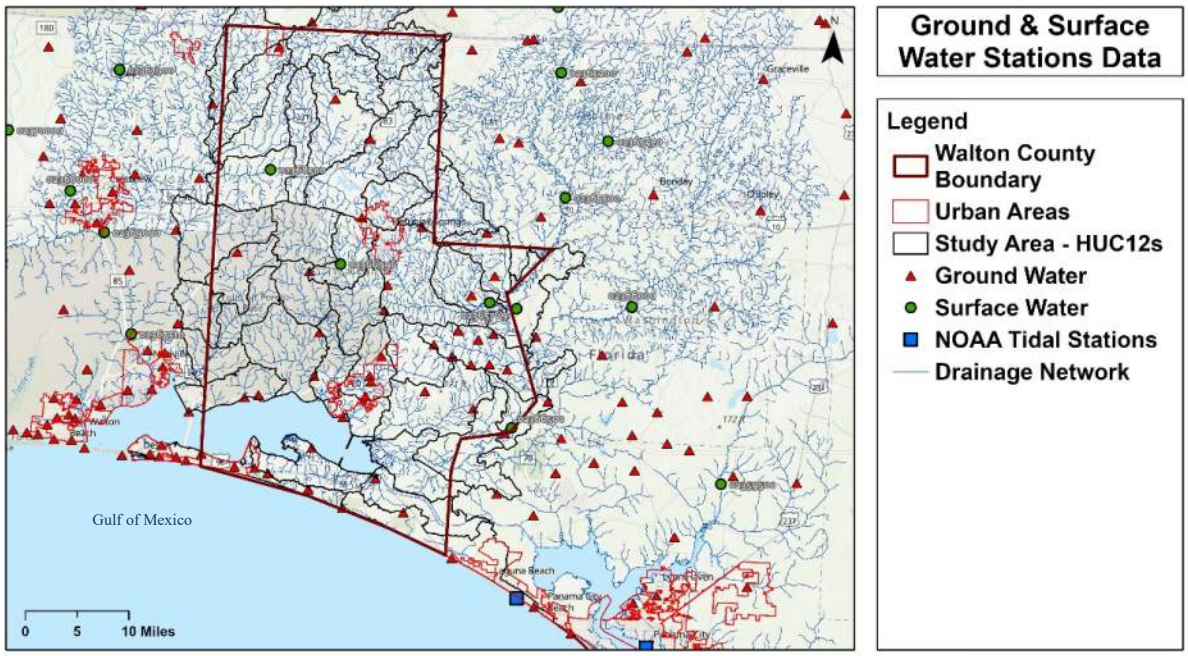

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031401020504 connects to the ocean via Rocky Bayou. The major waterbodies within the basin include:

- Rocky Creek
- Smith Branch
- Long Creek
- Bee Branch
- Deep Head
- Hickory Branch

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366996. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401020504, which is USGS 02366996 Alaqua Creek Near Pleasant Ridge, FL.

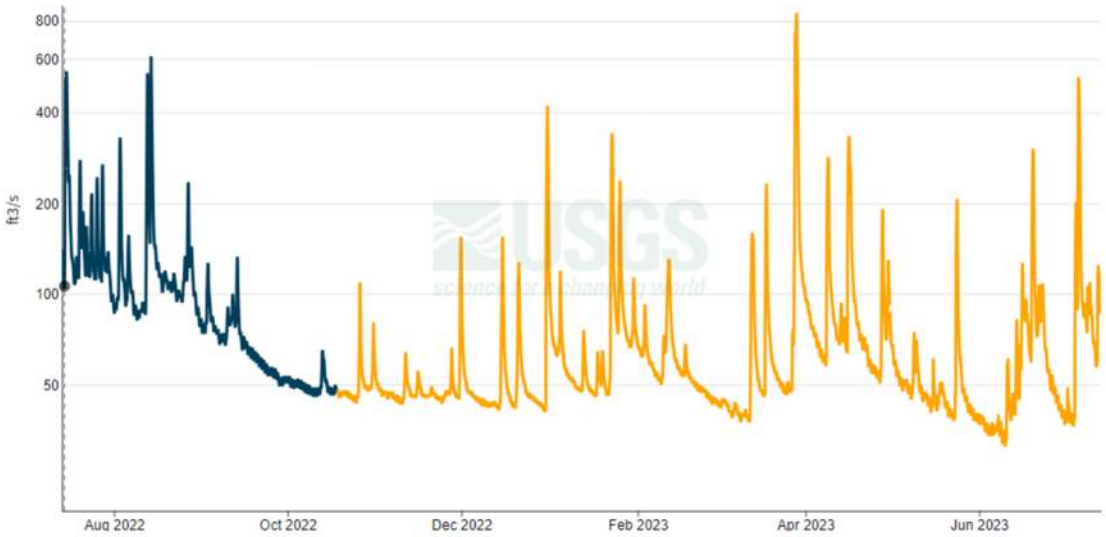

Figure 8. Average streamflow for Alaqua Creek Near Pleasant Ridge, FL (USGS 02366996 Surface-Water, June 2022 to July 2023.
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366996/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to

process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401020504 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031401020504 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

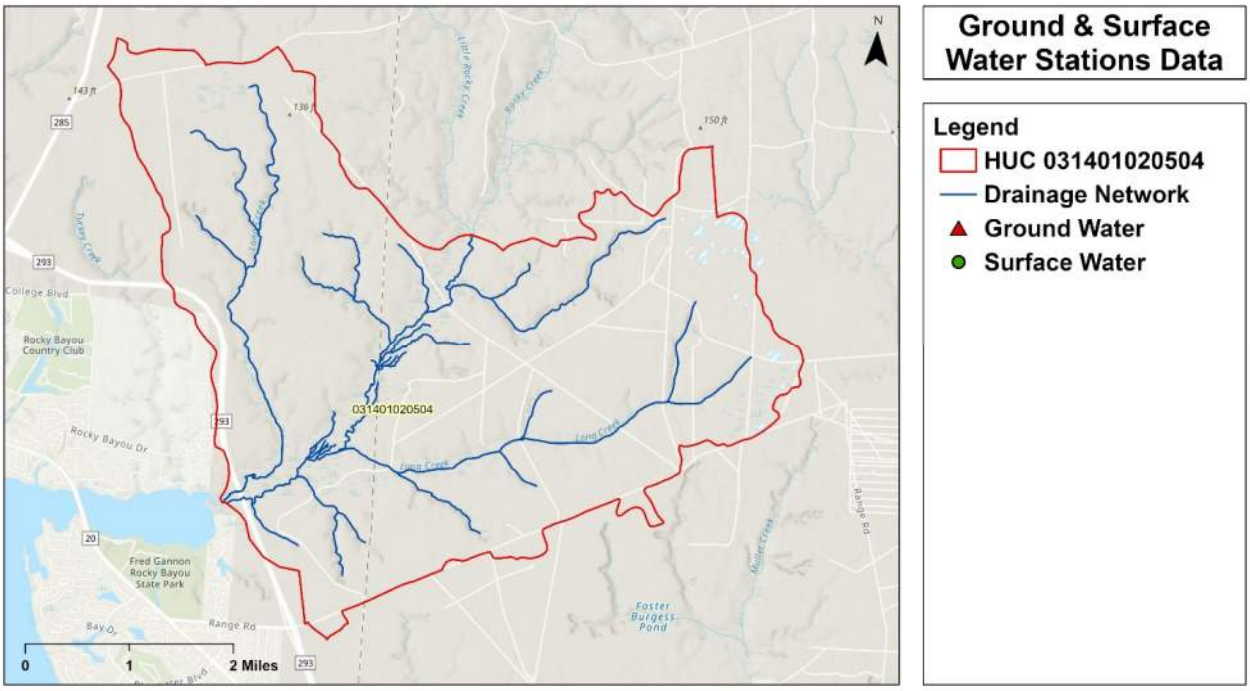

Figure 9. Ground and Surface Water Stations in the HUC 031401020504 sub-watershed, processed by FAU.

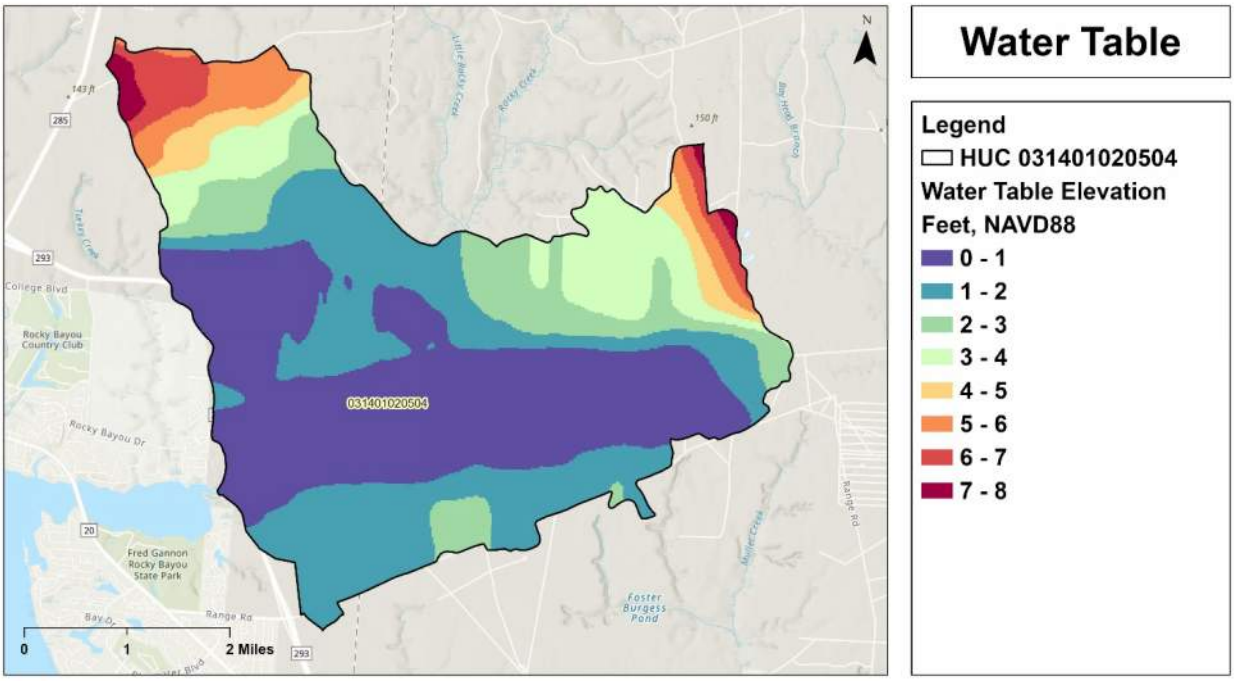

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401020504 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

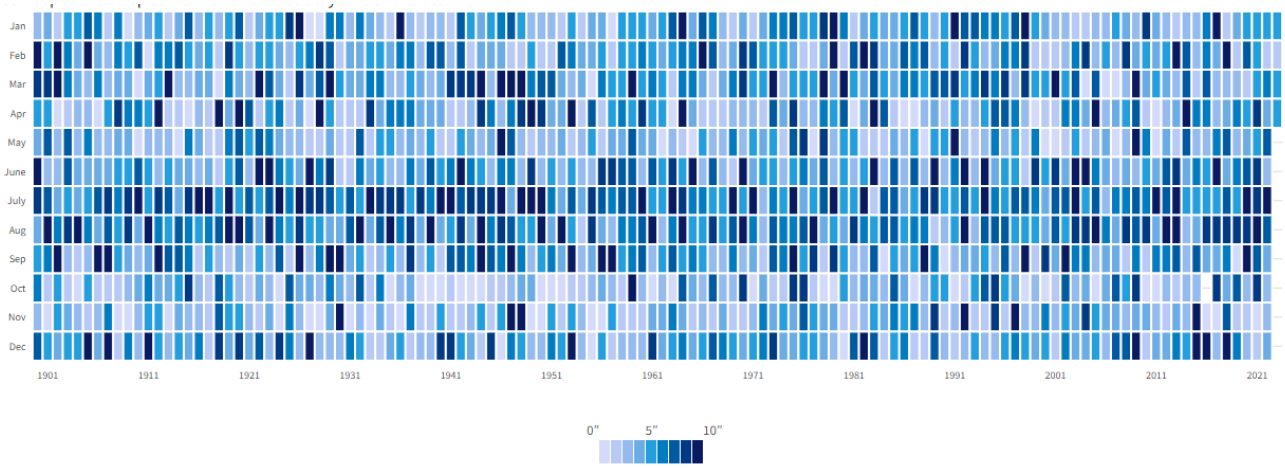

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/).

While the topography (Section 2.1) and native soil (Section 2.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there are no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

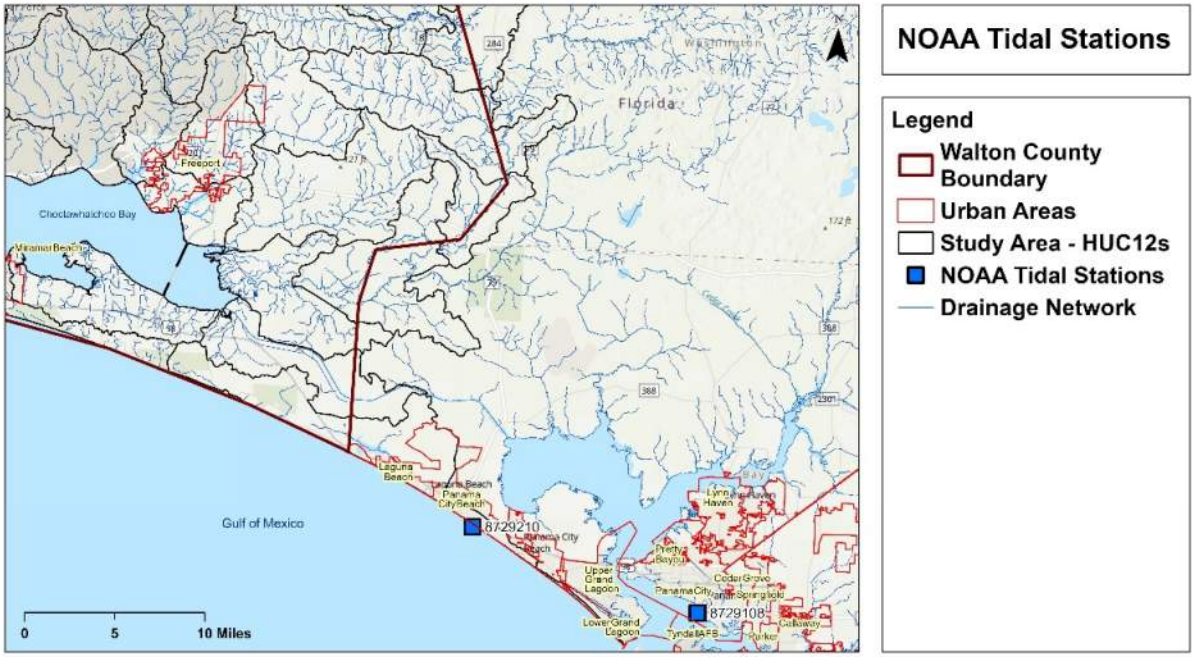

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

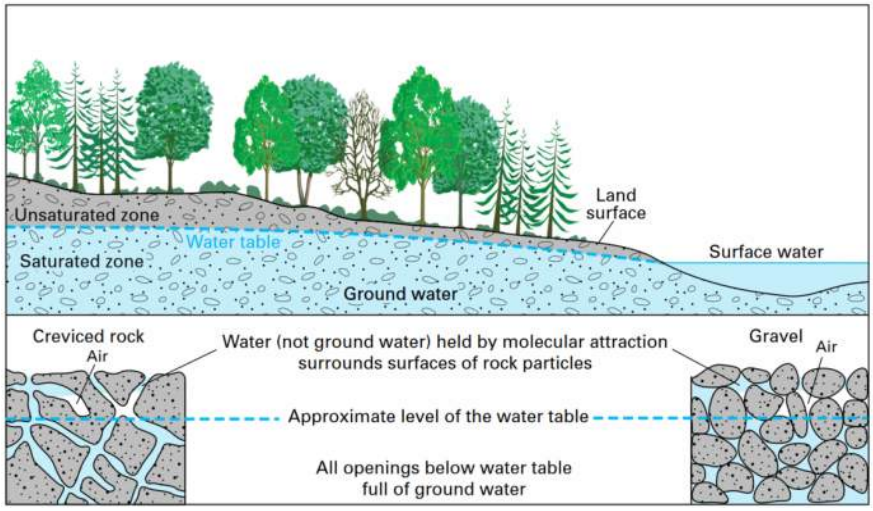

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

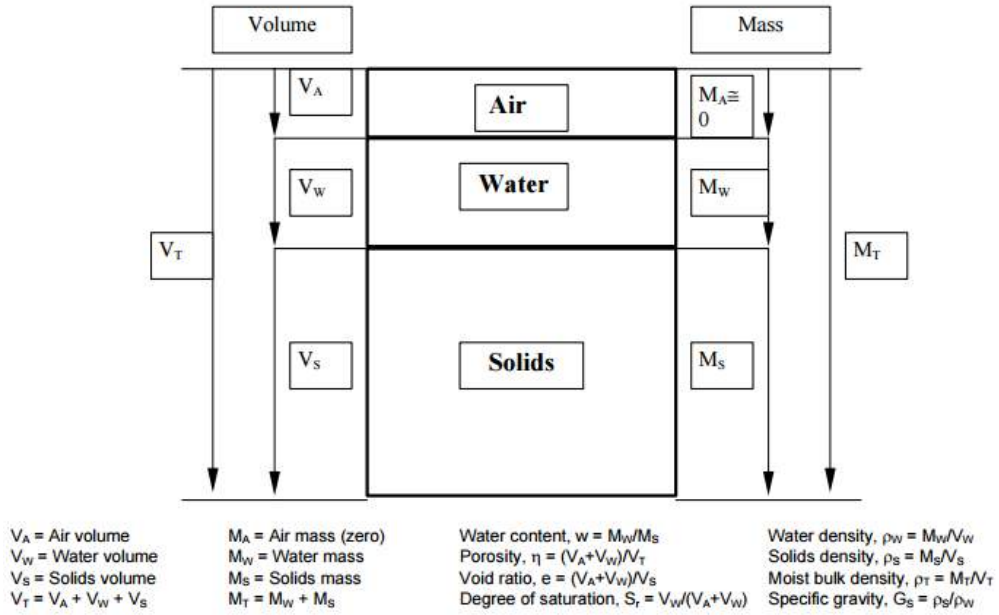

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

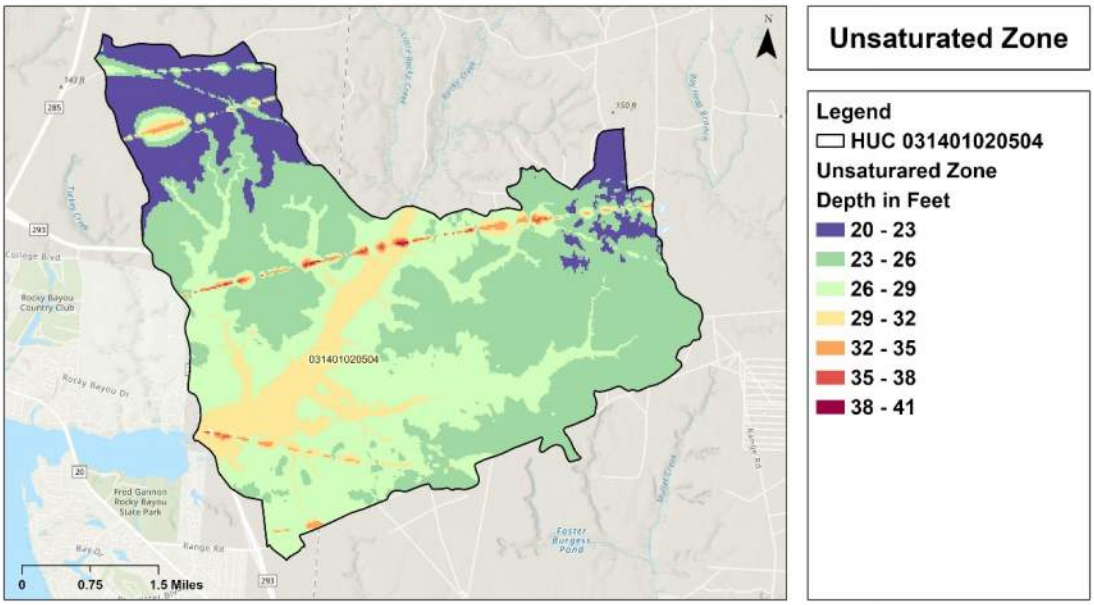

Figure 15. Unsaturated zone map for HUC 031401020504, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderate soil storage capacity, falling within the range of 20 to 32 feet of remaining capacity.

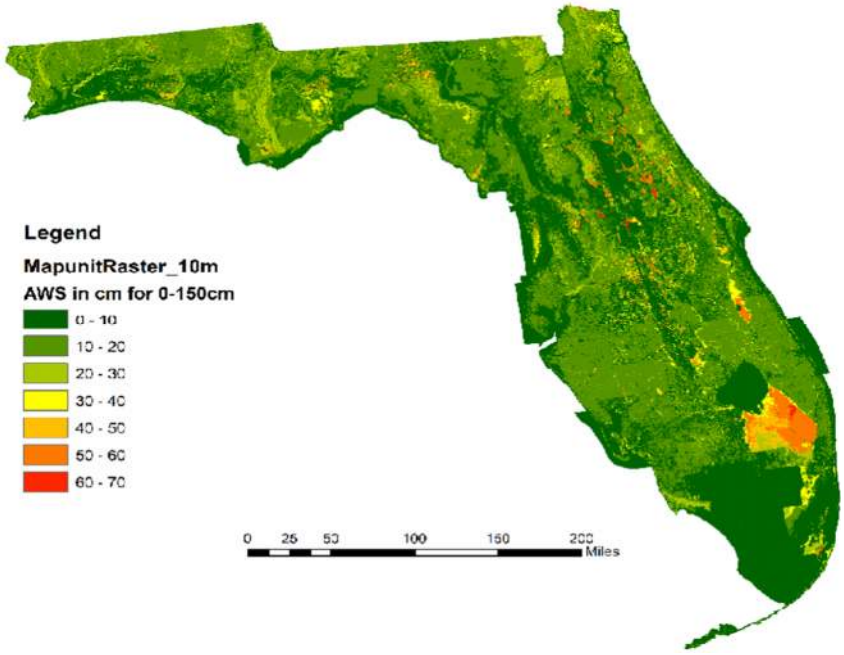

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

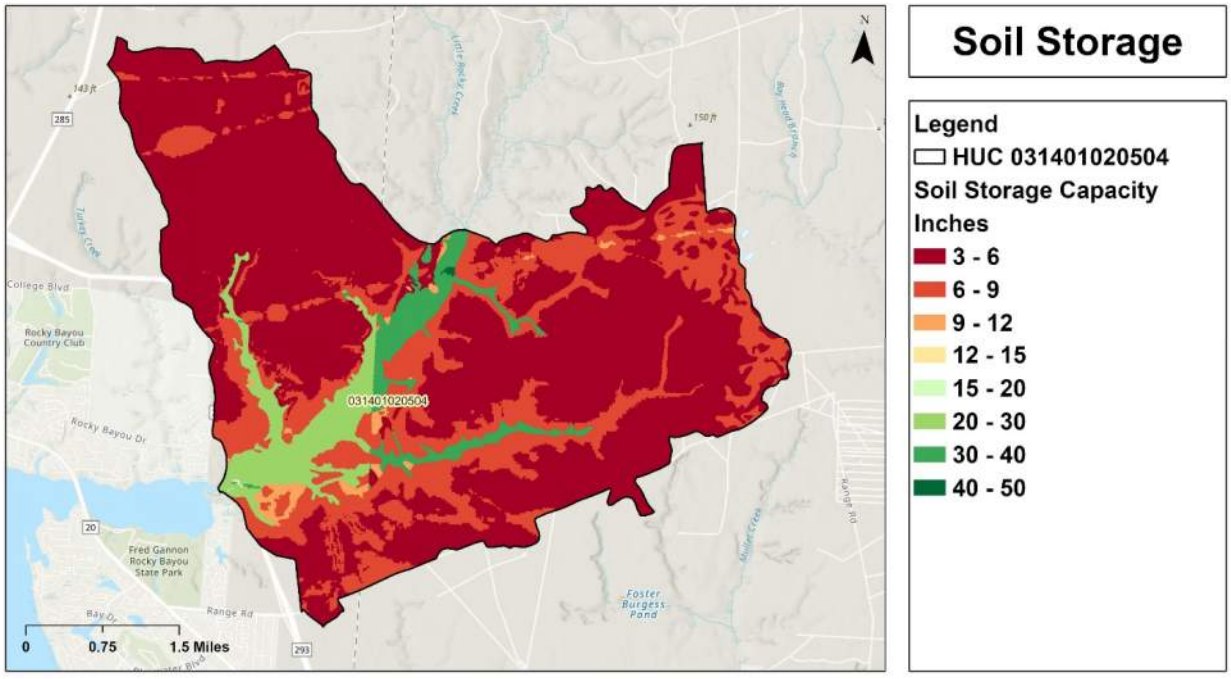

Figure 17. Water storage capacity of soil for the HUC 031401020504, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

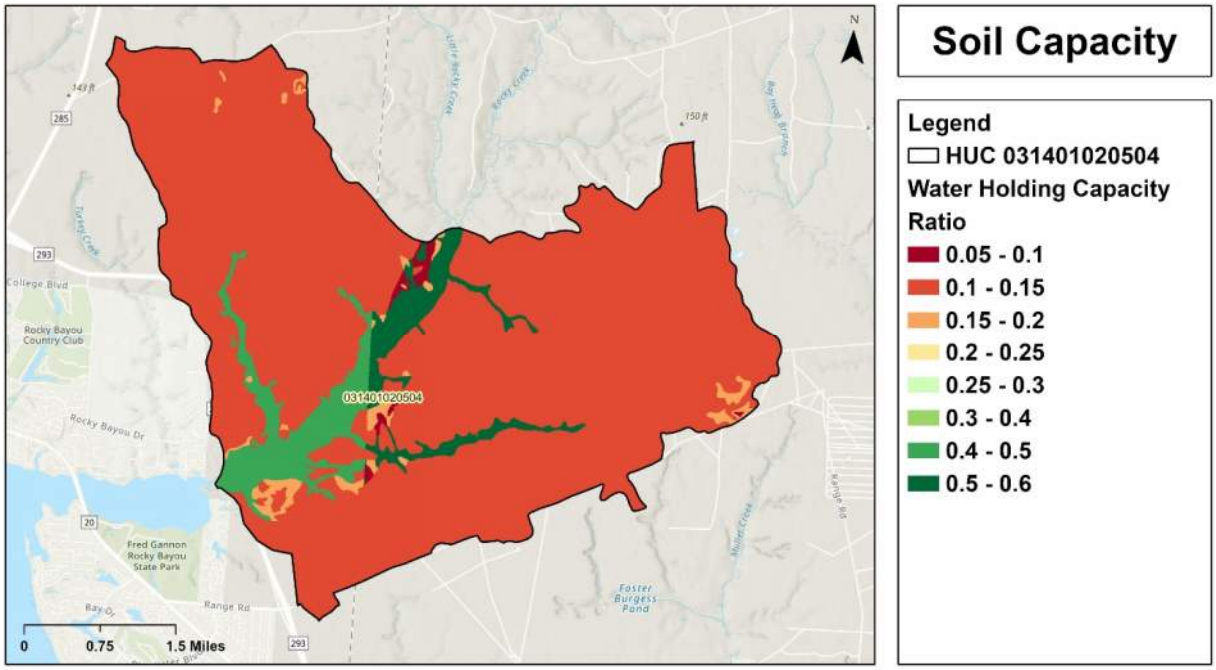

Figure 18. Water Holding Capacity (ratio) for the HUC 031401020504, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

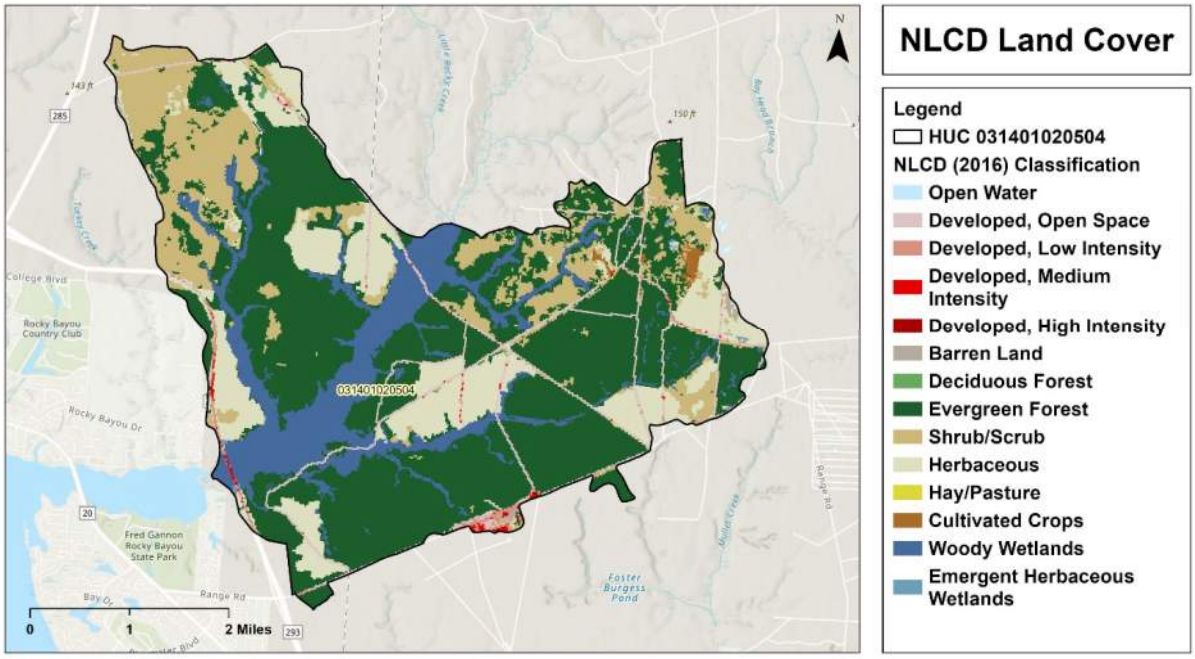

Figure 19. Land use in the HUC 031401020504 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

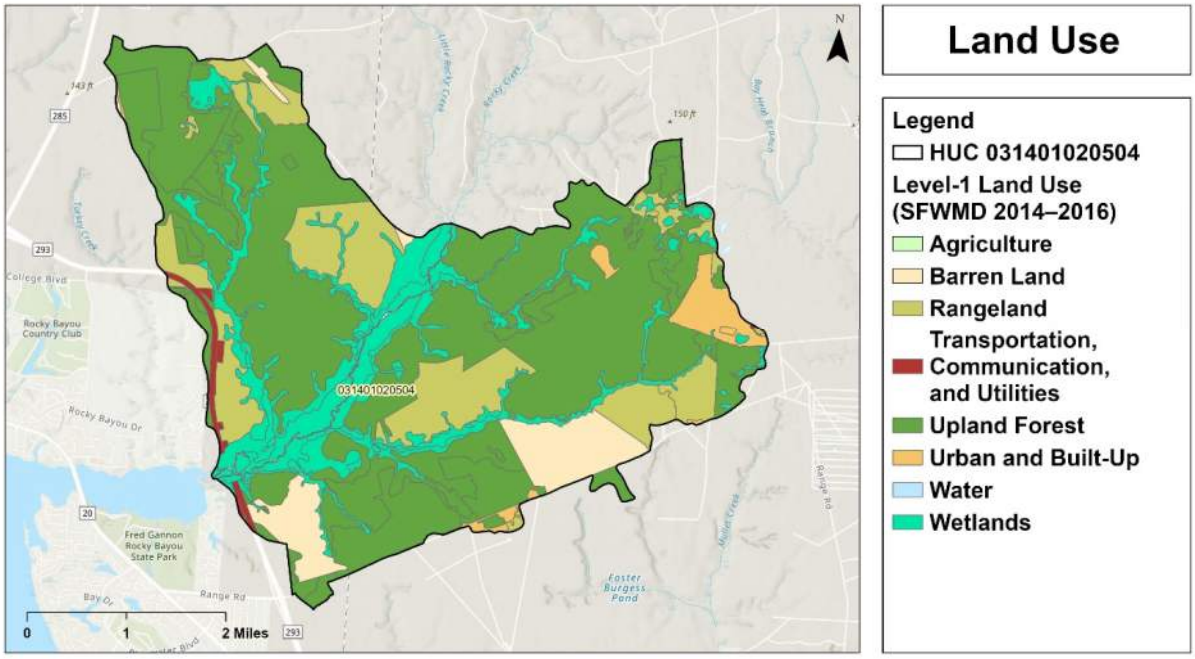

Figure 20. Land use in the HUC 031401020504 (2023 Florida Geographic Data Library (FGDL) database)) processed by FAU.

In the HUC 031401020504 sub-watershed, the predominant land cover is upland forest, accounting for 68.30% of the area. Rangeland comes in second at 9.72%, followed by wetlands at 8.51%. Developed land constitutes also a good portion, with 7.61% categorized as urban and built-up, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031401020504 sub-watershed (2023 Florida Geographic Data Library (FGDL) database)).

Level 1 Land Use Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	0.00	0.00%
Barren Land	887.38	3.74%
Rangeland	2306.56	9.72%
Transportation, Communication, and Utilities	465.05	1.96%
Upland Forest	16200.15	68.30%
Urban and Built-Up	1805.86	7.61%
Water	37.96	0.16%
Wetlands	2017.66	8.51%
Grand Total:	**23720.62**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

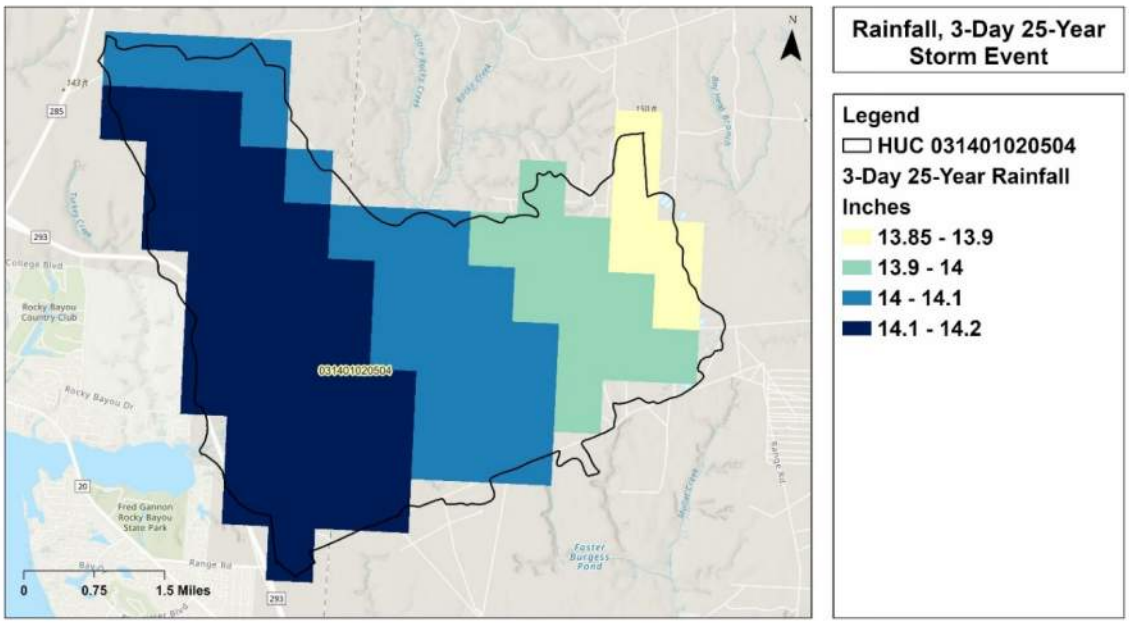

Figure 21. Rainfall distribution map across HUC 031401020504 sub-watershed, for 3-day 25-year storm event, processed by FAU.

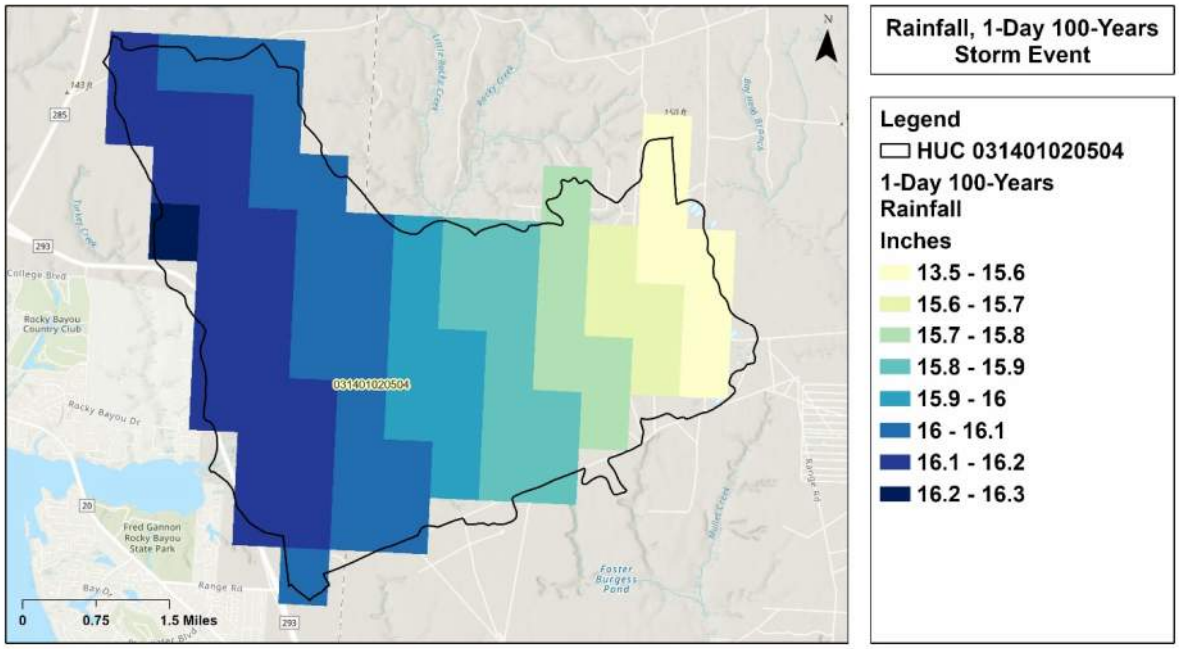

Figure 22. Rainfall distribution map across HUC 031401020504 sub-watershed, for 1-day 100-year storm event, processed by FAU.

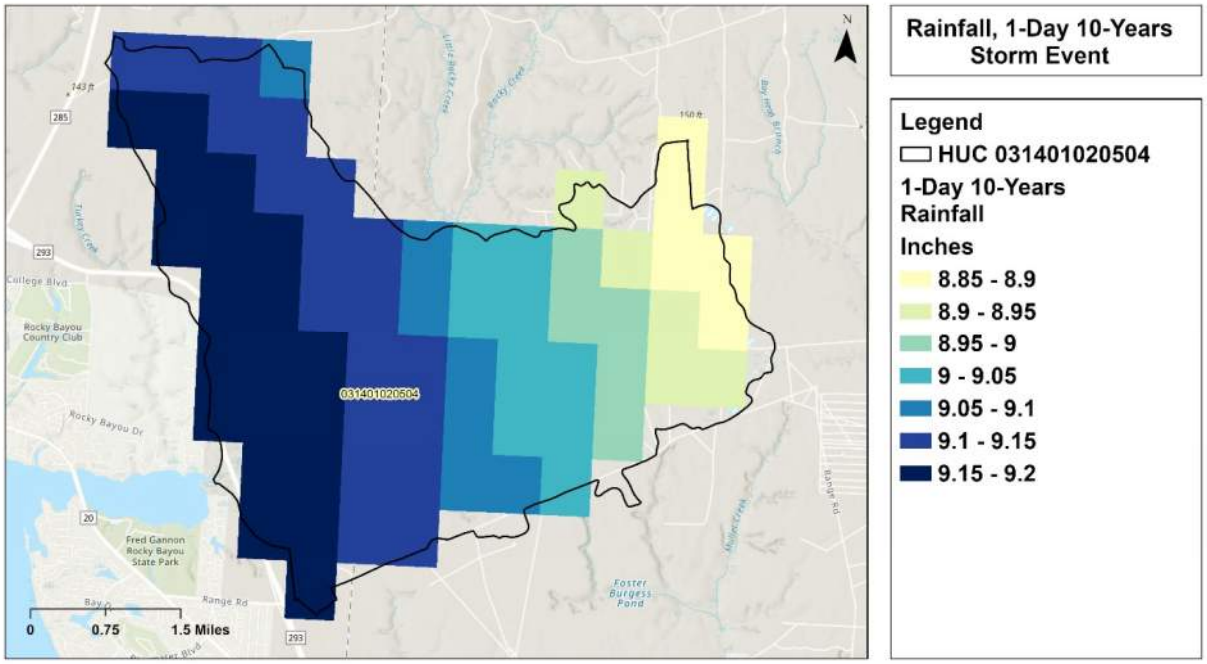

Figure 23. Rainfall distribution map across HUC 031401020504 sub-watershed, for 1-day 10-year storm event, processed by FAU.

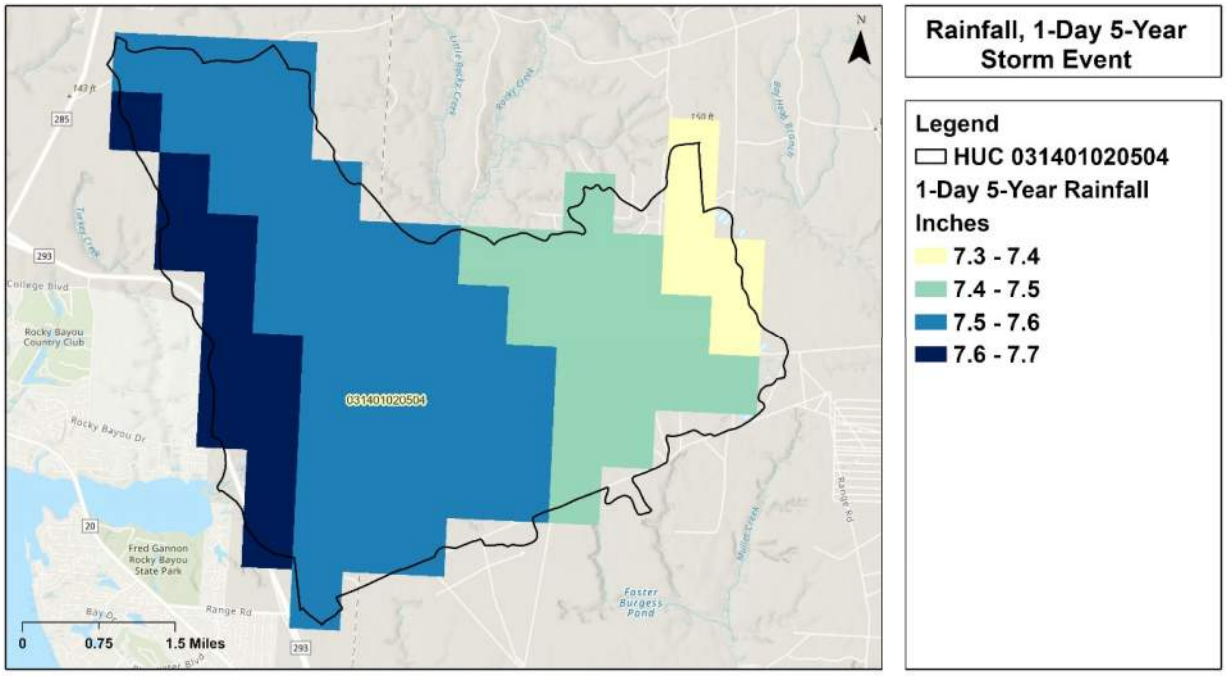

Figure 24. Rainfall distribution map across HUC 031401020504 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land

cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

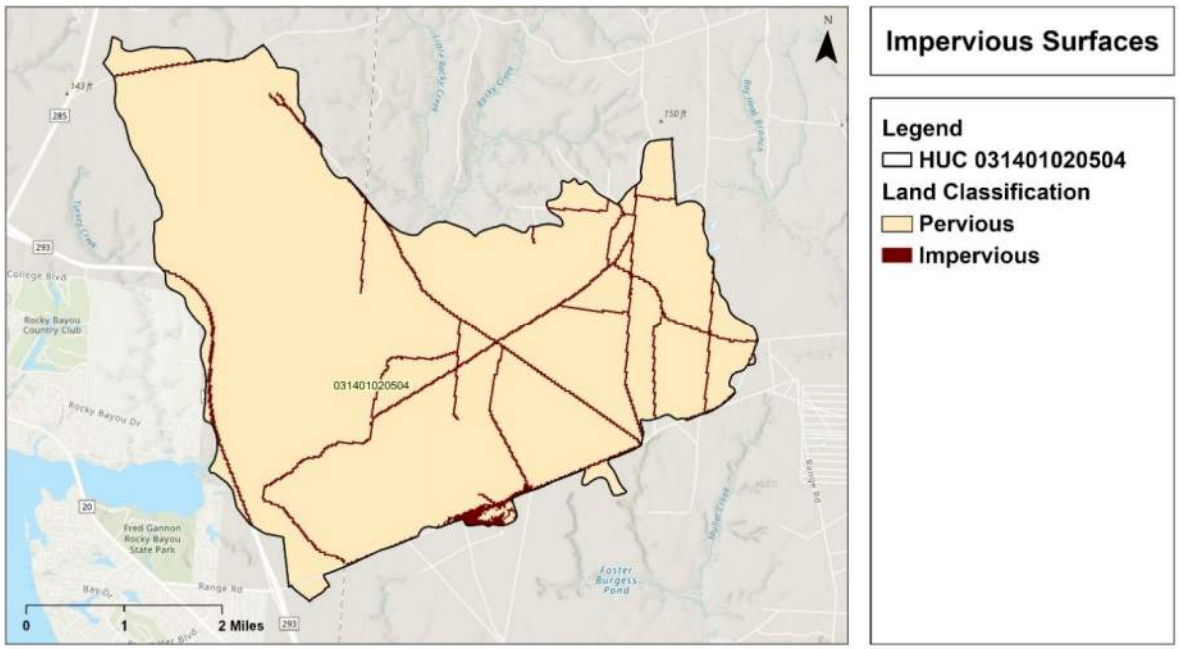

Figure 25. Impervious area map for the HUC 031401020504 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

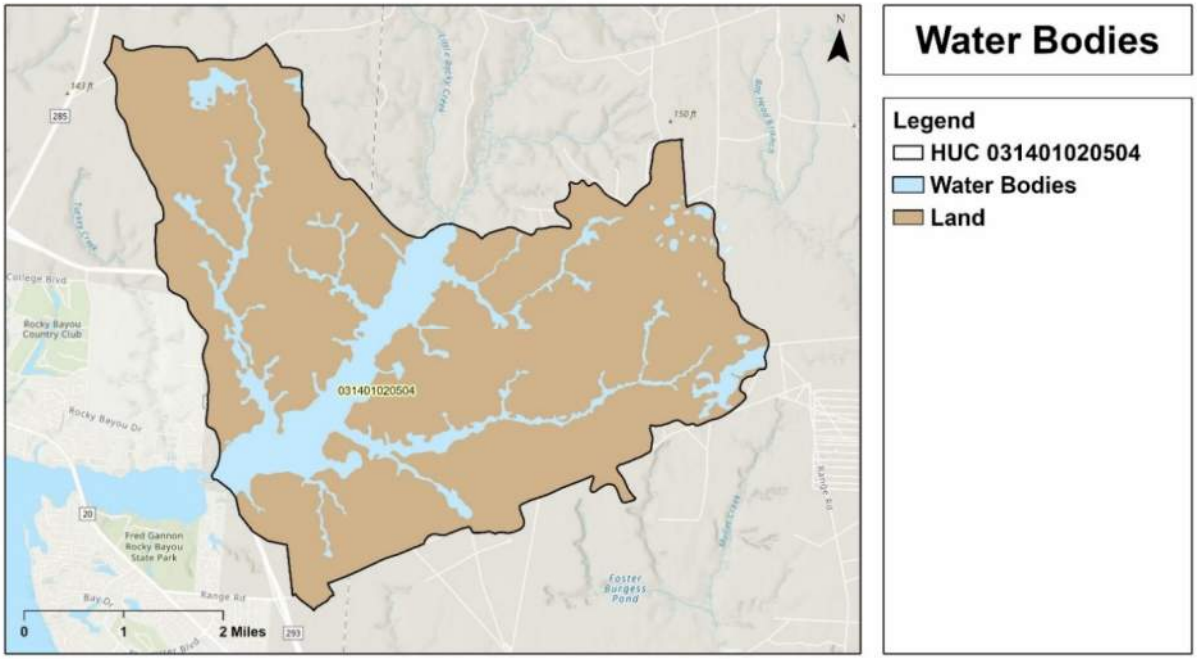

Figure 26. Water bodies map for the HUC 031401020504 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, , such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

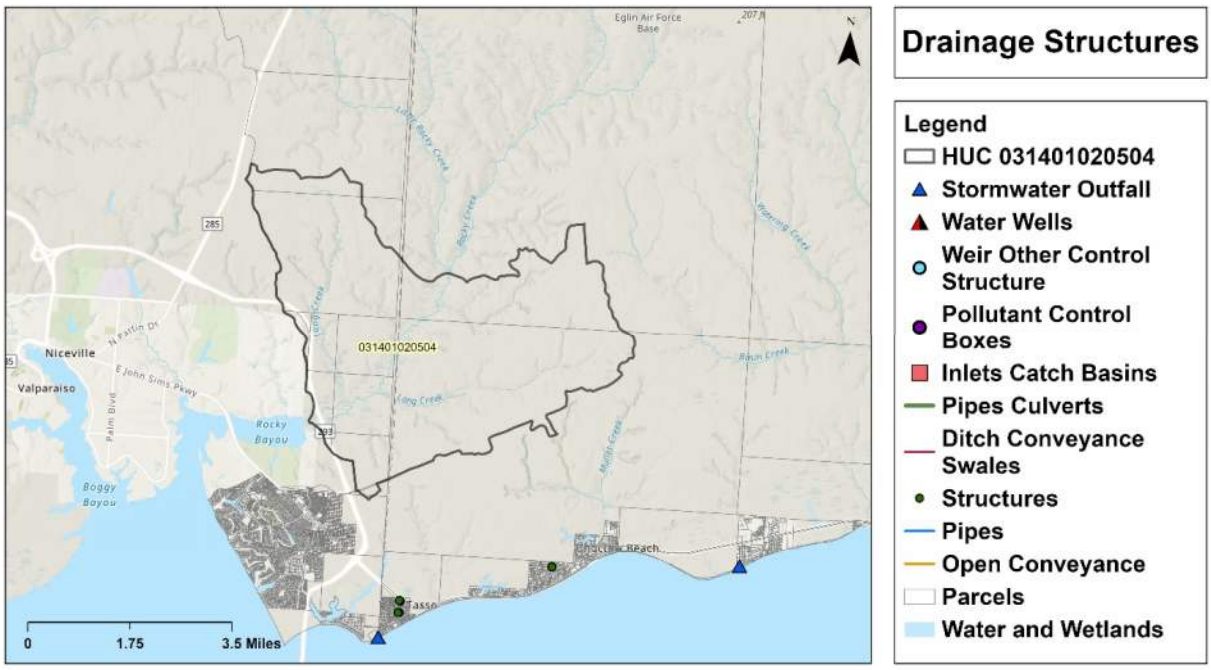

Figure 27. Stormwater Infrastructure for the HUC 031401020504. Processed by FAU.

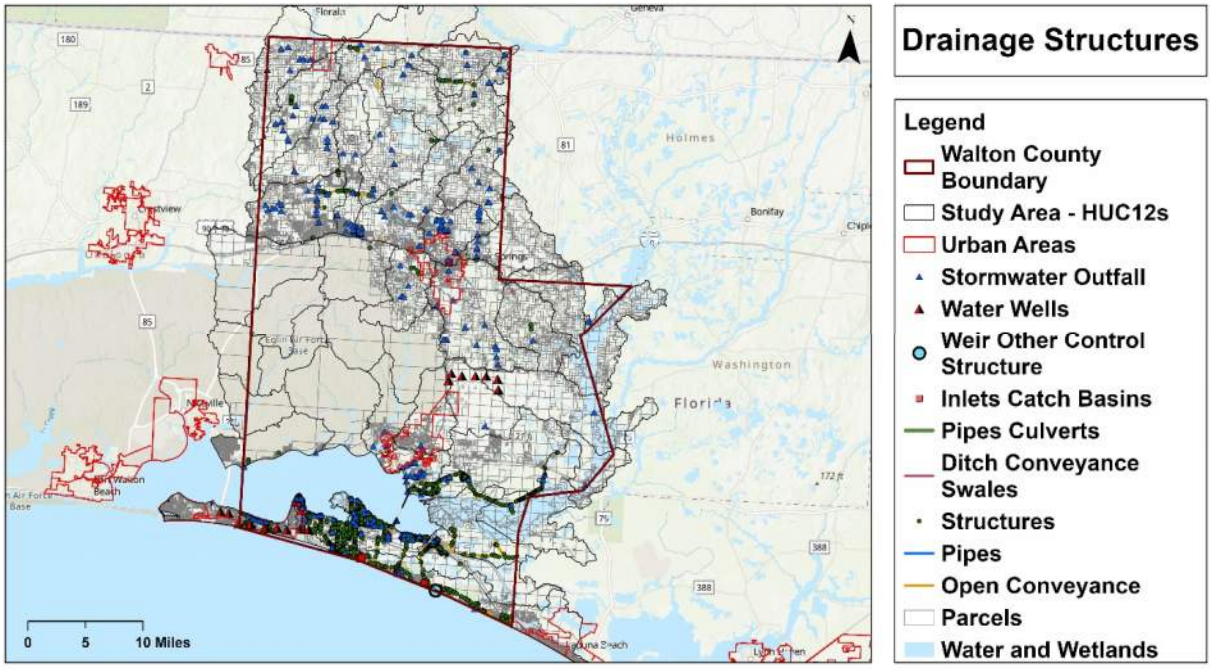

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401020504 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

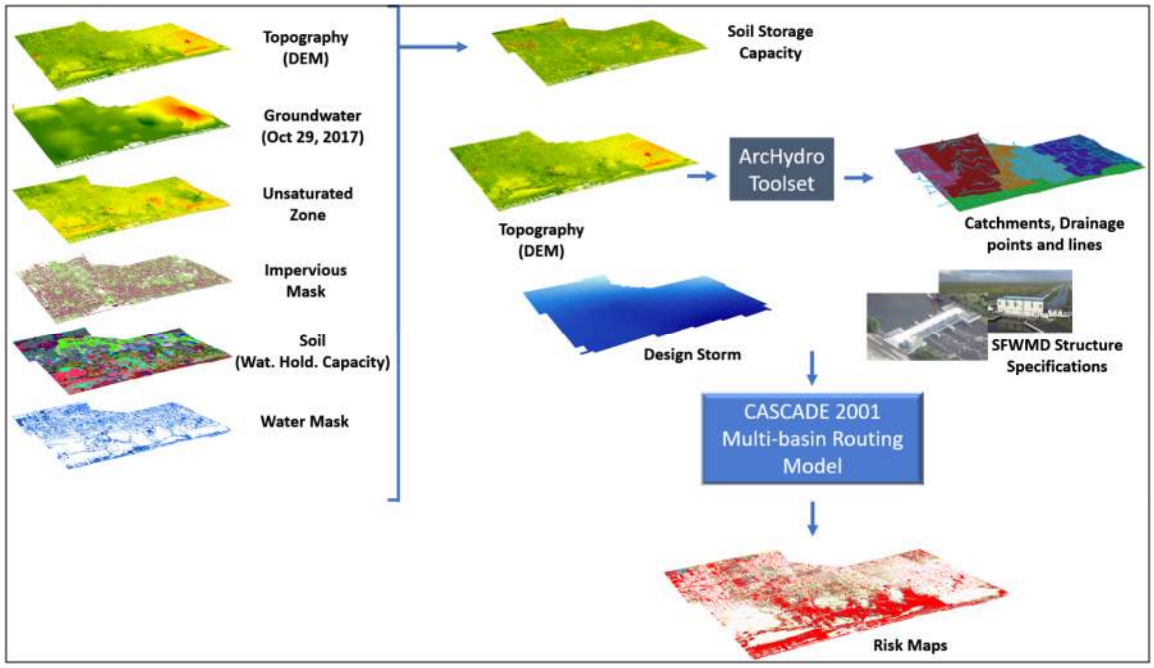

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)

= 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

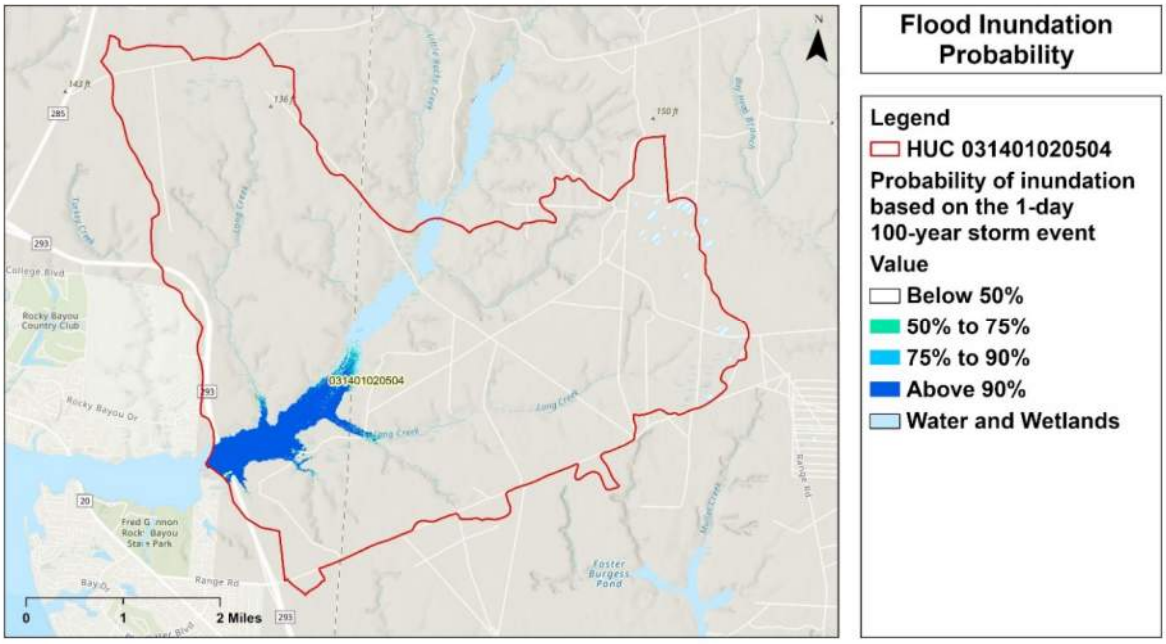

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401020504, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees

and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Future Challenges of Sea Level Rise and Climate Change

Global observations from satellites and long-term data collection have made it possible to document and analyze patterns in the Earth's climate. Scientific analysis of the impact of these changes has helped to improve the understanding of future flood hazard driving forces and long-term impacts on human activities and watershed master planning (http://www.research.noaa.gov/climate/t_observing.html). Examples of impacts are rising global average air and ocean temperatures, increased and earlier snow and ice melt, shorter subtropical rainy seasons, shifted seasons, sea level rise and greater variations in temperature and precipitation (IPCC, 2013; Freas et al., 2008; Marshall et al., 2004; Bloetscher et al., 2010). Marshall et al. (2004) specifically focused on the Florida peninsula to predict changes in rainfall and warmer temperatures but interspersed lower low temperatures due to the potential loss of wetlands.

Future changes in climate will add to the existing impacts, at a time when the population of the state is expected to nearly double by 2030. Additional research and high-resolution climate modeling for the Florida peninsula and local jurisdictions is needed to help guide long-term plans like WMPs. Rainfall appears to be decreasing and temperatures rising (see **Error! Reference source not found.**).

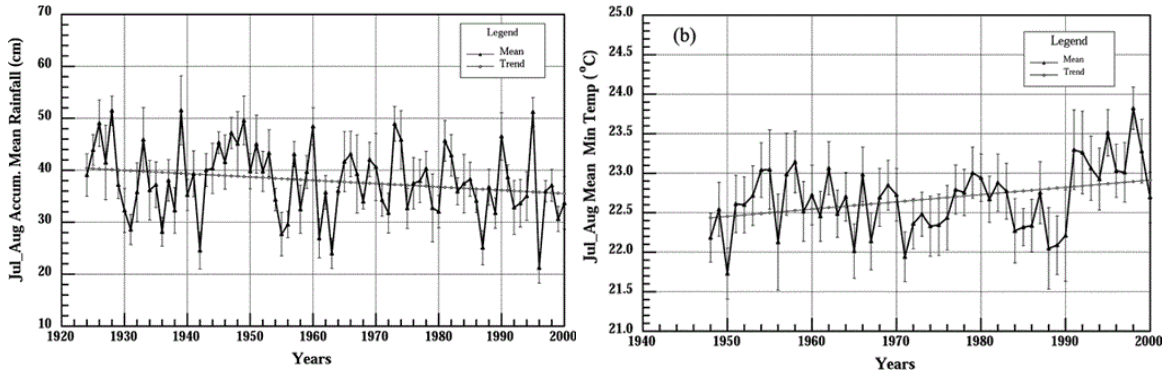

Figure 31. Change in average rainfall and change in average temp 1924 to 2000. Note the reversed trend, which means groundwater input variability is lessened. Source: Marshall et al., 2004.

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3 feet. Accompanying these drivers are potential changes in storm frequency and intensity, desertification, population migration, ocean acidification and coastal flooding (IPCC, 2007), exacerbated by the land cover and land use changes, which are substantially impacted by the fluxes, timing and quality of precipitation (Adrians et al., 2003; Scanlon et al., 2005; Marshall et al., 2004; Salmun and Molod, 2006), and leading to changes in the timing of peak flows and volumes (Richey and Costa-Cabral, 2006).

The results of these climatic changes are likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to

the ocean, c) increasingly An outcome of these climatic patterns is that during the past 140 years, an increase in sea levels has been observed (Bloetscher, 2012), a worrying pattern since sea level rise is a permanent phenomenon, that can be catastrophic to low lying areas in the long-term. The question is how much and how soon? Various studies (Bindoff et al., 2007; Domingues et al., 2008; Edwards, 2007; Gregory, 2008; Vermeer and Rahmstorf, 2009; Jevrejeva, Moore and Grinsted, 2010; Bloetscher, 2010, 2011; IPCC, 2007; Heimlich et al., 2009) indicate large uncertainty in projections of sea level rise by 2100. Gregory et al. (2012) note that during the last two decades, the global rate of sea level rise has been larger than the 20th-century time-mean, and Church et al. (2011) suggested that the cause was increased rates of thermal expansion, glacier mass loss, and ice discharge from icesheets. Gregory et al. (2012) suggested that there may also be increasing contributions to global sea level rise from the effects of groundwater depletion, reservoir impoundment, and loss of storage capacity in surface waters due to siltation. Measurements of Florida's east coast (Maul, 2008) show an average rate of sea level rise of 2.27 ± 0.04 mm per year from 1915 to 1992 based on tide gauge readings. Analyzing the tidal gauge readings for Florida shows that:

1. Florida average sea level rise is 2.10 ± 0.49 mm/yr
2. All but one location is within the 95% confidence limit range (the exception is Panama City where there is evidence of submergence and other land-based issues)
3. None of the Florida sea level rise rates differ statistically
4. Average global sea level rise for 1920-2000 was 2.0 mm/yr – within 95% confidence limit for Florida locations

From 1929 to 1992, over eight inches of sea, with another 6 inches added since 1992, which is already having significant impacts on coastal communities where population growth has increased the need for improved flood management strategies (Bloetscher, 2008; Parkinson, 2010; Zhang et al., 2011, 2011a; NFIP, 2011; Schmidt et al., 2011; Warner et al., 2012).

As a result, the SFRCCC (2015) adopted USACE's methodology to derive scenarios of sea level change intermediate to high rates of sea level rise for years 2030 (3" to 7") and 2060 (9" to 24") as the consensus projection to guide future planning. The path keeps increasing – now 14 inches since 1929 (**Error! Reference source not found.**) caused by thermal expansion of the ocean and melting ice caps (Jevrejeva et al., 2010; Vermeer and Rahmstorf, 2009). Sea level rise is a major concern in Florida, including Walton County, since the majority of the state's population live on the coast, involving most major commercial, residential, and economic enterprises. **Error! Reference source not found.** demonstrate the estimated sea level change for Panama City, considering the predictions of NOAA 2017. For NOAA high scenario SLR change scenario, the estimated level change is higher than 8 ft., while for the intermediate and low scenarios are about 3.9 feet and 1.7 feet respectively.

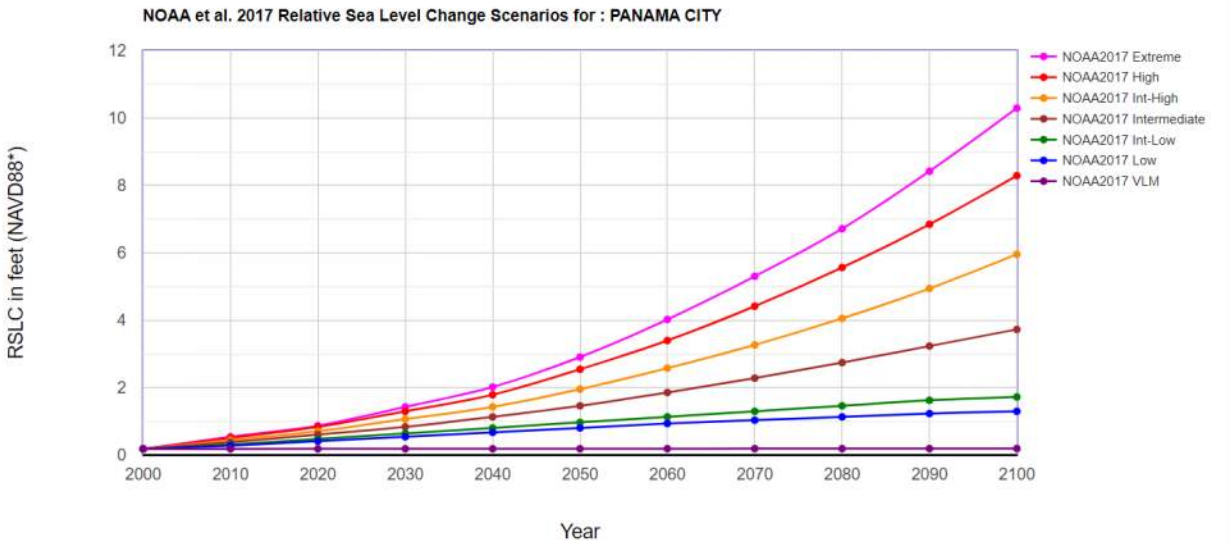

Figure 32. Relative Sea Level Change Scenarios for gauge 8729108, Panama City, FL. Source: NOAA 2017 (https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html).

NOAA (2017) outlines five scenarios for sea level rise. The NFIP proposes the use of the intermediate high projection, which is 1.2 meters or 4 ft globally from current sea level elevations (**Error! Reference source not found.**).

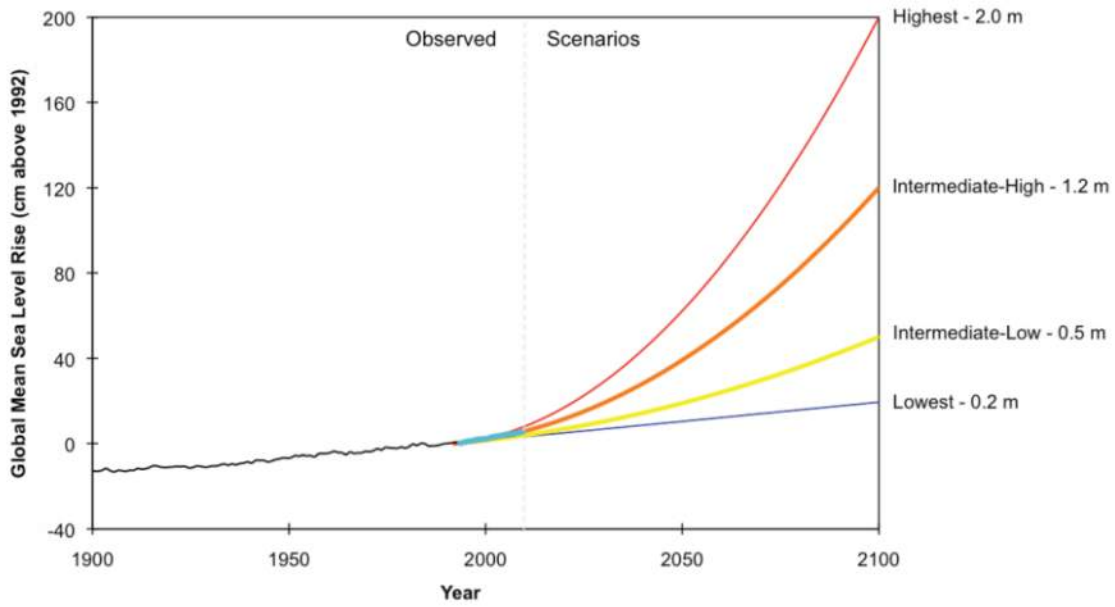

Figure 33. Graphic of global sea level rise projections from NOAA (2017). Source:https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

As sea level rises, access to roads, bridges, rail, and transit could be at risk of flooding, causing the effects of sea level rise to spread indirectly throughout the entire transportation network, affecting the overall system performance. For example, the flooding of a critical road or facility access can cause a shifting of traffic flow causing congested conditions in other roadways that are not actually flooded. Since the roadway network would be unable to carry the traffic demand, the system would experience operational failure; as a result, causing travel times and delays. Moreover, the inundation of a critical access could cause transportation connectivity problems to essential infrastructure like ports or airports. Transportation infrastructure relies on the effectiveness of flood control and stormwater drainage systems for the transportation corridors. Road integrity relies on adequate drainage. The increased risk of severe flooding in Florida's low-lying terrain can adversely affect transportation infrastructure along the coastline; roads can be inundated, and roadway beds can be damaged. Sea level rise will cause increased water table levels (FDOT, 2012), as regional water tables cannot exist naturally below mean high tide (2 feet in Florida). Adding 3 feet of sea level rise on top of groundwater would compound the risk of flooding in low-lying areas. Road bases below 5 feet NVGD would become saturated under this scenario, likely causing premature base failure. As soil storage capacity is diminished due to rising groundwater elevations associated with sea level rise, the potential for more frequently flooded roadways would likely damage pavements (FDOT, 2012). Hence sea level rise must be accounted for in WMPs in coastal areas. To allow flexibility in the analysis due to the range of increases within the different time periods, an approach that uses incremental increases of 1, 2, and 3 feet of sea level rise is suggested for modeling. The increments can work as threshold values in planning considerations in terms of allowing planners the ability to know ahead of time where the next set of vulnerable areas will be, to allow for a proactive response approach that can be matched to the observed future rates. Sea level rise is a major concern since nearly half the US population lives within 50 miles of the coast, involving most major commercial, residential, and economic enterprises. The effects of 5 ft sea level rise, King tide, and 1-day 100-yr storm event are shown in **Error! Reference source not found.**.

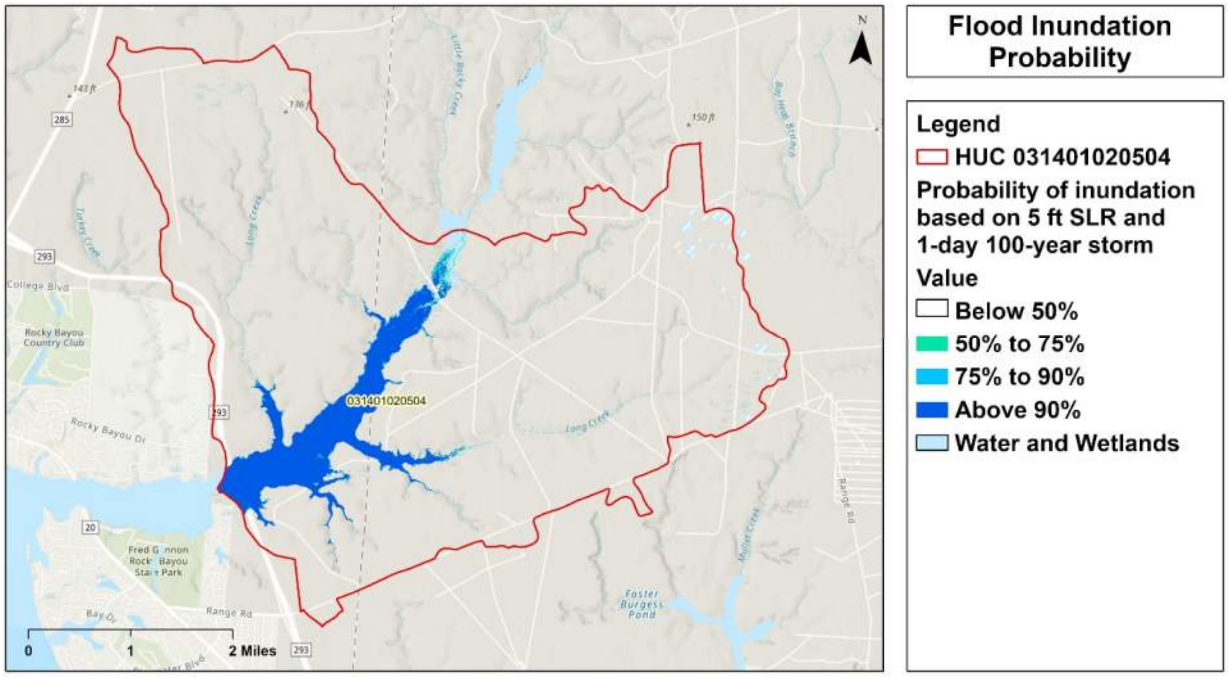

Figure 34. Flood Inundation Probability for a Sea level rise of 5 ft + 1-day 100-year storm event for HUC 031401020504 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Dark blue is area under 5 ft NAVD88 and potentially inundated at the 99th percentile tidal conditions. Processed by FAU.

2.4 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. **3-day 25-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 35)
2. **1-day 100-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 36)
3. **1-day 10-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 37)
4. **1-day 5-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 38)
5. **Sea level rise of 1 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 39)

6. **Sea level rise of 1 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations storm (Figure 40)
7. **Sea level rise of 1 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 41)
8. **Sea level rise of 1 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 42)
9. **Sea level rise of 2 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 43)
10. **Sea level rise of 2 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 44)
11. **Sea level rise of 2 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 45)
12. **Sea level rise of 2 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 46)
13. **Sea level rise of 3 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 47)
14. **Sea level rise of 3 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 48)
15. **Sea level rise of 3 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 49)
16. **Sea level rise of 3 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 50)
17. **Sea level rise of 4 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 51)
18. **Sea level rise of 4 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 52)

19. **Sea level rise of 4 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 53)
20. **Sea level rise of 4 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 54)
21. **Sea level rise of 5 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 55)
22. **Sea level rise of 5 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 56)
23. **Sea level rise of 5 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 57)
24. **Sea level rise of 5 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 58)

In all cases, a great amount of flooding is noted along the waterbodies and wetlands. As this basin connects to the ocean though Rocky Bayou, SLR scenarios plays an important hole, implying a considered growth as the projected scenario of rising tides rises.

The design storm simulation determined that approximately 5.7% of the HUC total area or 1.11 mi² has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 3.5% of the HUC's total area, or 0.67 mi² would be expected to be inundated during a 1-day 100-year design storm. Approximately 4.6% of the HUC's total area, or 0.91 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 3.9% of the HUC's total area, or 3.9 mi², would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401020504 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	18.39	1.11	94.3%	5.7%
1-day 100-year	18.83	0.67	96.5%	3.5%
1-day 10-year	18.60	0.91	95.4%	4.6%
1-day 5-year	18.74	0.77	96.1%	3.9%

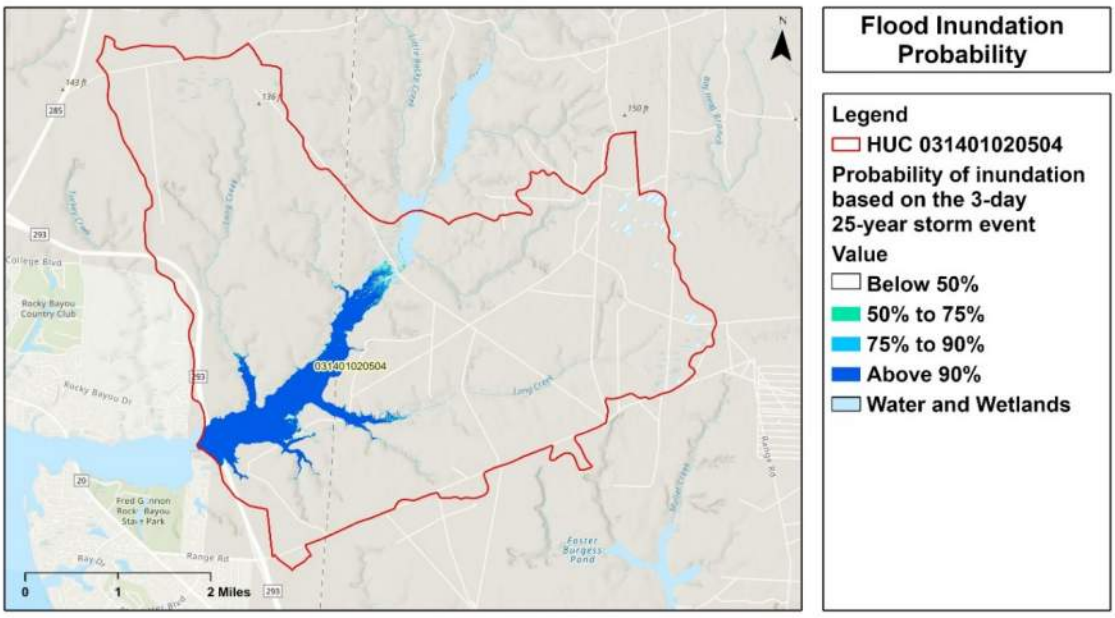

Figure 35. 3-day 25-year storm event for HUC 031401020504 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

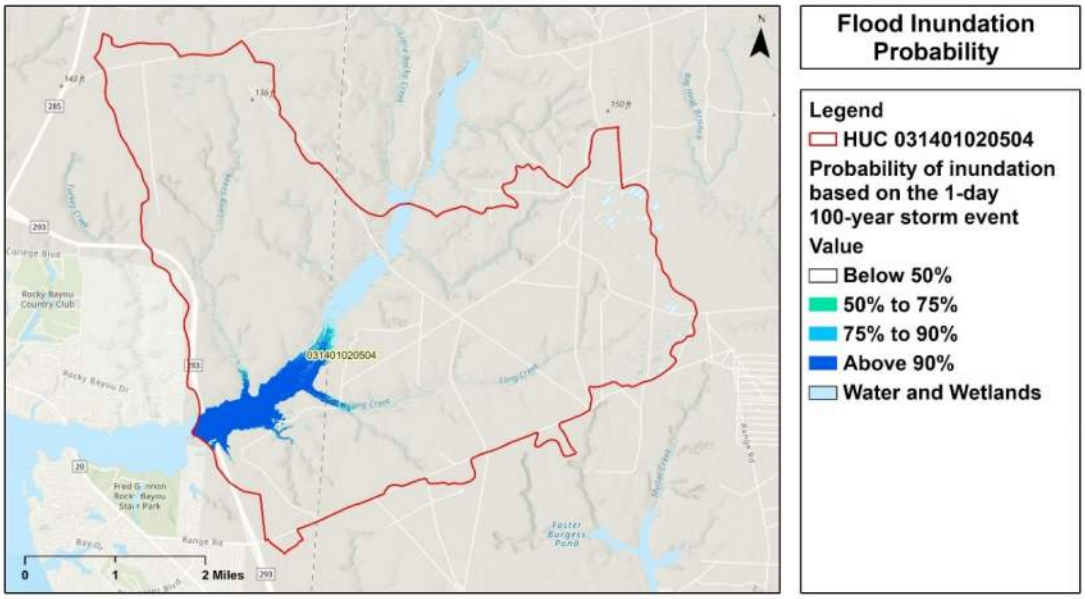

Figure 36. 1-day 100-year storm event for HUC 031401020504 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

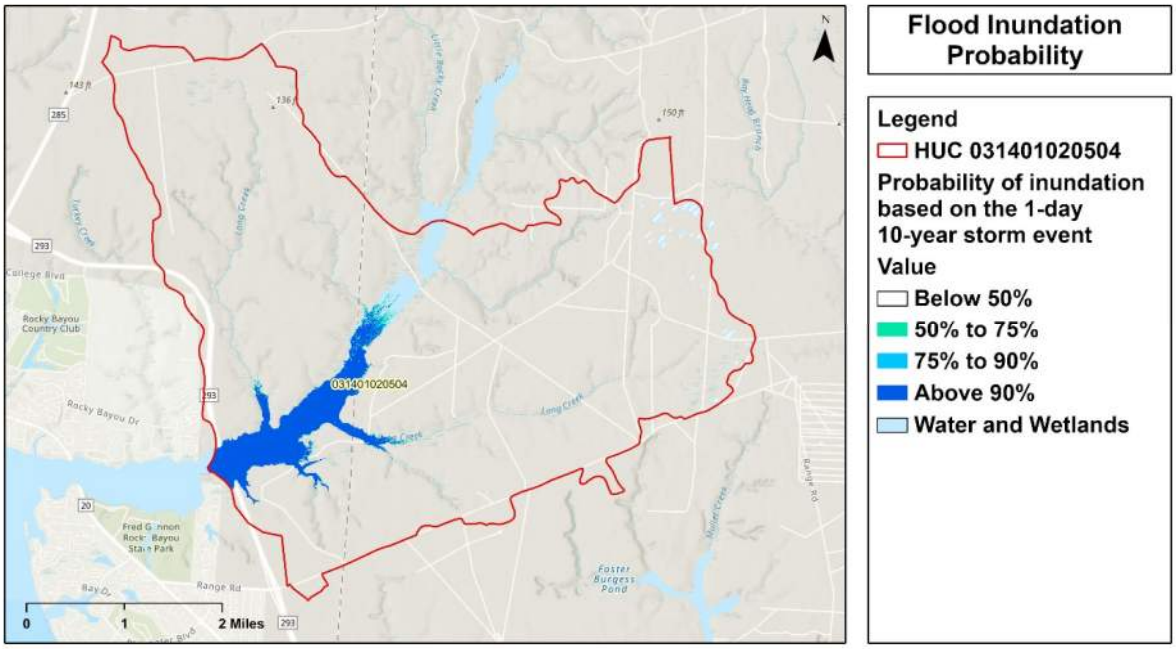

Figure 37. 1-day 10-year storm event for HUC 031401020504 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

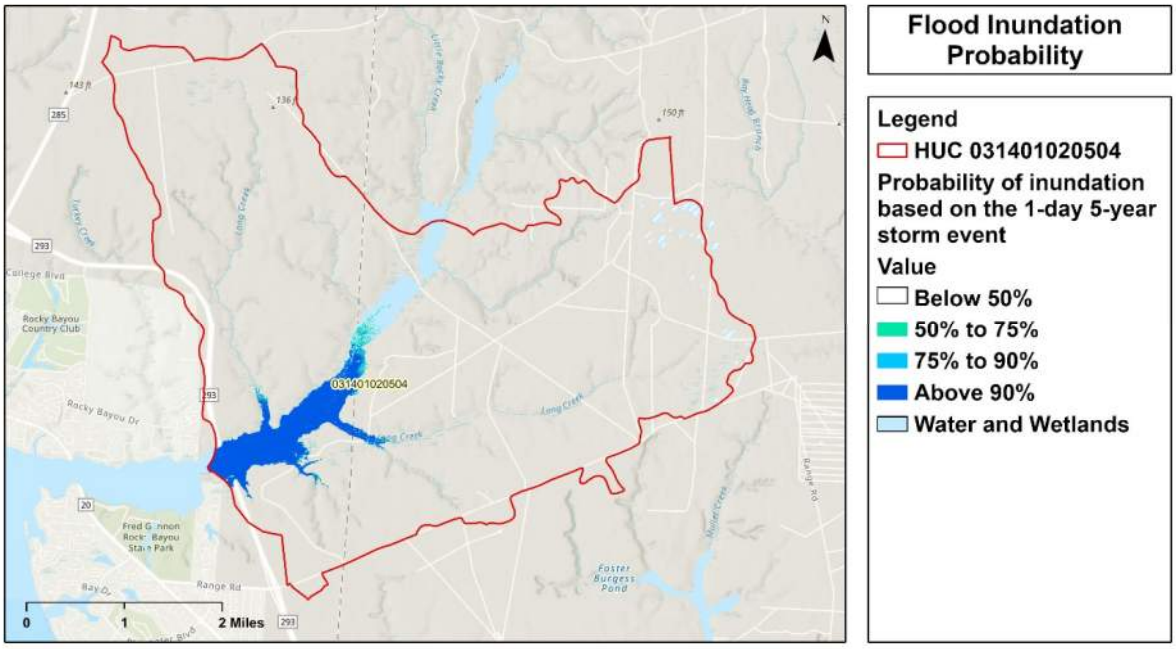

Figure 38. 1-day 5-year storm event for HUC 031401020504 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

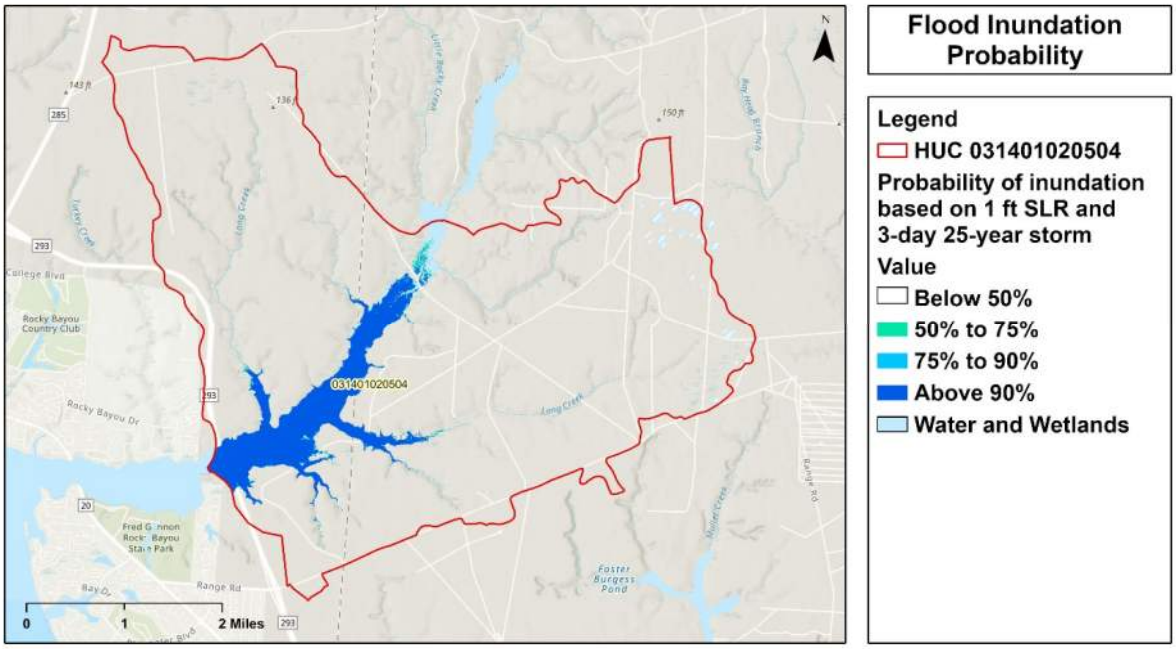

Figure 39. Sea level rise of 1 ft + 3-day 25-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

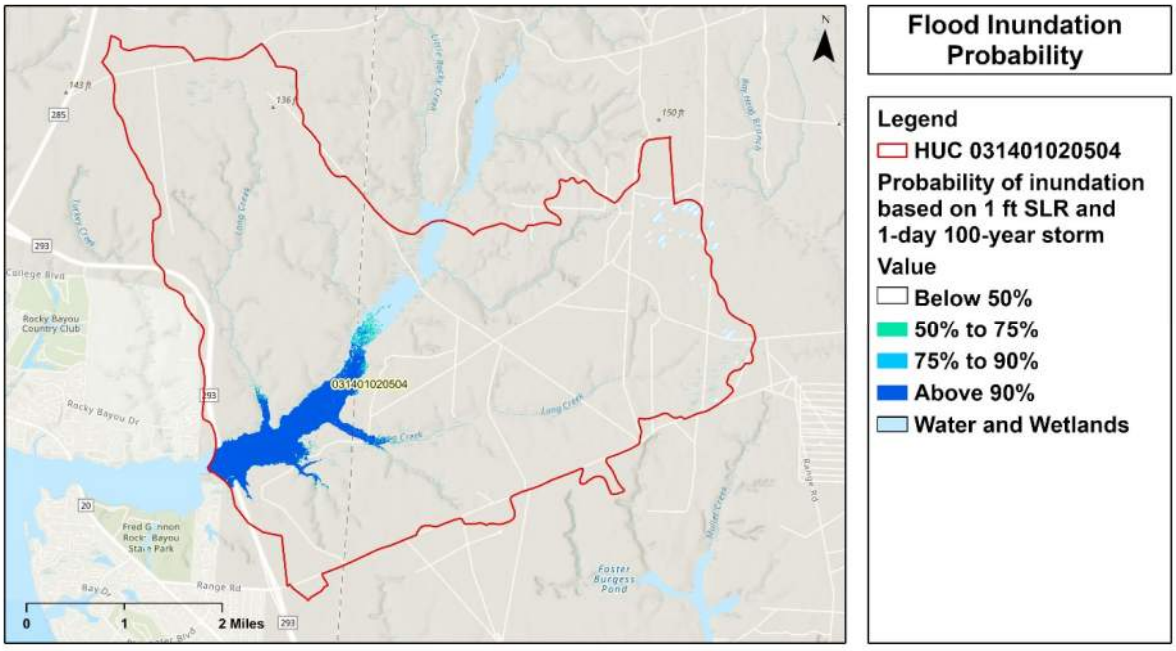

Figure 40. Sea level rise of 1 ft + 1-day 100-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

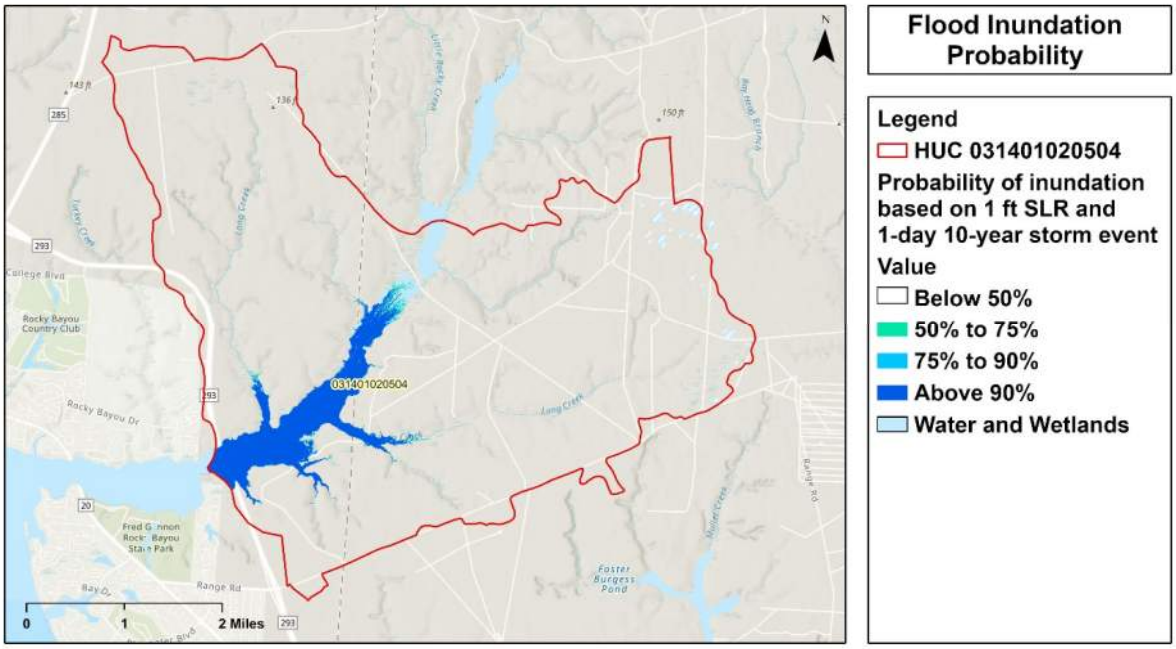

Figure 41. Sea level rise of 1 ft + 1-day 10-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

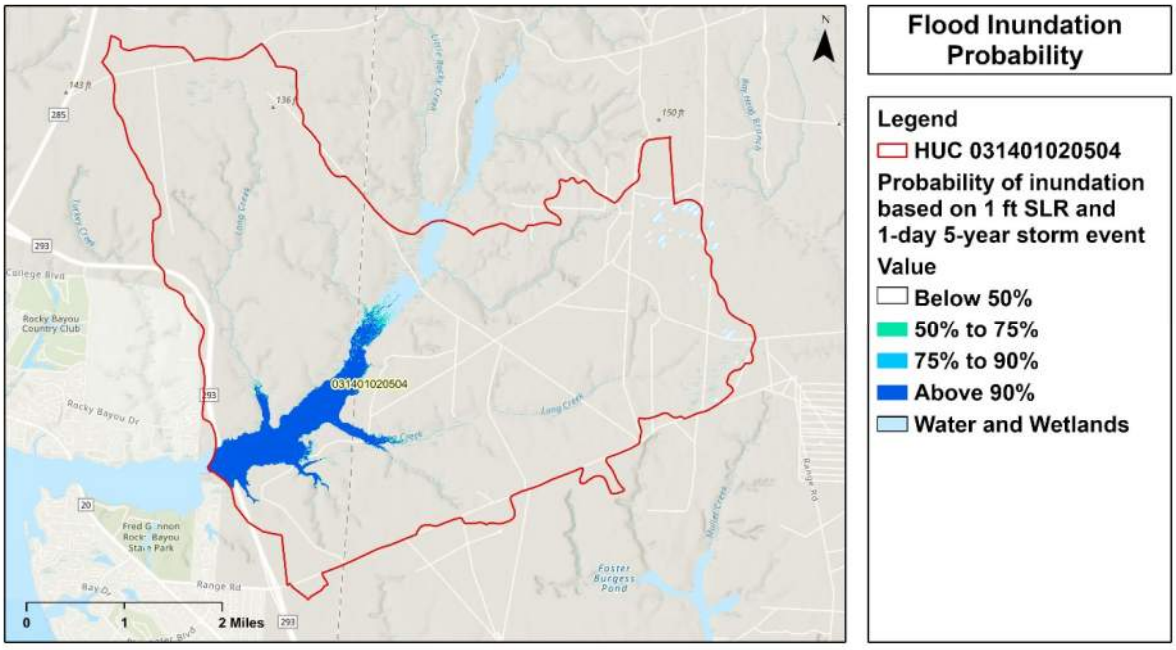

Figure 42. Sea level rise of 1 ft + 1-day 5-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

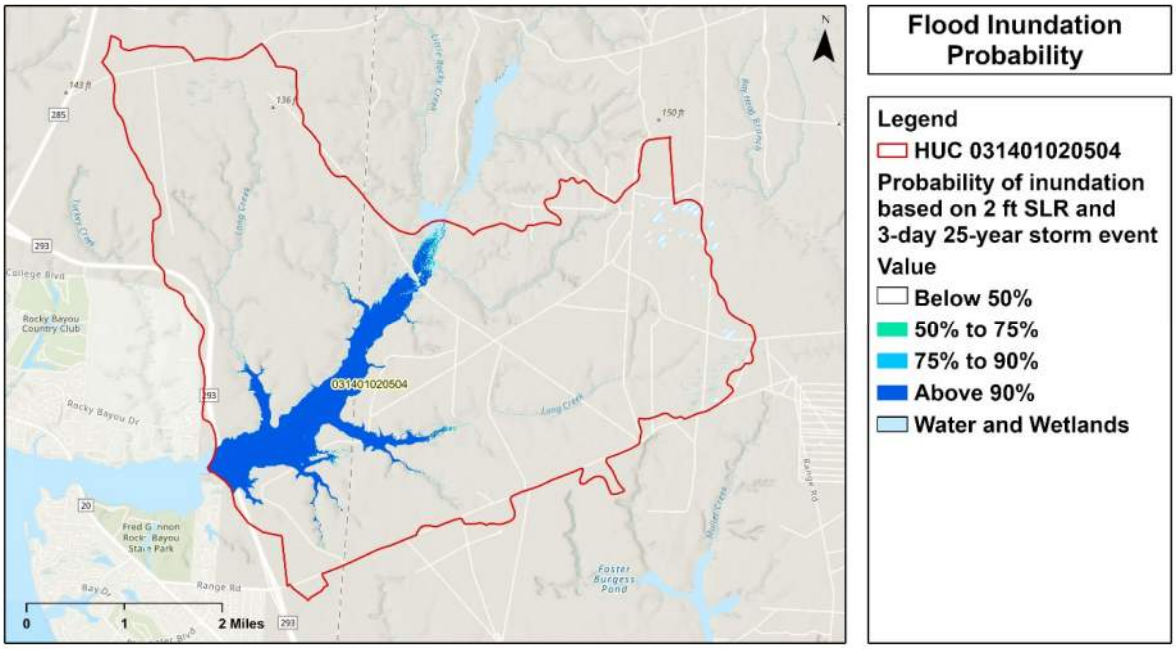

Figure 43. Sea level rise of 2 ft + 3-day 25-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

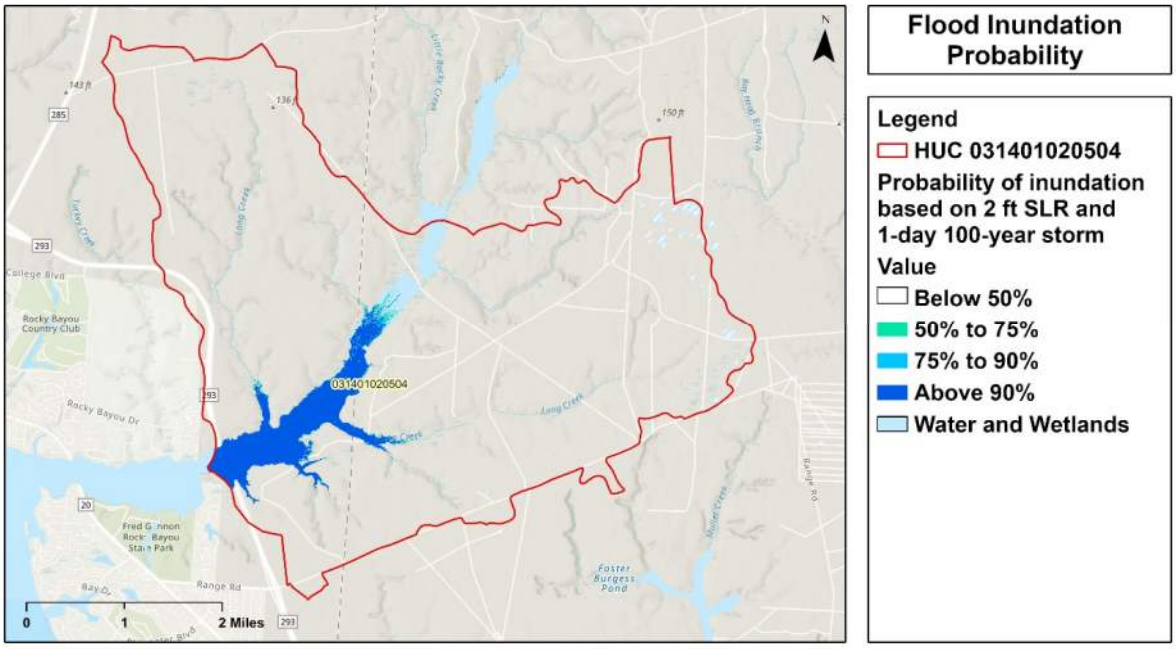

Figure 44. Sea level rise of 2 ft + 1-day 100-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

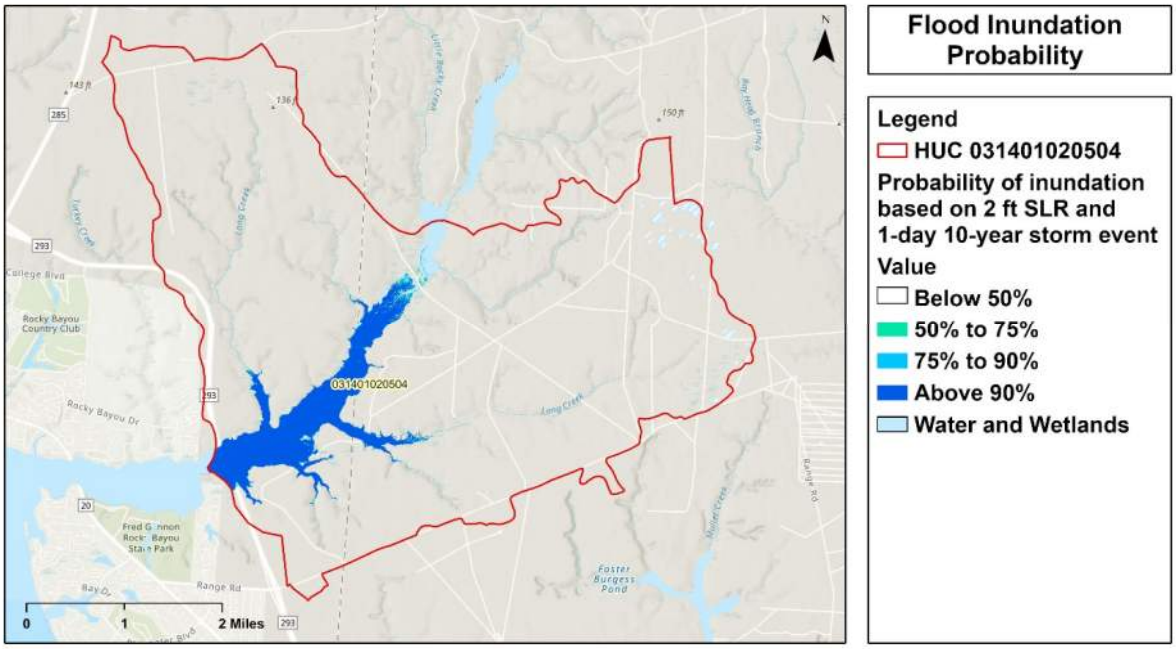

Figure 45. Sea level rise of 2 ft + 1-day 10-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

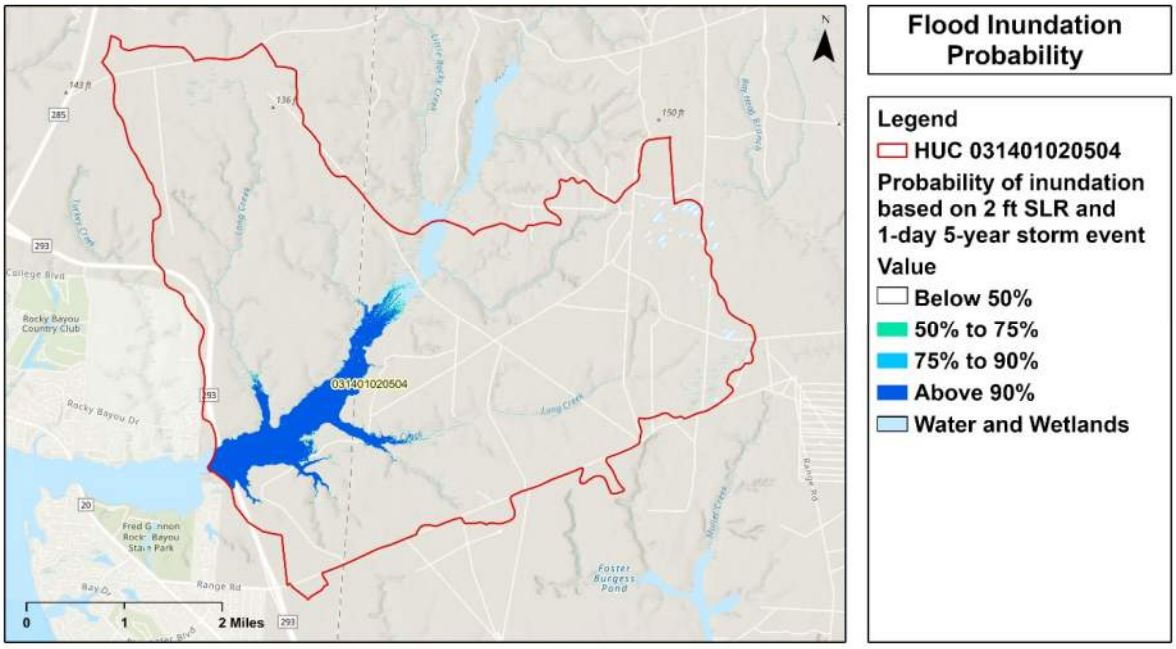

Figure 46. Sea level rise of 2 ft + 1-day 5-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

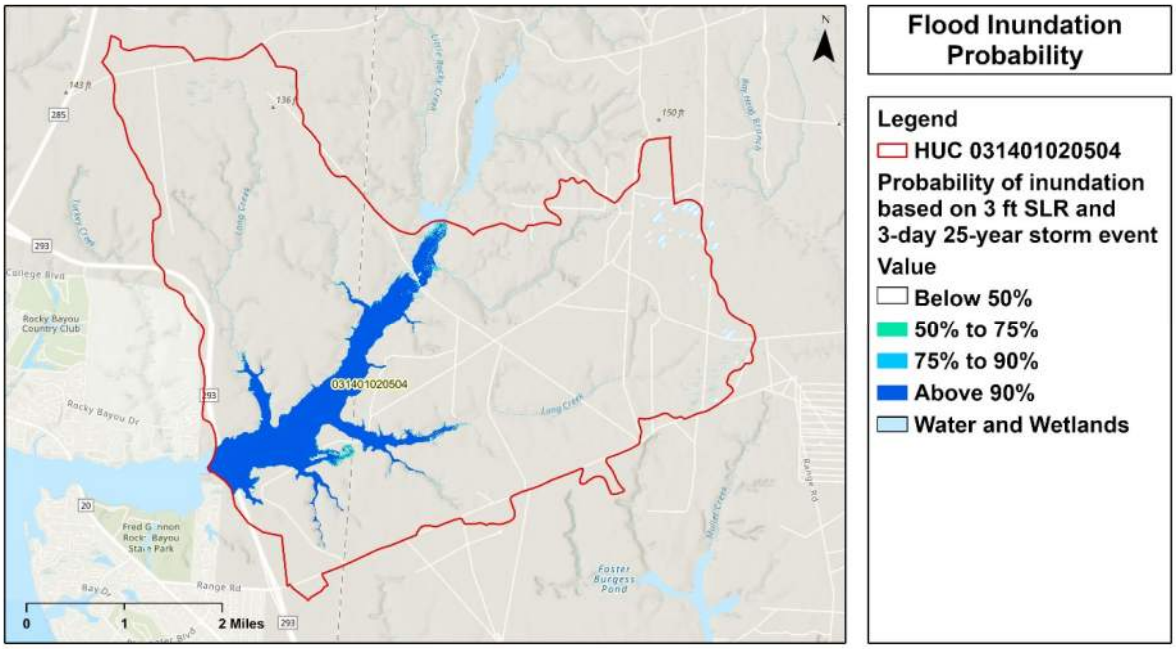

Figure 47. Sea level rise of 3 ft + 3-day 25-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

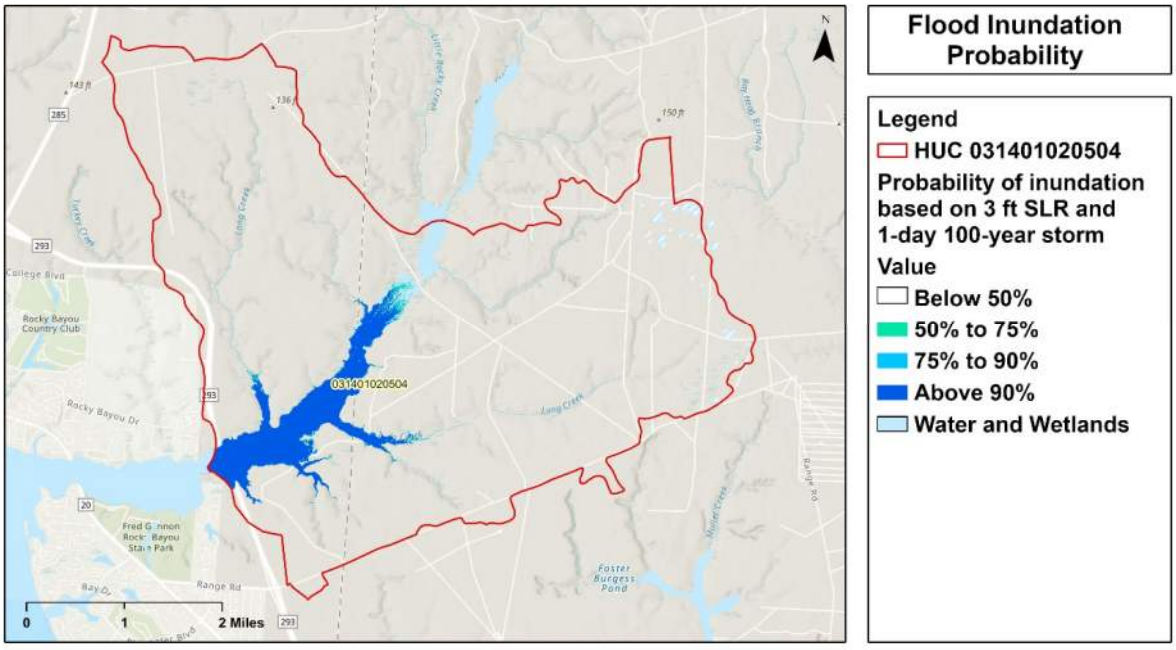

Figure 48. Sea level rise of 3 ft + 1-day 100-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

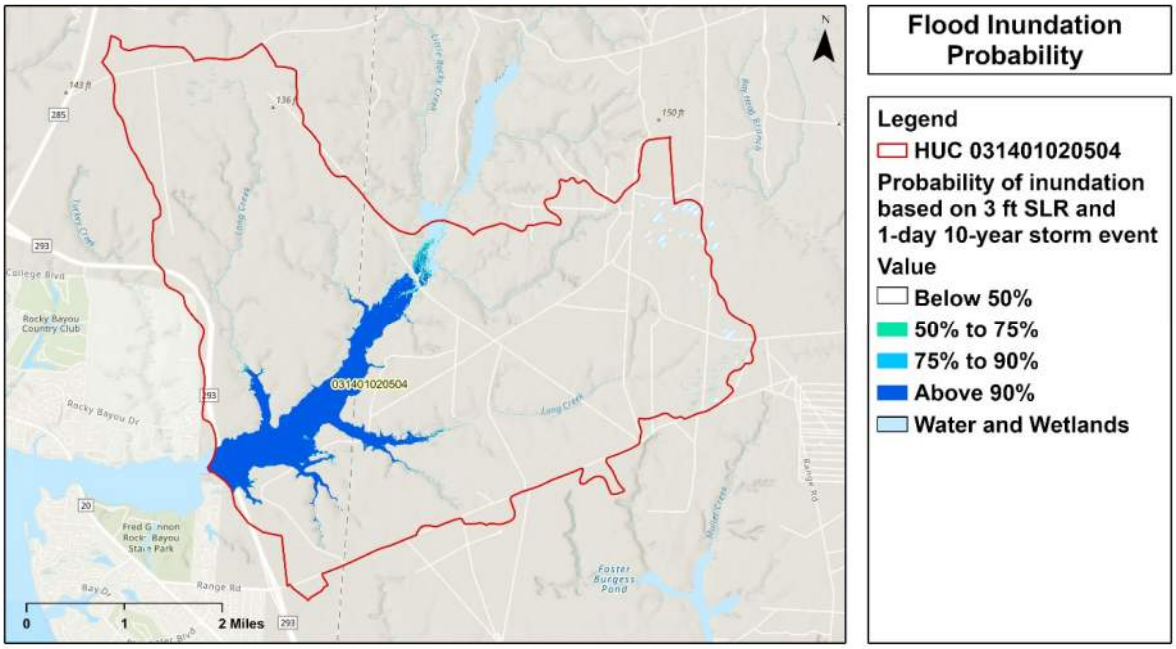

Figure 49. Sea level rise of 3 ft + 1-day 10-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

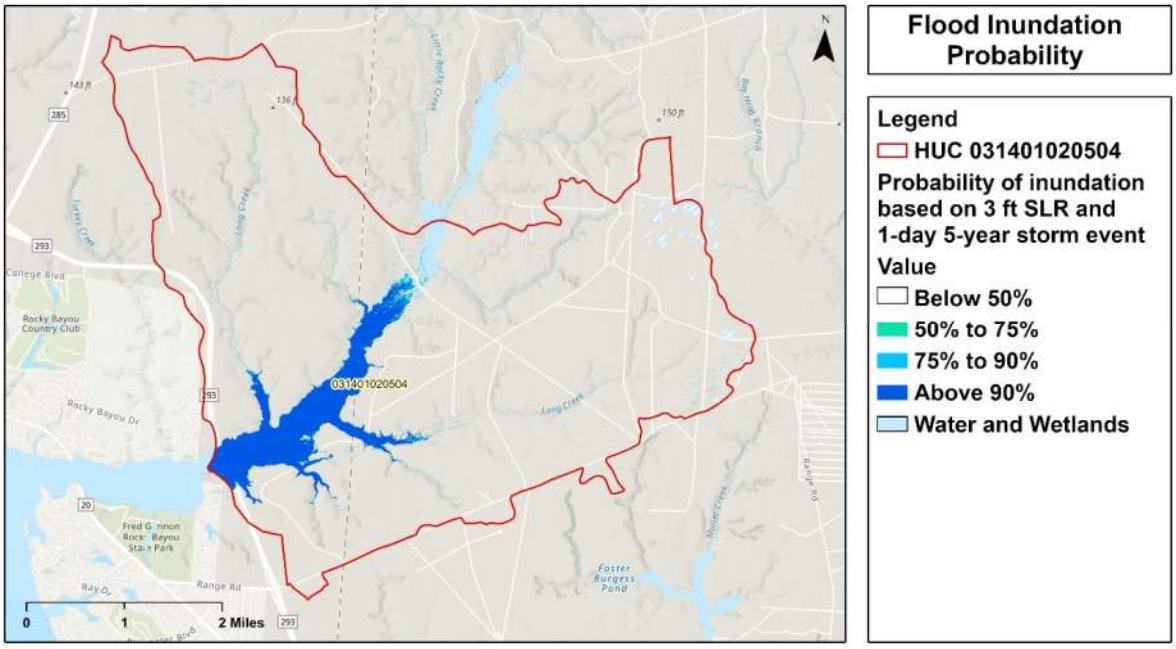

Figure 50. Sea level rise of 3 ft + 1-day 5-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

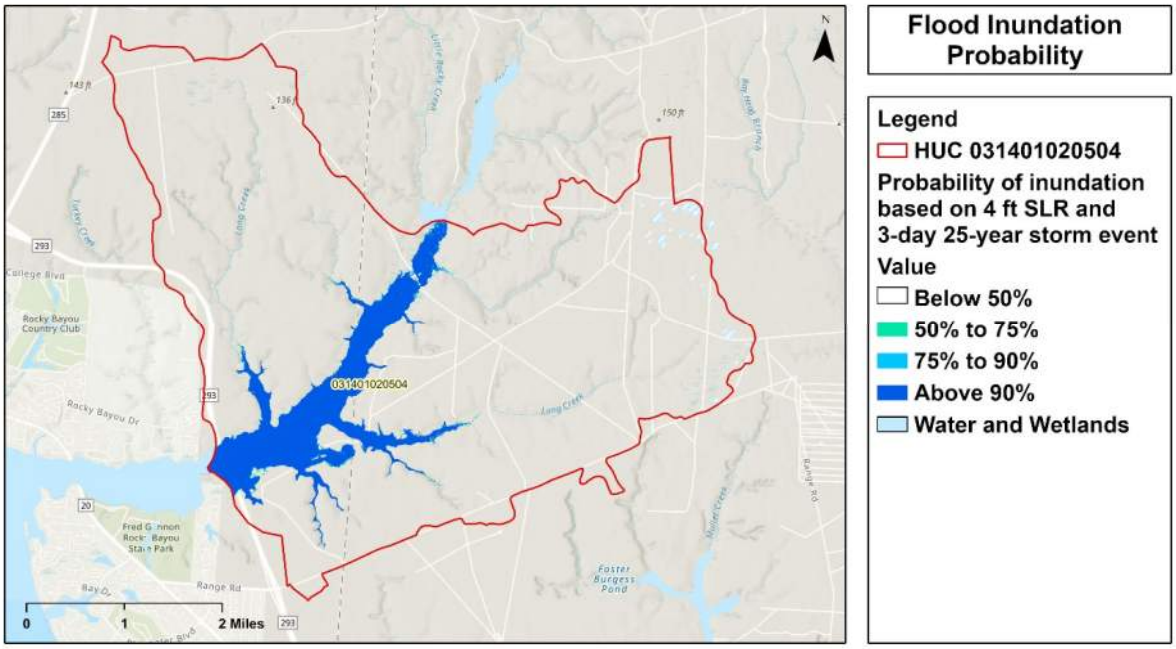

Figure 51. Sea level rise of 4 ft + 3-day 25-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

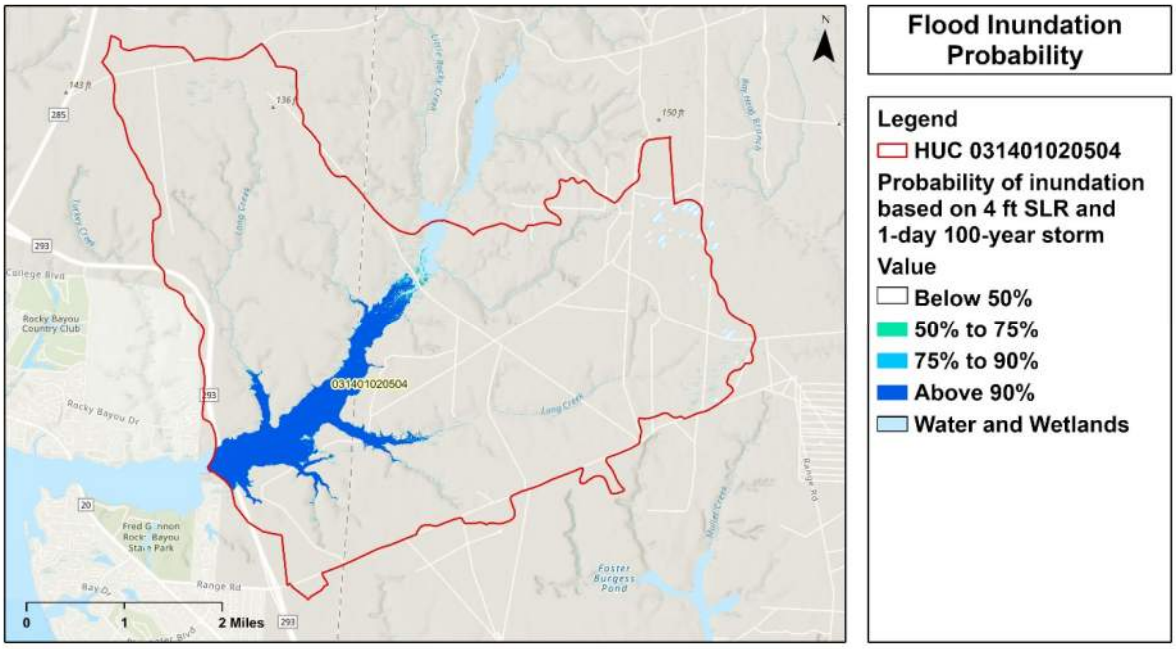

Figure 52. Sea level rise of 4 ft + 1-day 100-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

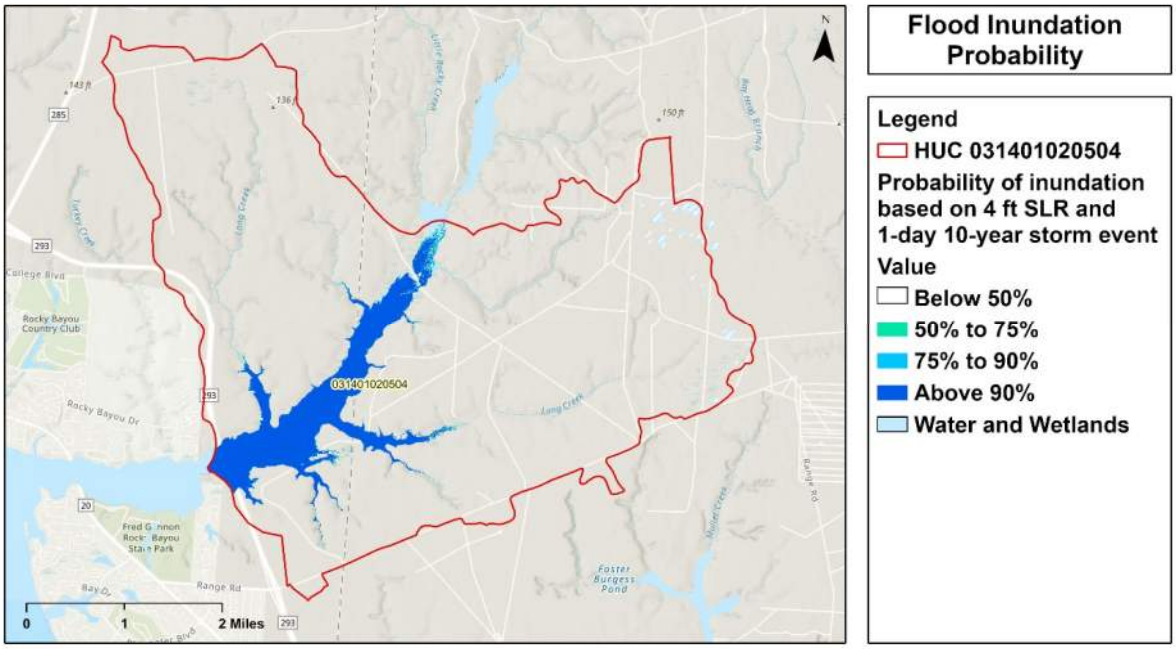

Figure 53. Sea level rise of 4 ft + 1-day 10-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

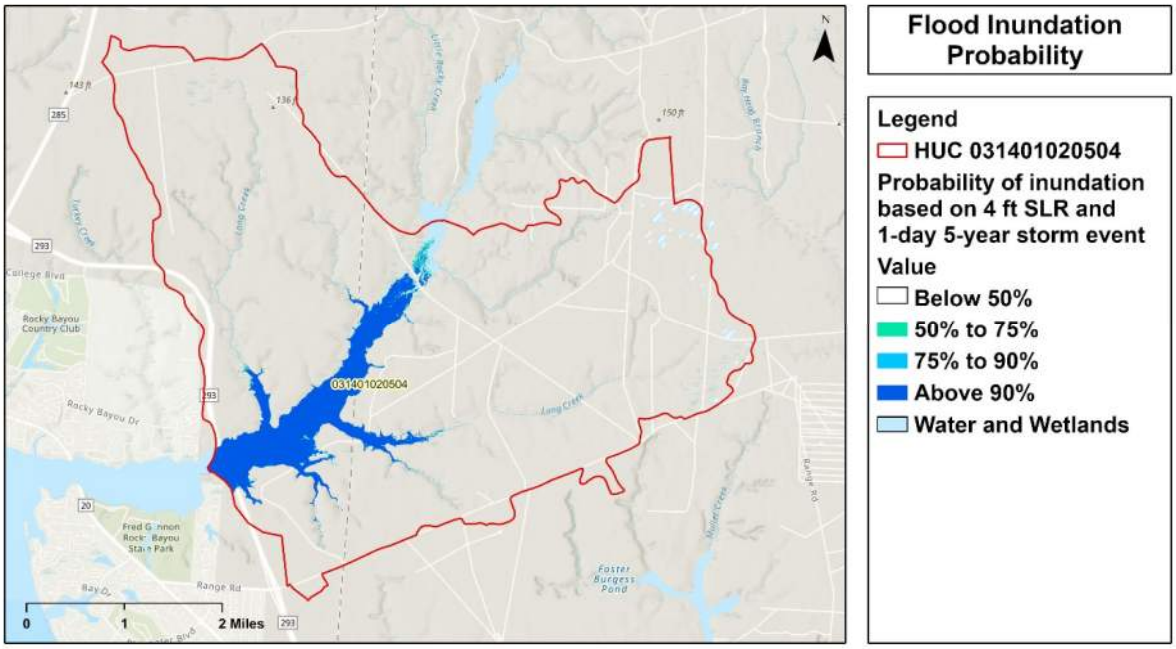

Figure 54. Sea level rise of 4 ft + 1-day 5-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

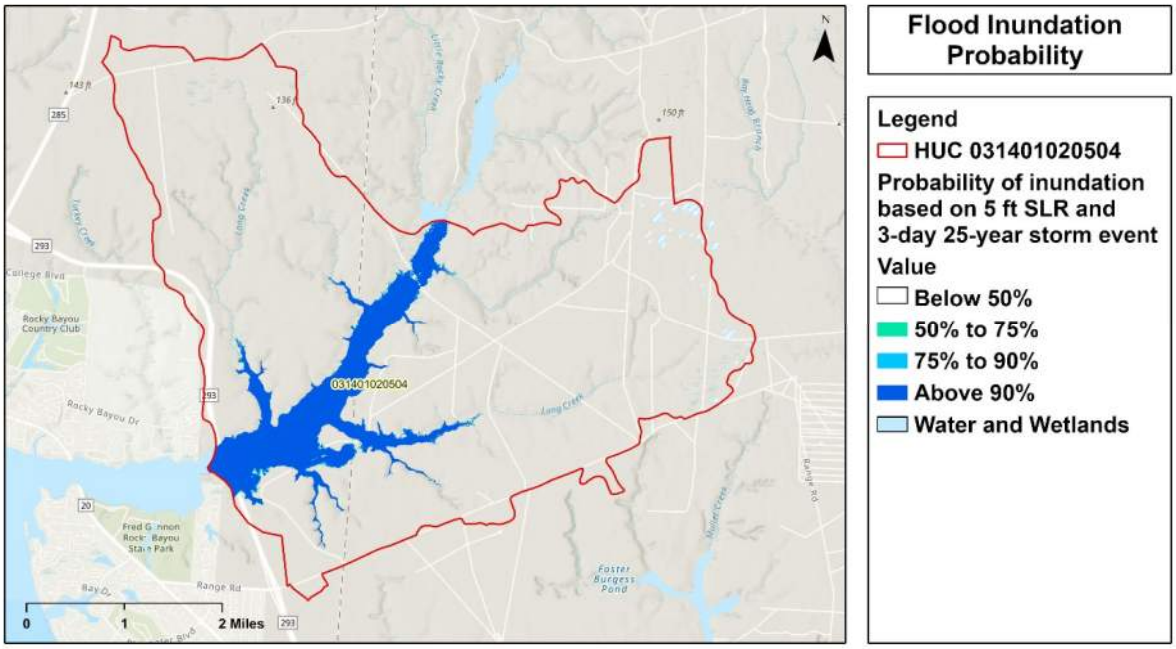

Figure 55. Sea level rise of 5 ft + 3-day 25-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

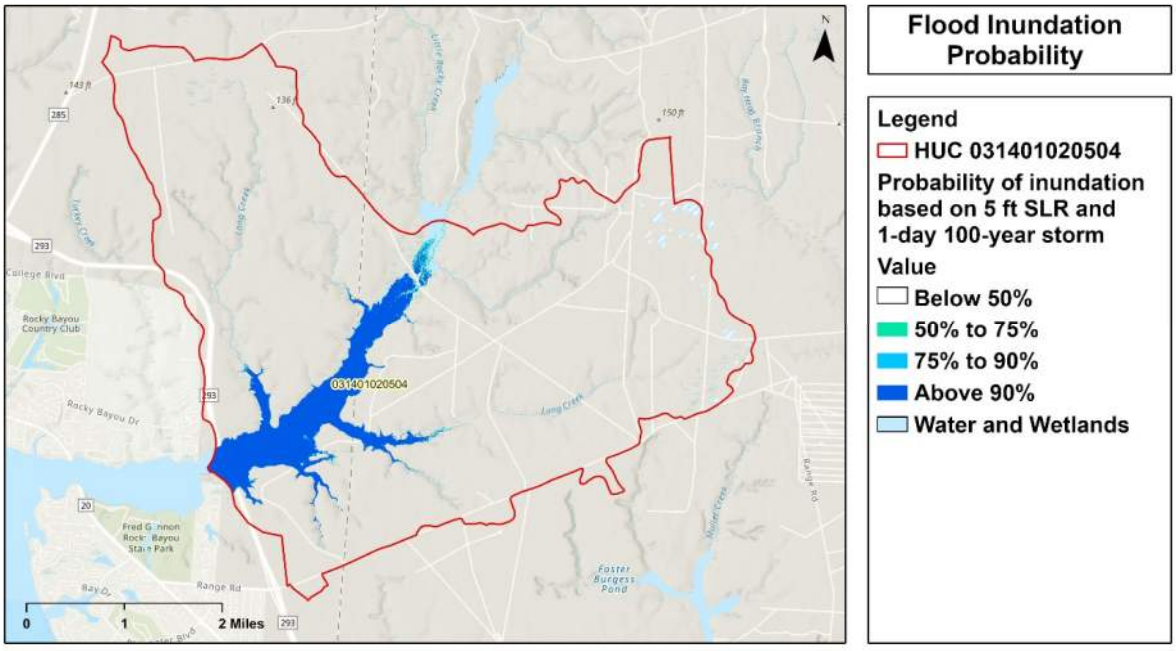

Figure 56. Sea level rise of 5 ft + 1-day 100-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

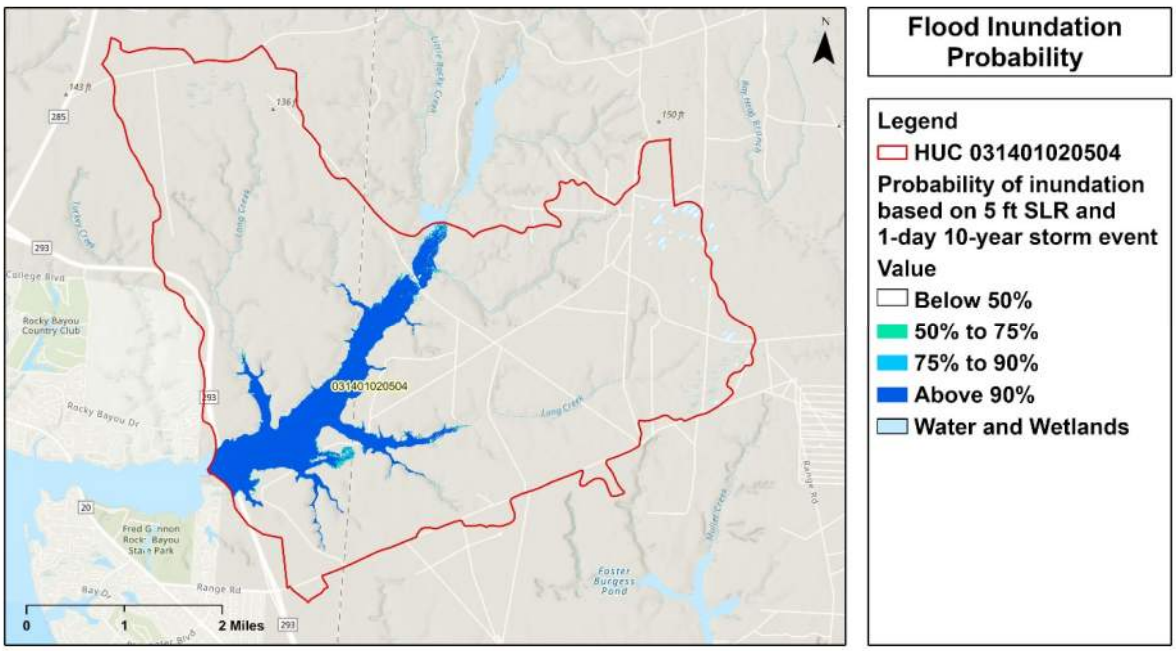

Figure 57. Sea level rise of 5 ft + 1-day 10-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

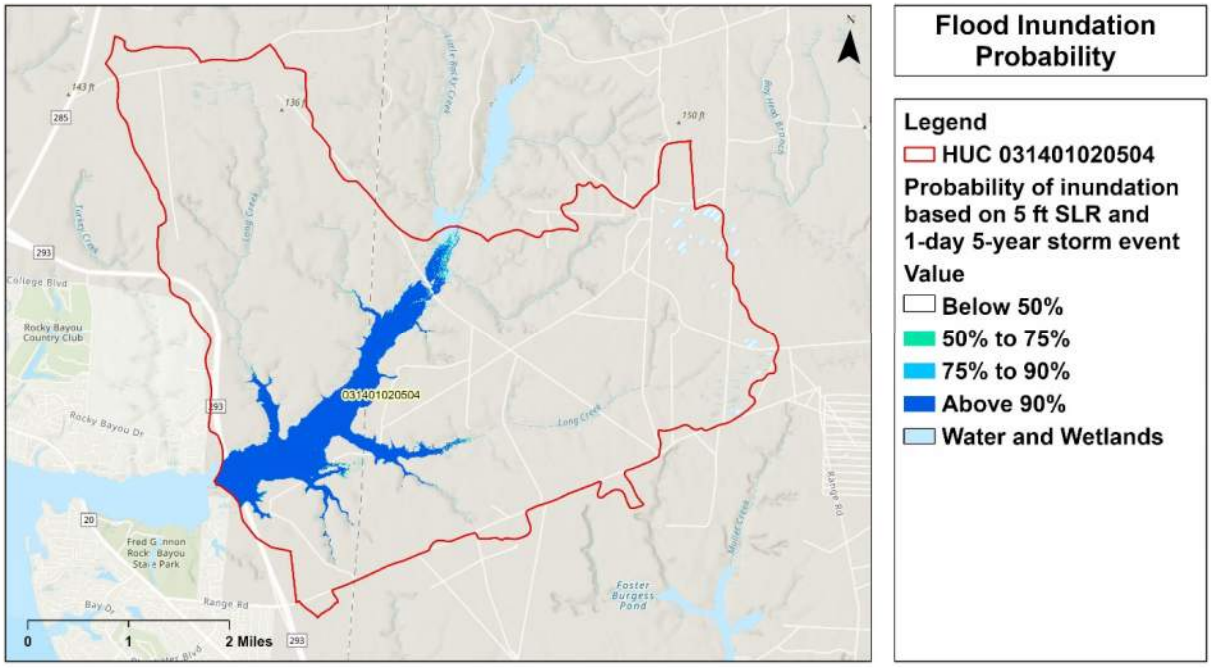

Figure 58. Sea level rise of 5 ft + 1-day 5-year storm for HUC 031401020504 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.*

2.5 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6

11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3

43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5

78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, as shown in **Error! Reference source not found.**.:

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.5.1 Results

Error! Reference source not found. to **Error! Reference source not found.**depict the HUC 031401020504 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 60) overlays critical facilities onto the 1-day 100-year storm event scenario, while the third map (**Error! Reference source not found.**) represents the same overlay within the context of 5 feet of sea level rise (SLR) combined with the 1-day 100-year storm event. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 5 feet SLR + 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** and **Error! Reference source not found.** illustrate the composite score for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. **Error! Reference source not found.** represents the calculation for composite score based on 1-day 100-year storm event, while **Error! Reference source not found.** shows the calculation for composite score for the same storm event, but including a 5 feet of Sea Level Rise scenario. **Error! Reference source not found.** shows the same area zoomed out.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

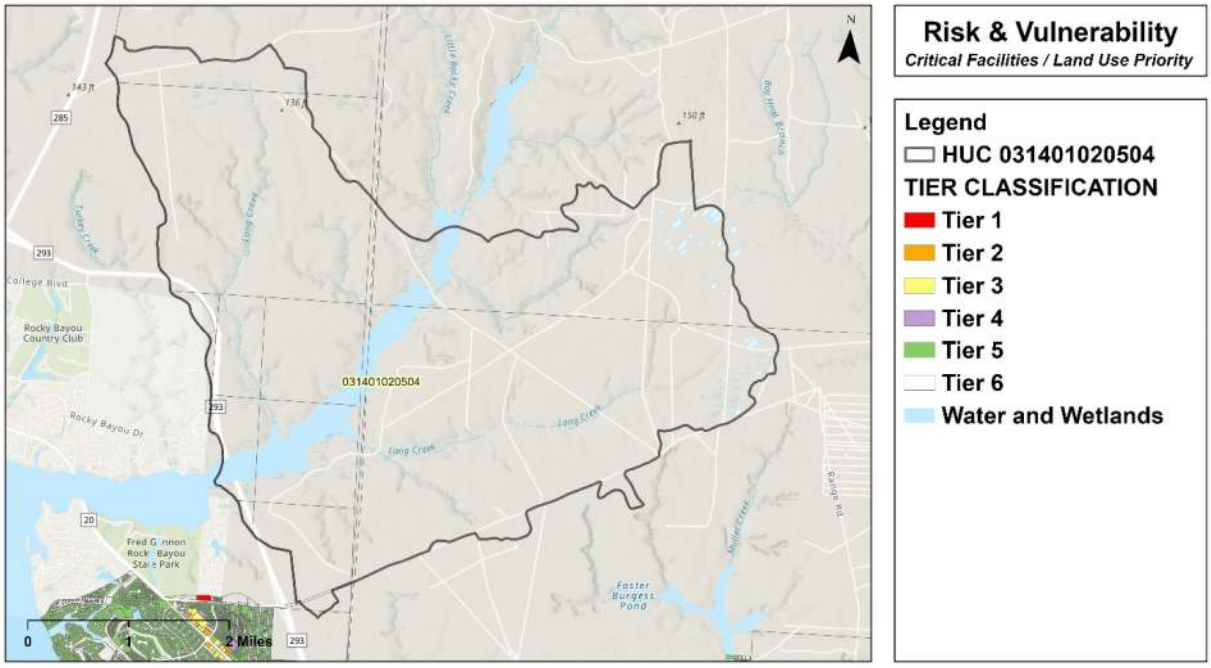

Figure 59. HUC 031401020504 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

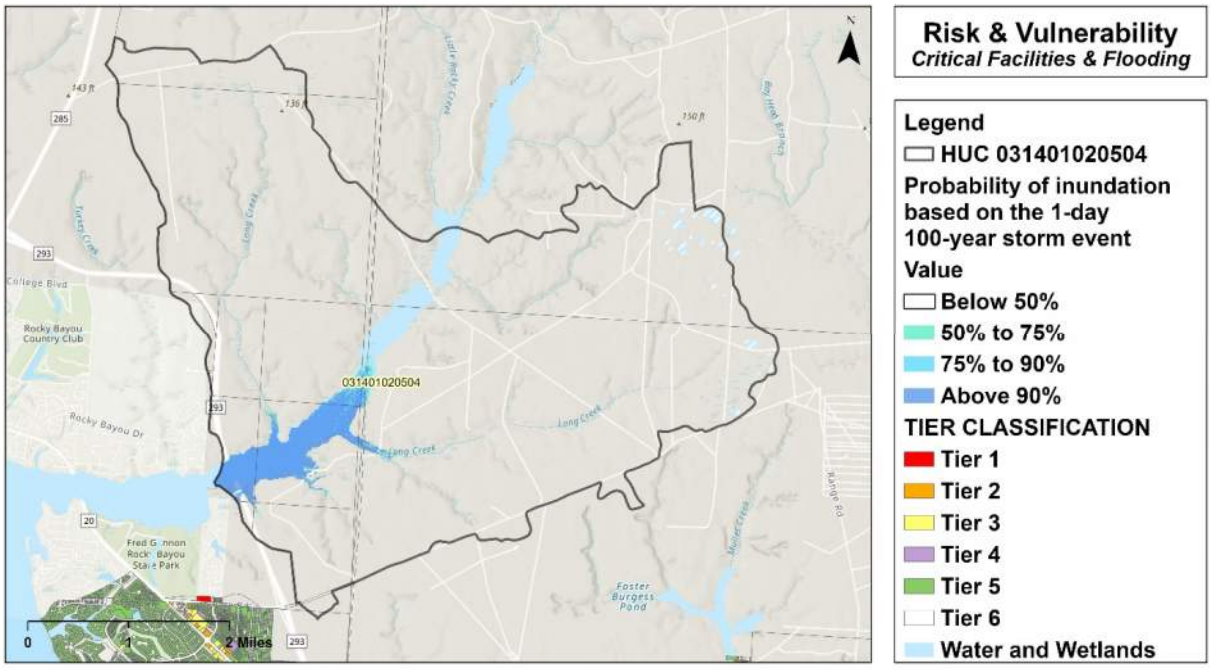

Figure 60. HUC 031401020504 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

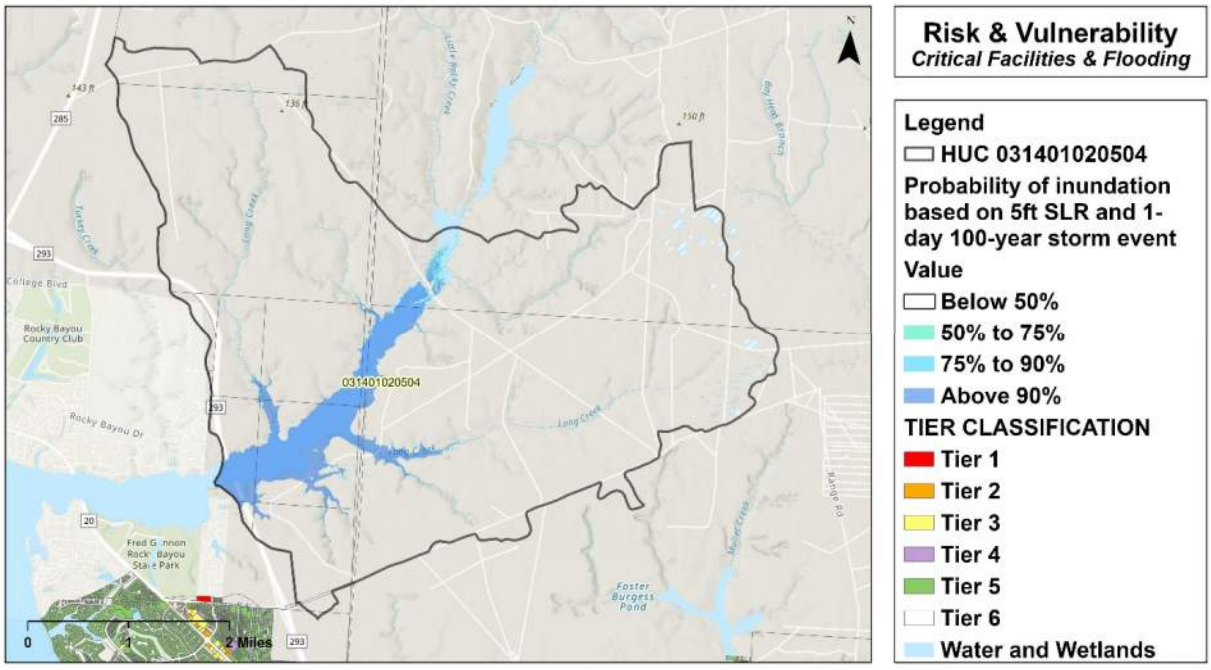

Figure 61. HUC 031401020504 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

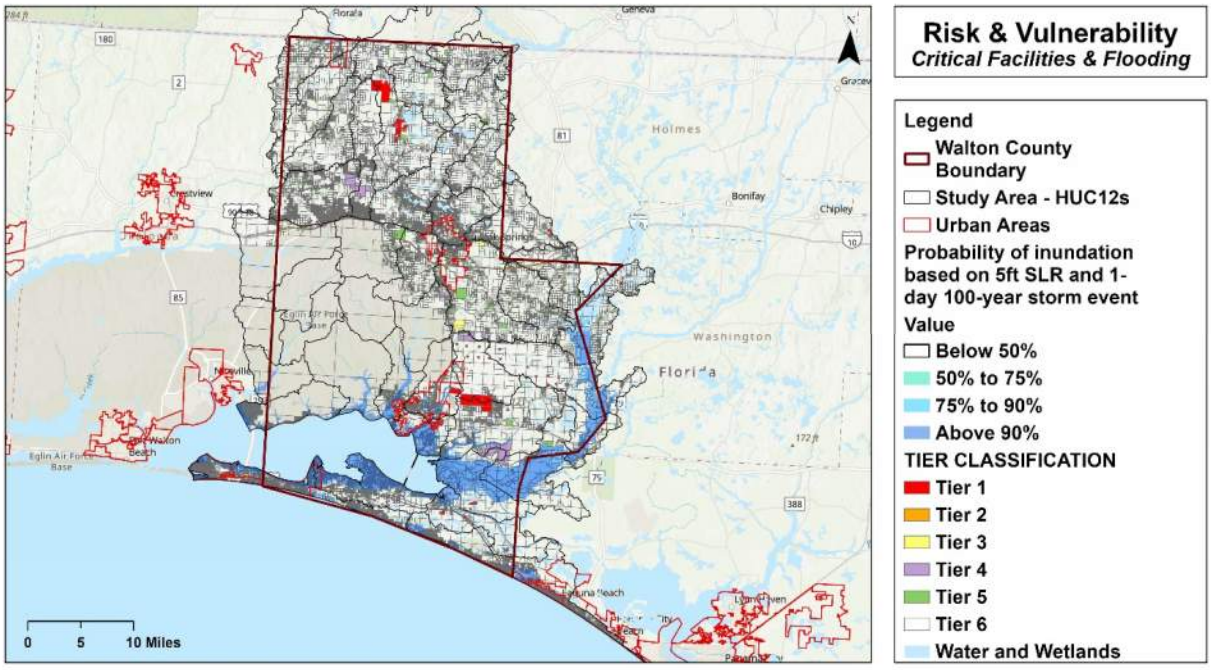

Figure 62. Walton County (mosaic) - Critical Facilities (priority of land uses) map, overlaid on the 1-day 100-year storm event + 5 ft. SLR probability of inundation for Walton County. Processed by FAU.

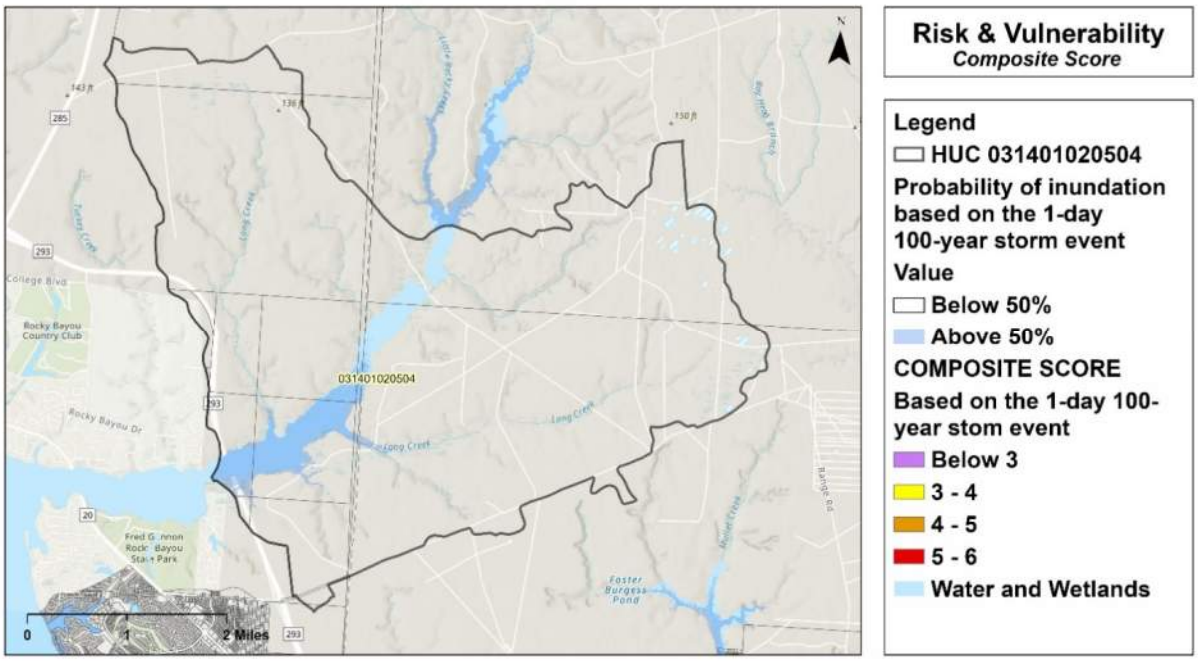

Figure 63. HUC 031401020504 sub-watershed Composite Score Risk map based on the 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation. Processed by FAU.

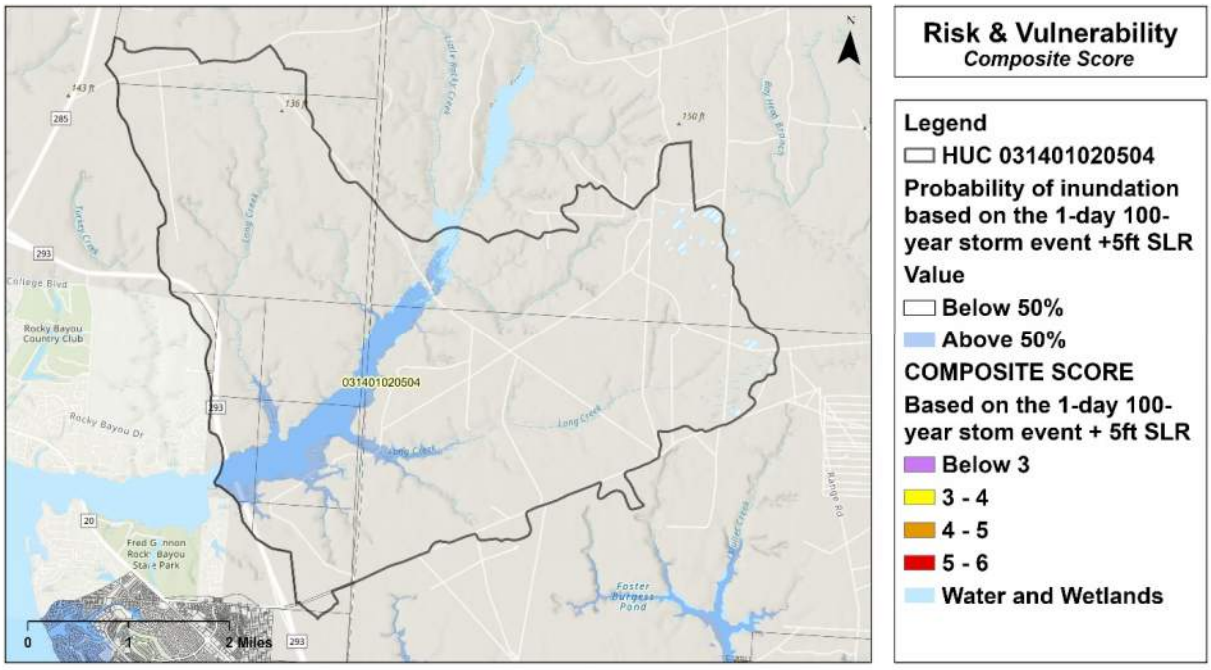

Figure 64. HUC 031401020504 sub-watershed Composite Score Risk map based on 1-day 100-year storm event + 5 ft. SRL, overlaid on the 1-day 100-year + 5 ft. SLR probability of inundation. Processed by FAU.

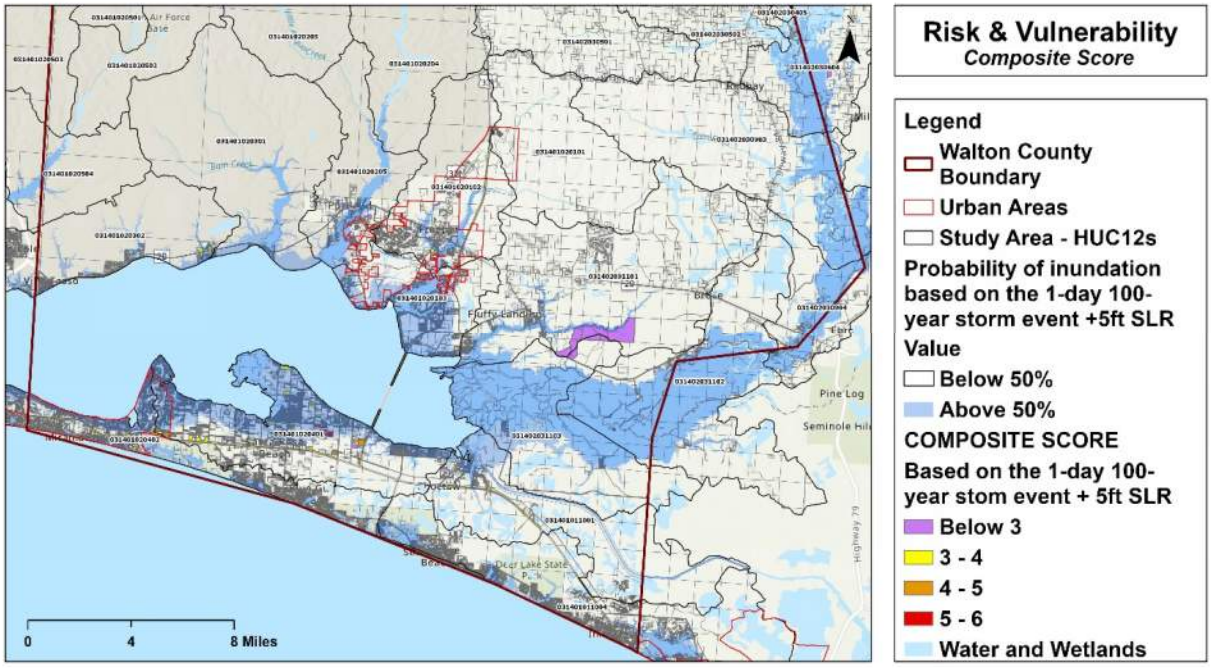

Figure 65. Coastal Area of Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

2.5.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401020504. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.5.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401020504. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401020504	12485.20
All of the 1-day 100-year storm event inundation	**431.46**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	331.44
B. Federal Land in 1-day 100-year inundation > 10 acres	100.01
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	0.00
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	0.00

2.5.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not**

found. indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

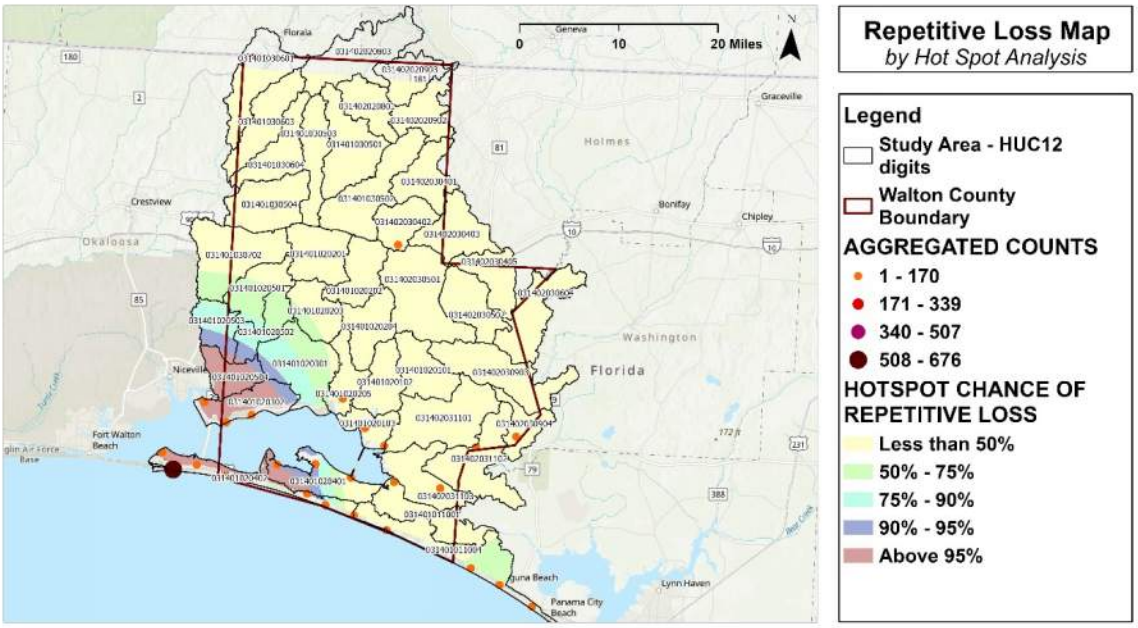

Figure 66. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.5.5 Priority Projects

The entire HUC area is undeveloped. As a result, there are no critical facilities or other land uses that require priority for intervention. The flooding is substantial as it is a coastal area, but not alarming since there is no proprieties being impacted. Therefore, the composite score is null, indicating that there is no pressing priority for interventions to address inundation impact within the basin.

APPENDIX T

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401030501

BIG SWAMP CREEK

Principal Investigator: Frederick Bloetscher, Ph.D., P.E.

Co-Principal Investigators: Weibo Liu, Ph.D., Daniel Meeroff, Ph.D., Diana Mitsova, Ph.D., S. Nagarajan, Ph.D., Hongbo Su, Ph.D., Ramesh Teegavarapu, Ph.D., Zhixiao Xie, Ph.D., Yan Yong, Ph.D., and Caiyun Zhang, Ph.D., Ahmet Urusan, Ph.D., Shannon Egger, Eva Suarez, Ph.D.

Research Assistant: Leticia Sabio

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401030501) is highlighted among all the HUCs to help identifying its location.

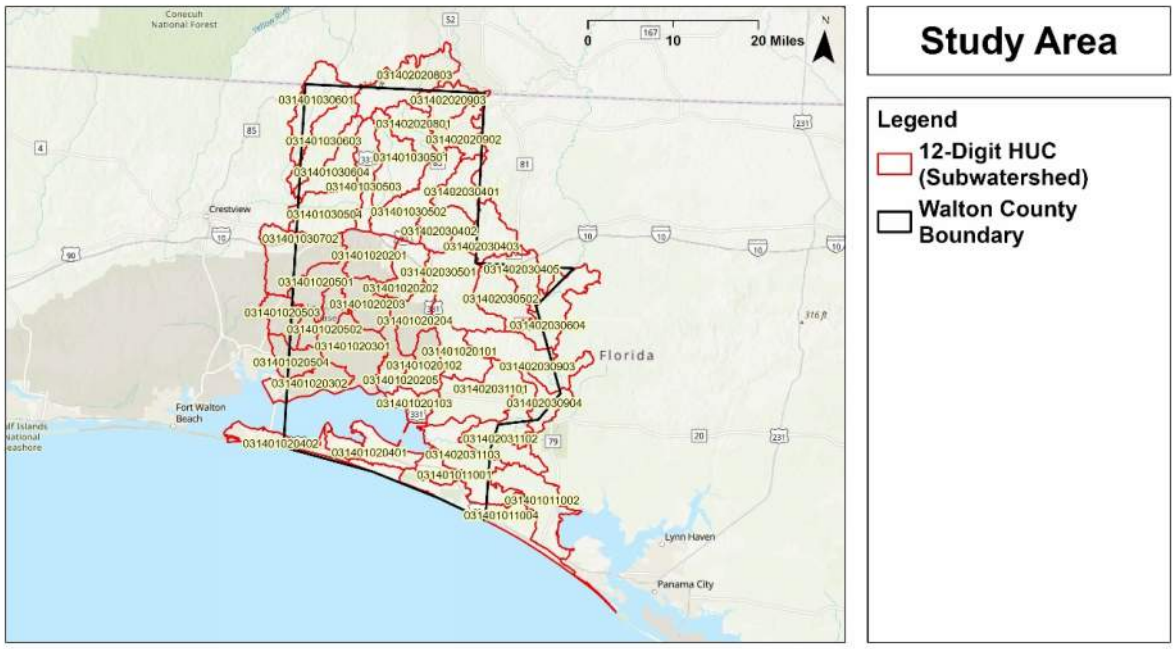

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

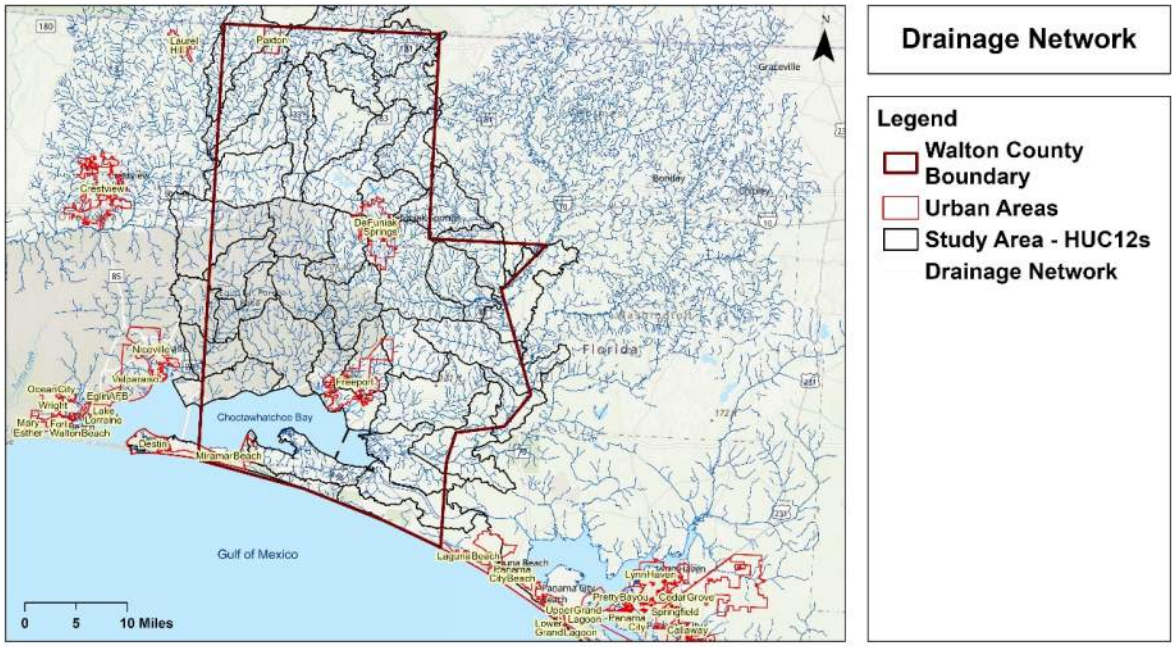

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

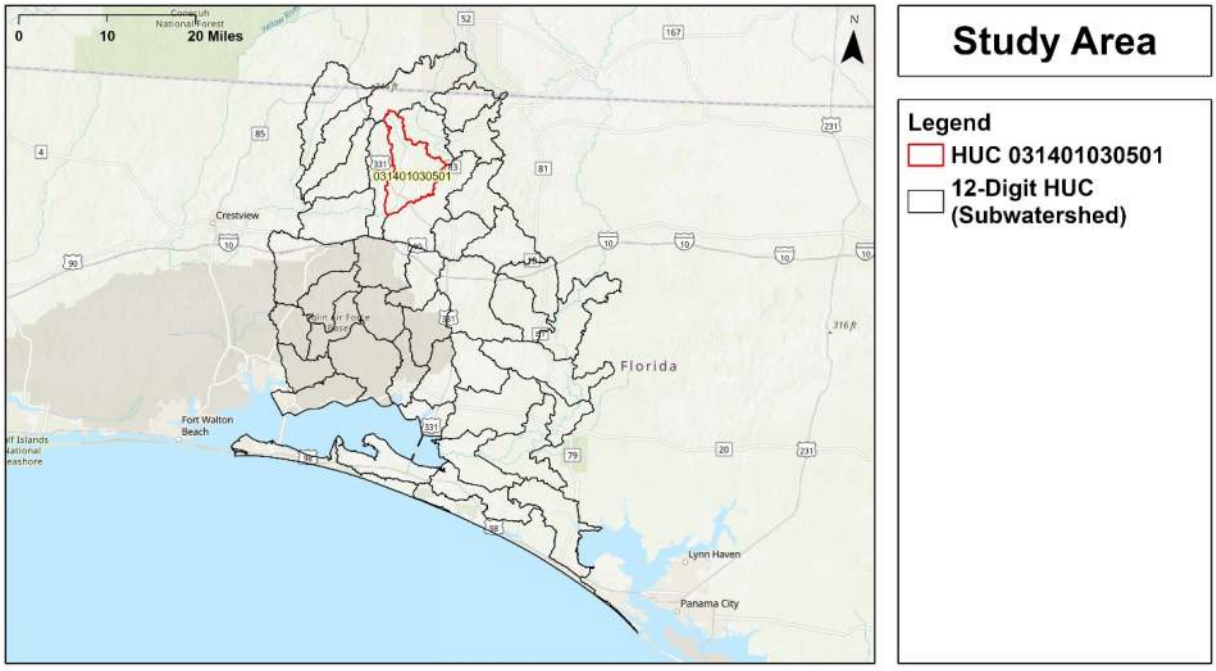

Figure 3. HUC 031401030501 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Figures 12 and 13 in the county-wide report show the current and projected land use for the County. Based on the 2017 future land use map for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding.

The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

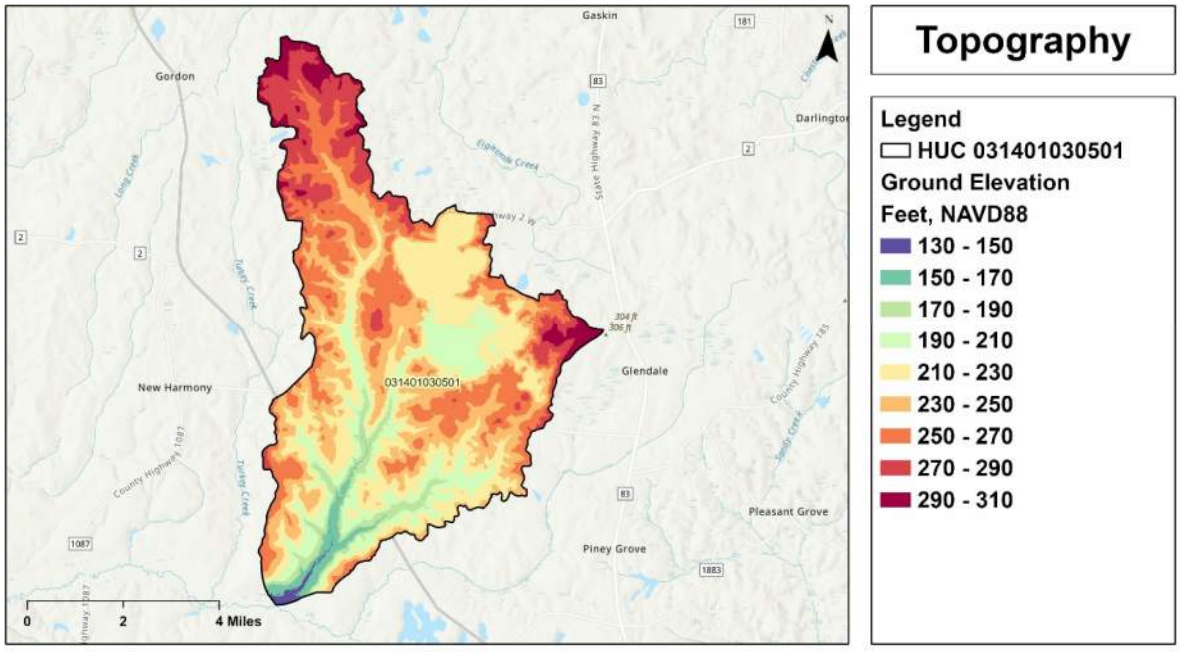

Figure 4. Topographic map of the HUC 031401030501 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401030501 sub-watershed is shown in **Error! Reference source not found.**.

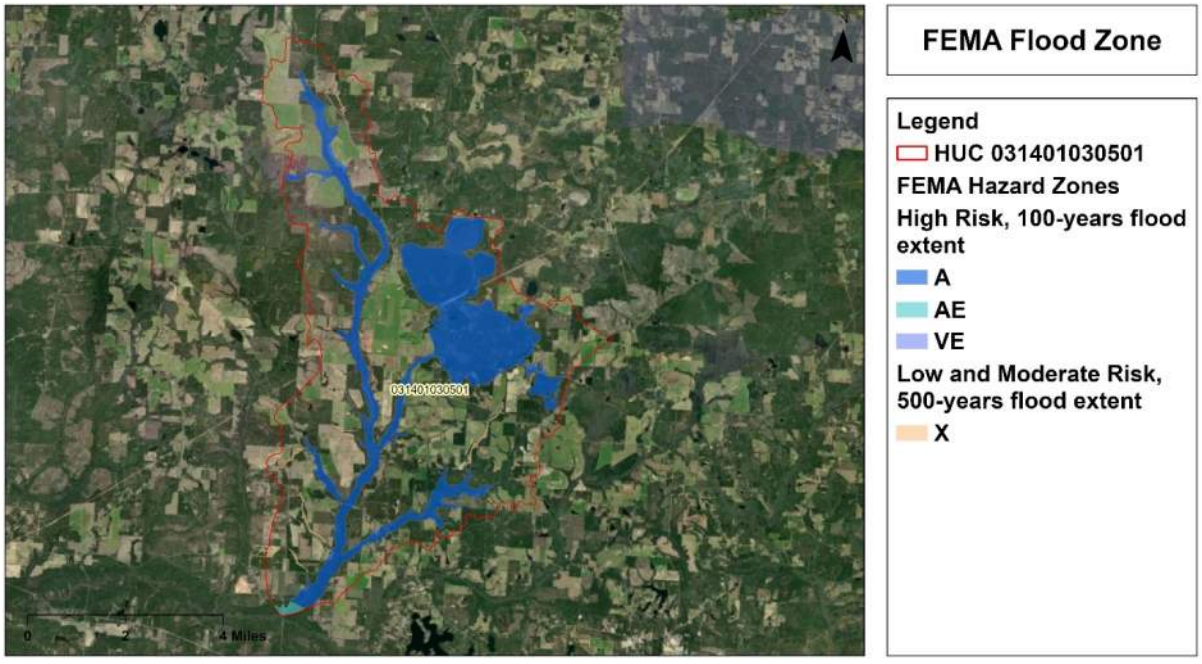

Figure 5. FEMA Flood Zone map (2020) for HUC 031401030501 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401030501 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

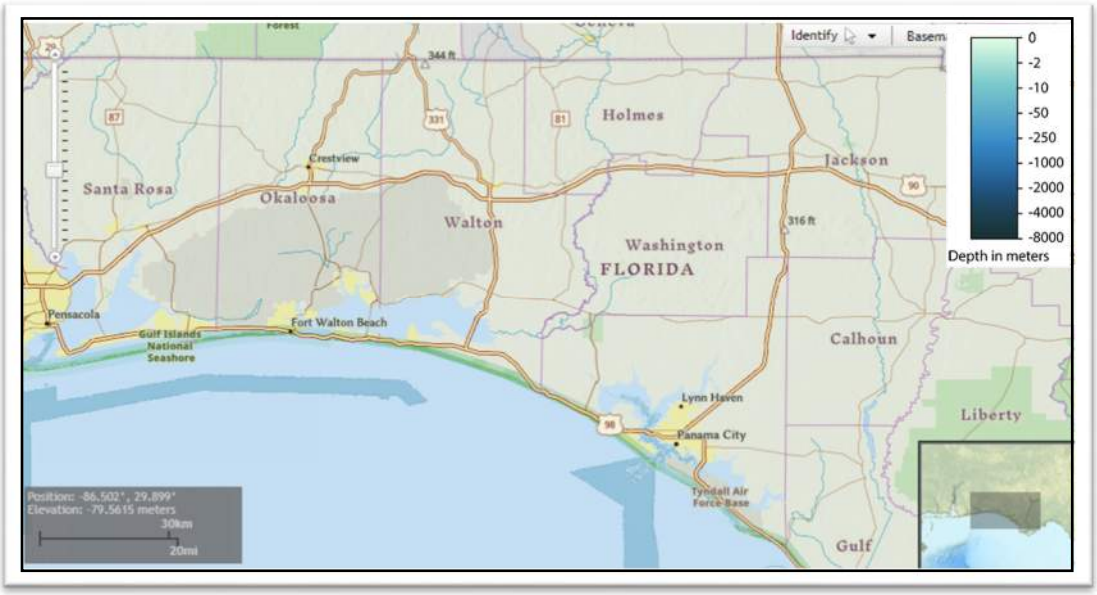

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

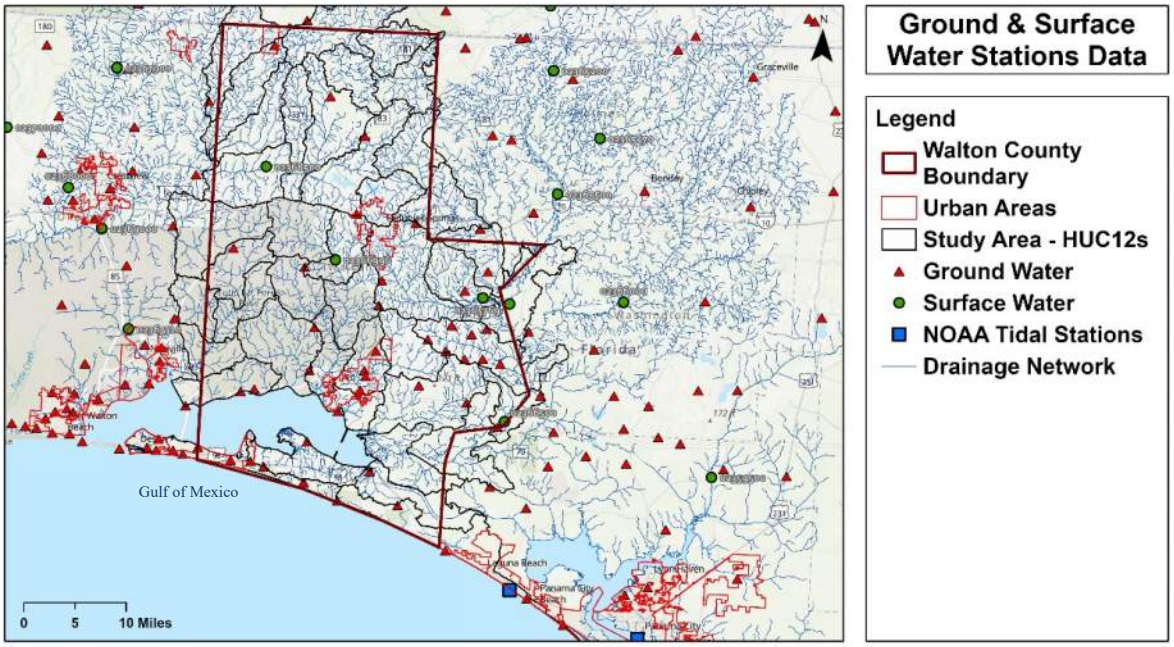

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031401030501 has no major rivers and canals, but creeks and branches, include:

- Rocky Creek
- Bear Branch

- Dogwood Head Branch
- Green Head Branch
- Exline Creek
- Wildcat Creek
- Mount Sinai Branch

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02368500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401030501, which is USGS 02368500 Shoal River NR Mossy Head, FLA.

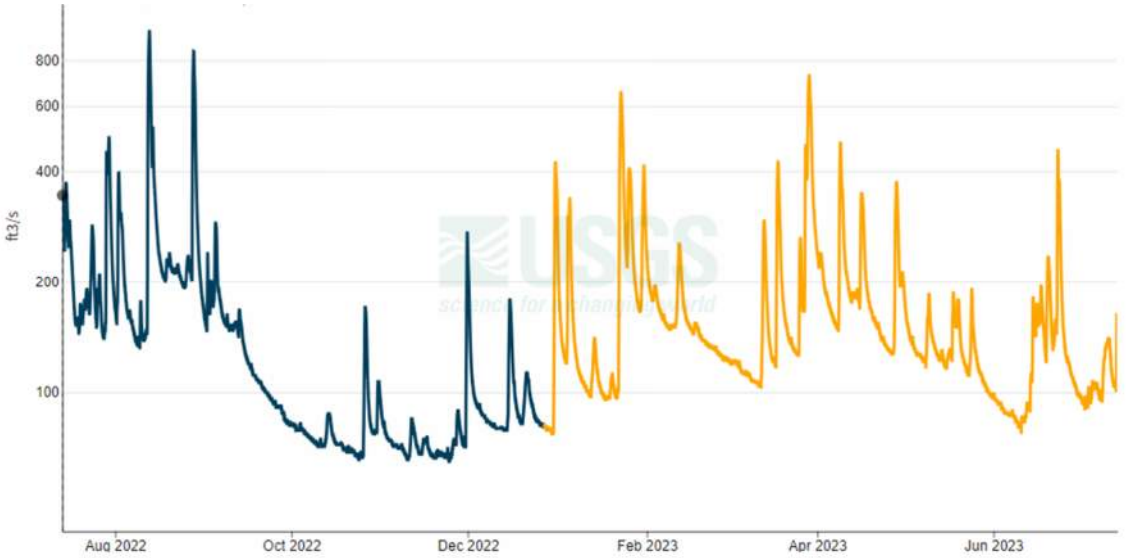

Figure 8. Average streamflow for Shoal River NR Mossy Head, Fla. – 02368500
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02368500/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are

estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401030501 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031401030501 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

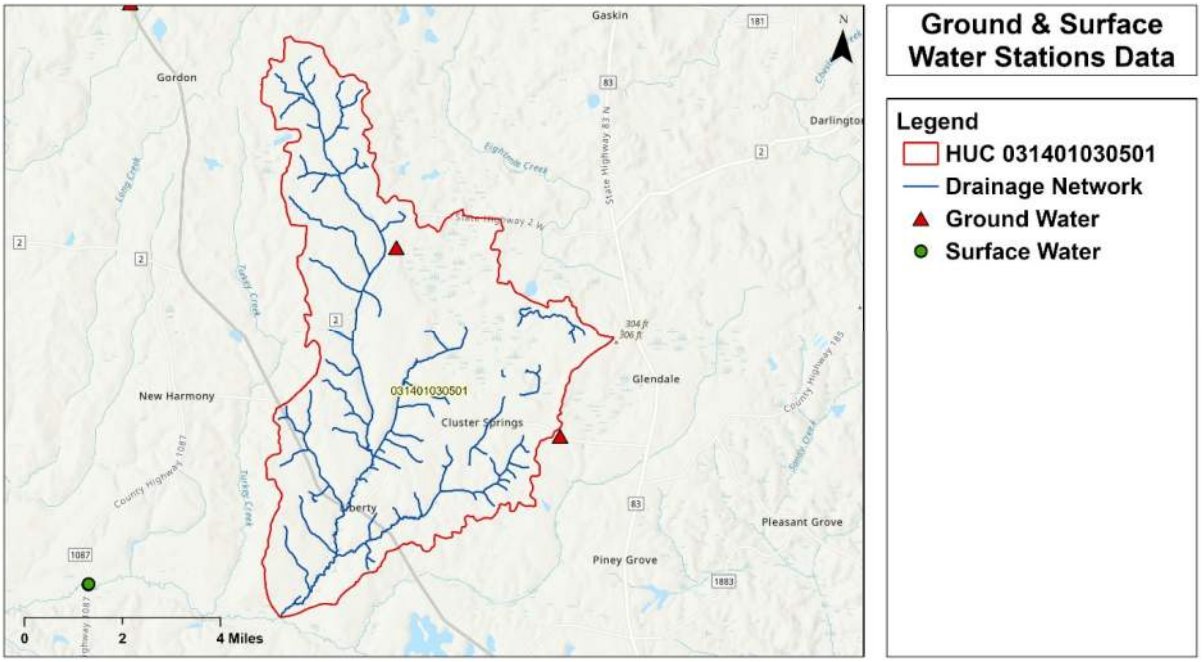

Figure 9. Ground and Surface Water Stations in the HUC 031401030501 sub-watershed, processed by FAU.

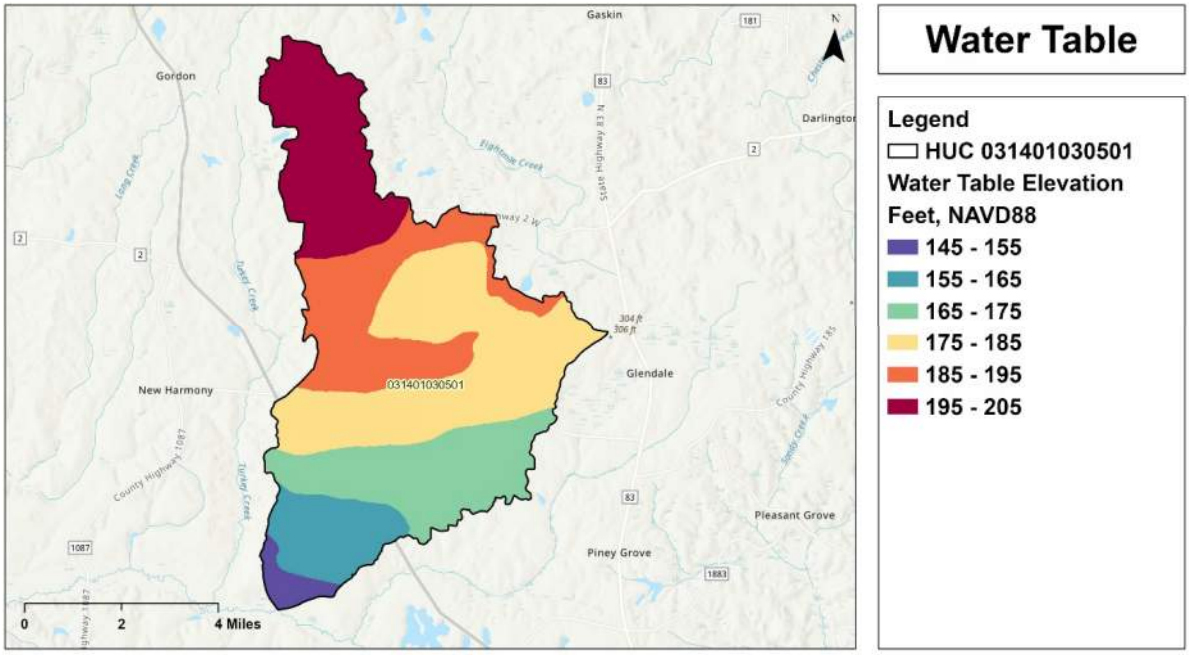

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401030501 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

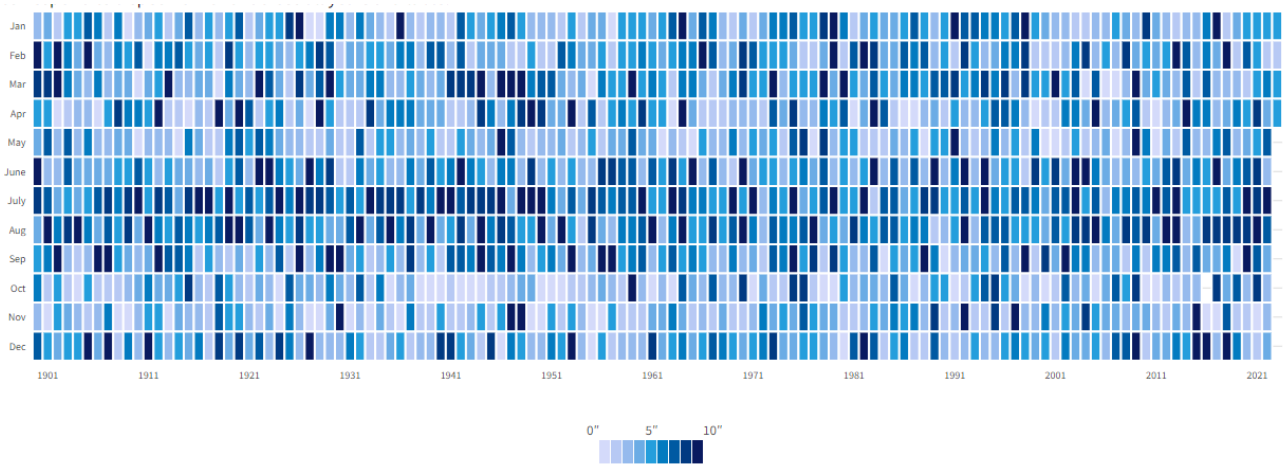

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/).

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there are no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

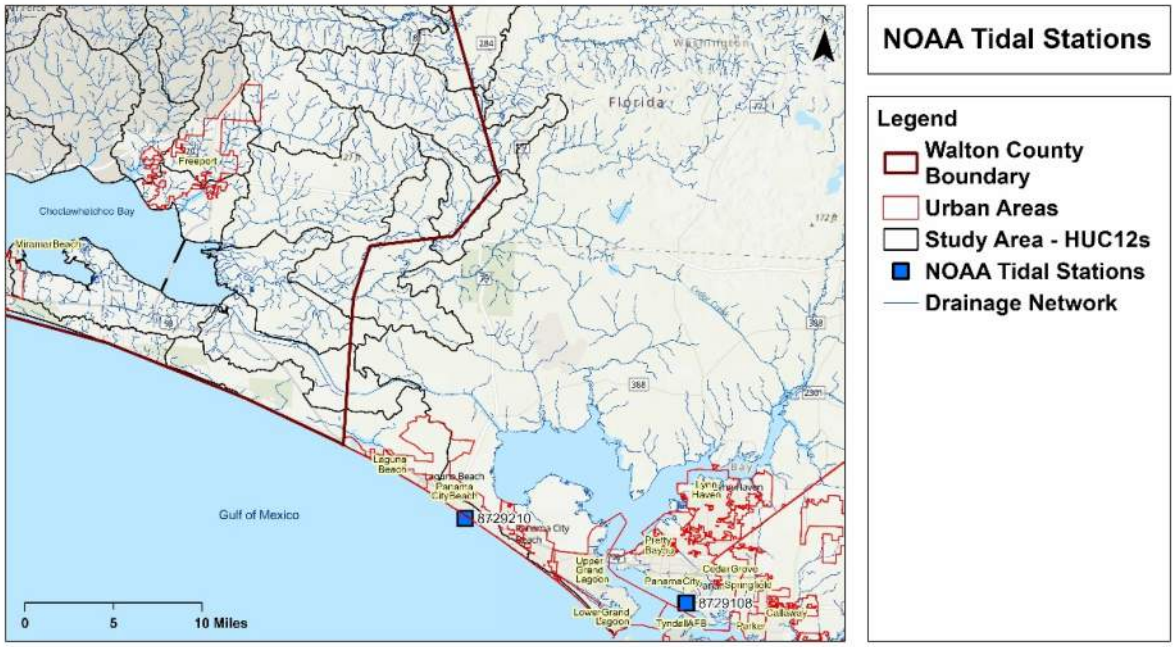

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**..

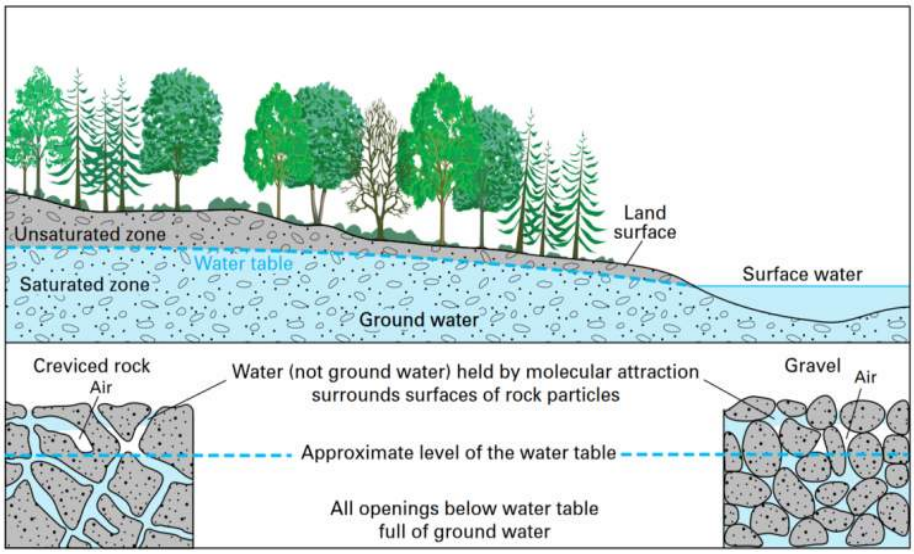

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

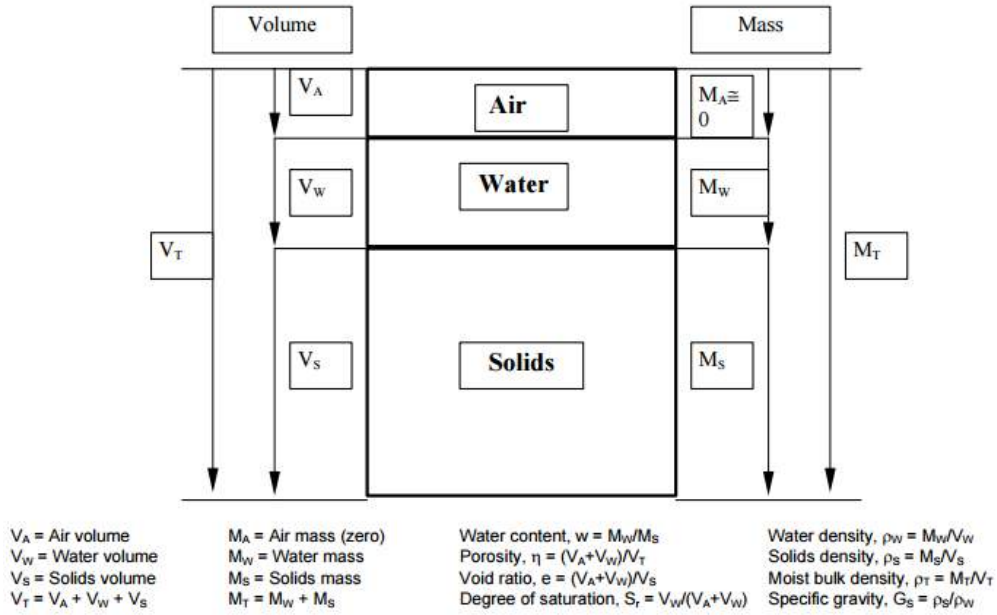

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

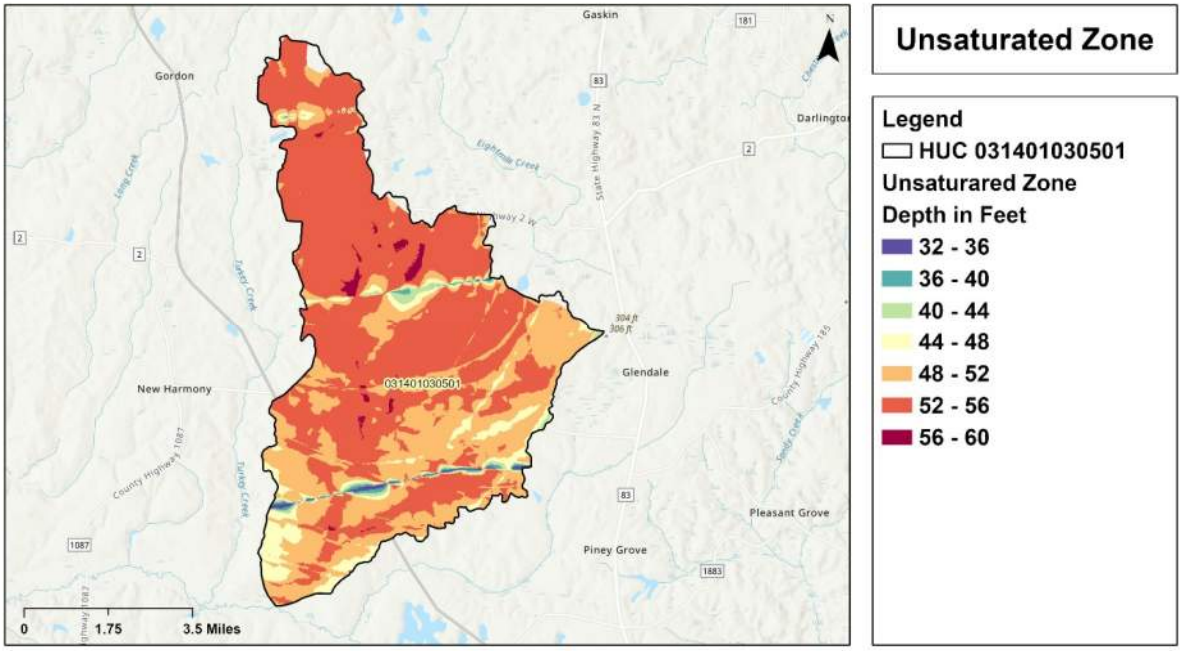

Figure 15. Unsaturated zone map for HUC 031401030501, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. Much of the basin has a medium amount of soil storage capacity, ranging between 30 to 33 inches of capacity left.

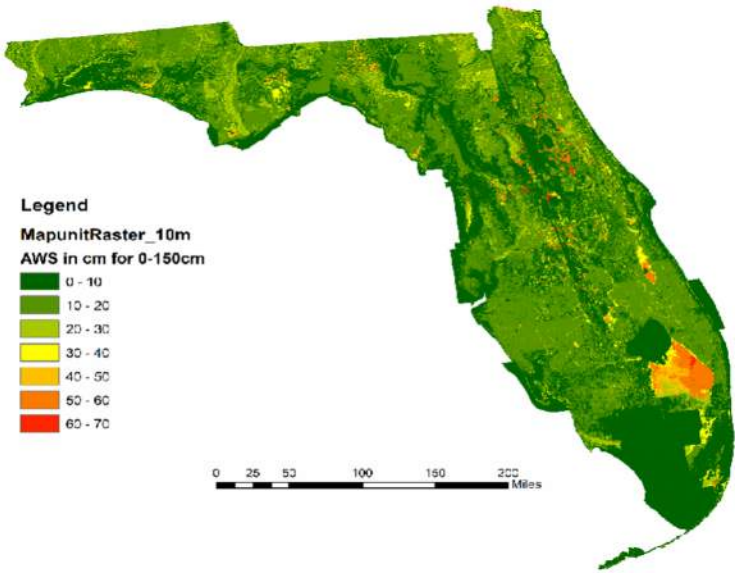

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

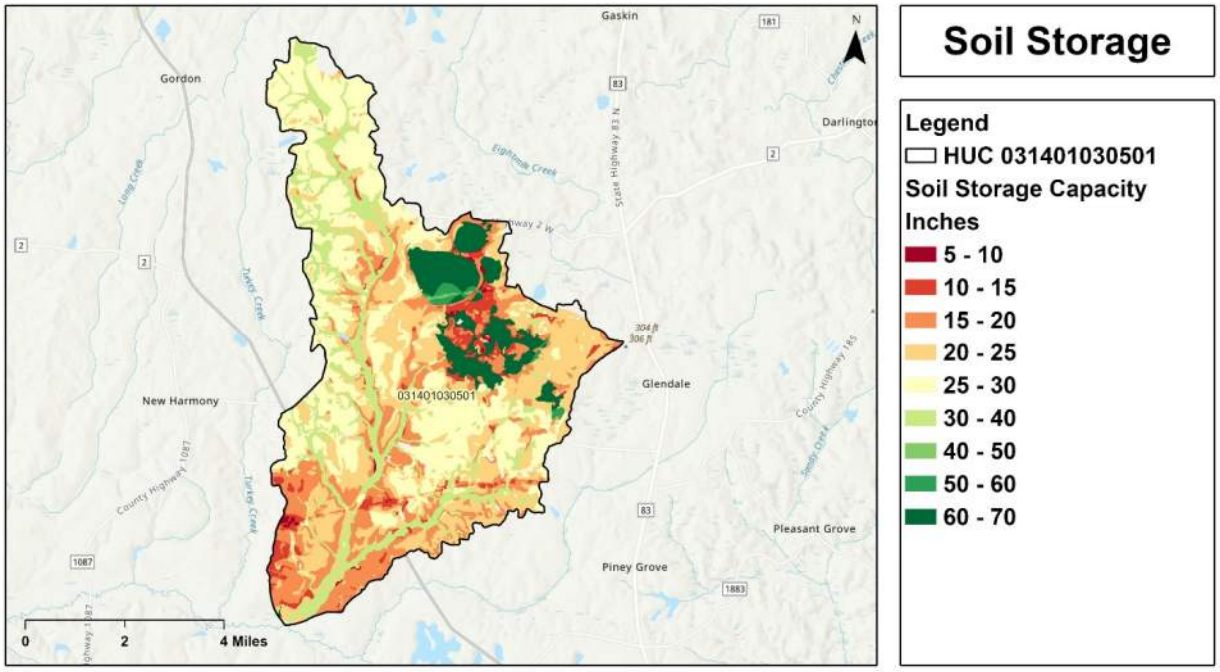

Figure 17. Water storage capacity of soil for the HUC 031401030501 (inches), processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

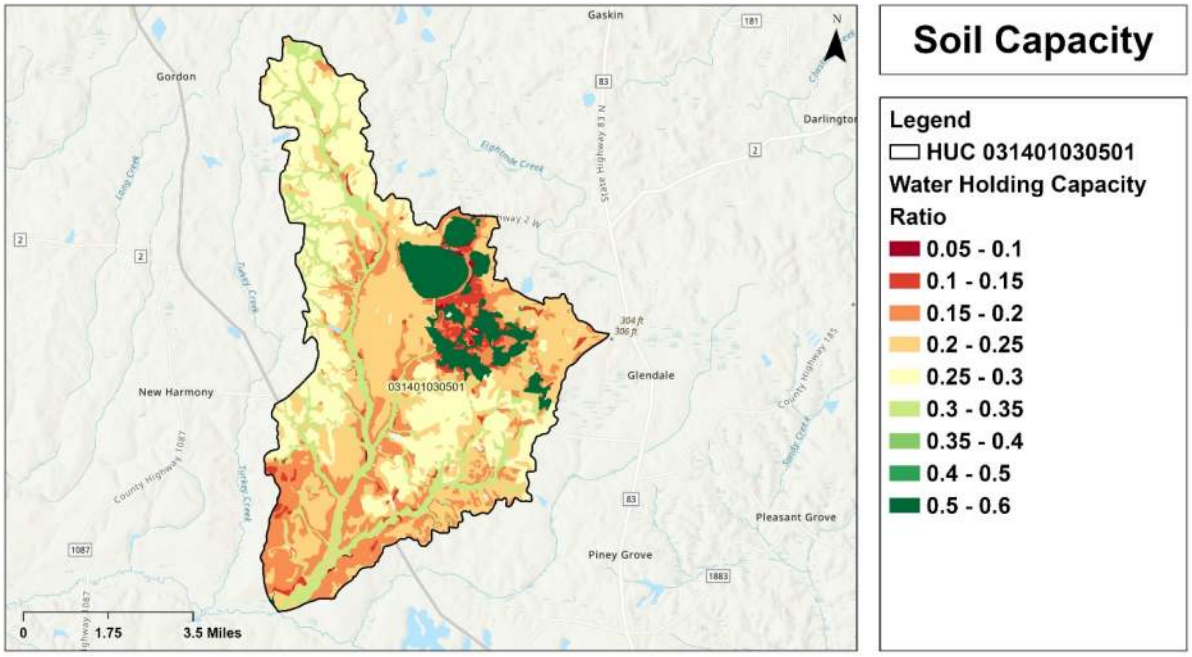

Figure 18. Water Holding Capacity (ratio) for the HUC 031401030501, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

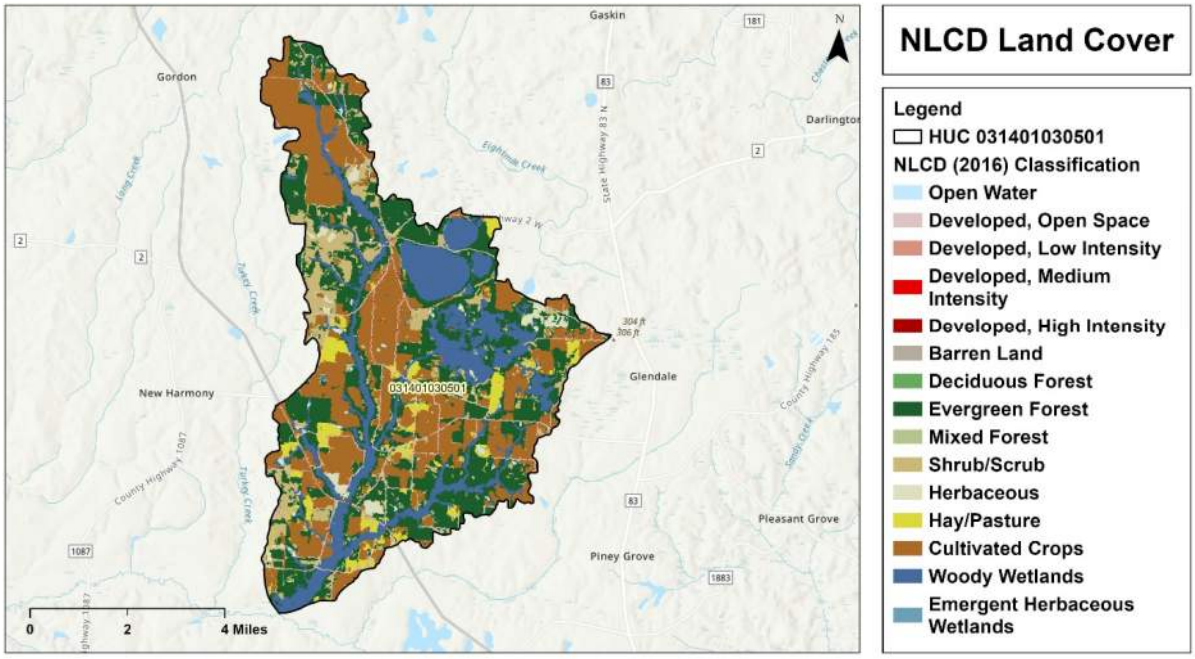

Figure 19. Land use in the HUC 031401030501 (from the NLCD 2016 database), processed by FAU.

In the HUC 031401020203 sub-watershed, the predominant land cover is upland forest, accounting for 62.90% of the area. Urban and built-up comes in second at 13.92%, followed by wetlands at 10.80%, and rangeland at 9.73%, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

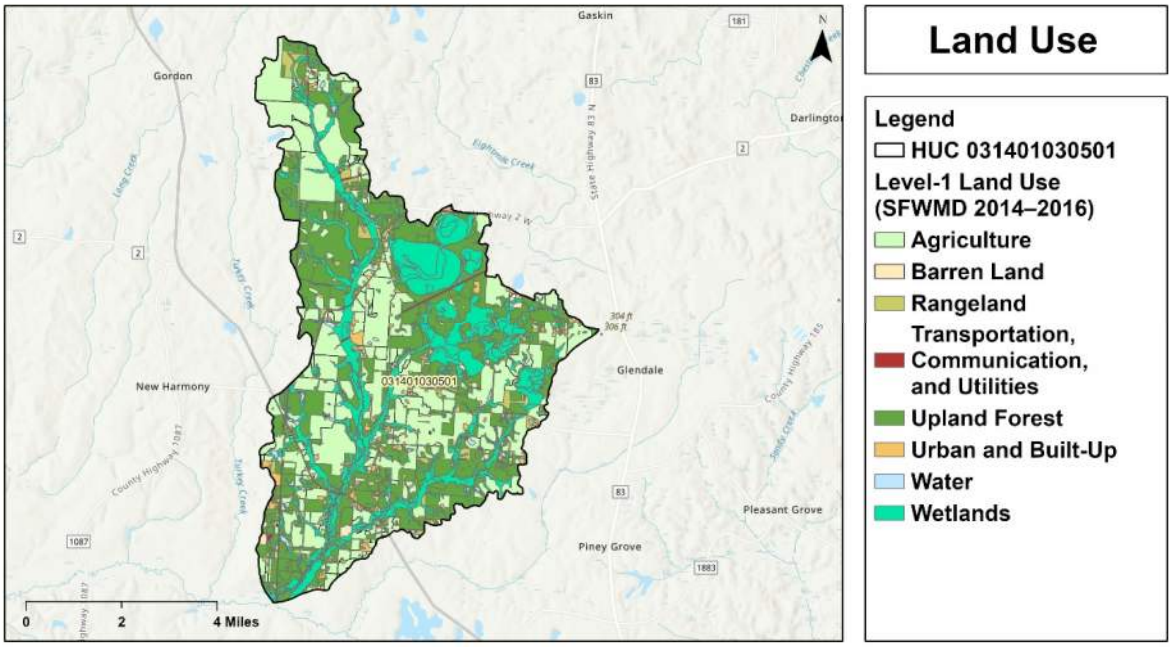

Figure 20. Land use in the HUC 031401030501 (2023 Florida Geographic Data Library (FGDL)), processed by FAU.

In the HUC 031401030501 sub-watershed, the predominant land cover is upland forest, accounting for 37.80% of the area. Agriculture comes in second at 31.26%, followed by wetlands at 16.50%, and Transportation, Communication, and Utilities at 8.06%. Developed land constitutes a minor portion, with only 2.42% categorized as urban and built-up, as indicated in Table 3.

Table 3. Land use for HUC 031401030501 subwatershed (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	11614.09	31.26%
Barren Land	179.10	0.48%
Rangeland	761.86	2.05%
Transportation, Communication, and Utilities	2995.04	8.06%
Upland Forest	14041.44	37.80%
Urban and Built-Up	899.12	2.42%
Water	528.62	1.42%
Wetlands	6130.98	16.50%
Grand Total:	**37150.25**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

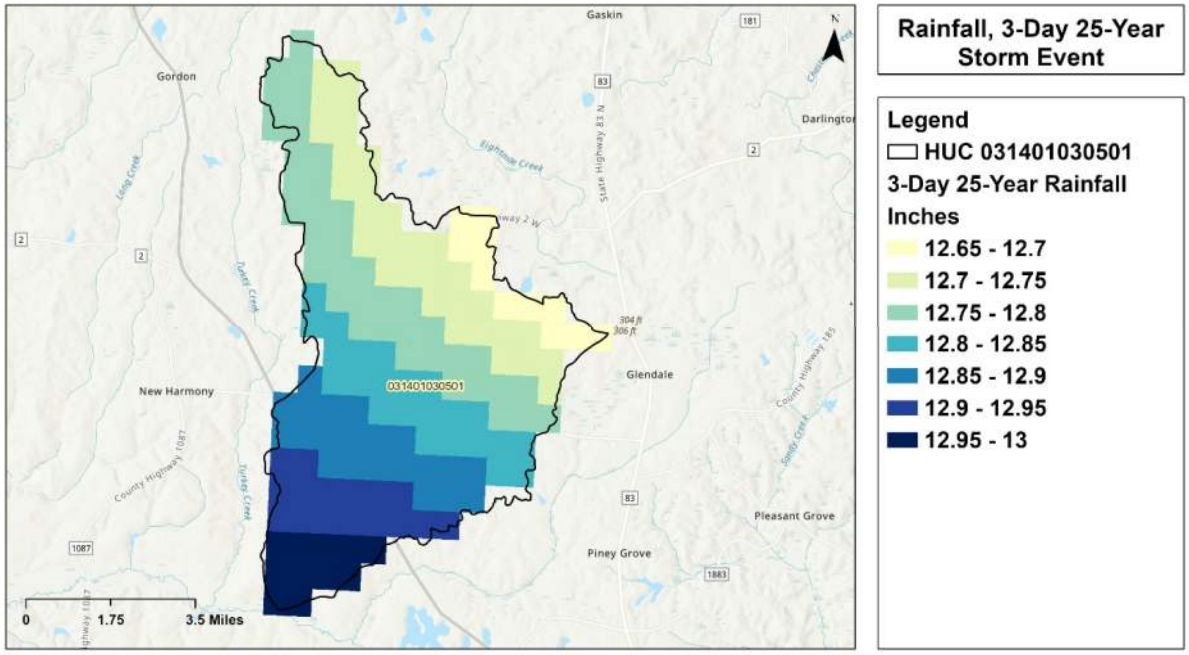

Figure 21. Rainfall distribution map across HUC 031401030501 sub-watershed, for 3-day 25-year storm event, processed by FAU.

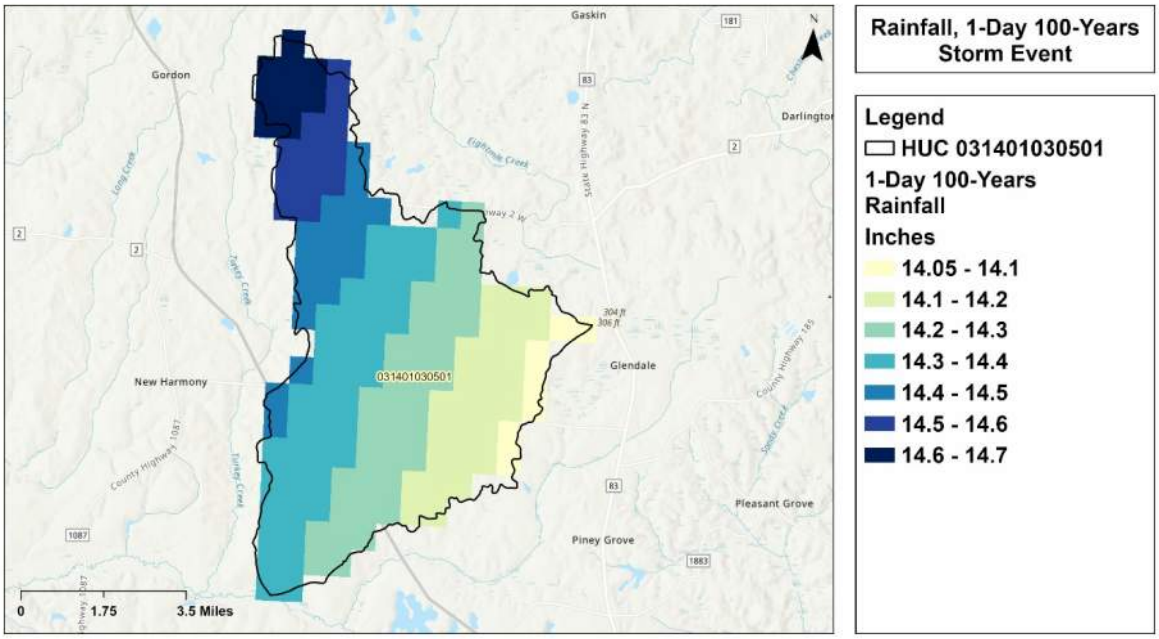

Figure 22. Rainfall distribution map across HUC 031401030501 sub-watershed, for 1-day 100-year storm event, processed by FAU.

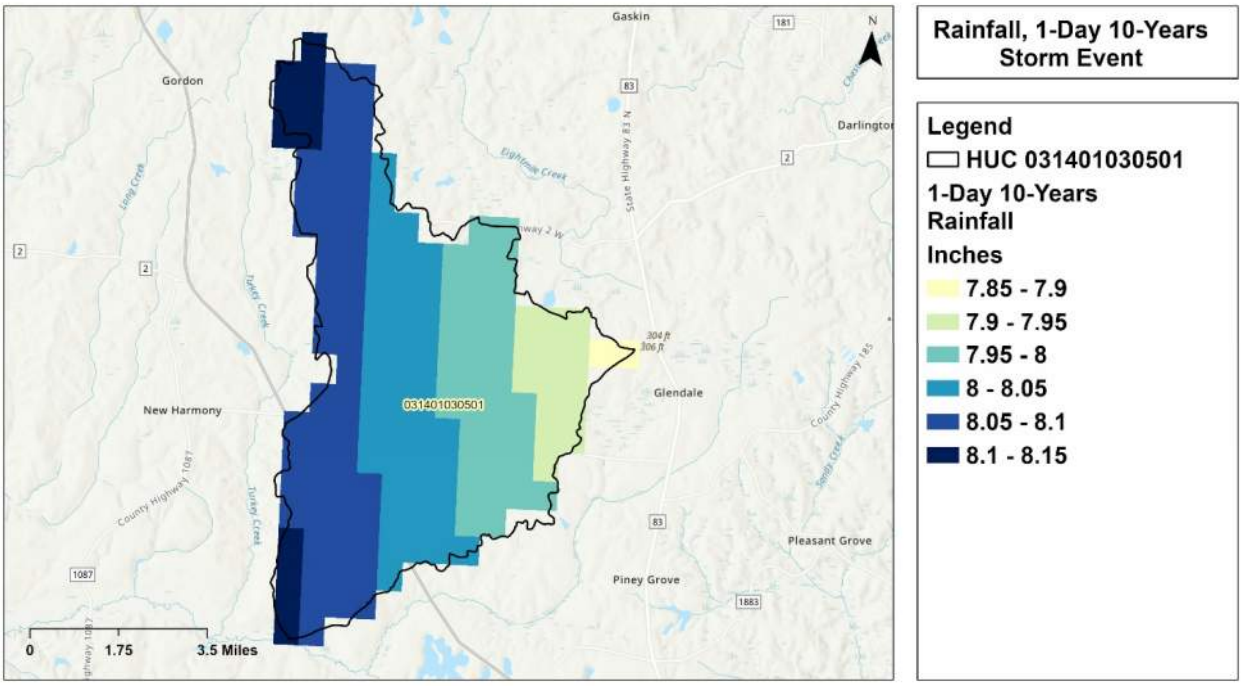

Figure 23. Rainfall distribution map across HUC 031401030501 sub-watershed, for 1-day 10-year storm event, processed by FAU.

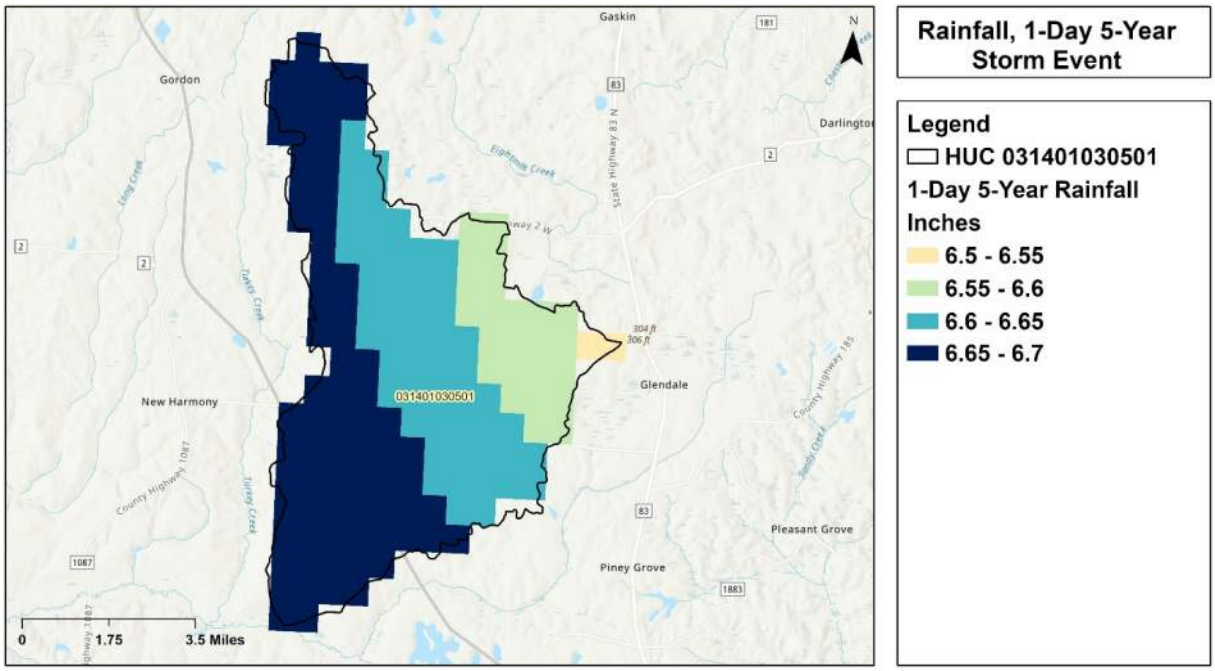

Figure 24. Rainfall distribution map across HUC 031401030501 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land

cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

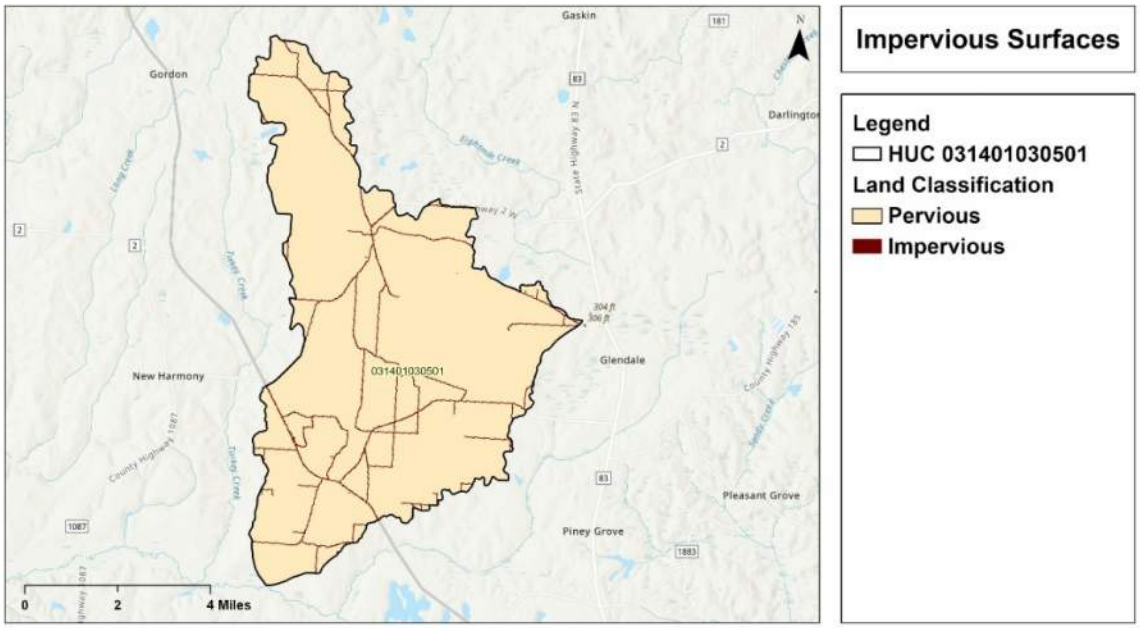

Figure 25. Impervious area map for the HUC 031401030501 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

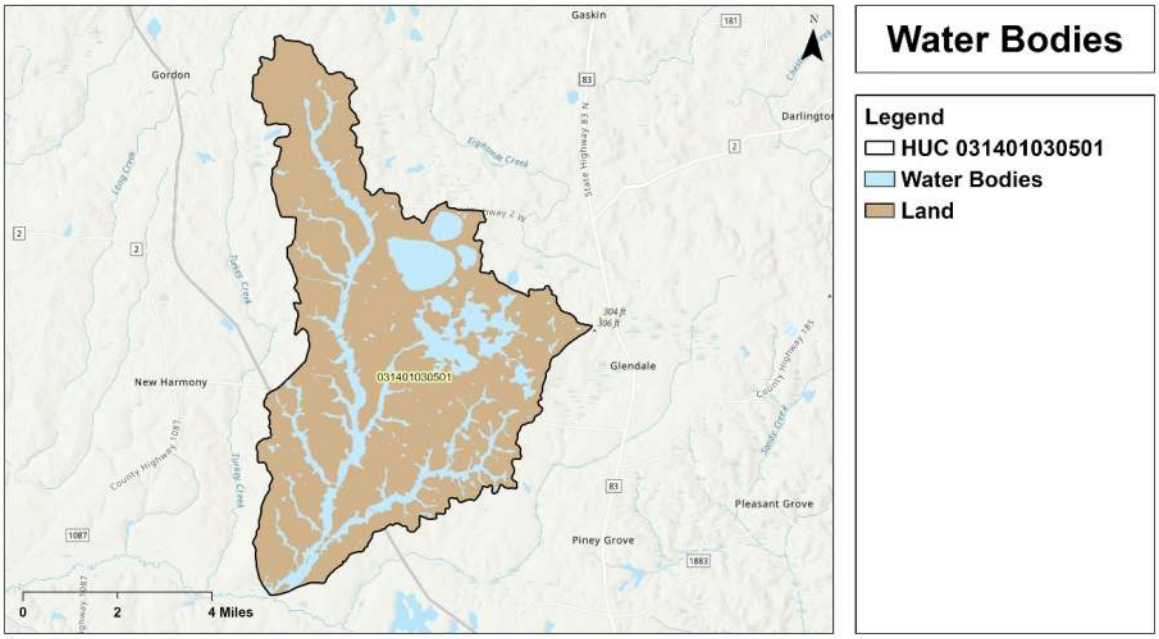

Figure 26. Water bodies map for the HUC 031401030501 sub-watershed, processed by FAU.

1.10. Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

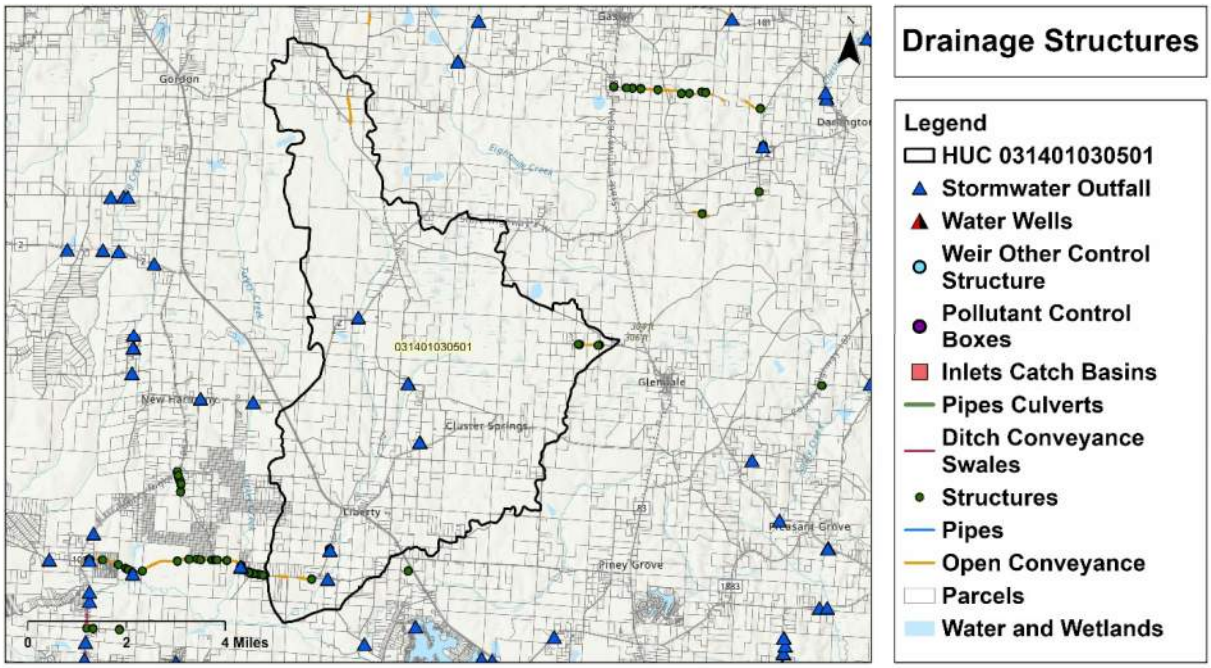

Figure 27. Stormwater Infrastructure for the HUC 031401030501. Processed by FAU.

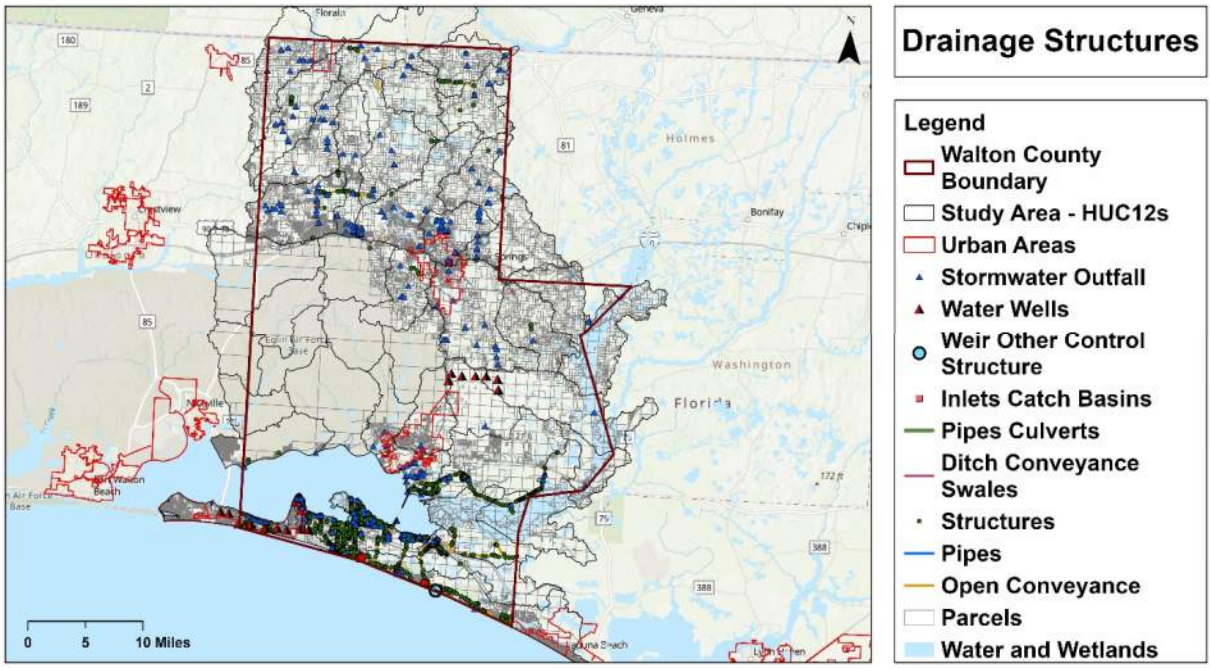

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Ground water	FL_GW	South FL Water Management District	Florida, Excel	Daily, 1980-2020	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_GW\South Florida District	140 M bytes, excel	Native
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401030501 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the

coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. Figure 29 shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

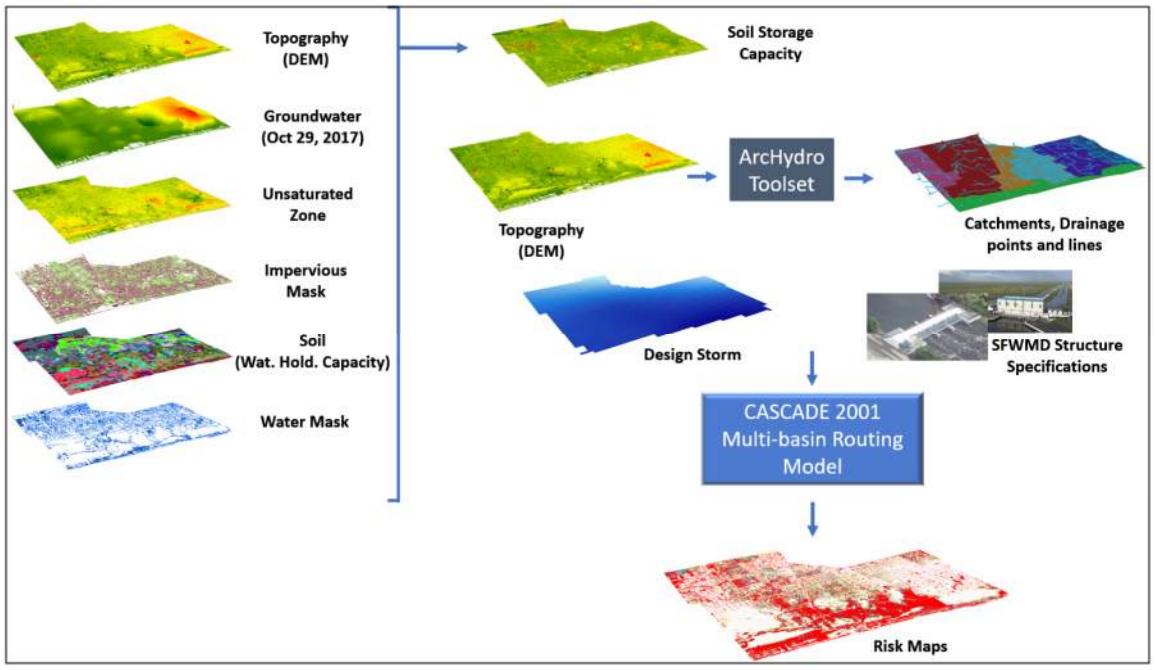

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are

critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

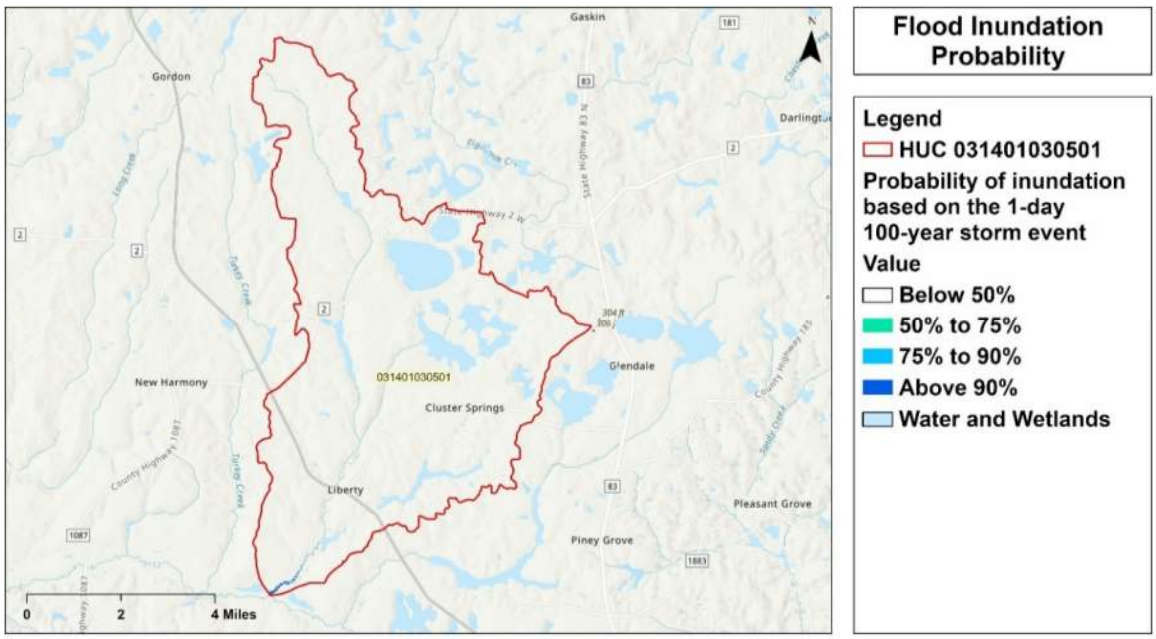

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401030501, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is

used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed later in this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not

eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a very small portion of flooding is noted at the entrance to the creek into the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, sea level rise should not impact the HUC, therefore SLR scenarios were not calculated.

The design storm simulation determined that approximately 0.1% of the HUC total area or 0.02 mi² has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 0.1% of the HUC's total area, or 0.04 mi² would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.1% of the HUC's total area, or 0.02 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0% of the HUC's total area, or 0.01 mi², would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401030501 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	41.90	0.02	99.9%	0.1%
1-day 100-year	41.88	0.04	99.9%	0.1%
1-day 10-year	41.90	0.02	99.9%	0.1%
1-day 5-year	41.91	0.01	100.0%	0.0%

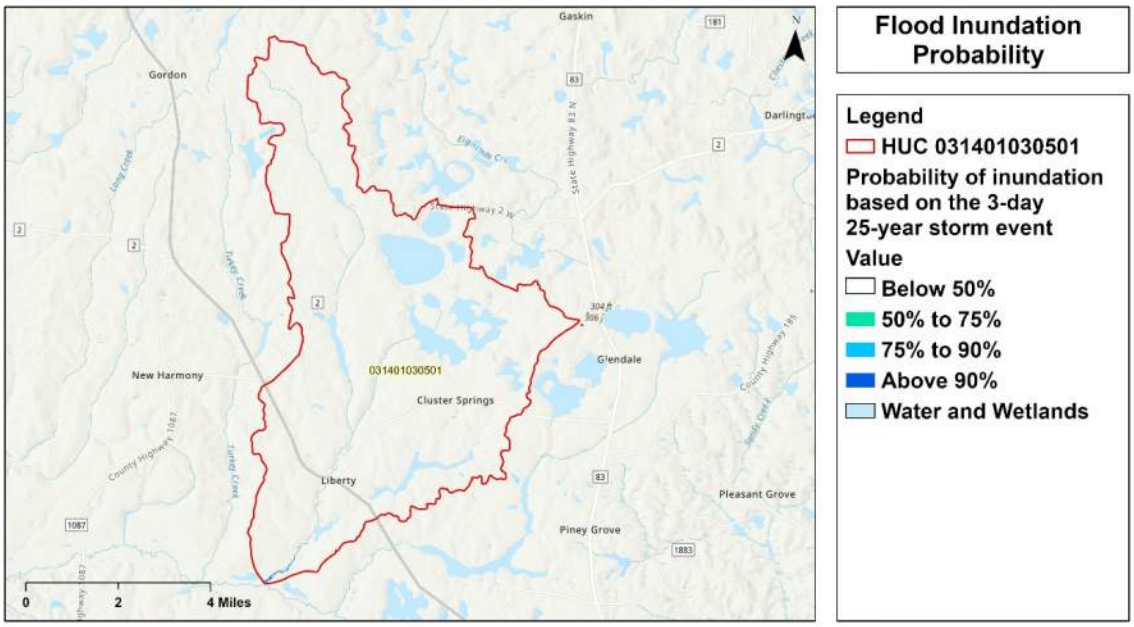

Figure 31. 3-day 25-year storm event for HUC 031401030501 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

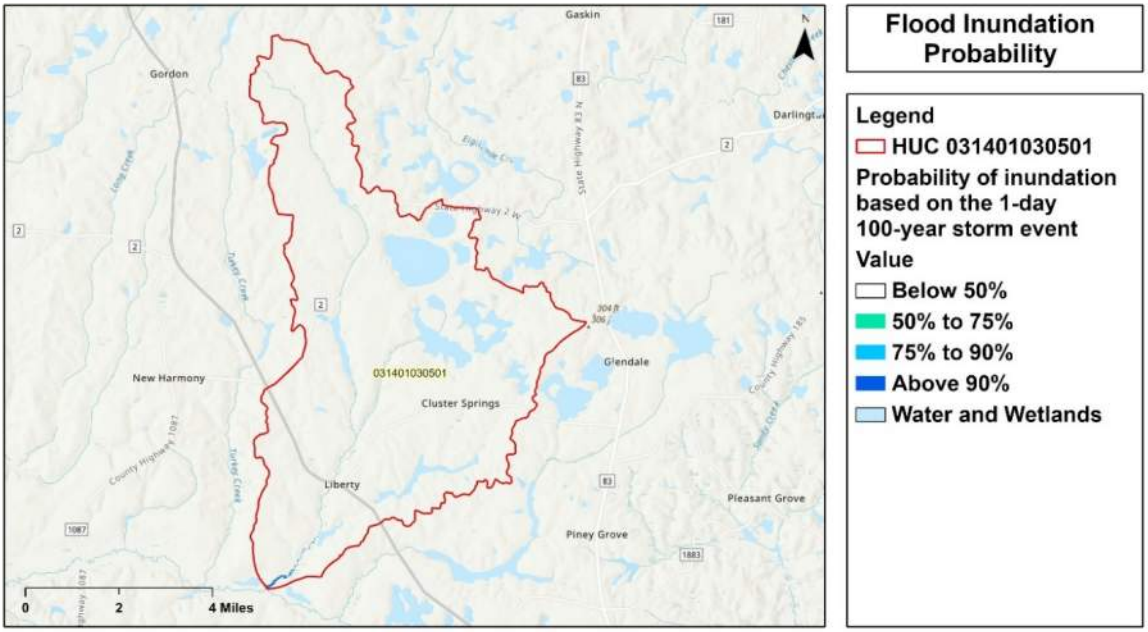

Figure 32. 1-day 100-year storm event for HUC 031401030501 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

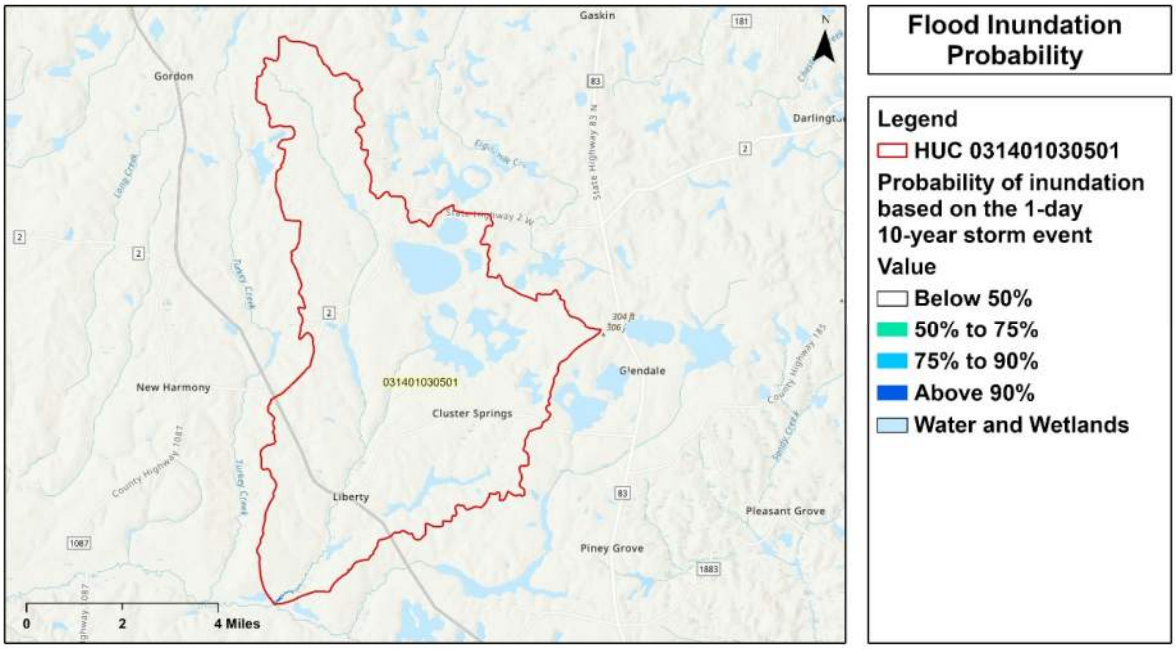

Figure 33. 1-day 10-year storm event for HUC 031401030501 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

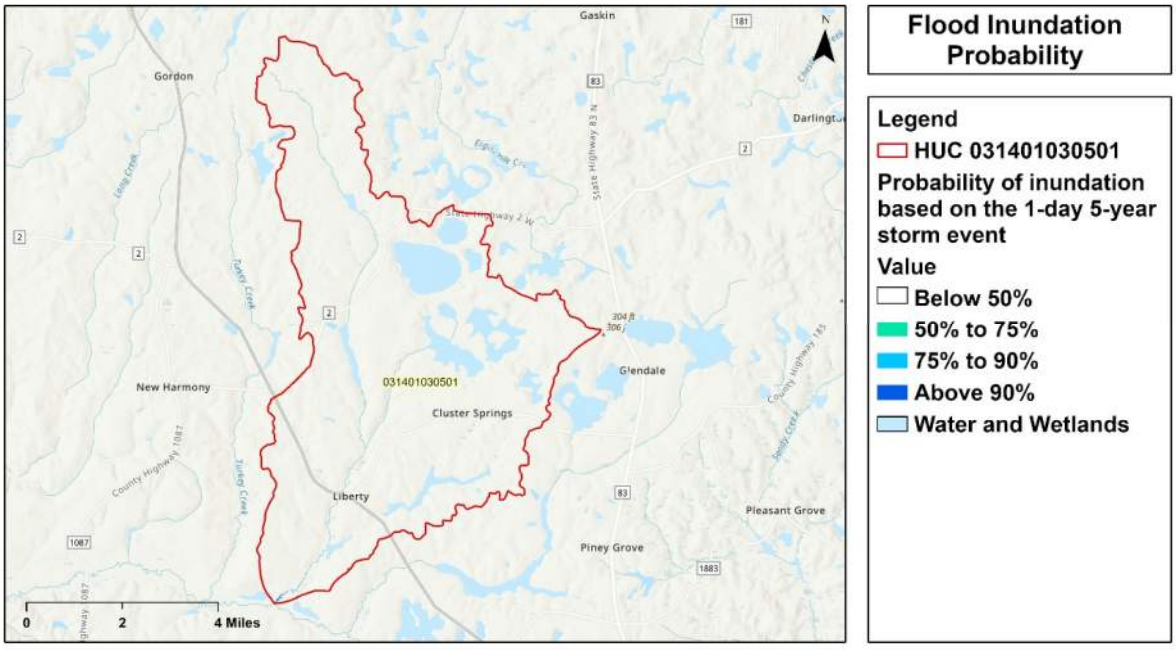

Figure 34. 1-day 5-year storm event for HUC 031401030501 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6

11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6

37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6

60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1

92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5

70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031401020203 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.**is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.**illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

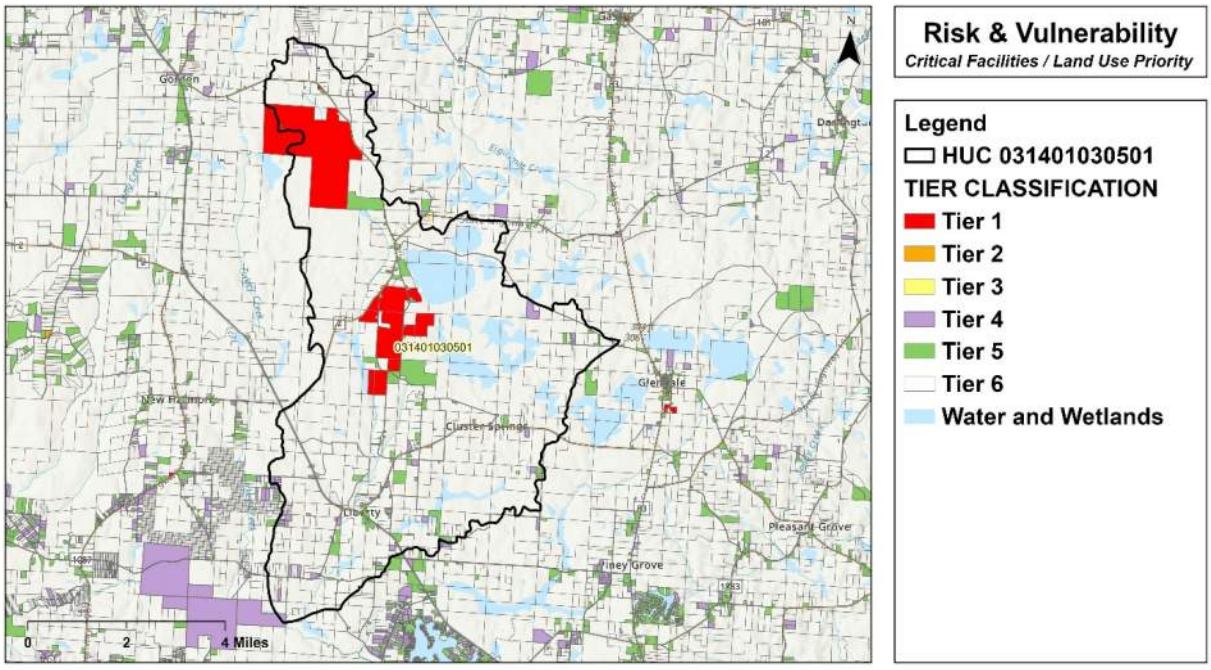

Figure 35. HUC 031401030501 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

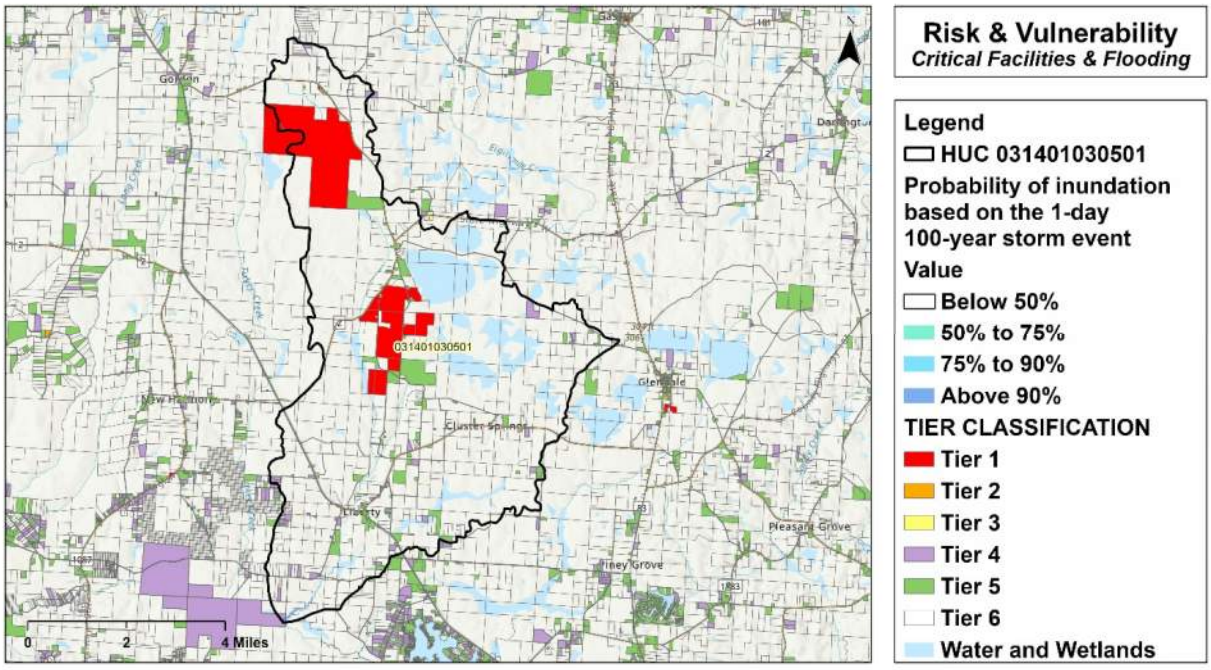

Figure 36. HUC 031401030501 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

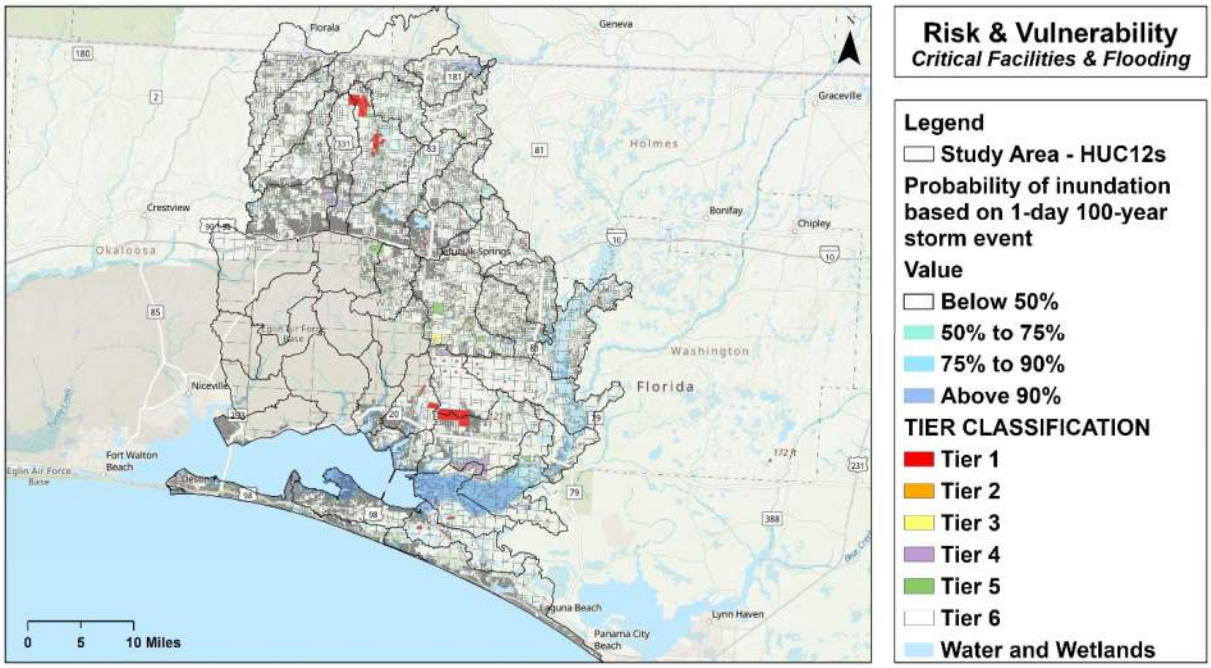

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

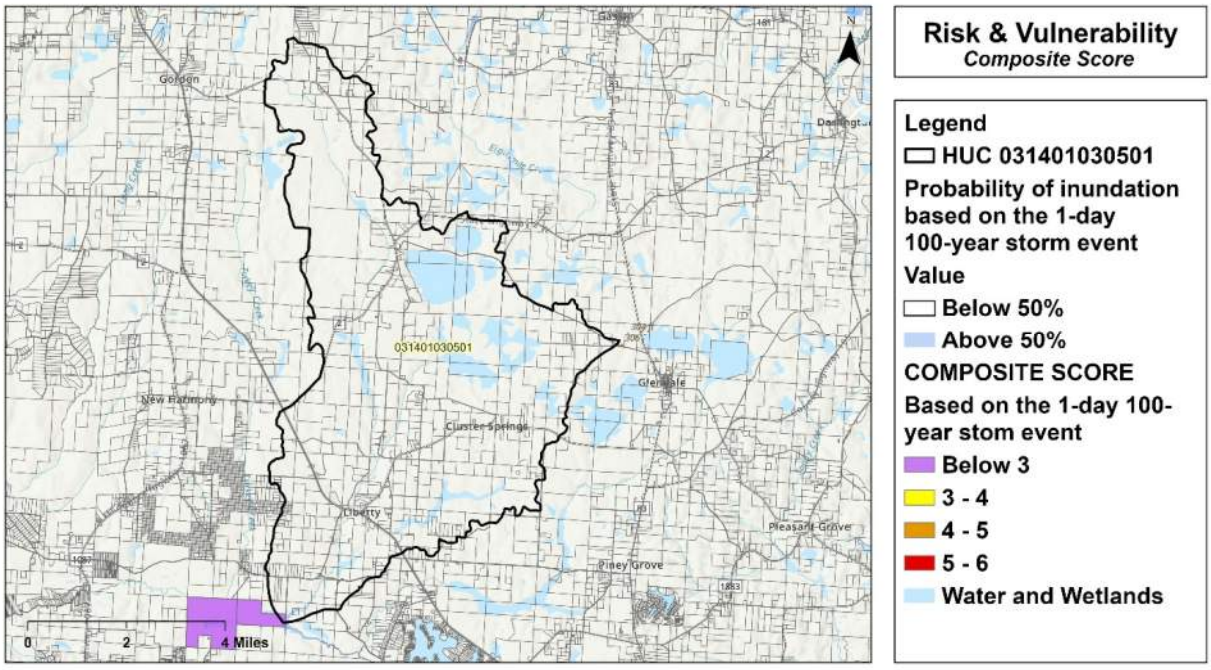

Figure 38. HUC 031401030501 sub-watershed Composite Score Risk map, calculation based on 1-day 100-year storm event. Processed by FAU.

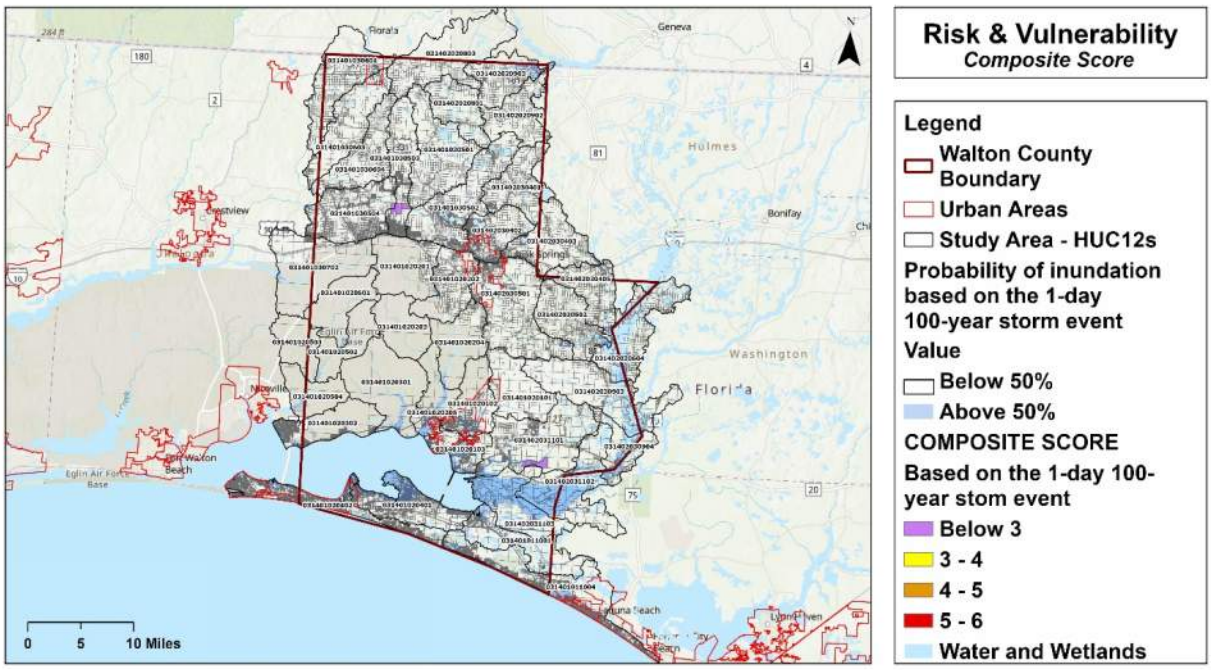

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

Please note that due to the scale of the map, the composite score layer is not properly visible in this map.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401020203. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401030501. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401030501	26830.11
All of the 1-day 100-year storm event inundation	**25.00**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	25.00
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	25.00

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not**

found. indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

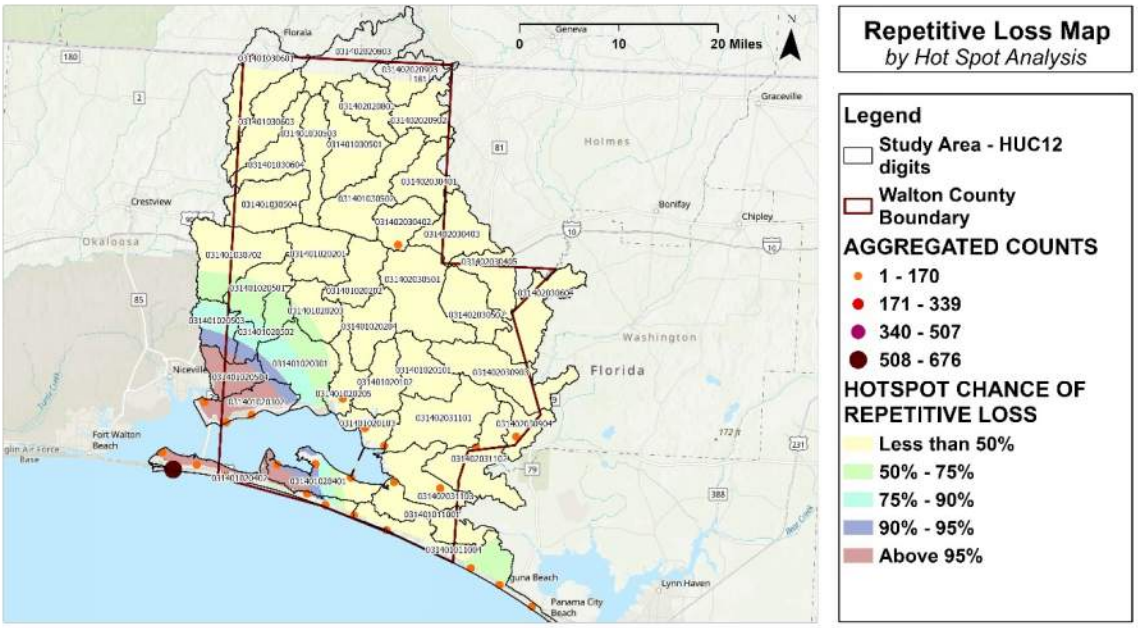

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5 Priority Projects

Although there are a few parcels falling within classification tier 1 and 4 and a good amount of parcels falling within 5 priority of land uses, none of them are within the flooding zone, once flooding in the area is relatively minor and not alarming. Consequently, when considering the composite score, it notable that there are no critical facilities situated within the flooding zone, indicating no necessity for priority projects intervention within the basin.

APPENDIX U

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401030502

KINGS LAKE

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Research Assistant: Leticia Sabio

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (Figure 1). Figure 2 shows Walton County Drainage Network and the location of urban areas (cities and towns). In Figure 3, the HUC-12 digits (031401030502) is highlighted among all the HUCs to help identifying its location. (Figure 3).

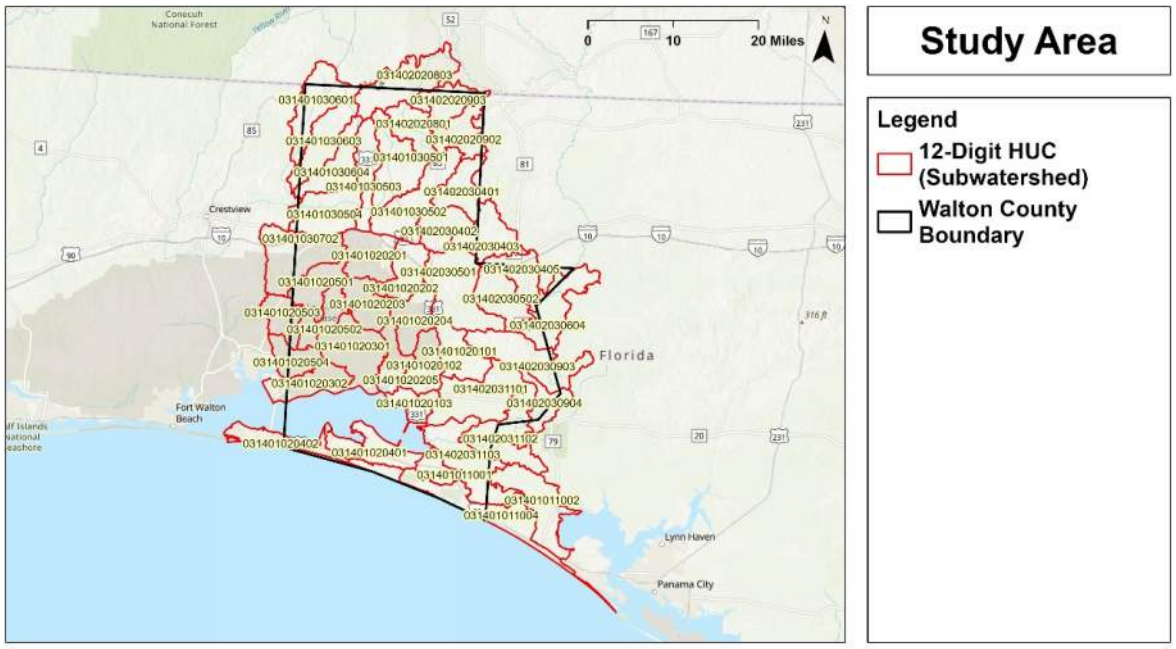

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

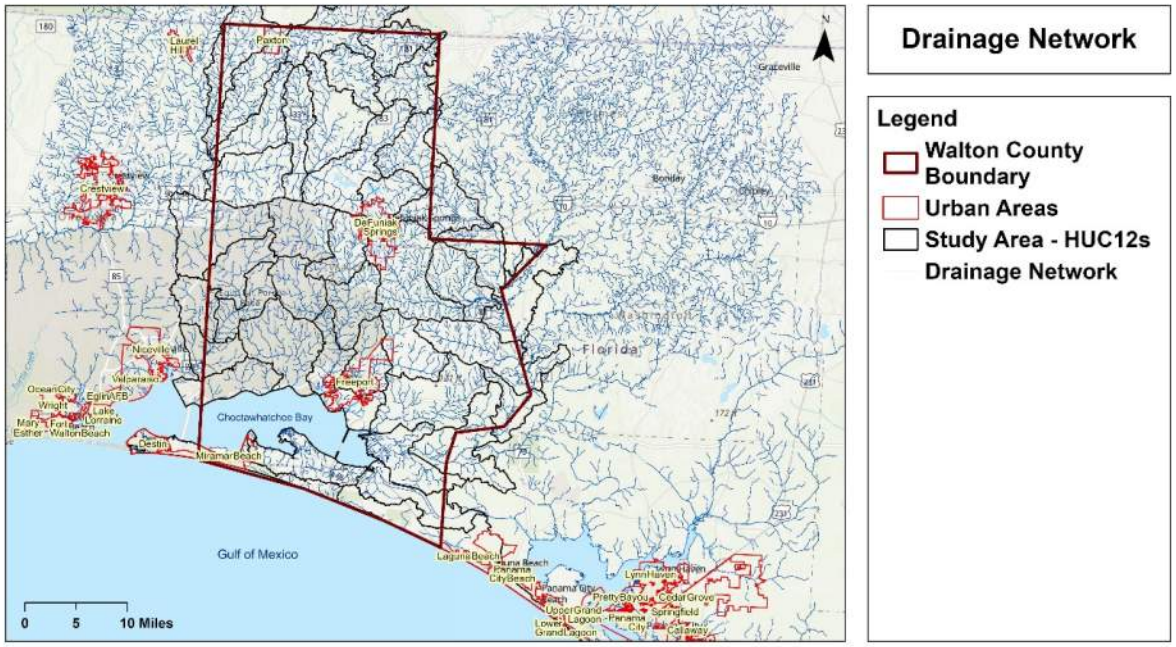

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

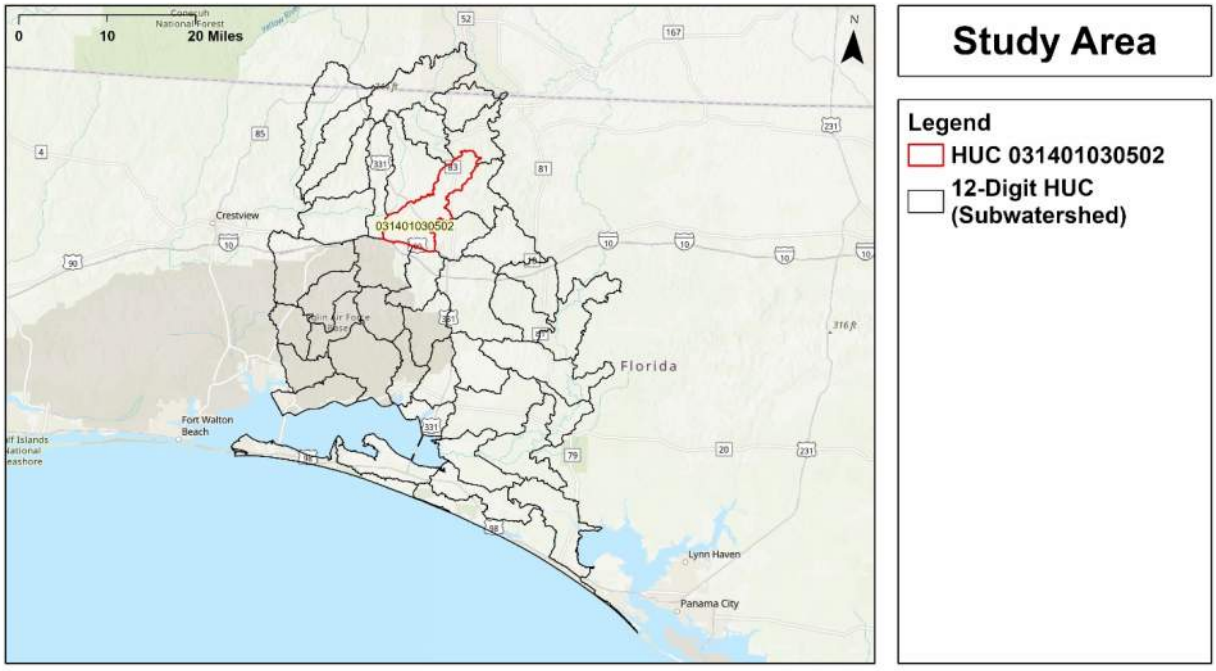

Figure 3. HUC 031401030502 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Figures 12 and 13 in the county-wide report show the current and projected land use for the County. Based on the 2017 future land use map for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.9	7.17%
Barren Land	9242.1	1.25%
Rangeland	40326.7	5.46%
Transportation, Communication, and Utilities	11815.7	1.60%
Upland Forest	356796.1	48.30%
Urban and Built-Up	52194.8	7.07%
Water	61593.9	8.34%
Wetlands	153759.9	20.82%
Total	**738687.9**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the

potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

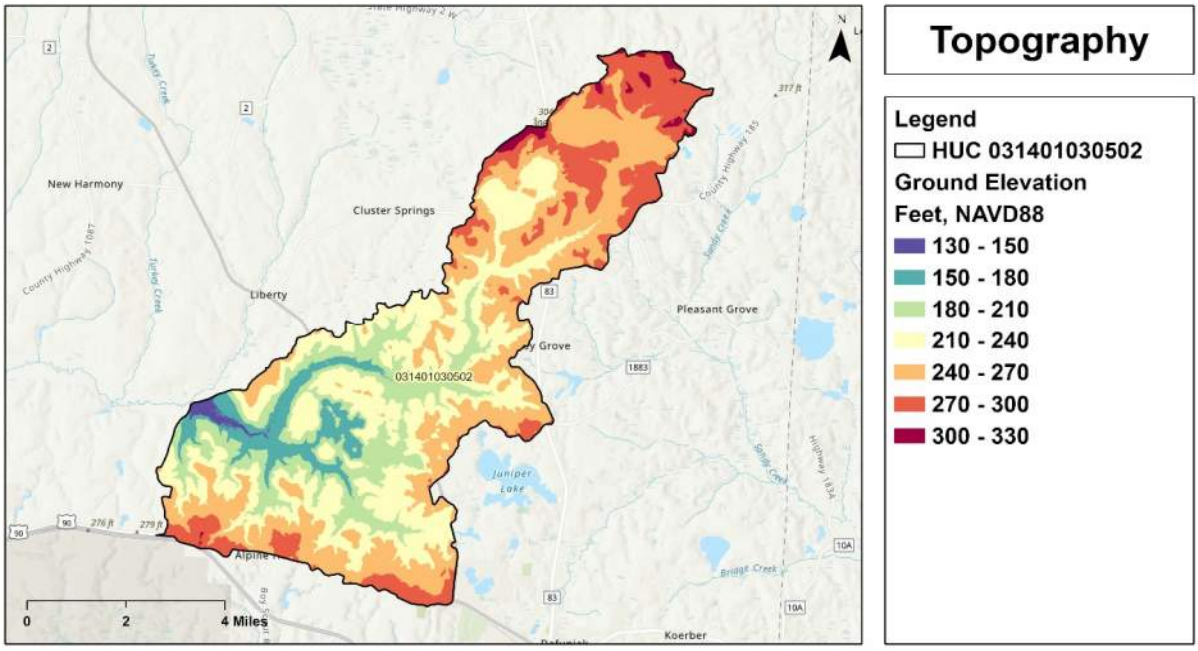

Figure 4. Topographic map of the HUC 031401030502 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401030502 sub-watershed is shown in **Error! Reference source not found.**.

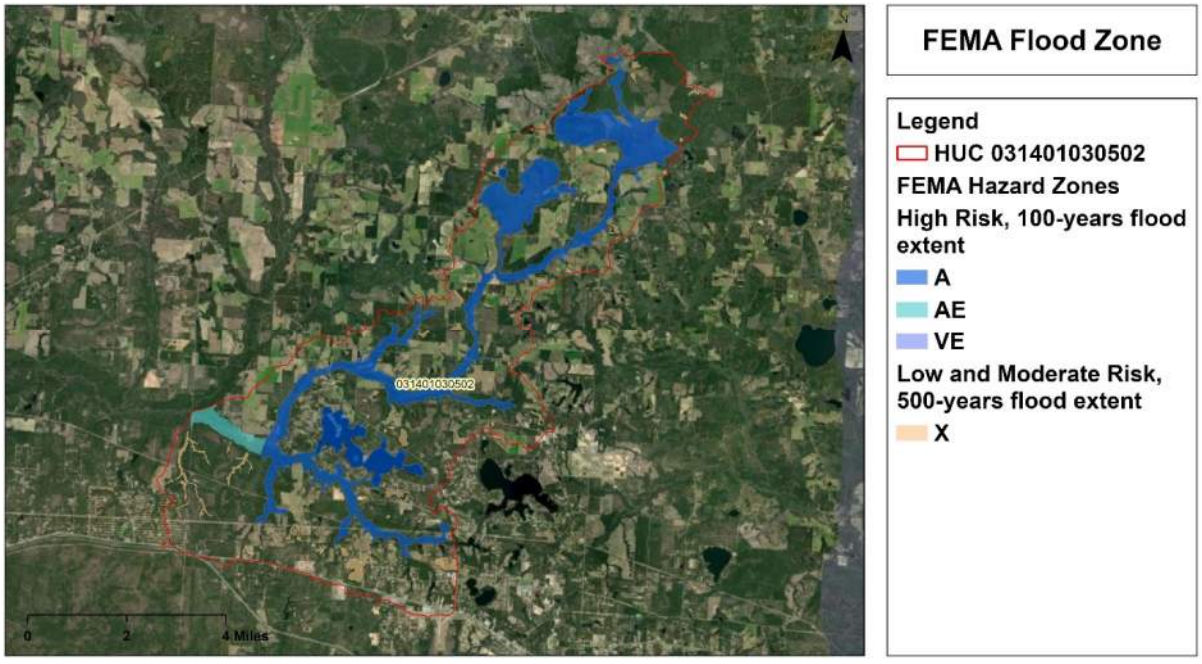

Figure 5. FEMA Flood Zone map (2020) for HUC 031401030502 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401030502 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

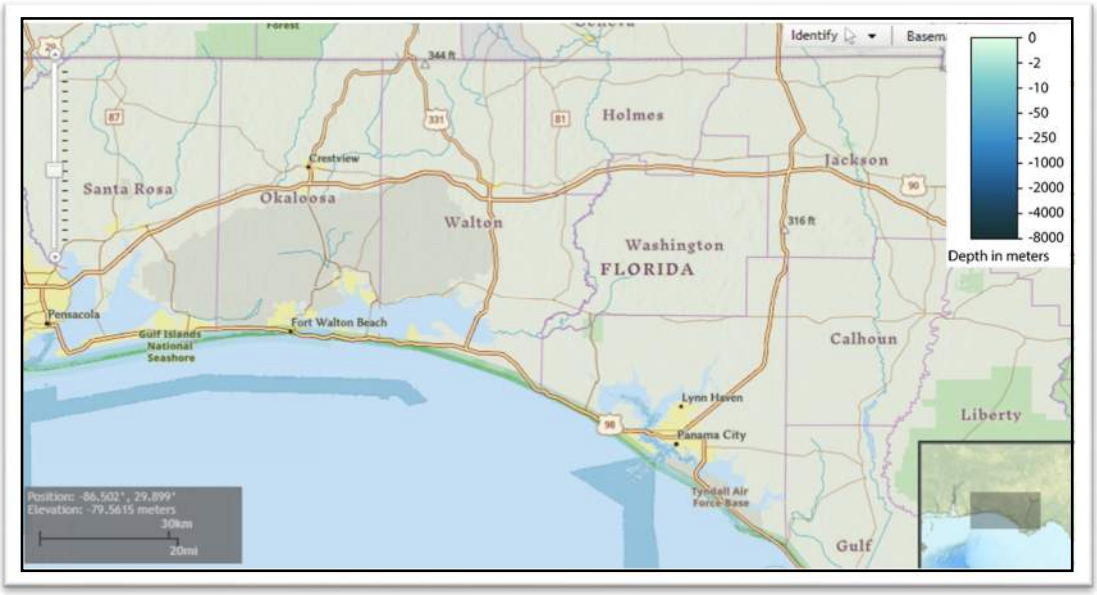

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

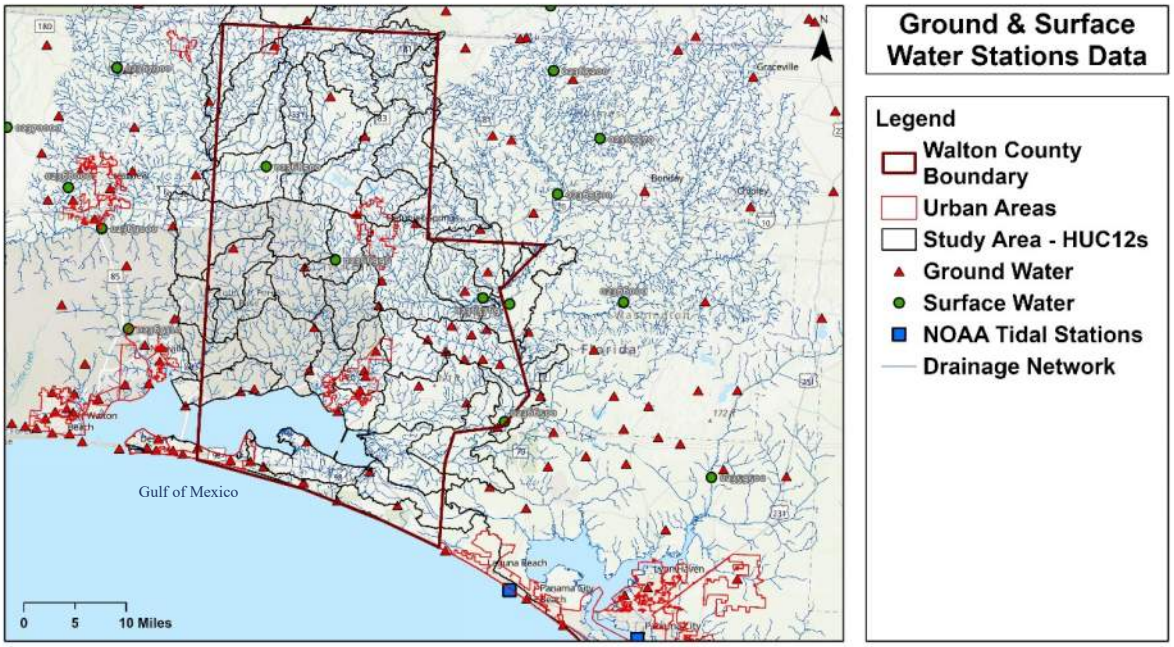

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031401030502 has no major rivers and canals, but creeks and branches include:

- Rocky Creek
- Schoolhouse Branch
- Fox Branch

- Yellow Root Branch
- Old Peg Branch
- Bear Bay Branch
- Bully Horselot Branch
- East Rocky Creek
- Mattress Head Branch
- Open Branch

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02368500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401030502, which is USGS 02368500 Shoal River NR Mossy Head, FLA.

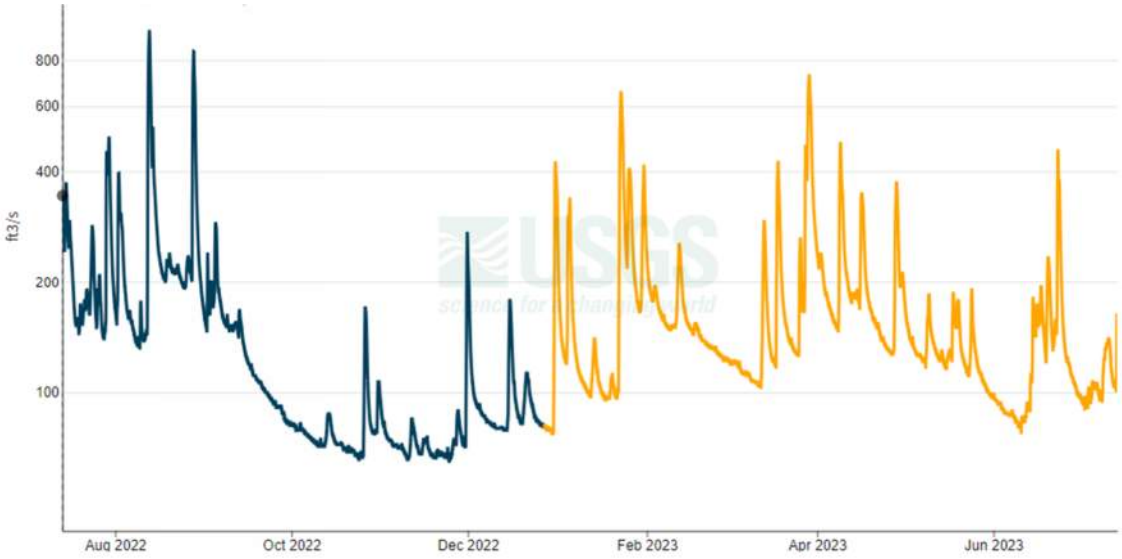

Figure 8. Average streamflow for Shoal River NR Mossy Head, Fla. – 02368500
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02368500/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the

database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401030502 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031401030502 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

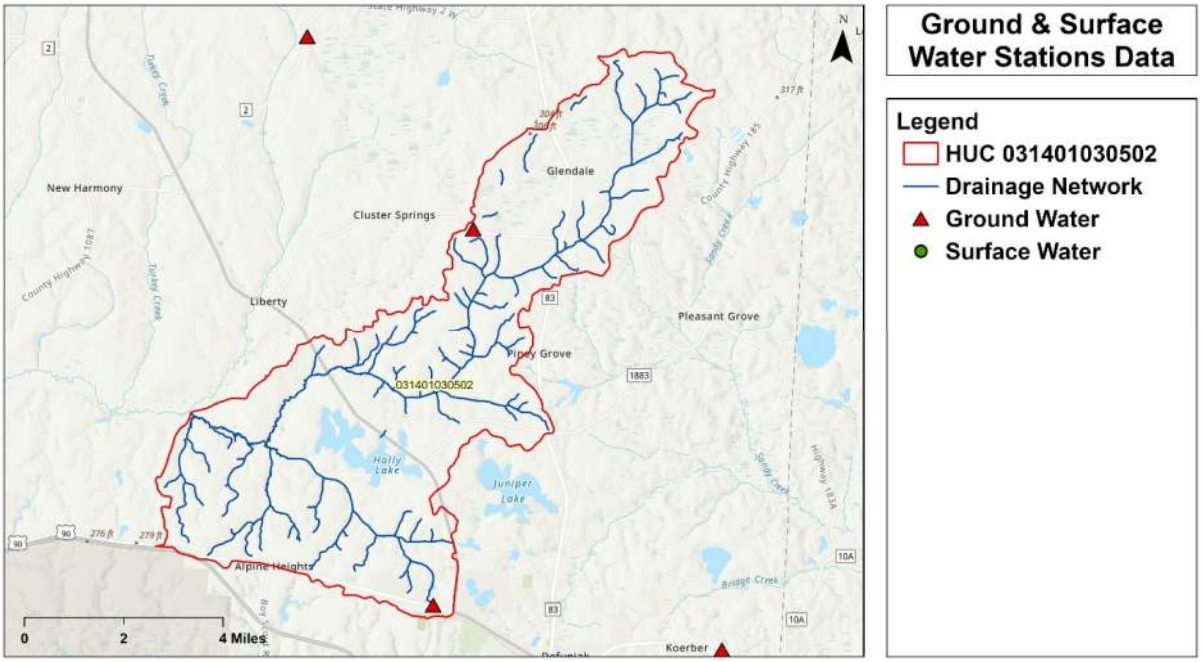

Figure 9. Ground and Surface Water Stations in the HUC 031401030502 sub-watershed, processed by FAU.

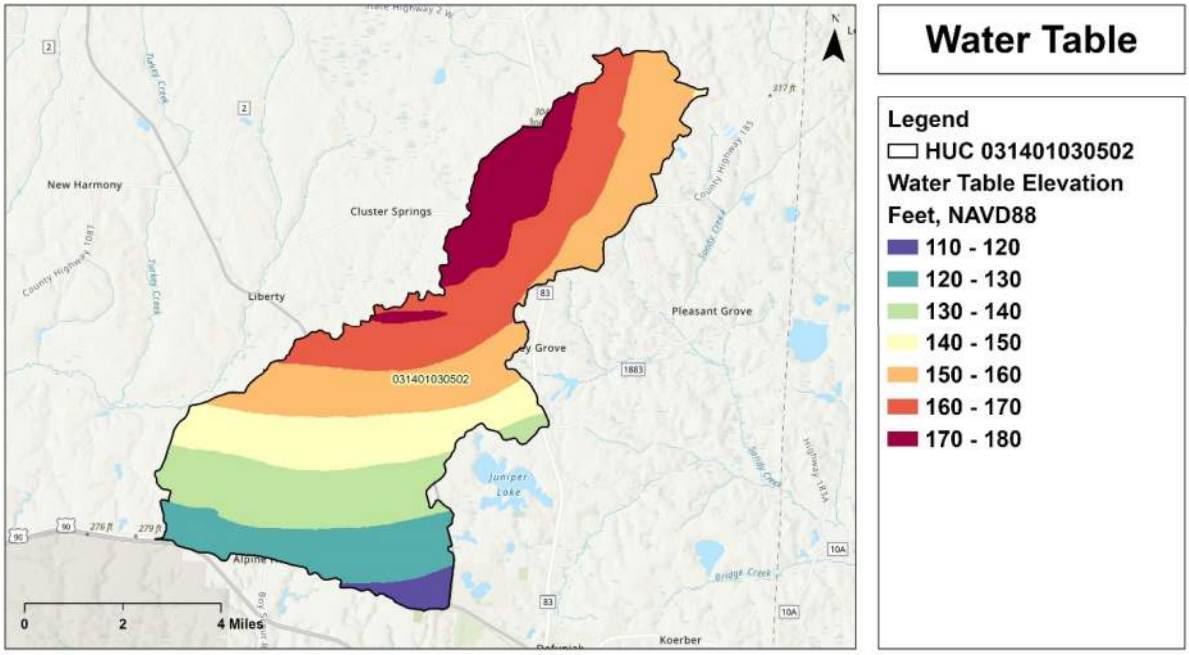

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401030502 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

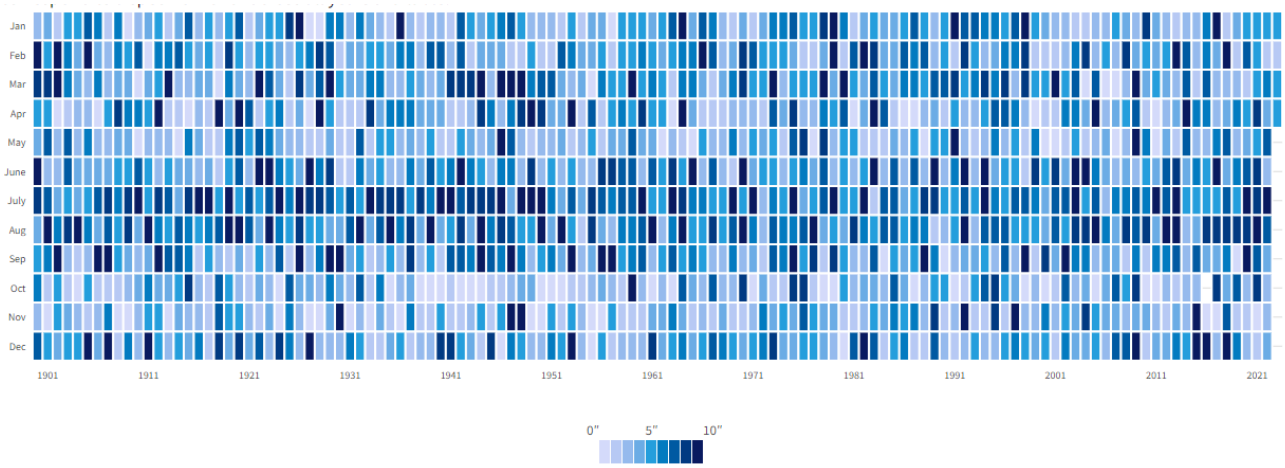

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/)

While the topography (Section 2.1) and native soil (Section 2.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there are no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

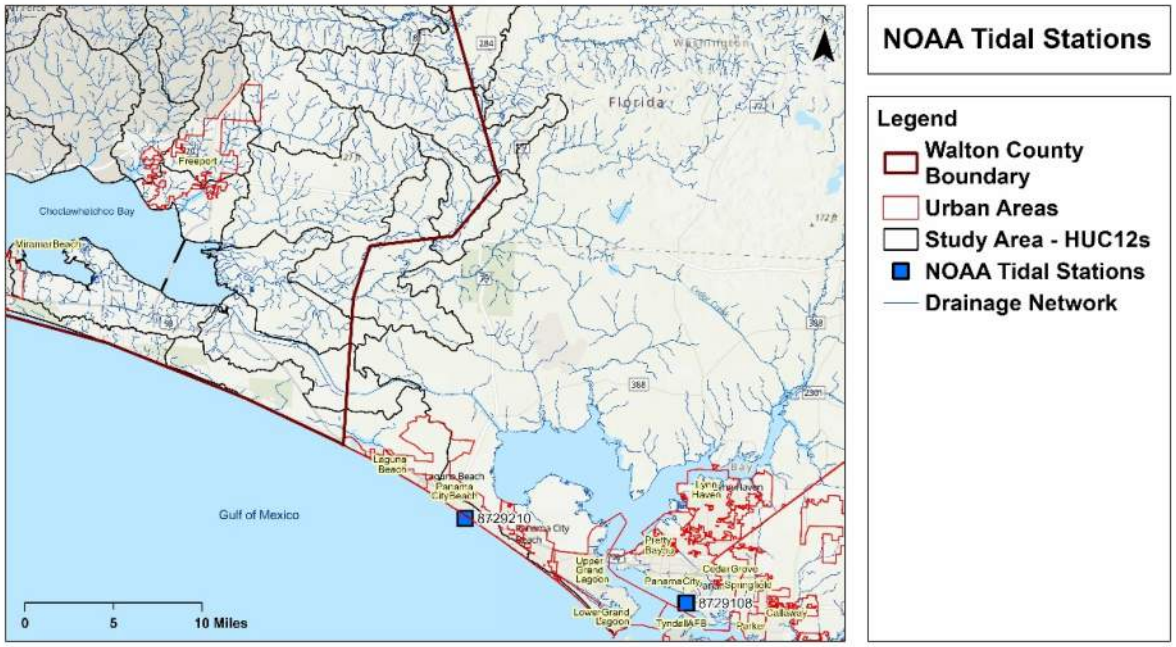

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

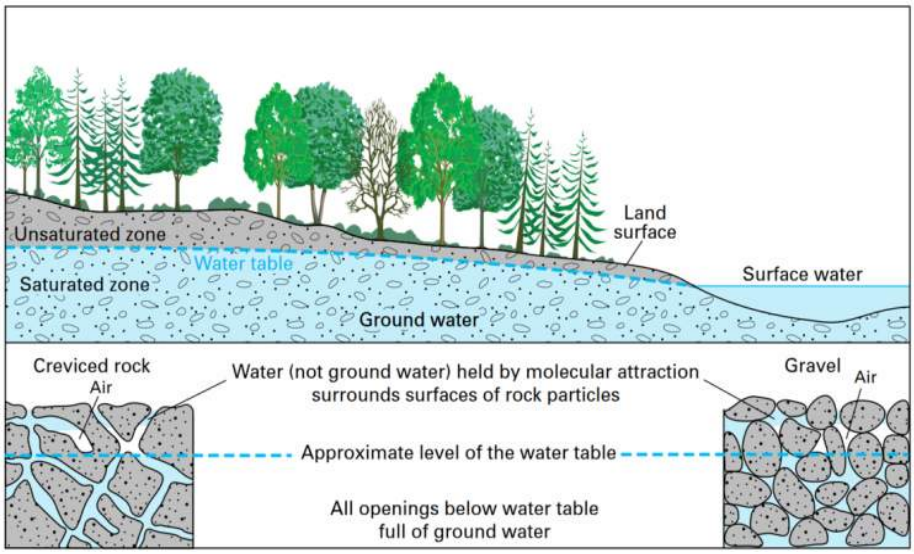

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

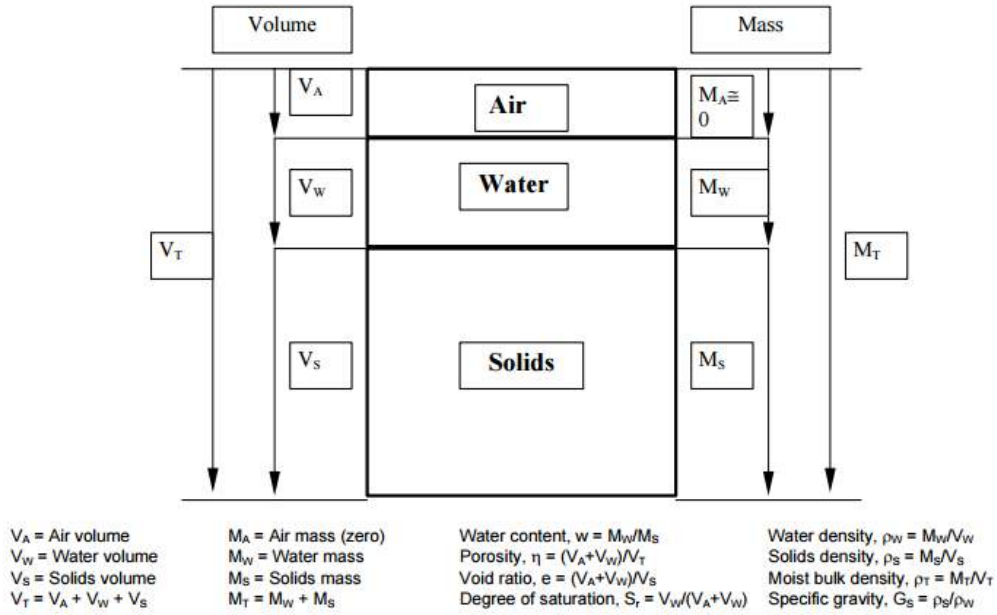

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

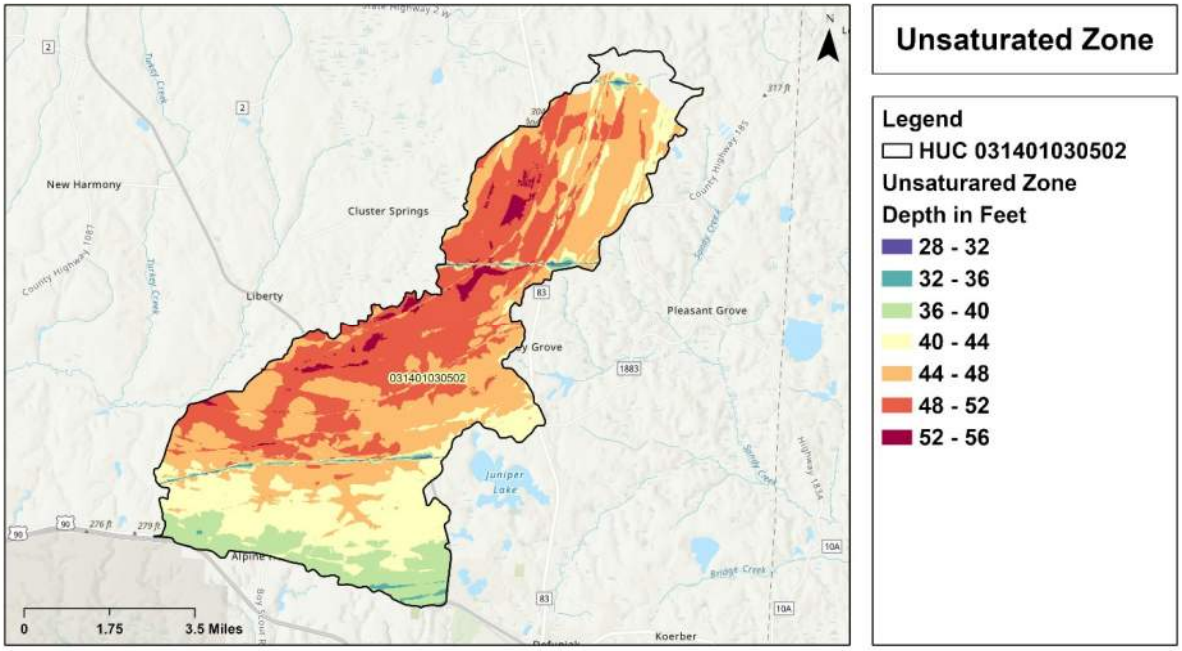

Figure 15. Unsaturated zone map for HUC 031401030502, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. Much of the basin has a medium amount of soil storage capacity, ranging between 30 to 33 inches of capacity left.

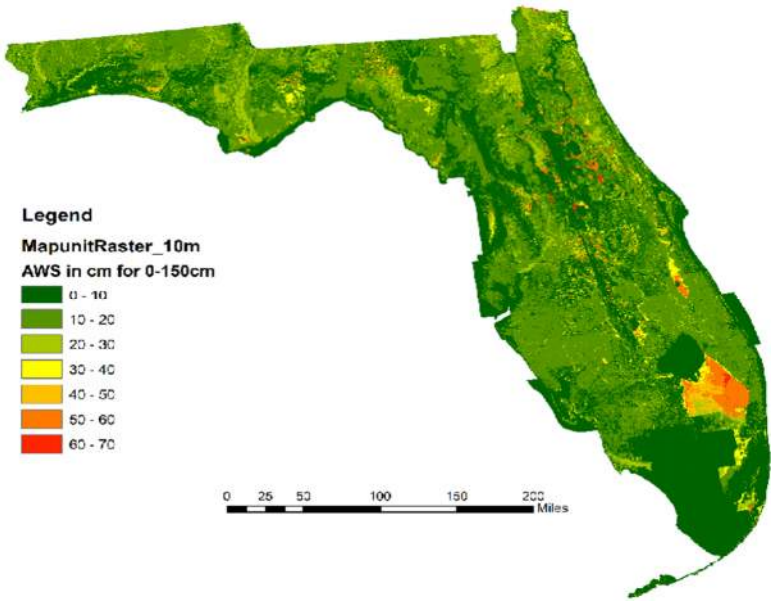

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

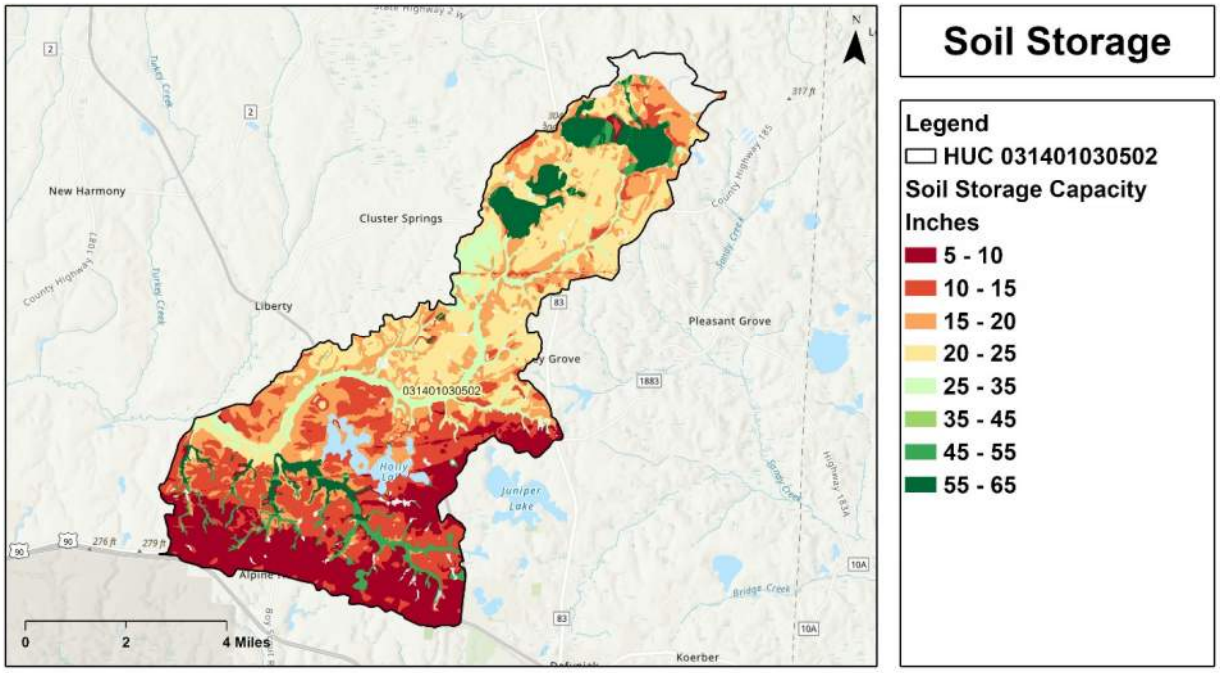

Figure 17. Water storage capacity of soil for the HUC 031401030502, processed by FAU

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

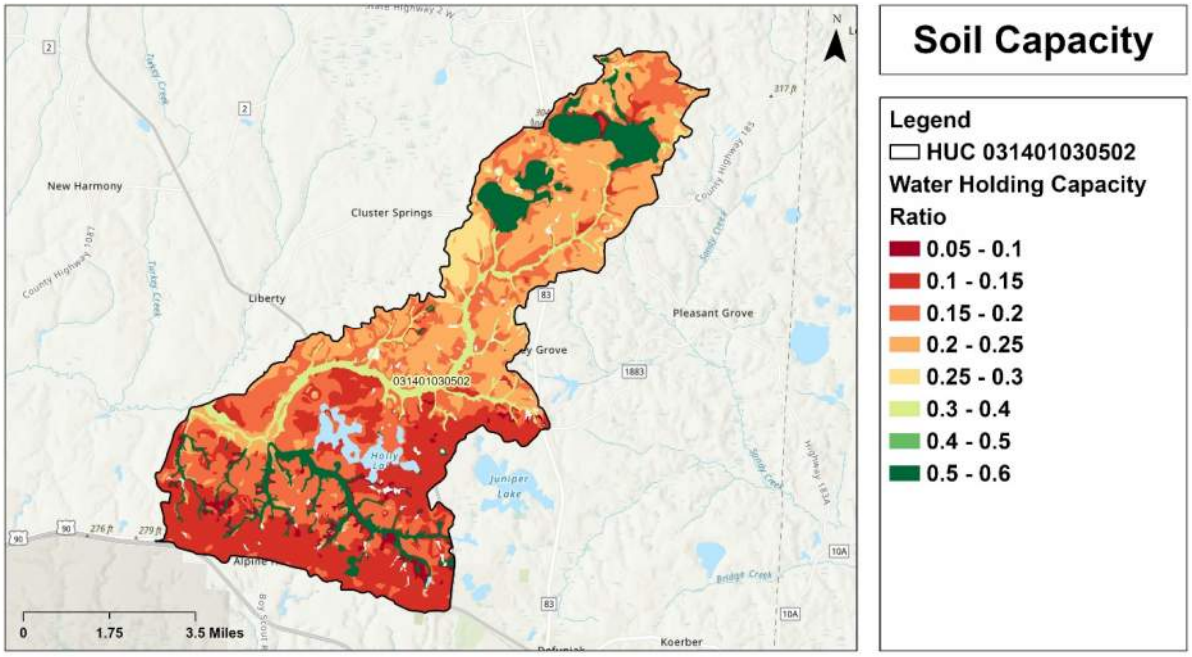

Figure 18. Water Holding Capacity (ratio) for the HUC 031401030502, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

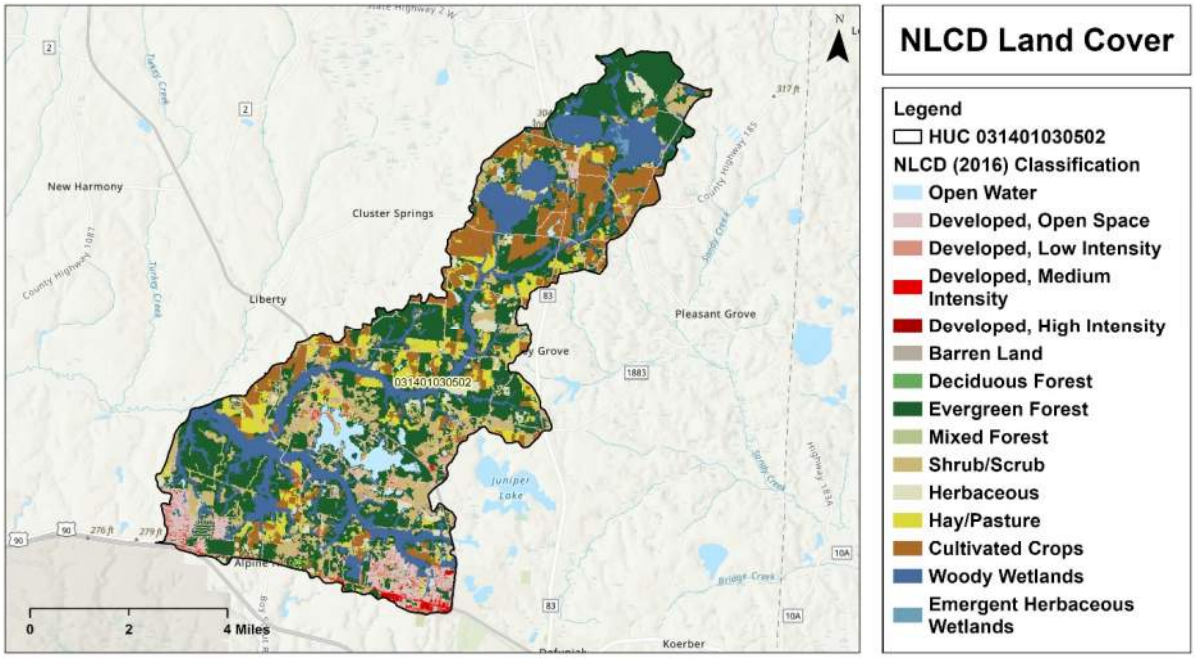

Figure 19. Land use in the HUC 031401030502 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

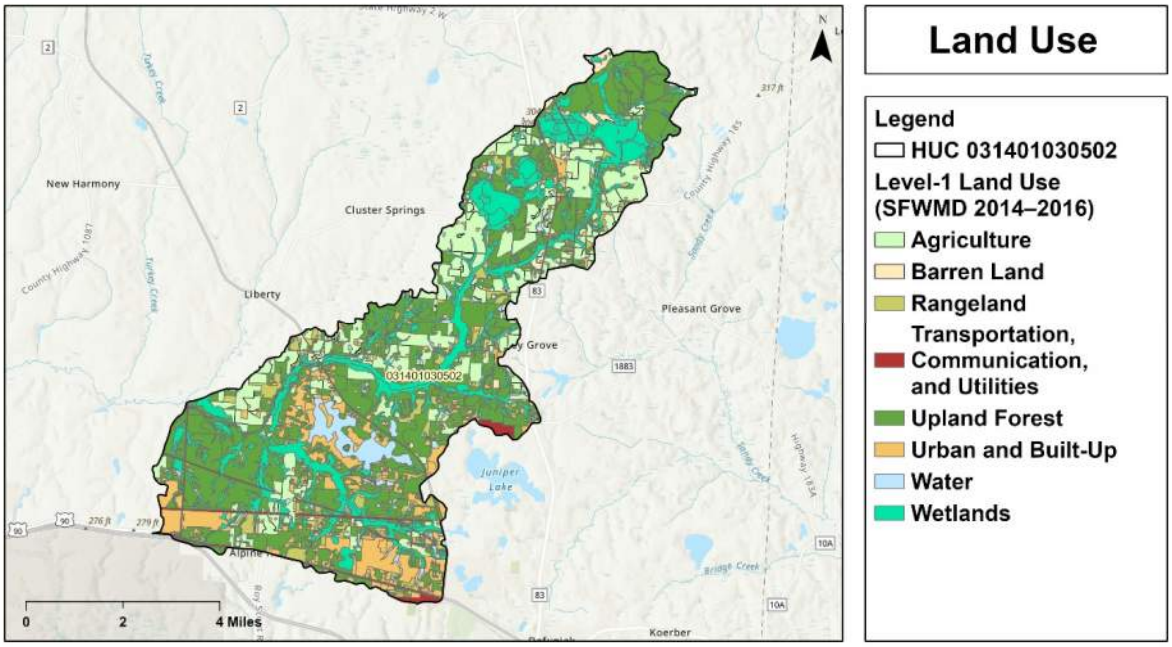

Figure 20. Land use in the HUC 031401030502 (2023 Florida Geographic Data Library (FGDL))), processed by FAU.

In the HUC 031401030502 sub-watershed, the predominant land cover is upland forest, accounting for 37.80% of the area. Agriculture comes in second at 17.17%, followed by wetlands at 15.19%. Developed land constitutes also a good portion, with 11.86% categorized as urban and built-up, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031401030502 subwatershed (2023 Florida Geographic Data Library (FGDL))).

Level 1 Land Use Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	6656.86	17.17%
Barren Land	559.50	1.44%
Rangeland	1355.14	3.49%
Transportation, Communication, and Utilities	3717.51	9.59%
Upland Forest	14660.66	37.80%
Urban and Built-Up	4598.01	11.86%
Water	1340.20	3.46%
Wetlands	5892.10	15.19%
Grand Total:	**38779.99**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

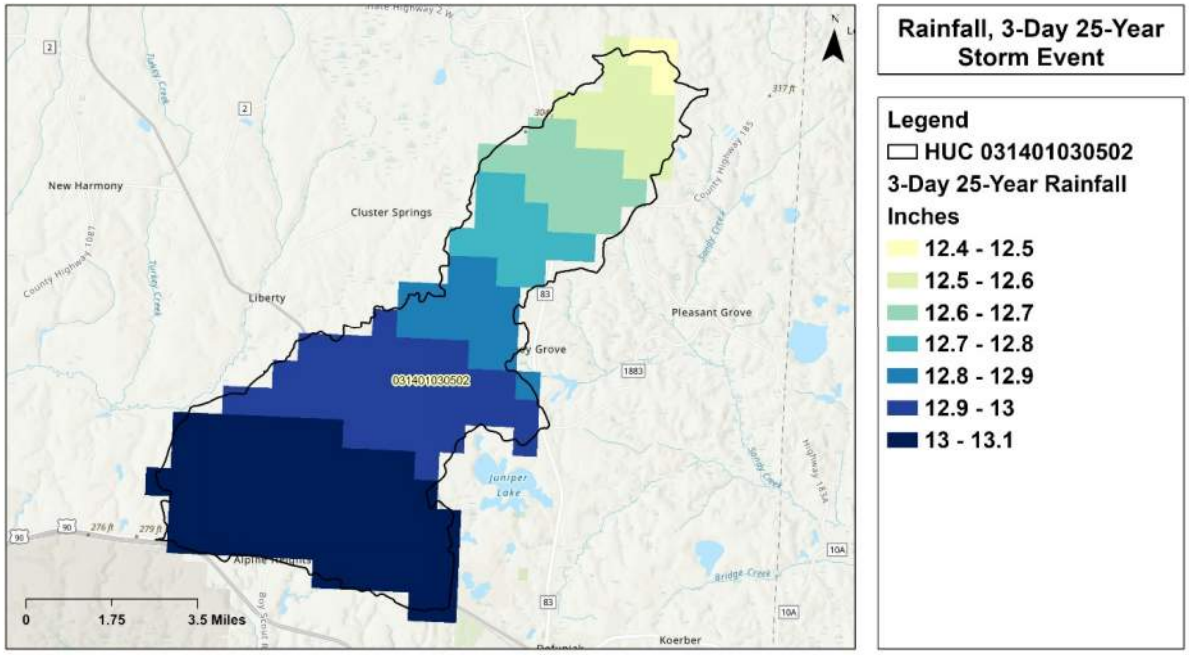

Figure 21. Rainfall distribution map across HUC 031401030502 sub-watershed, for 3-day 25-year storm event, processed by FAU.

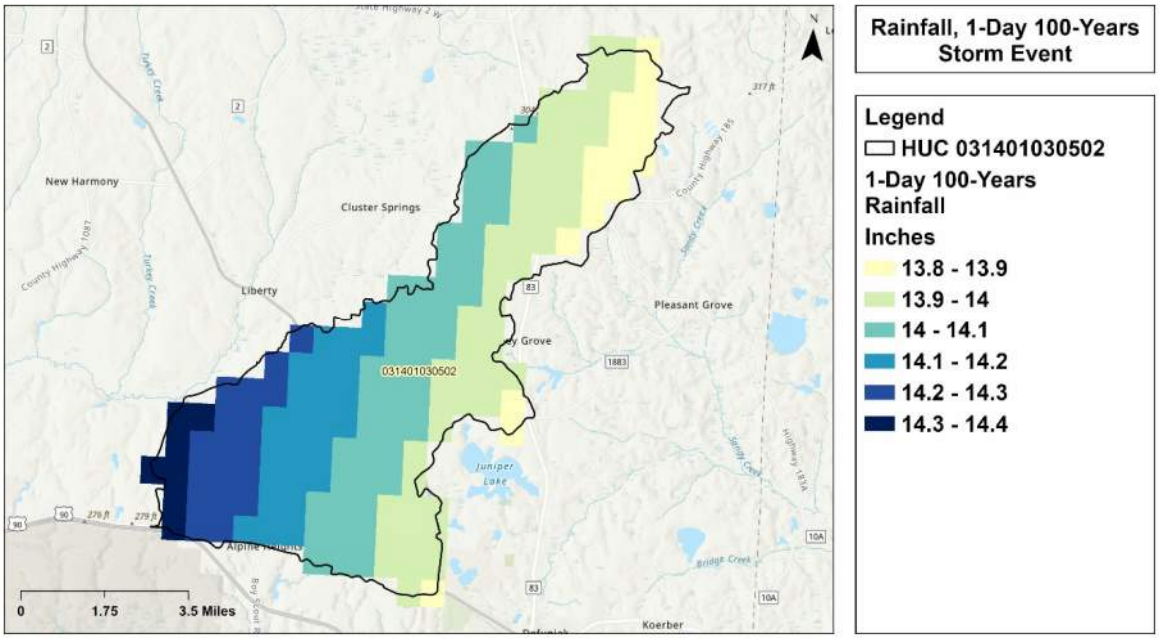

Figure 22. Rainfall distribution map across HUC 031401030502 sub-watershed, for 1-day 100-year storm event, processed by FAU.

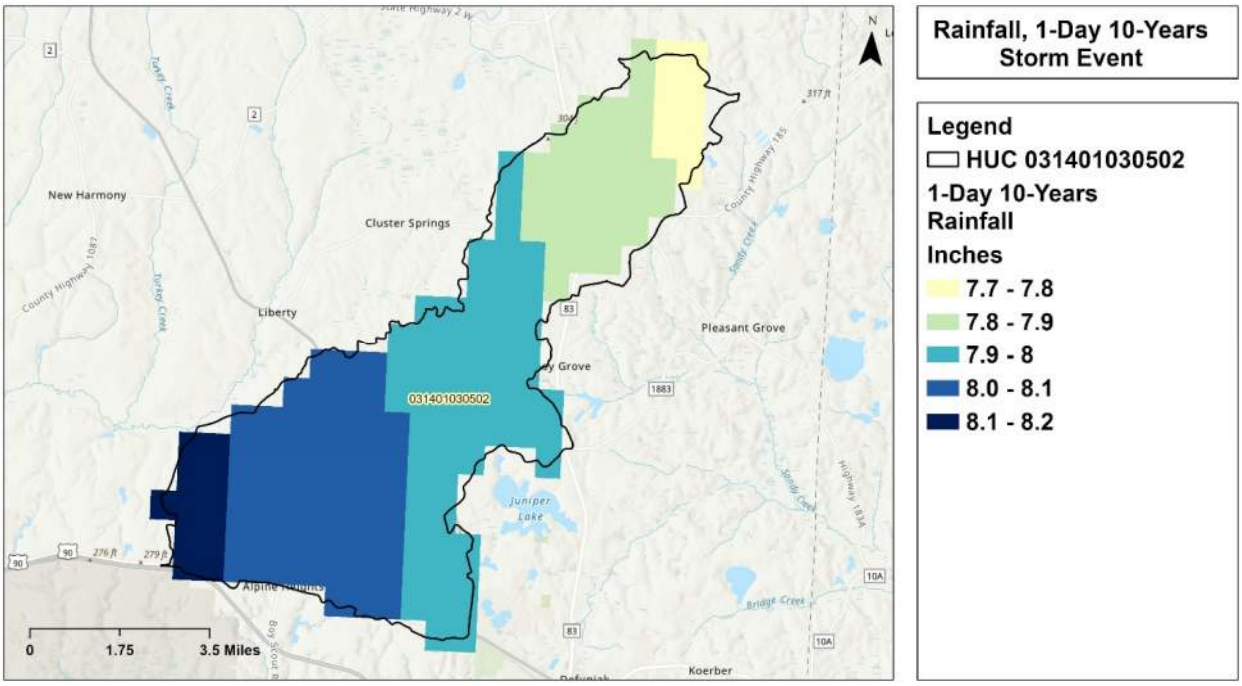

Figure 23. Rainfall distribution map across HUC 031401030502 sub-watershed, for 1-day 10-year storm event, processed by FAU.

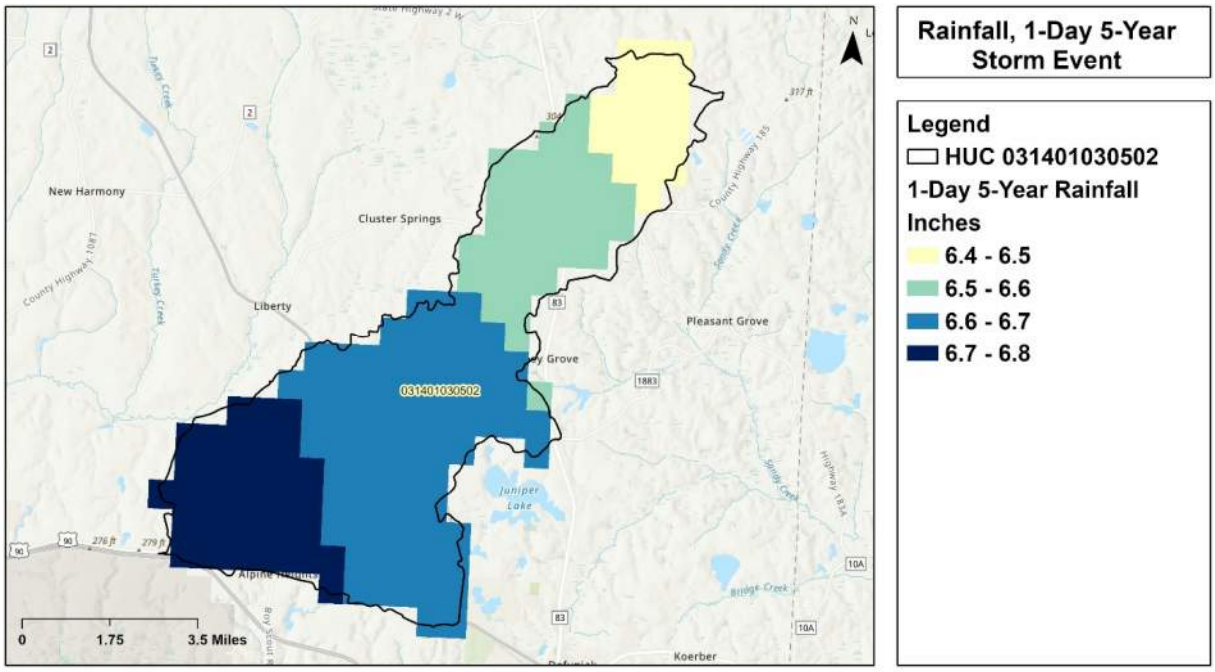

Figure 24. Rainfall distribution map across HUC 031401030502 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 2.5). Added to this will be the water bodies discussed in Section 2.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically

aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

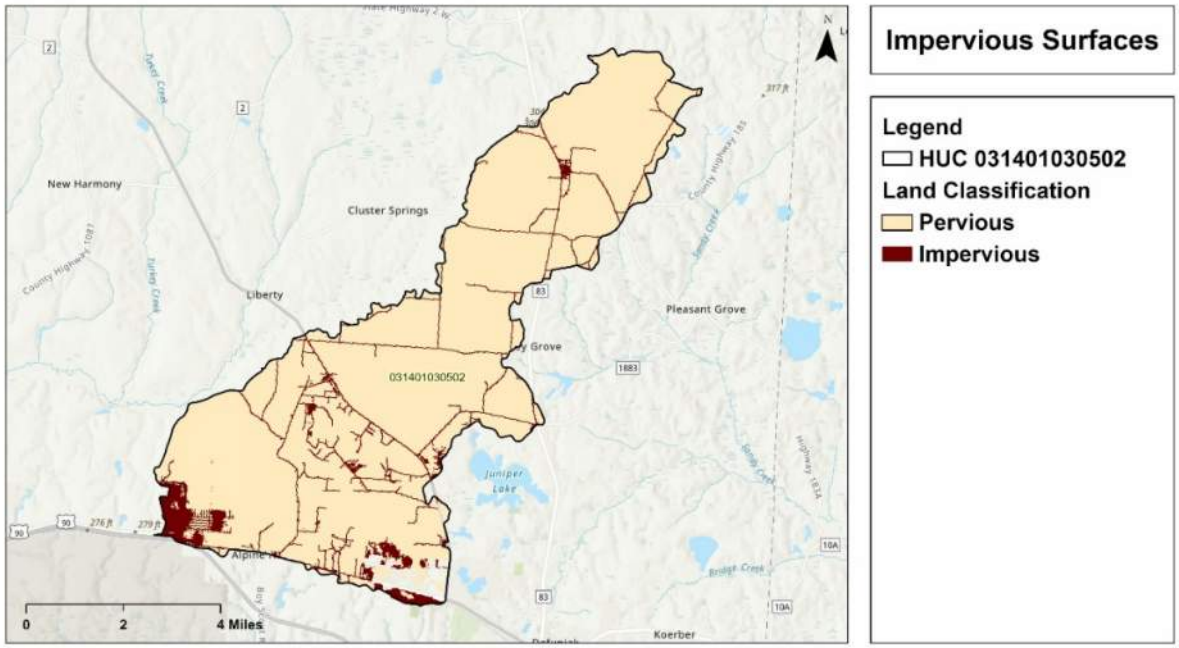

Figure 25. Impervious area map for the HUC 031401030502 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 2.4.

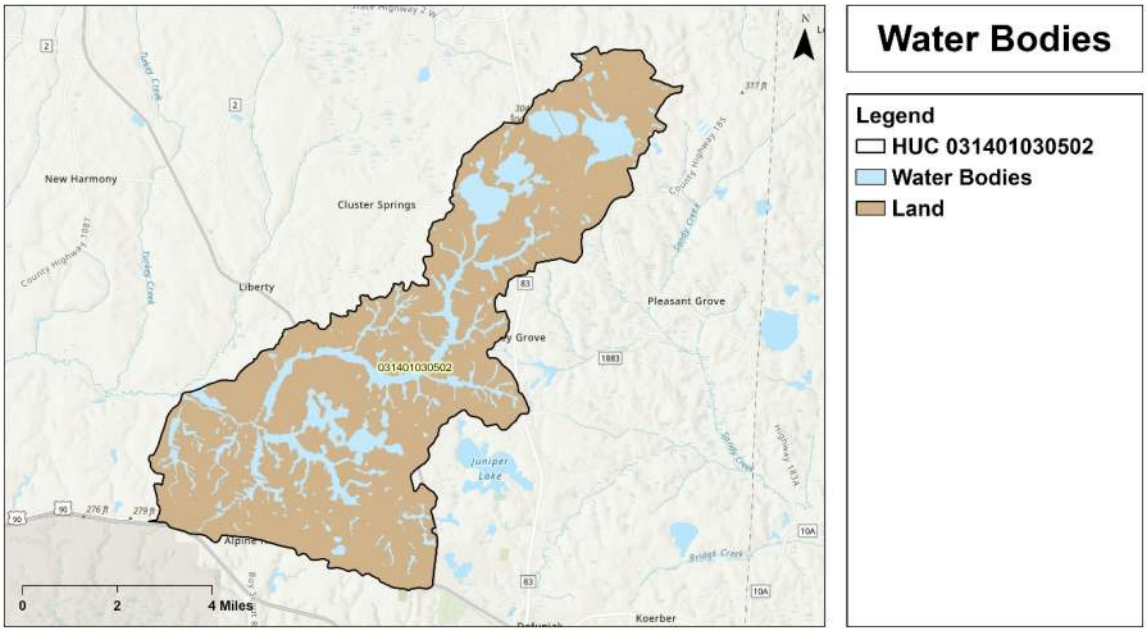

Figure 26. Water bodies map for the HUC 031401030502 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other

waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant

control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

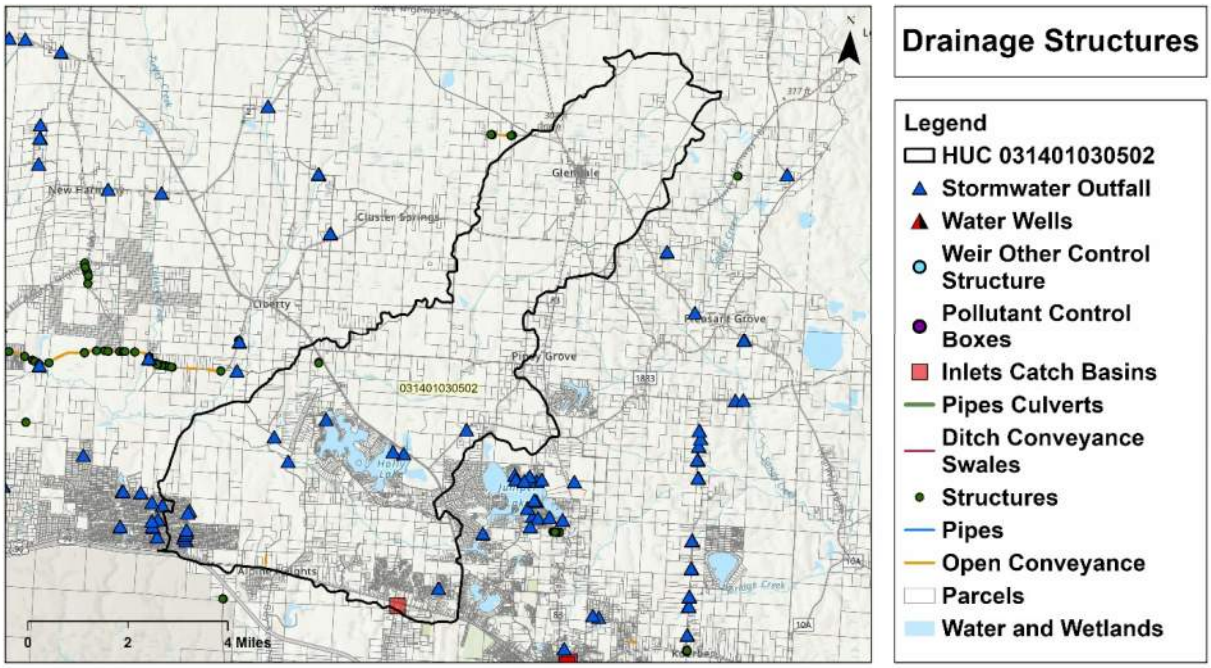

Figure 27. Stormwater Infrastructure for the HUC 031401030502. Processed by FAU.

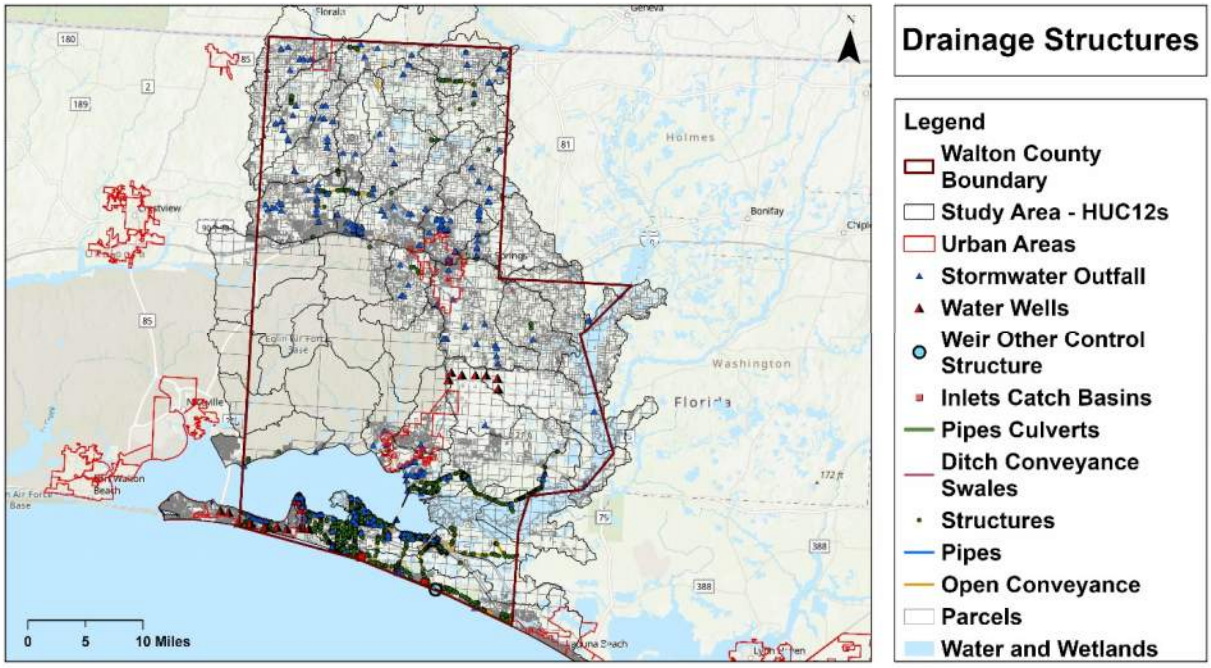

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in Table 5. The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Ground water	FL_GW	South FL Water Management District	Florida, Excel	Daily, 1980-2020	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_GW\South Florida District	140 M bytes, excel	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapter 1, and analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401030502 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the

coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. Figure 29 shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

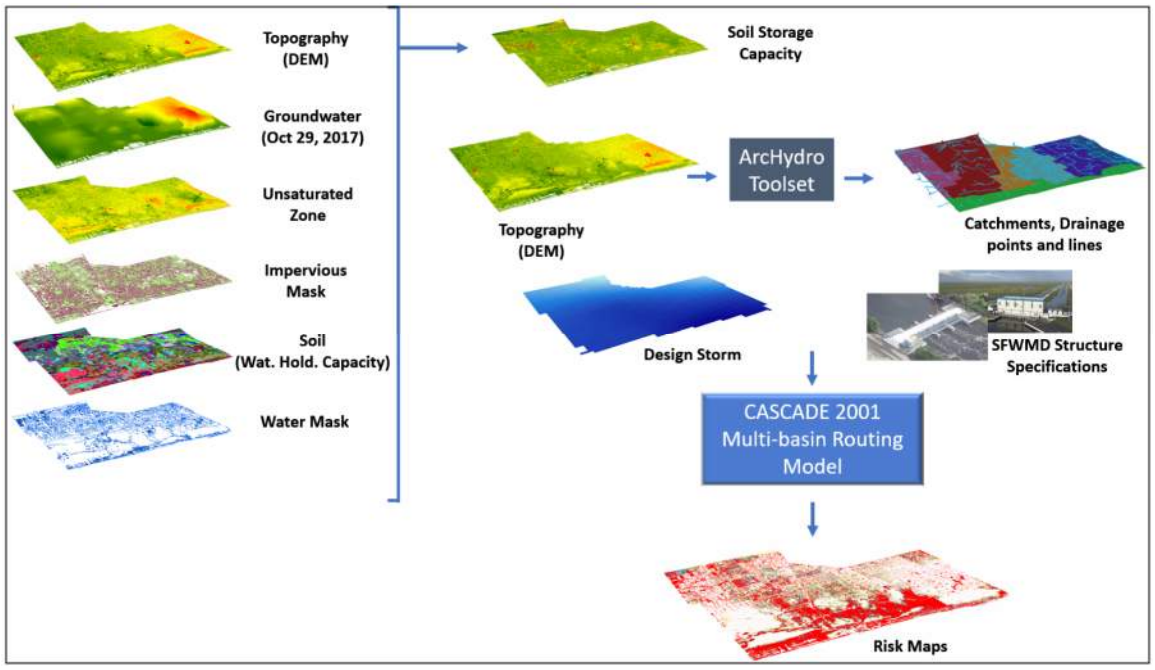

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are

critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

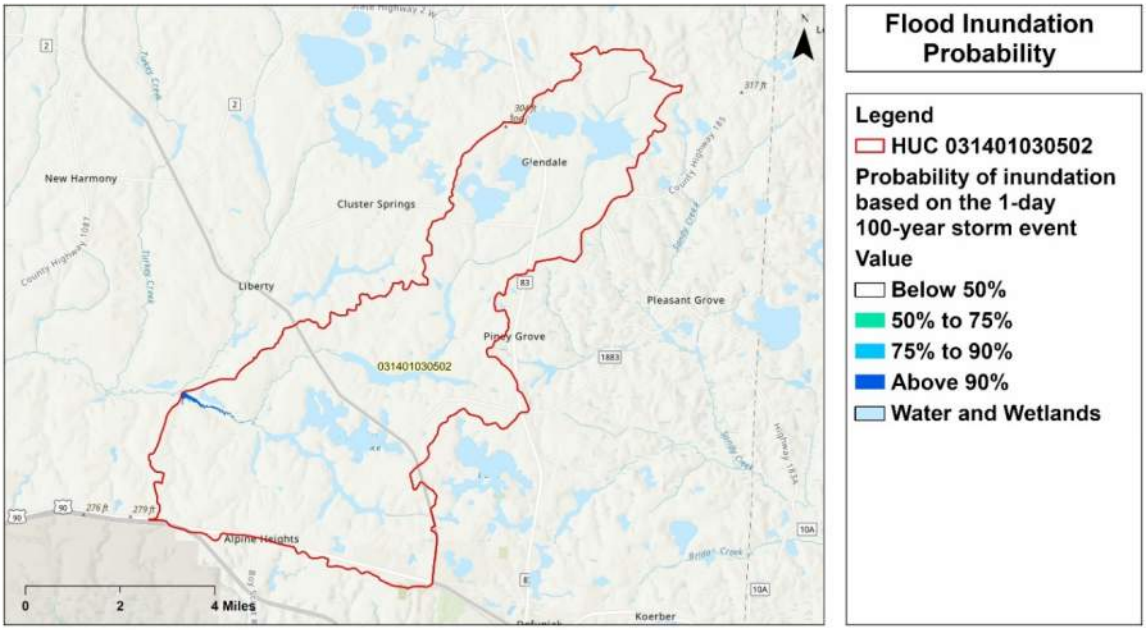

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401030502, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is

used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not

eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a very small portion of flooding is noted at the entrance to the creek into the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, sea level rise should not impact the HUC, therefore SLR scenarios were not calculated.

The design storm simulation determined that approximately 1.9% of the HUC total area or 0.56 mi² has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 1.9% of the HUC's total area, or 0.56 mi² would be expected to be inundated during a 1-day 100-year design storm. Approximately 1.9% of the HUC's total area, or 0.56 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 1.9% of the HUC's total area, or 0.56 mi², would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401030502 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	28.94	0.56	98.1%	1.9%
1-day 100-year	28.94	0.56	98.1%	1.9%
1-day 10-year	28.94	0.56	98.1%	1.9%
1-day 5-year	28.94	0.56	98.1%	1.9%

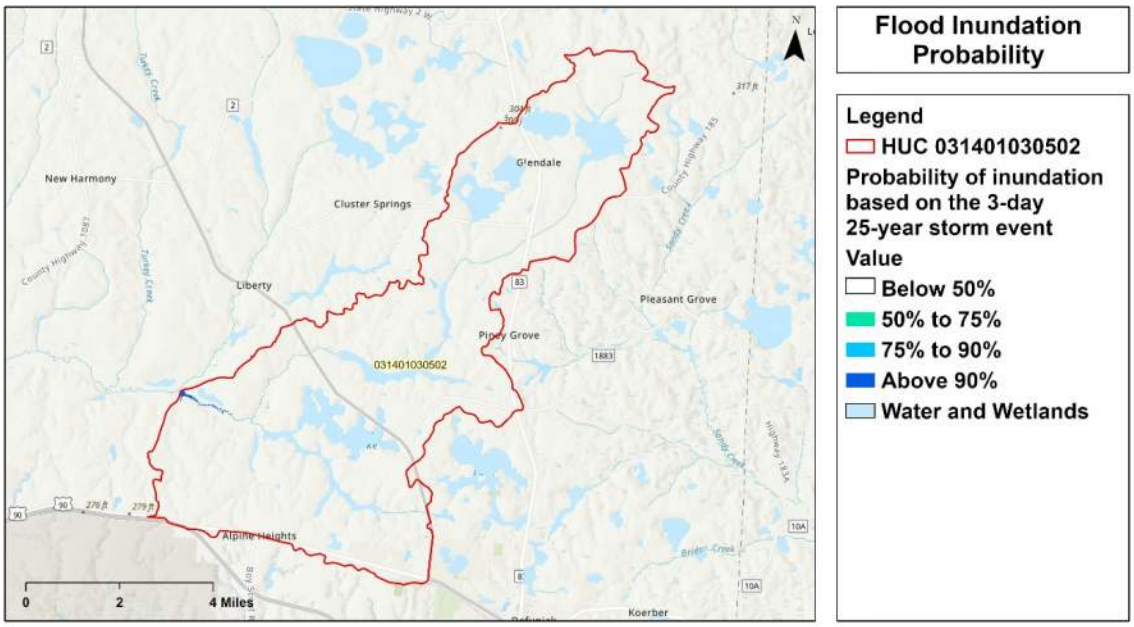

Figure 31. 3-day 25-year storm event for HUC 031401030502 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

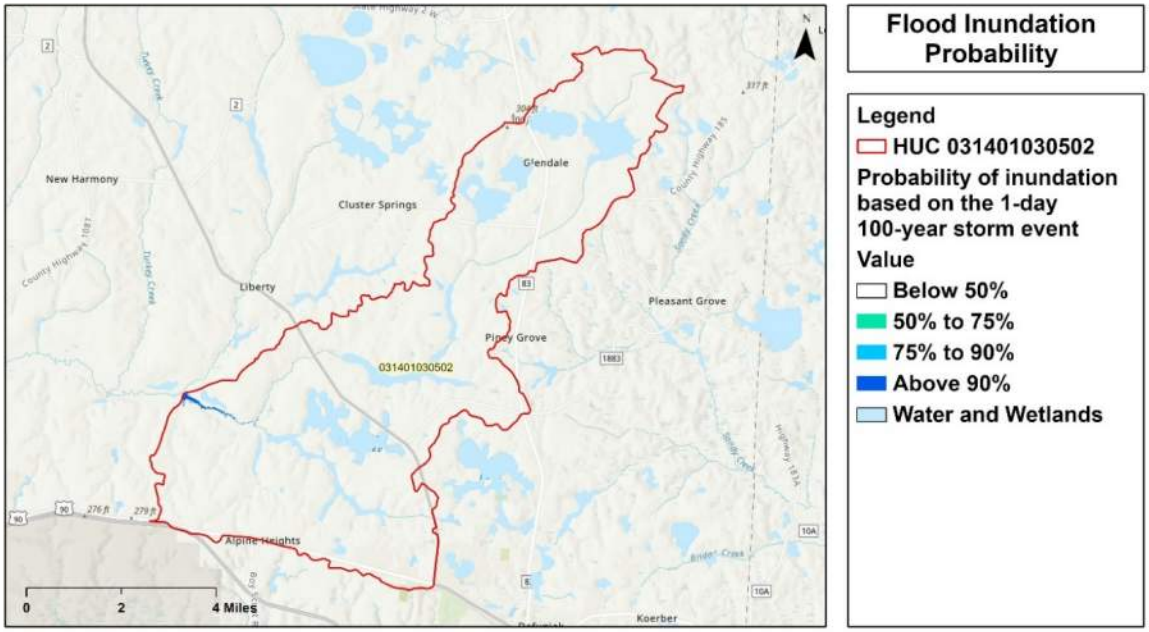

Figure 32. 1-day 100-year storm event for HUC 031401030502 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

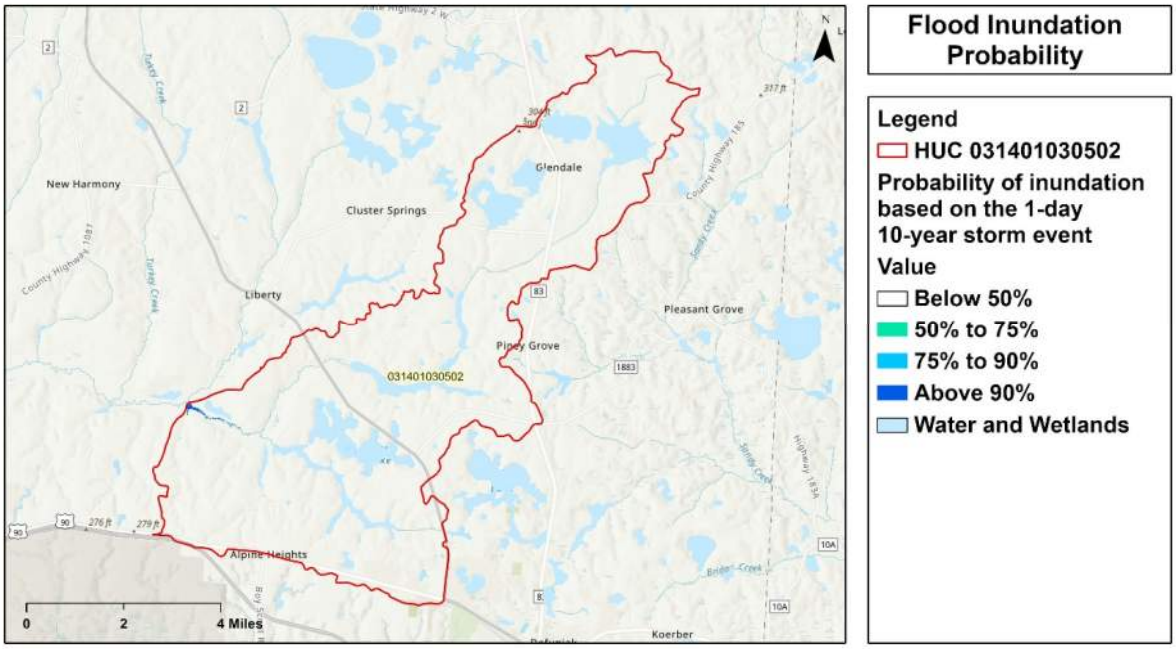

Figure 33. 1-day 10-year storm event for HUC 031401030502 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

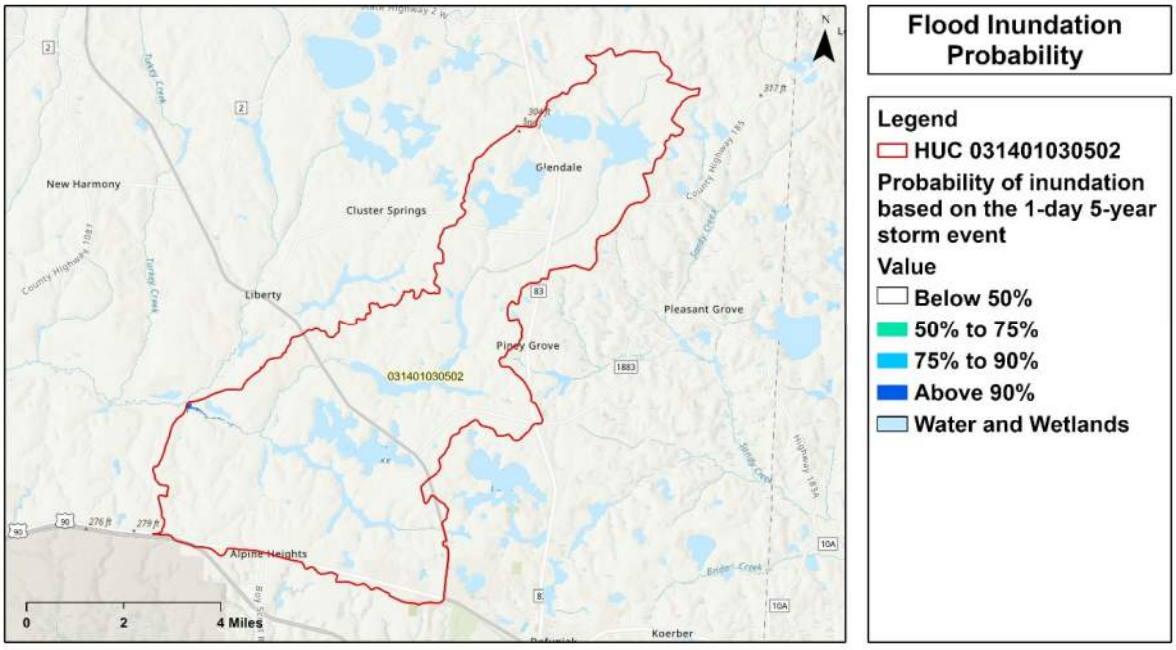

Figure 34. 1-day 5-year storm event for HUC 031401030502 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6

11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6

37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6

60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1

92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.**depict the HUC 031401030502 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.**is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.**illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

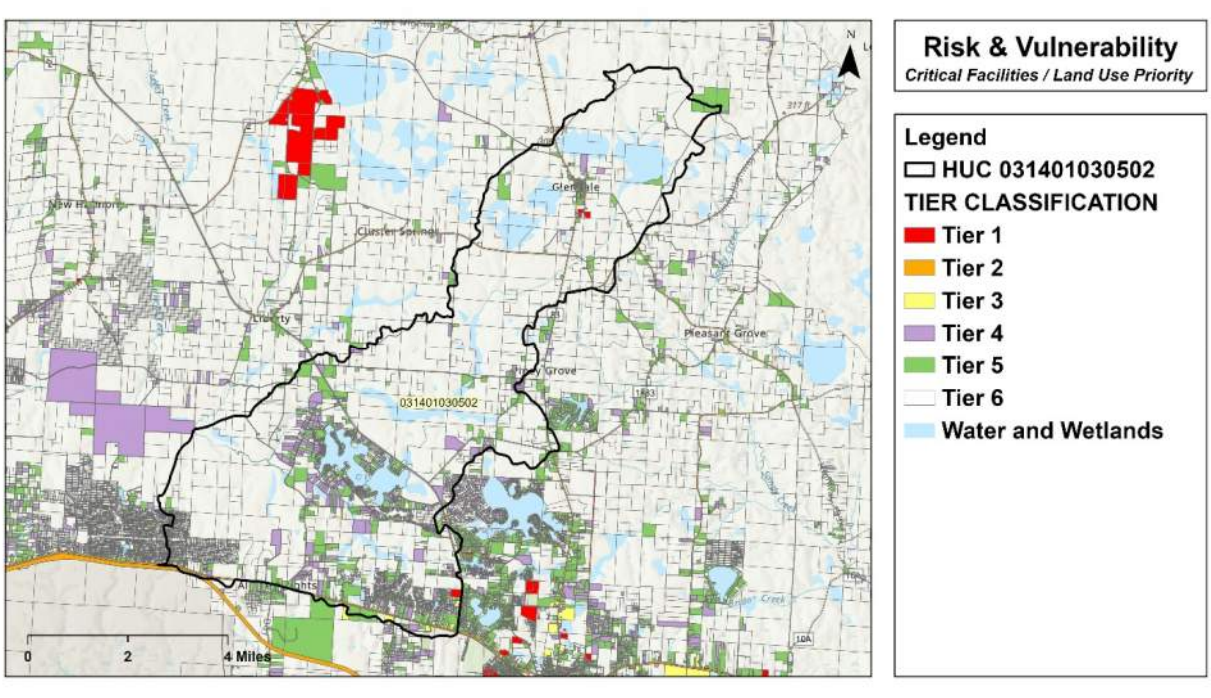

Figure 35. HUC 031401030502 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

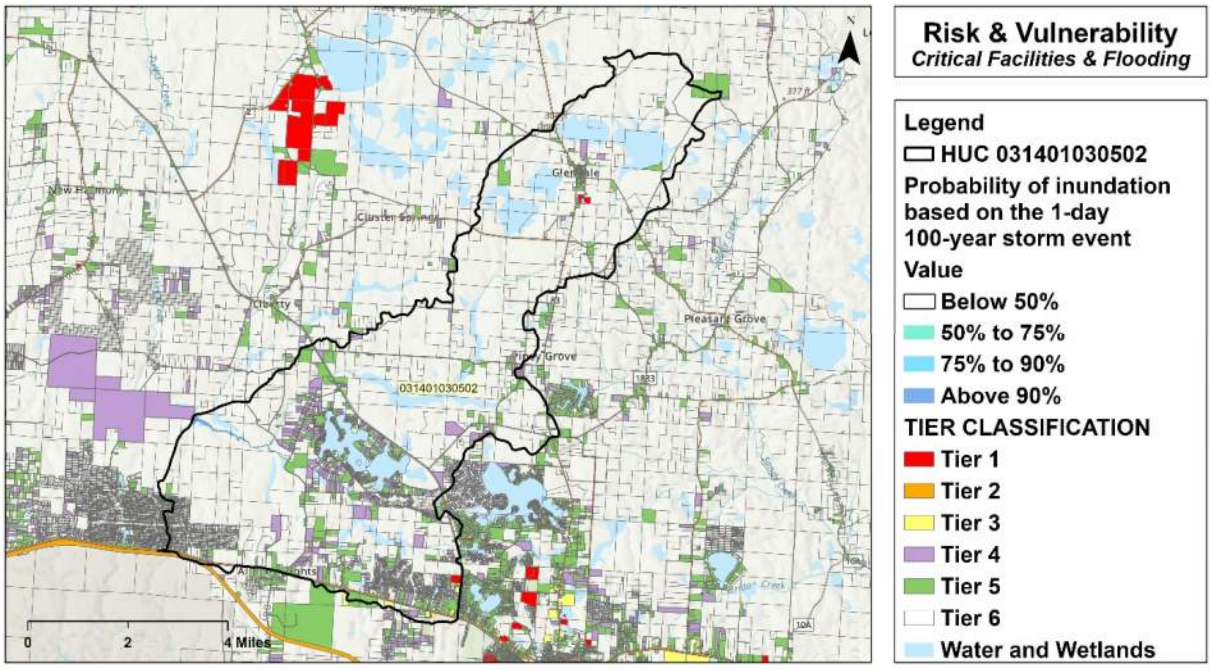

Figure 36. HUC 031401030502 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

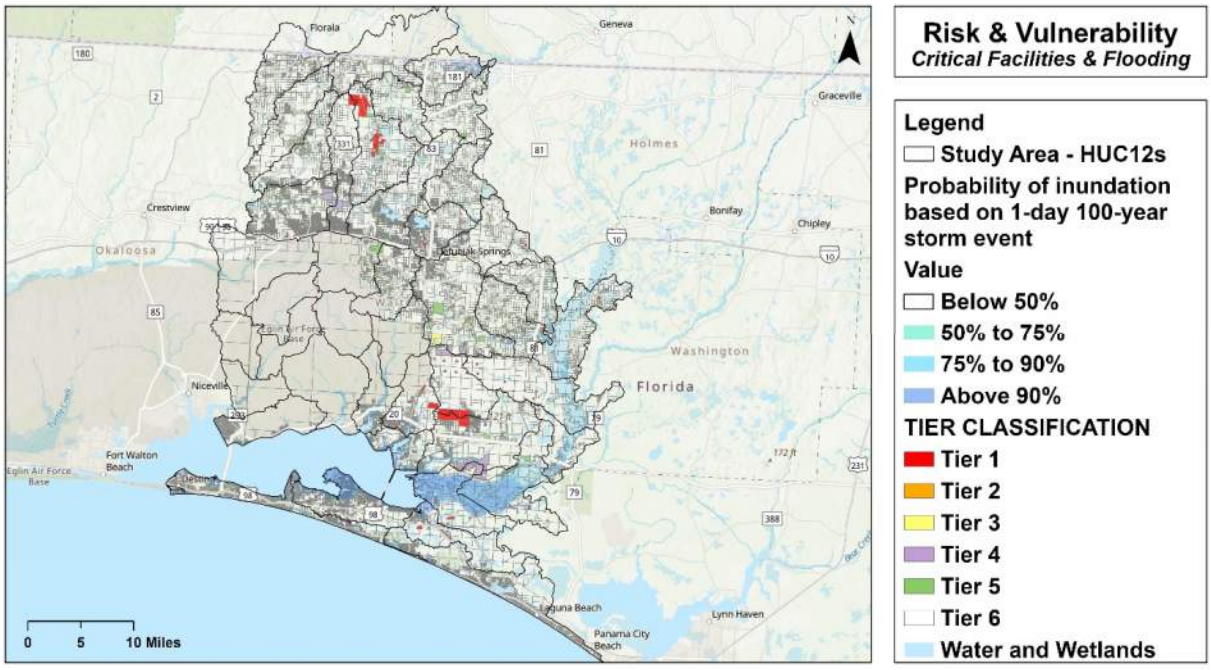

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

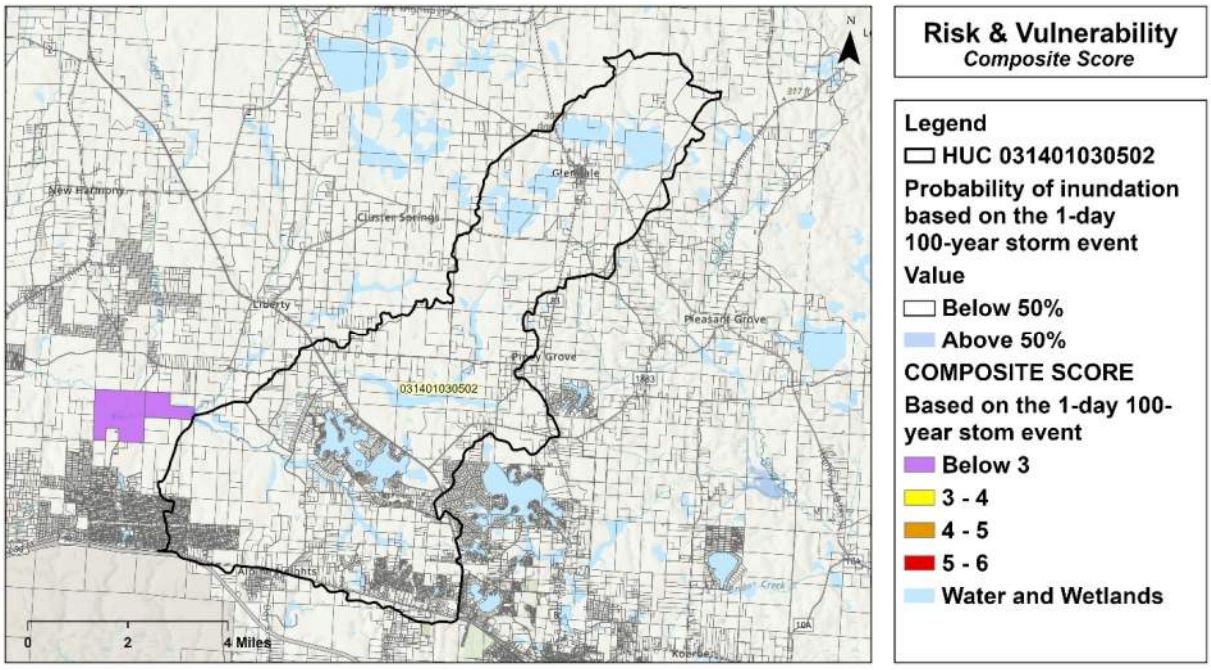

Figure 38. HUC 031401030502 sub-watershed Composite Score Risk map, calculation based on 1-day 100-year storm event. Processed by FAU.

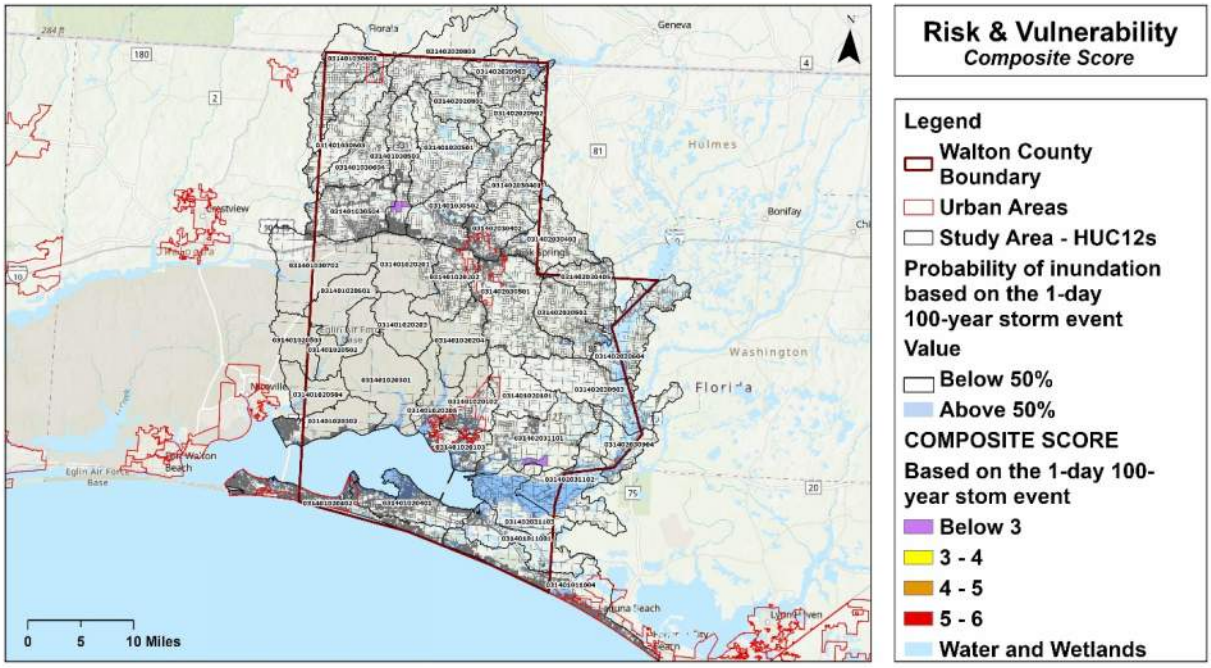

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

Please note that due to the scale of the map, the composite score layer is not properly visible.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401030502. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401030502. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401030502	28950.54
All of the 1-day 100-year storm event inundation	**45.29**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	45.29
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	45.29

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not**

found. indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

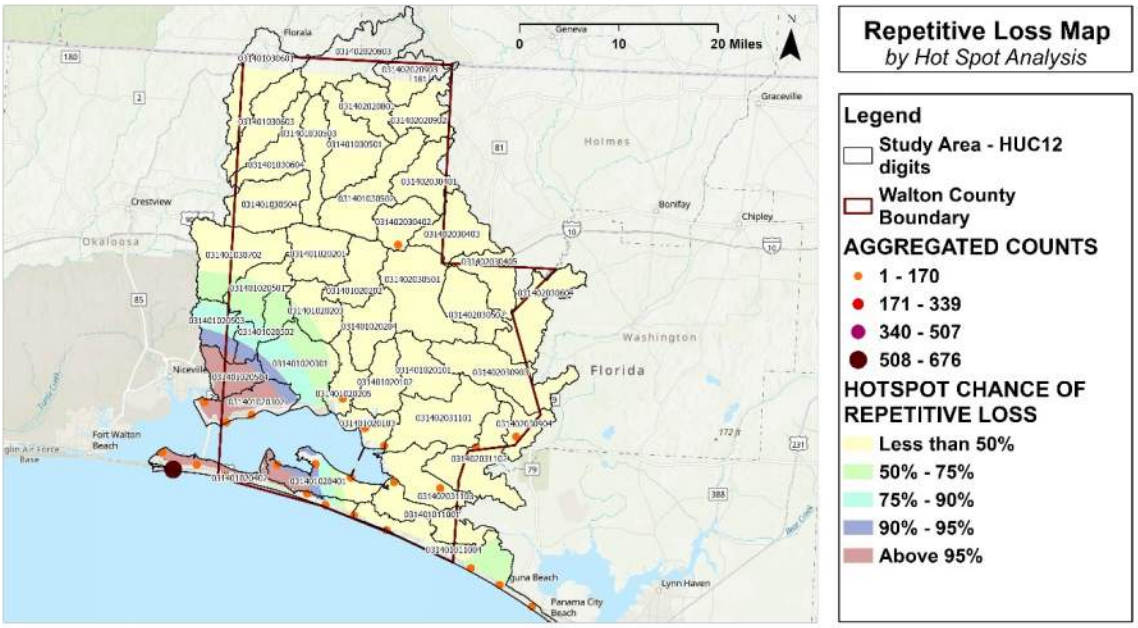

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5. Priority Projects

Although there are a few parcels falling within classification tier 1 to 3, and a good amount of parcels falling within tiers 4 and 5 of priority of land uses, none of them are within the flooding zone, once flooding in the area is minor and not alarming. Consequently, when considering the composite score, it notable that there is no critical facilities situated within the flooding zone, indicating no necessity for priority projects intervention within the basin.

More detail about flood solutions are described in the community plan and in Section 5.5 where drilldown to specific neighborhoods is outlined.

APPENDIX V

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401030503

KINGS LAKE

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Research Assistant: Leticia Sabio

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (Figure 1). Figure 2 shows Walton County Drainage Network and the location of urban areas (cities and towns). In Figure 3, the HUC-12 digits (031401030503) is highlighted among all the HUCs to help identifying its location. (Figure 3).

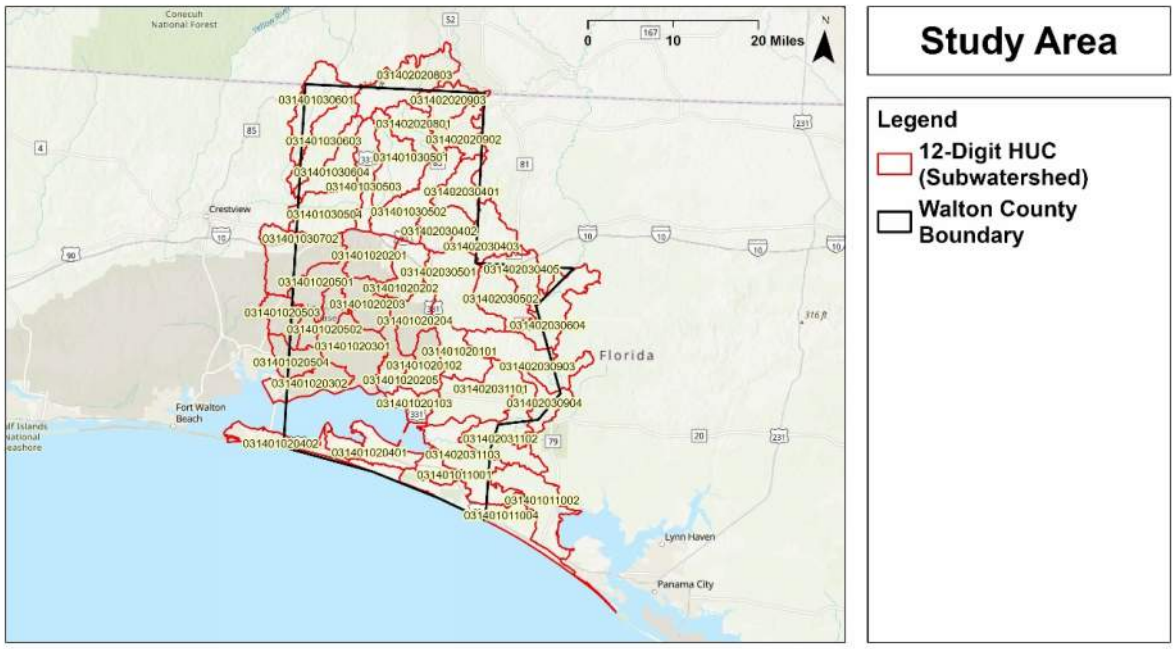

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

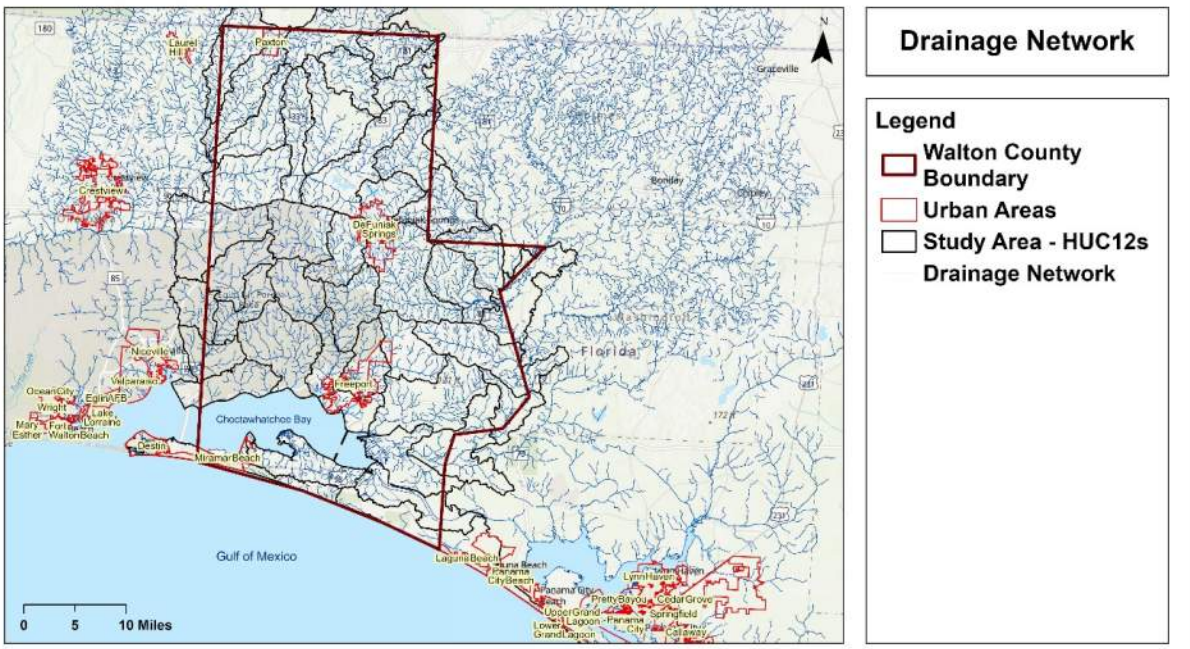

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

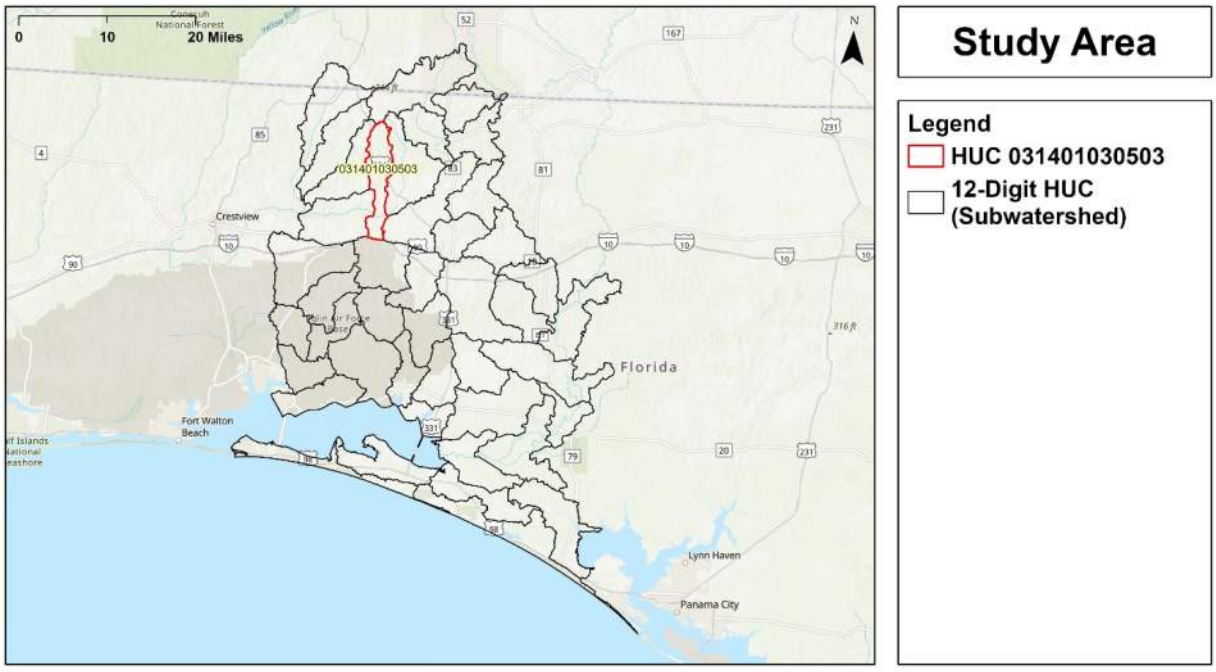

Figure 3. HUC 031401030503 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Based on the future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL))

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with

high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

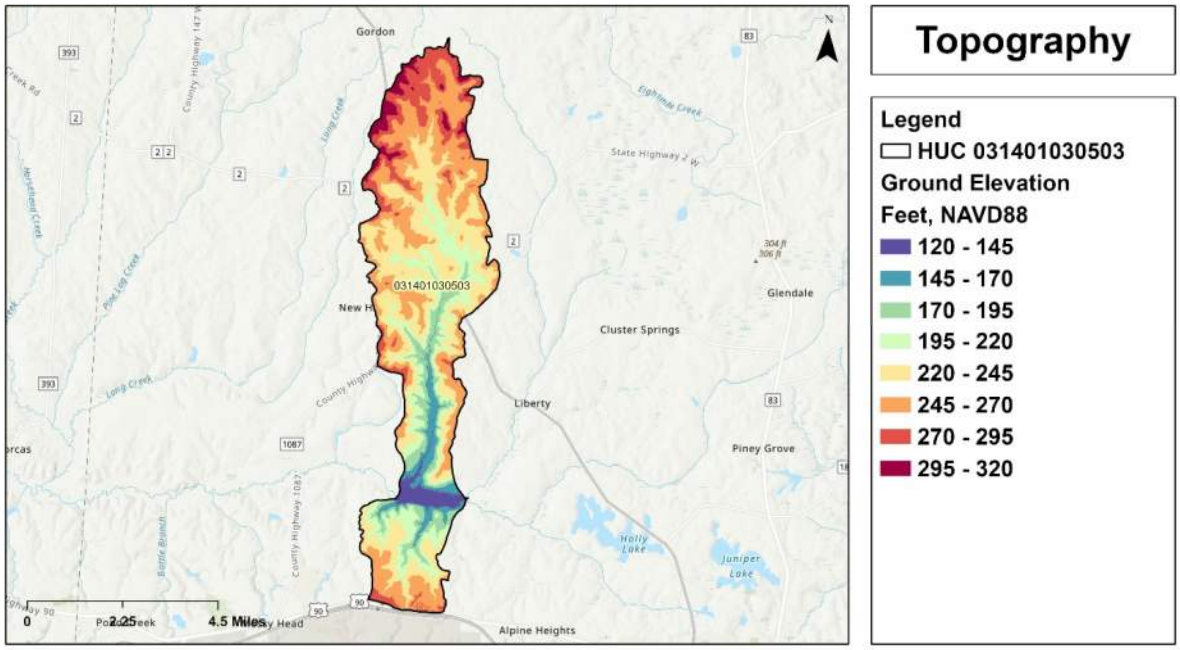

Figure 4. Topographic map of the HUC 031401030503 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of

wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology.
Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.
Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401030503 sub-watershed is shown in **Error! Reference source not found.**.

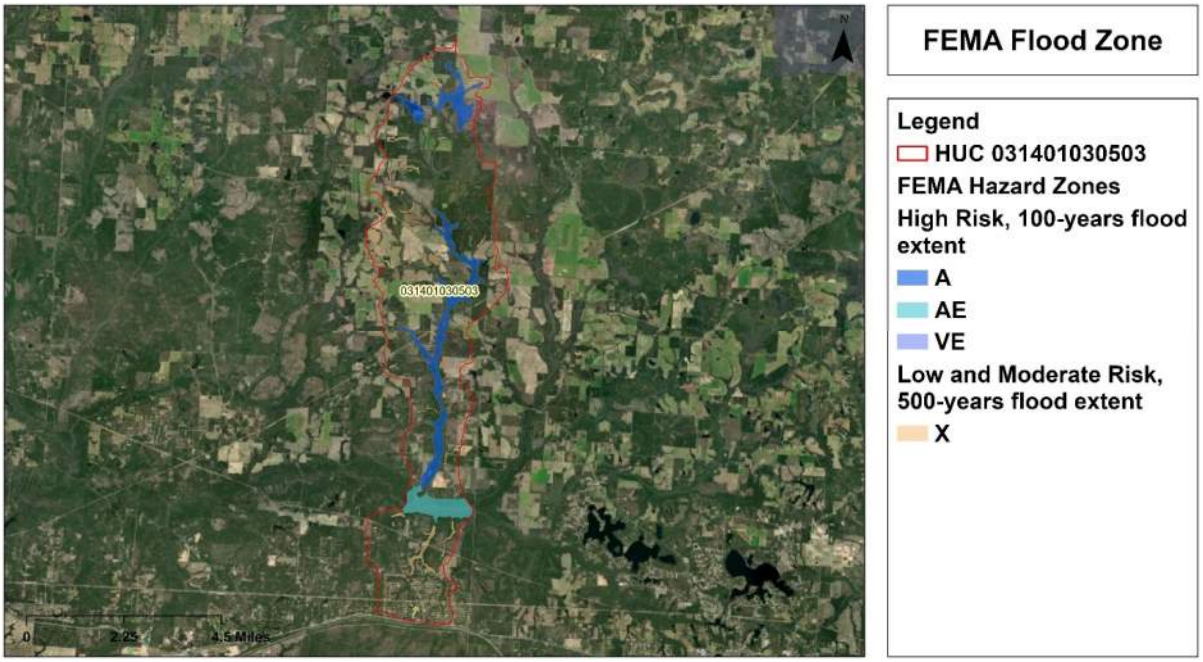

Figure 5. FEMA Flood Zone map (2020) for HUC 031401030503 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination

between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401030503 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

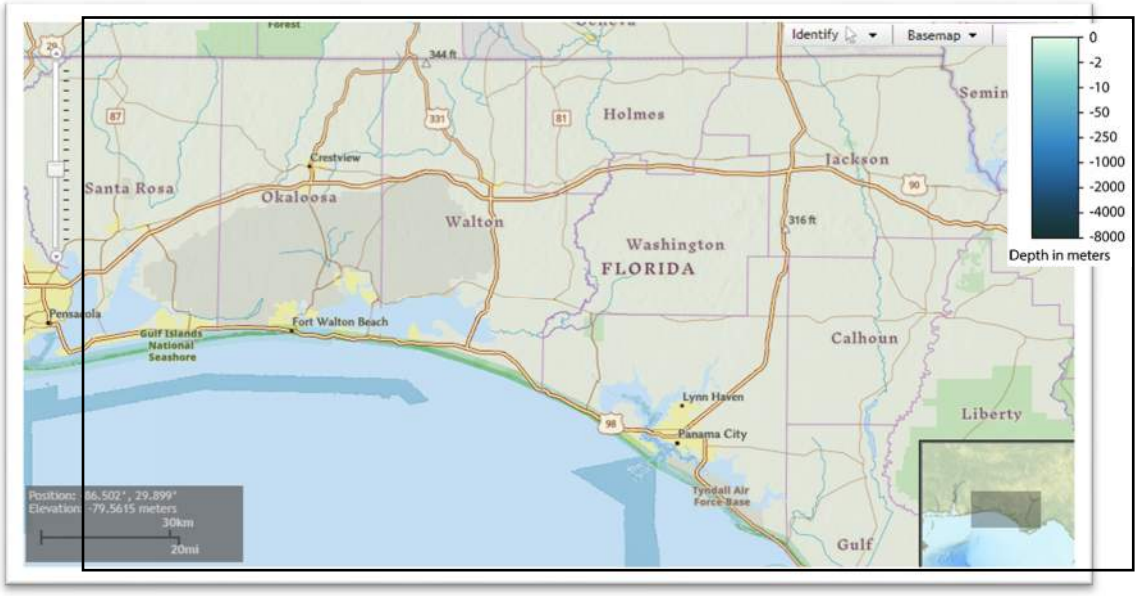

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle. Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological

conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

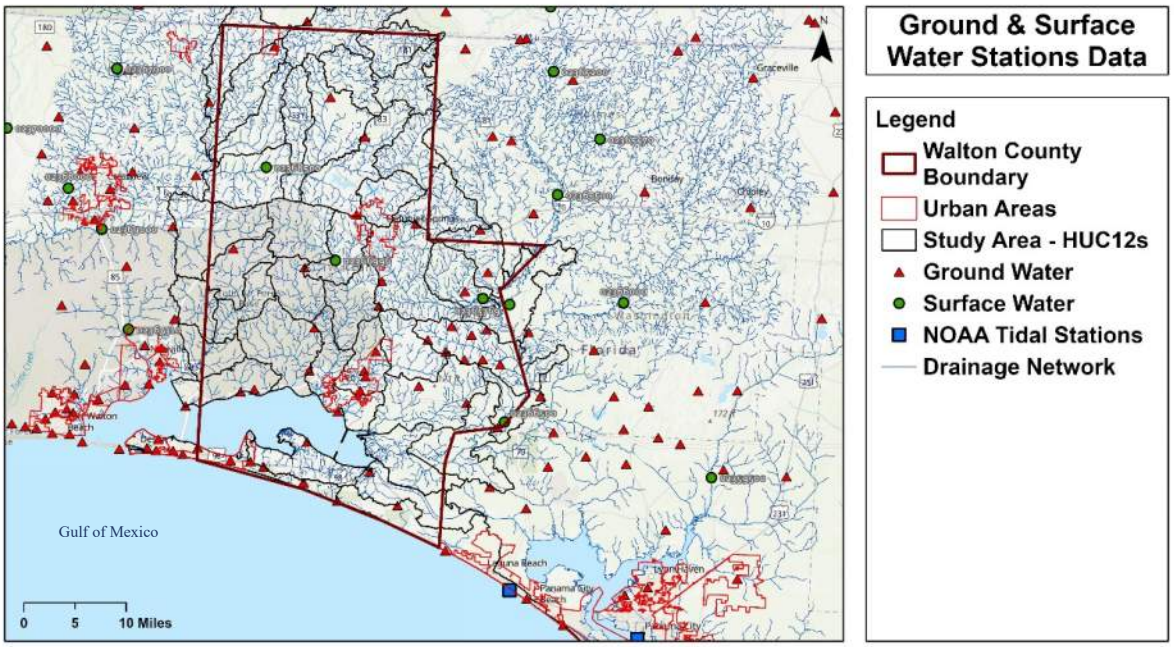

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The major water bodies in the HUC 031401030503 sub-watershed include:

- Shoal River
- Turkey Creek
- Mil Dam Creek

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02368500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401030503, which is USGS 02368500 Shoal River.

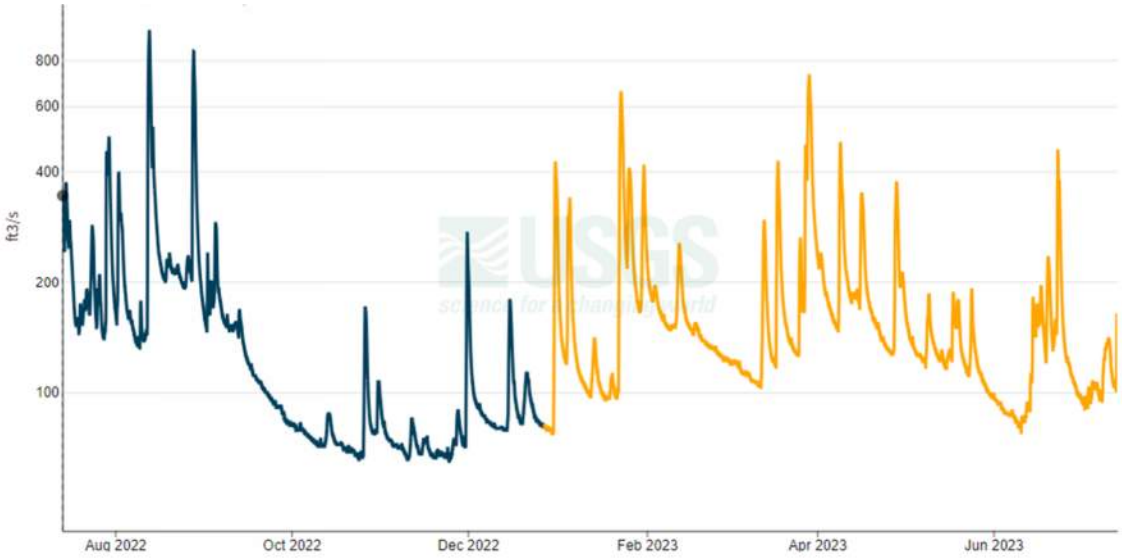

Figure 8. Average streamflow for Shoal River NR Mossy Head, Fla (USGS 02368500 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02368500/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99^{th}- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98^{th} - 100^{th} percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station

(or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401030503 and points out the location of the ground water station in the surroundings. A groundwater-surface layer for the HUC 031401030503 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

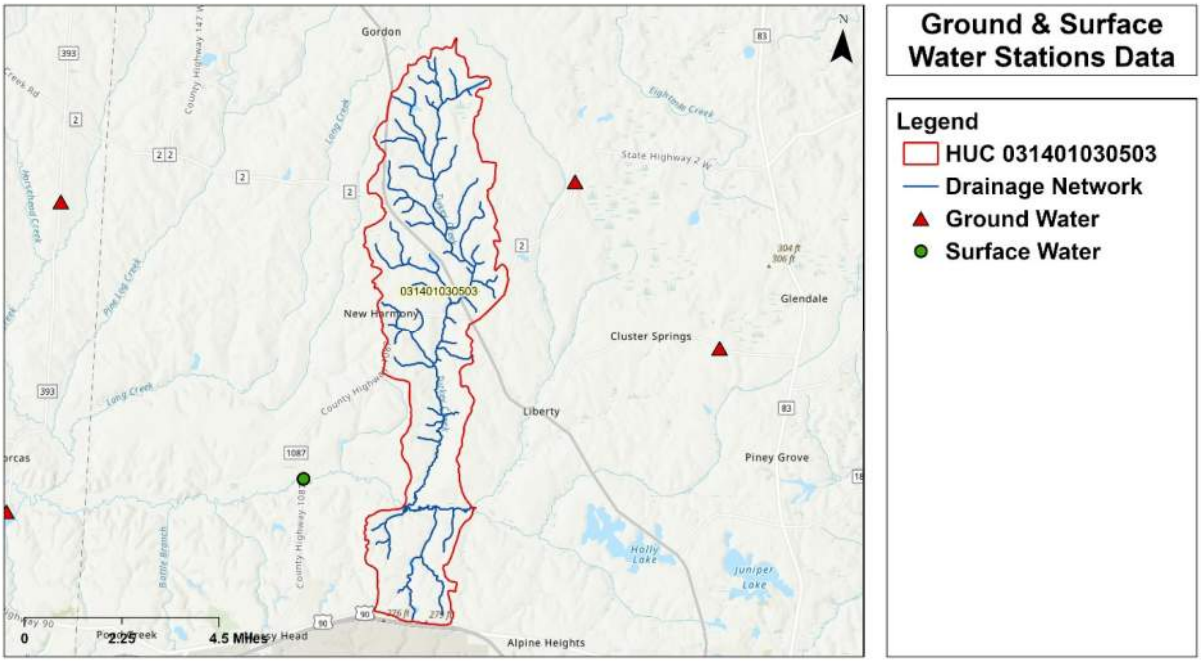

Figure 9. Ground and Surface Water Stations in the HUC 031401030503 sub-watershed, processed by FAU.

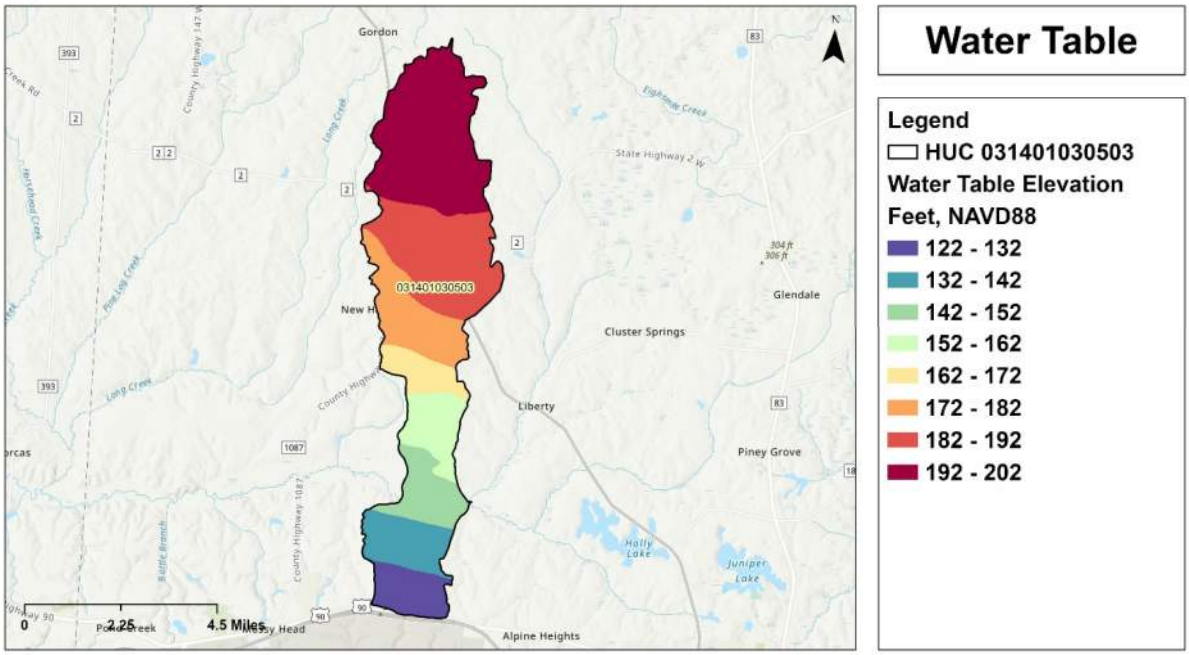

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401030503 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

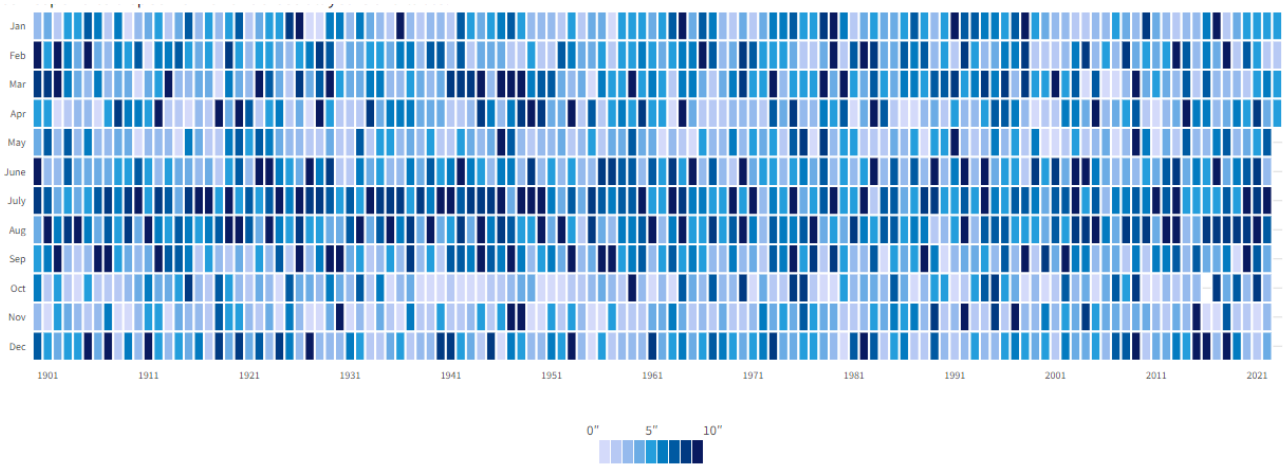

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information.
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/)

While the topography (Section 2.1) and native soil (Section 2.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is none NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

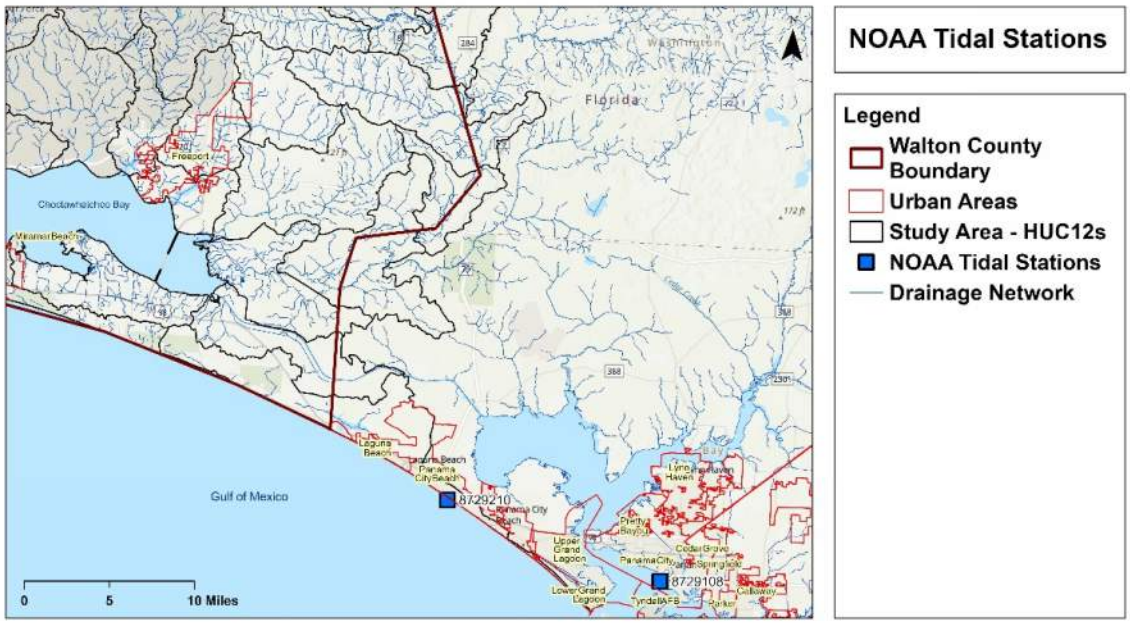

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

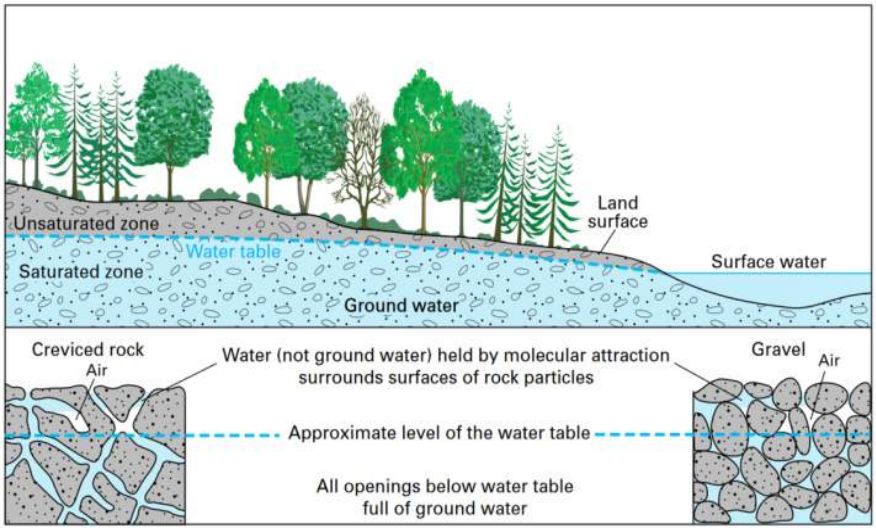

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

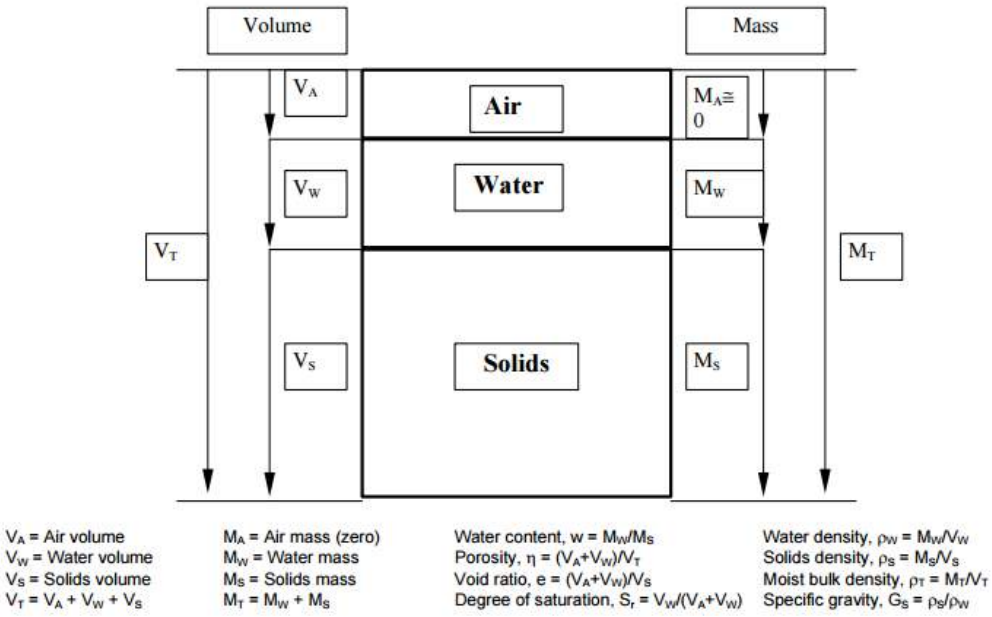

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

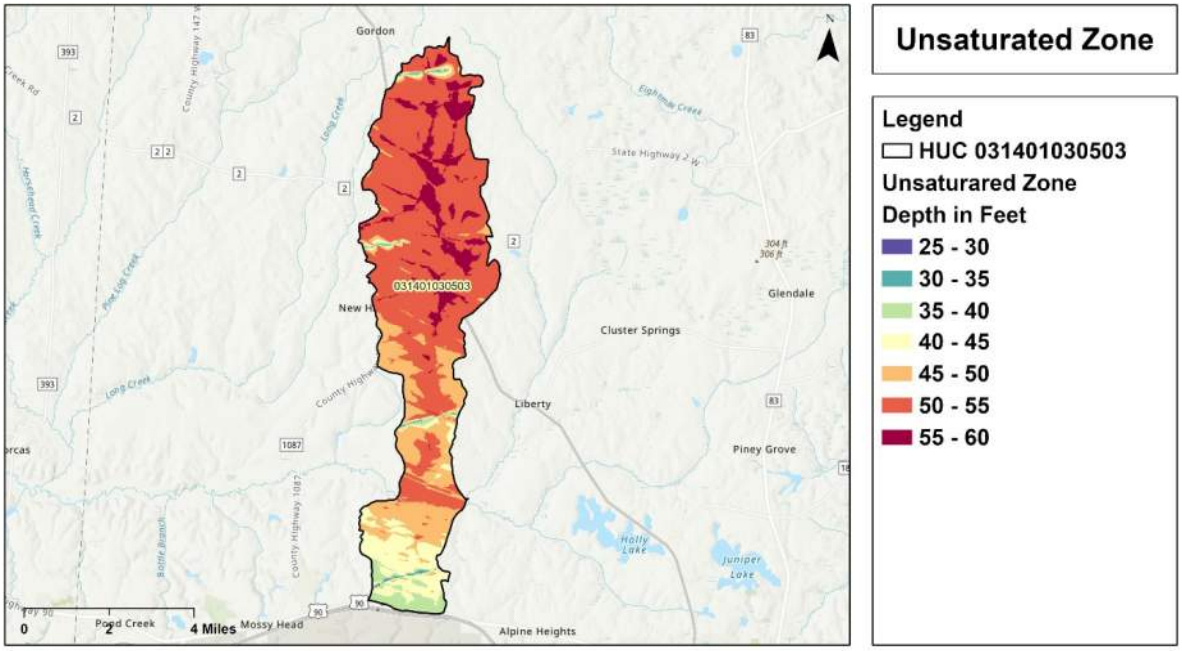

Figure 15 Unsaturated zone map for HUC 031401030503, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. Much of the basin has a great amount of soil storage capacity, ranging between 40 to 60 inches of capacity left.

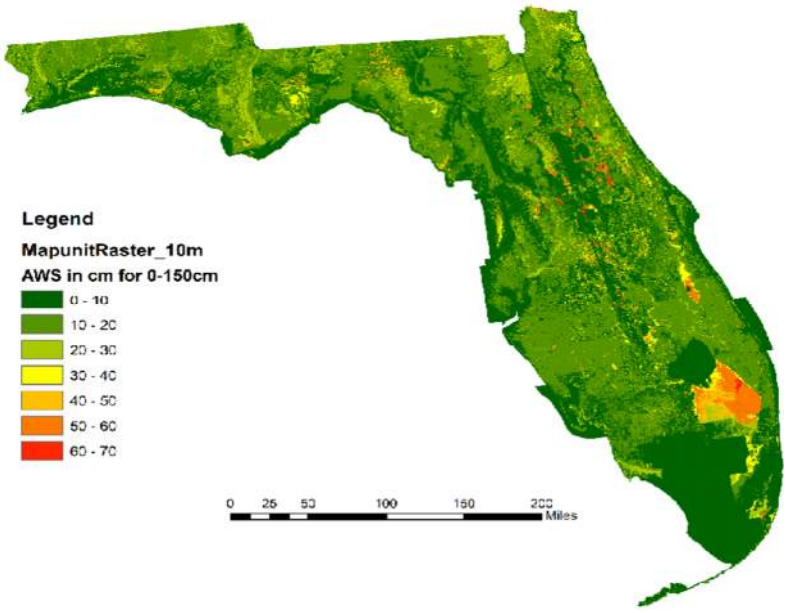

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

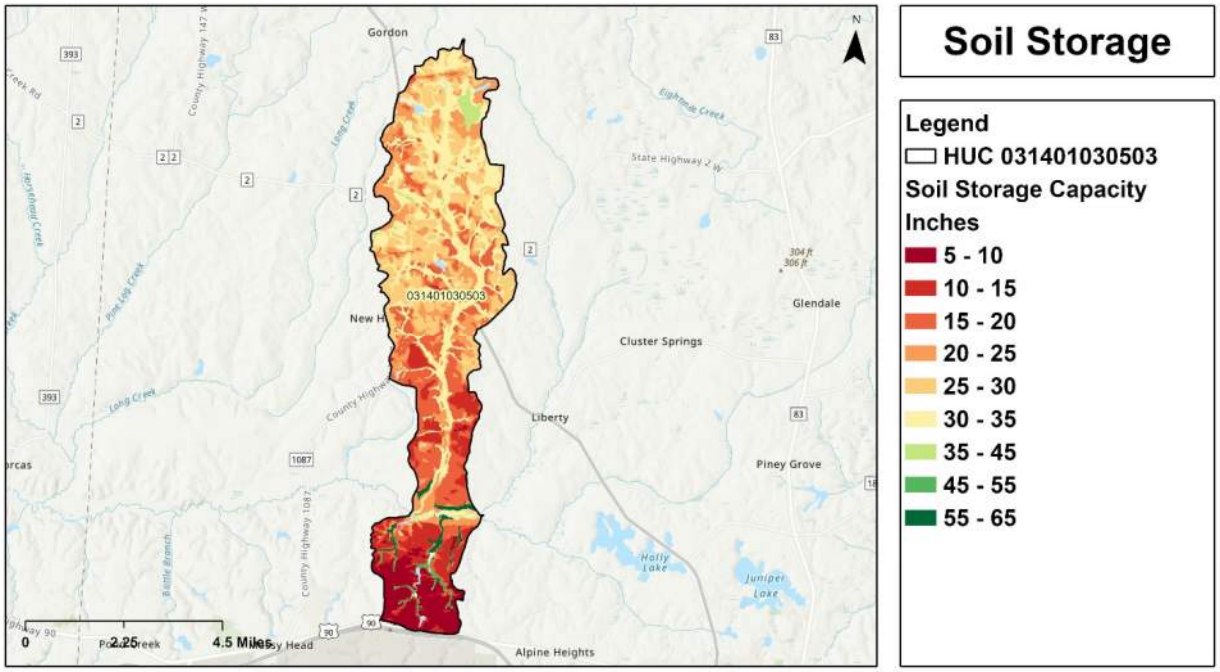

Figure 17. Water storage capacity of soil for the HUC 031401030503, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

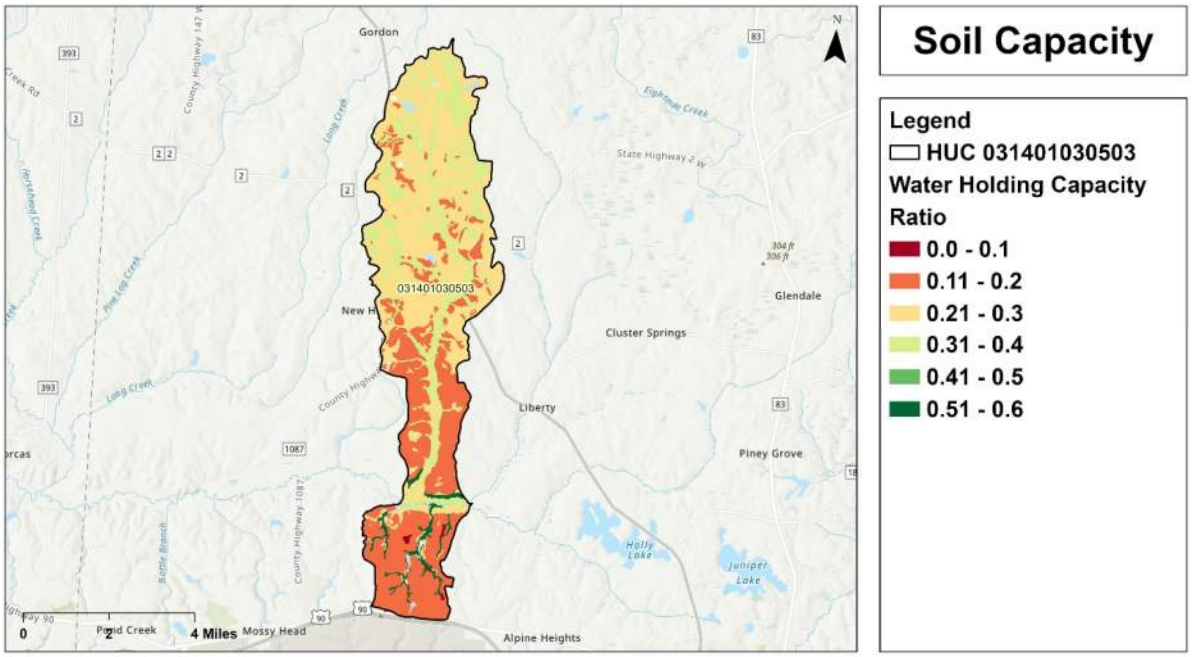

Figure 18: Water Holding Capacity (ratio) for the HUC 031401030503, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

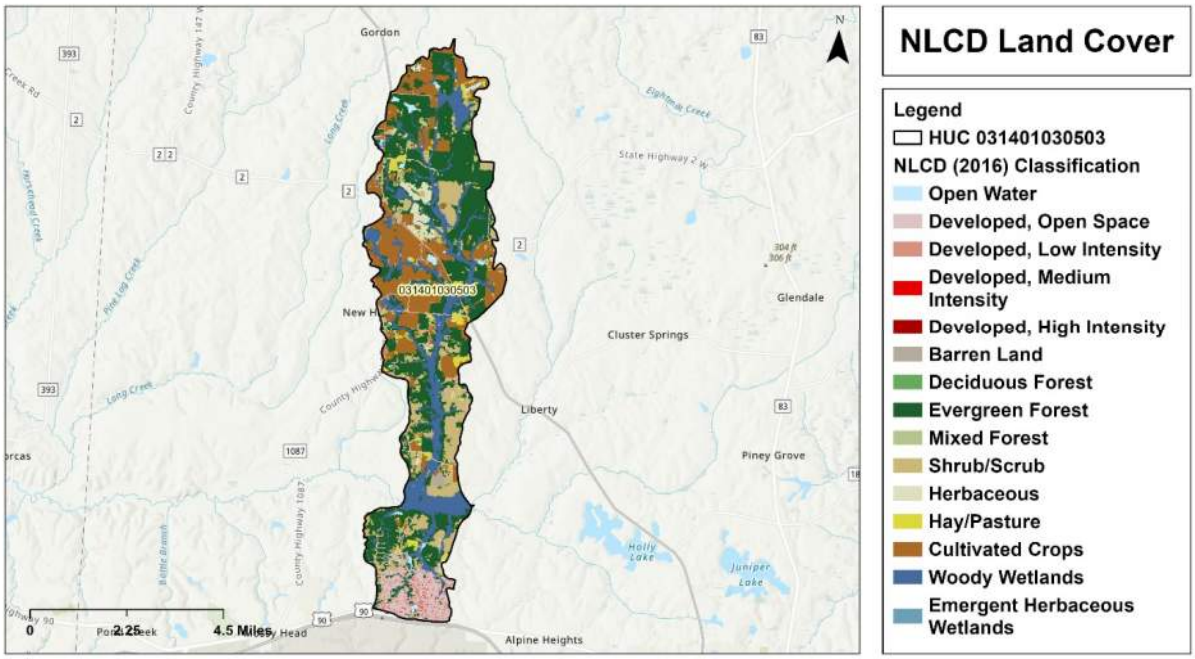

Figure 19. Land use in the HUC 031401030503 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps were used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

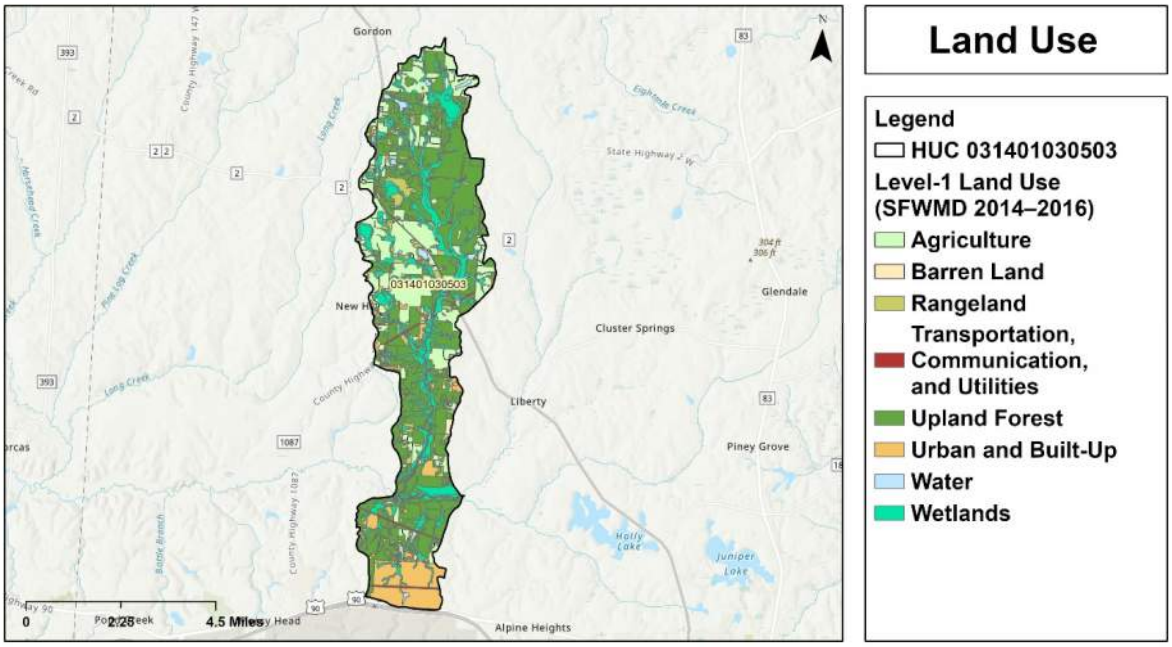

Figure 20. Land use in the HUC 031401030503 (2023 Florida Geographic Data Library (FGDL))database), processed by FAU.

In the HUC 031401030503 sub-watershed, mostly of the area is upland forest, with 40.90%. The second place is agriculture with 21.55%. There is no much developed land in the HUC – only 6.98% is urban and built-up, but there is a considerable amount of land being used for Transportation, Communication, and Utilities (12.92%), which is unusual, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031401030503 subwatershed (2023 Florida Geographic Data Library (FGDL))).

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	5680.73	21.55%
Barren Land	100.31	0.38%
Rangeland	557.81	2.12%
Transportation, Communication, and Utilities	3405.53	12.92%
Upland Forest	10781.12	40.90%
Urban and Built-Up	1839.39	6.98%
Water	558.63	2.12%
Wetlands	3434.03	13.03%
Grand Total:	**26357.54**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

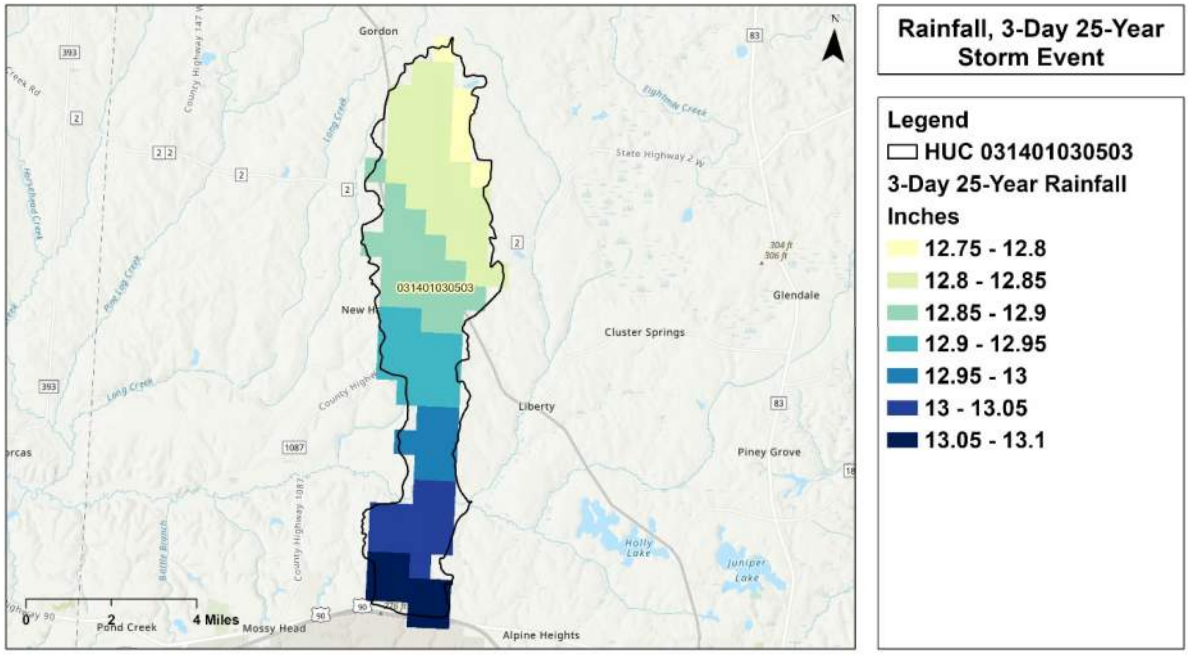

Figure 21. Rainfall distribution map across HUC 031401030503 sub-watershed, for 3-day 25-year storm event, processed by FAU.

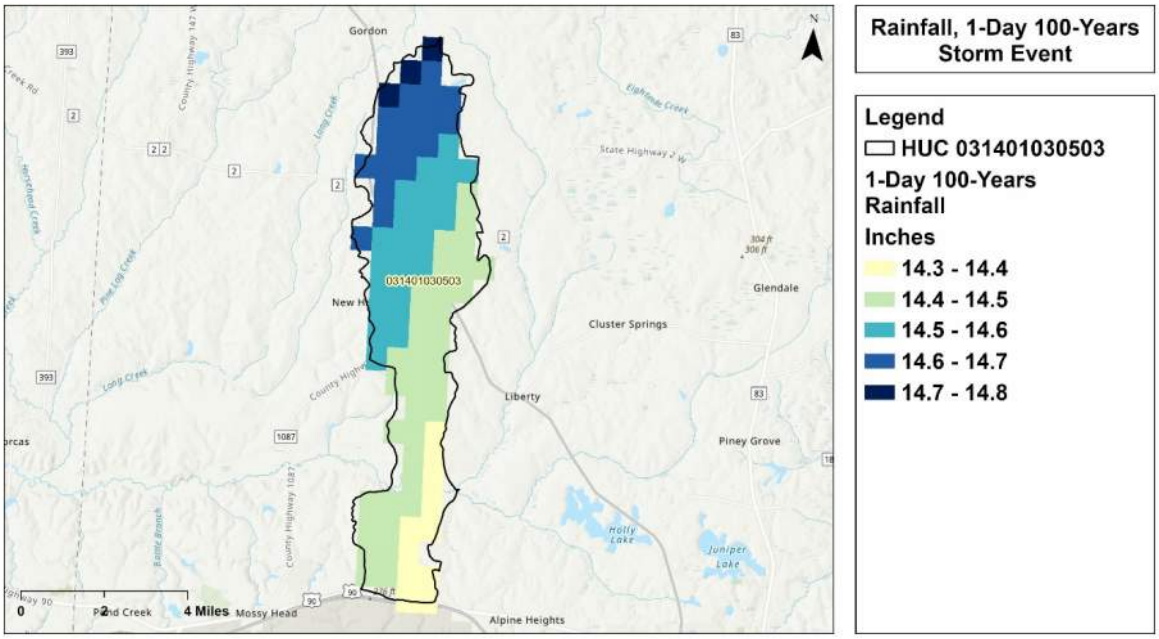

Figure 22. Rainfall distribution map across HUC 031401030503 sub-watershed, for 1-day 100-year storm event, processed by FAU.

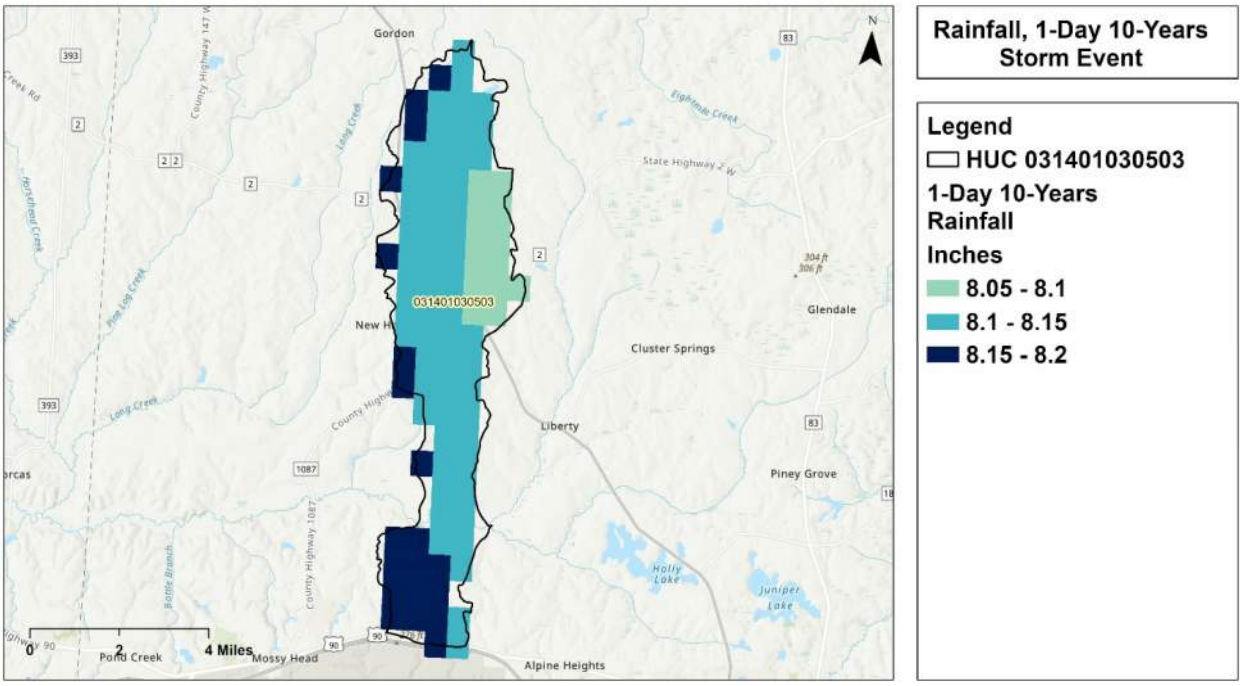

Figure 23. Rainfall distribution map across HUC 031401030503 sub-watershed, for 1-day 10-year storm event, processed by FAU.

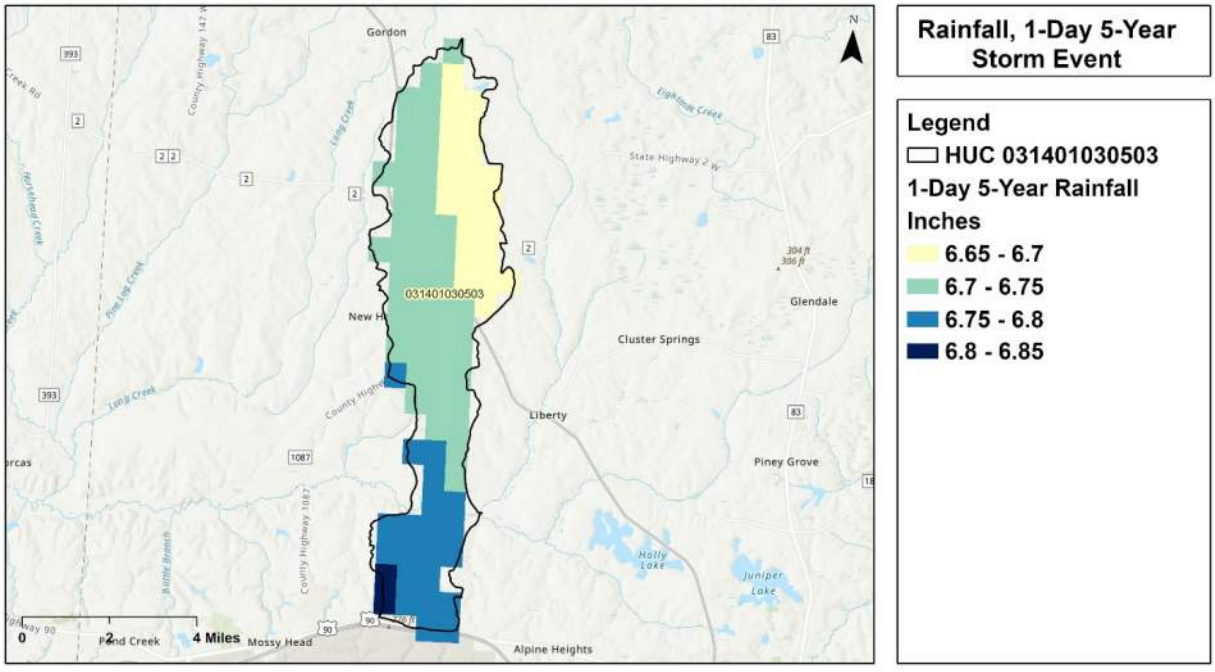

Figure 24. Rainfall distribution map across HUC 031401030503 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

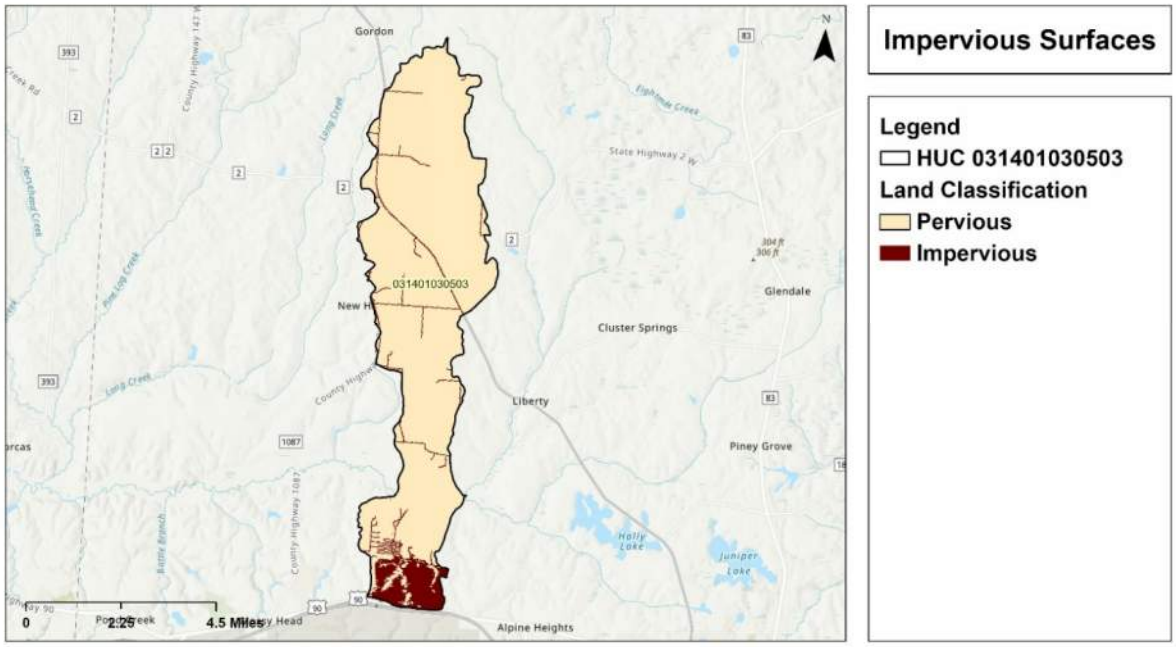

Figure 25. Impervious area map for the HUC 031401030503 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

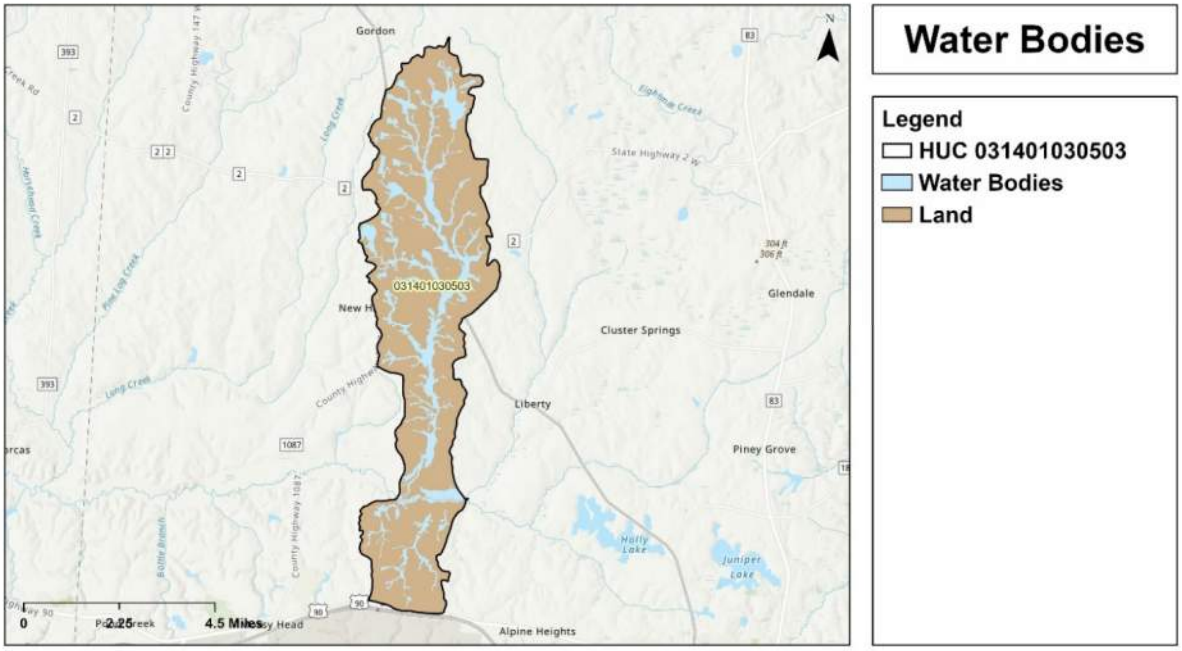

Figure 26. Water bodies map for the HUC 031401030503 sub-watershed, processed by FAU.

1.10. Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place.

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

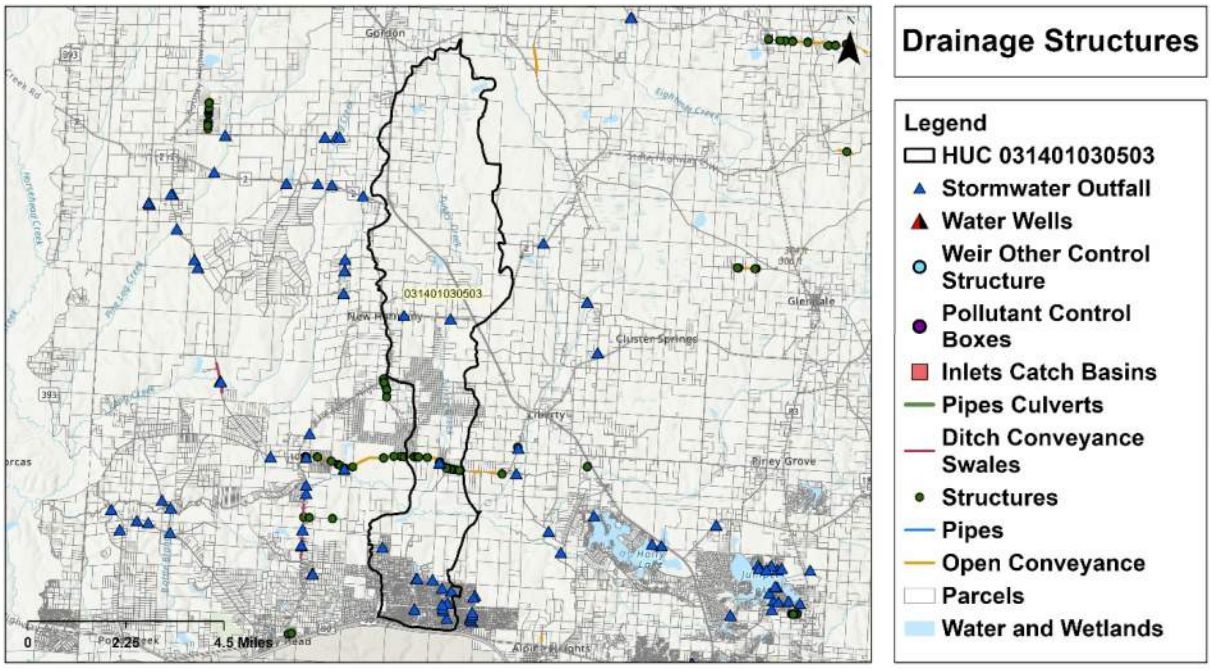

Figure 27. Stormwater Infrastructure for the HUC 031401030503. Processed by FAU.

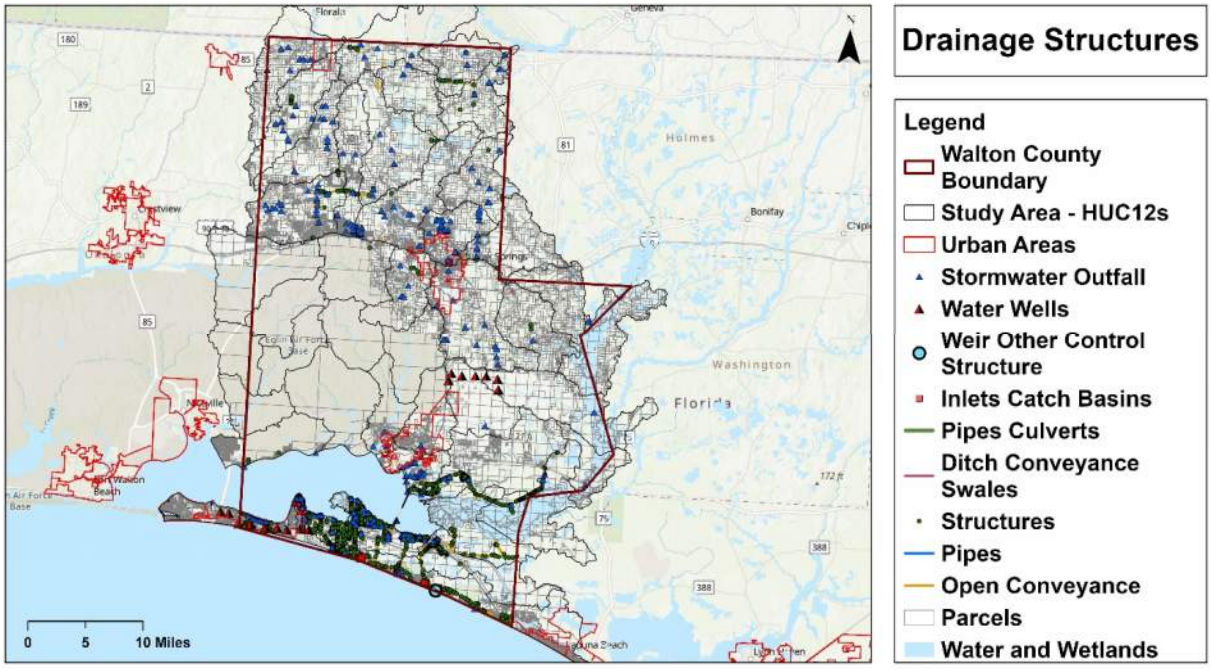

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020)

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401030503 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

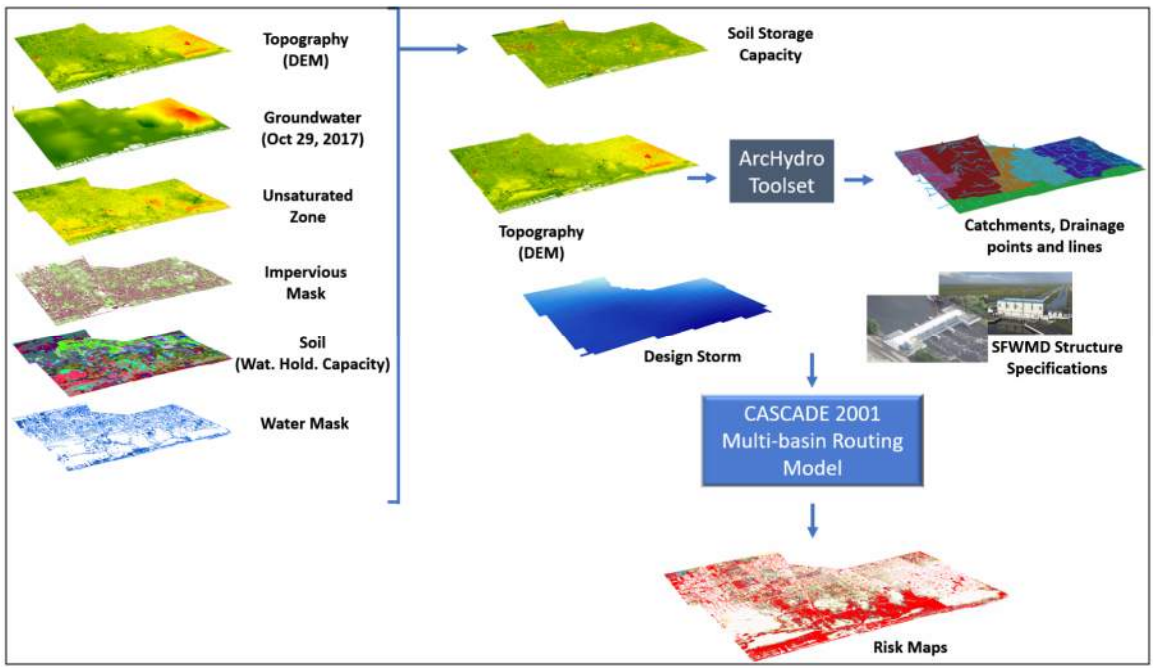

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)

= 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

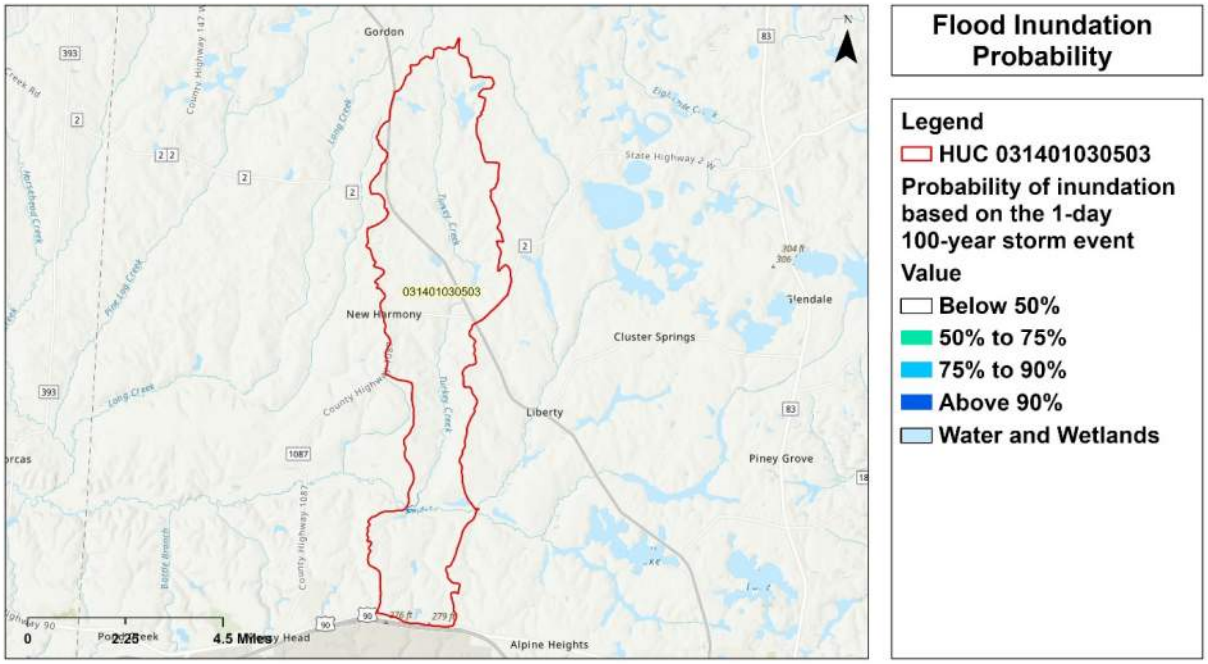

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401030503, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees

and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a very small portion and almost imperceptible flooding is noted at the entrance to the creek into the HUC, due to its high altitudes. As this basin is not connected to the ocean and its altitude is above 20 feet, sea level rise should not have impact on the area, therefore SLR scenarios were not calculated.

The design storm simulation determined that approximately 0.1% of the HUC total area or 0.03 mi^2 has a probability of inundation above 50% for all four design storm, indicating that 0.03 mi^2 will be expected to be inundated in all four storm event scenarios. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401030503 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	26.54	0.03	99.9%	0.1%
1-day 100-year	26.54	0.03	99.9%	0.1%
1-day 10-year	26.54	0.03	99.9%	0.1%
1-day 5-year	26.54	0.03	99.9%	0.1%

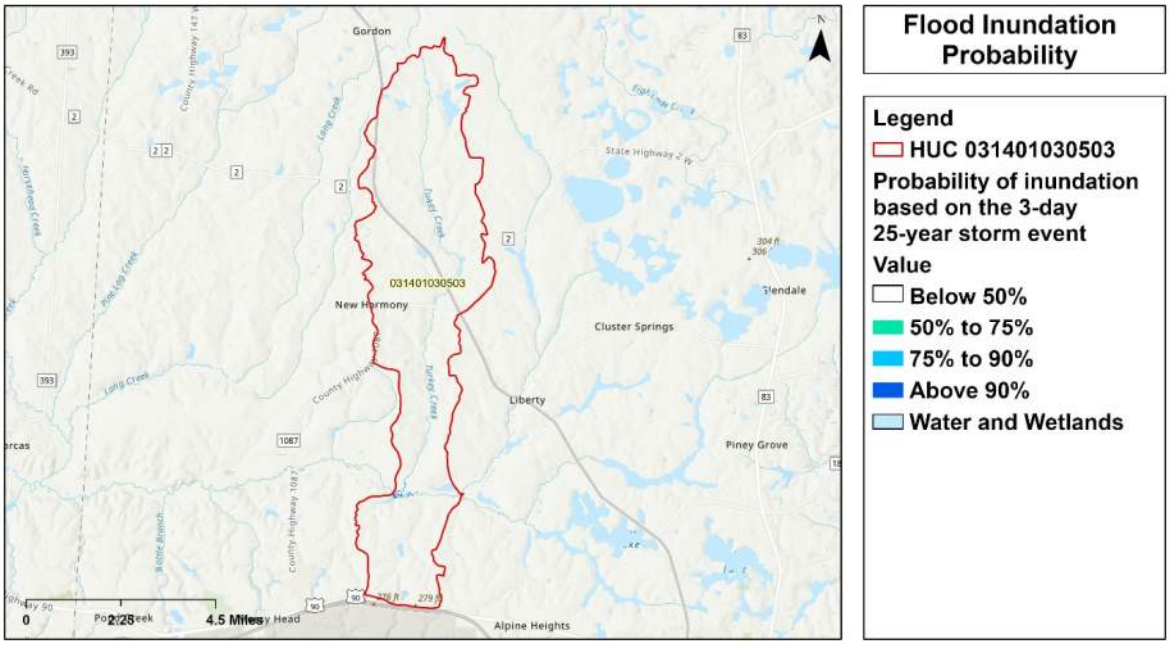

Figure 31. 3-day 25-year storm event for HUC 031401030503 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

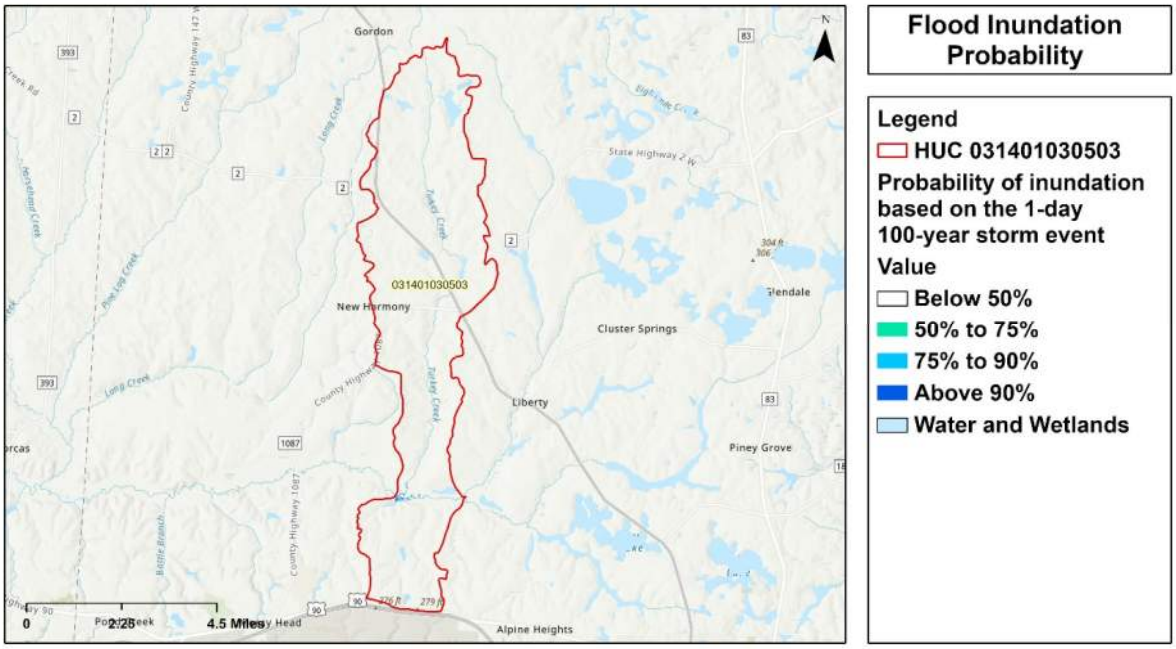

Figure 32. 1-day 100-year storm event for HUC 031401030503 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

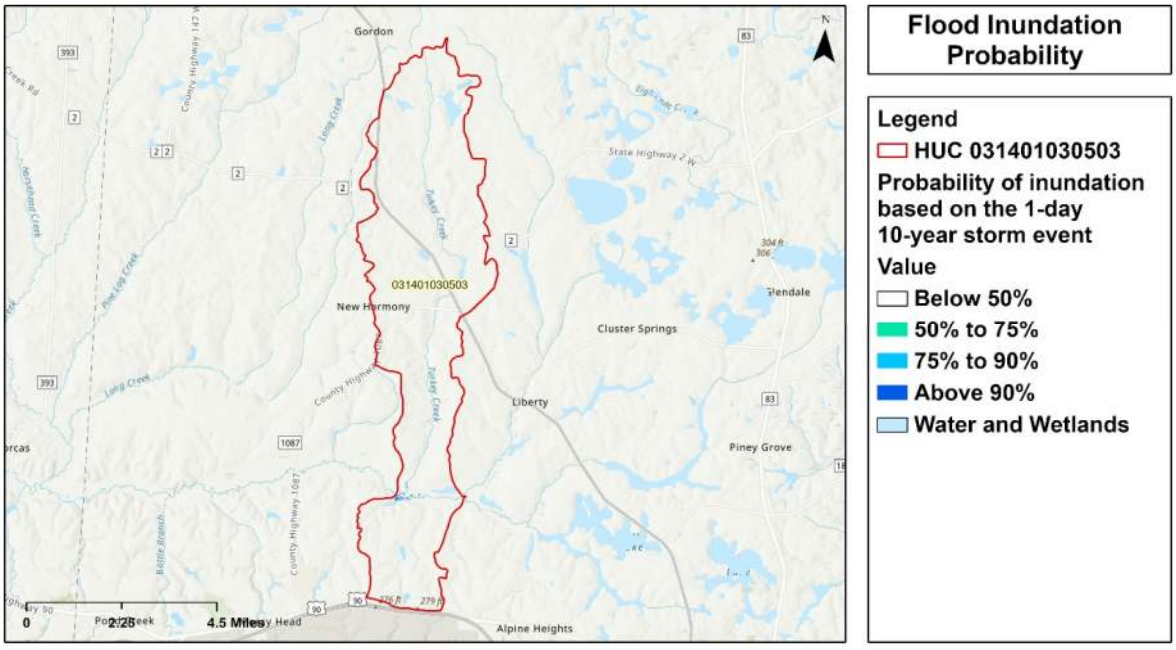

Figure 33. 1-day 10-year storm event for HUC 031401030503 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

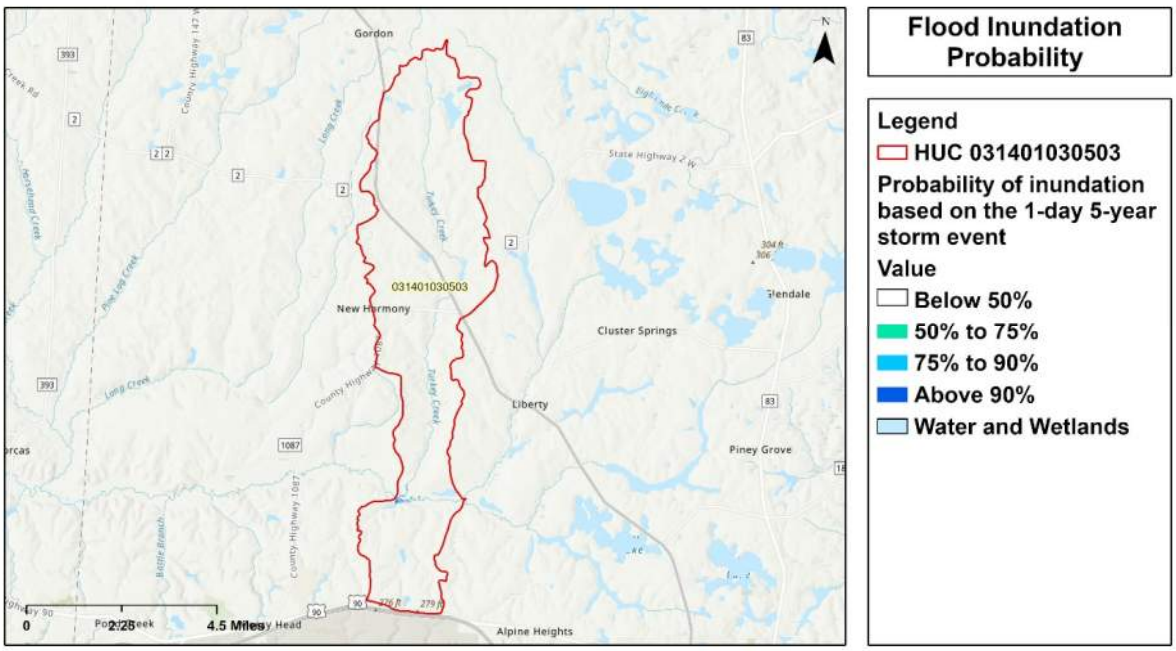

Figure 34. 1-day 5-year storm event for HUC 031401030503 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have

lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3

26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6

53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6

87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is

converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031401030503 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

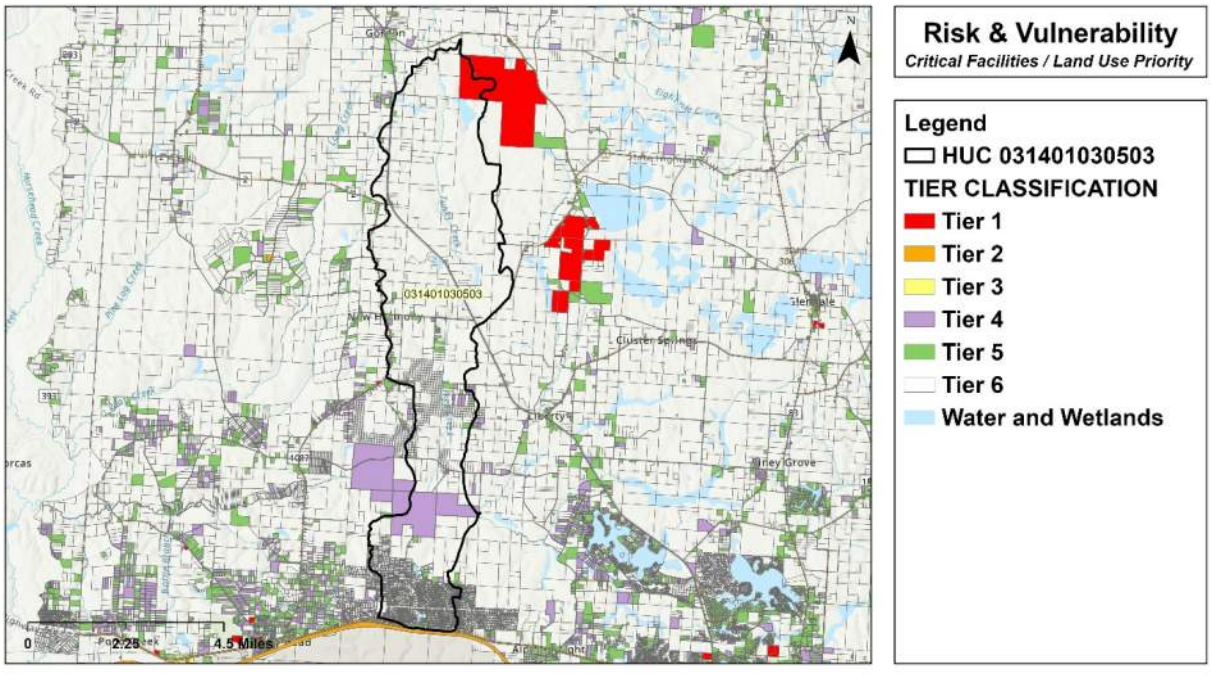

Figure 35. HUC 031401030503 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

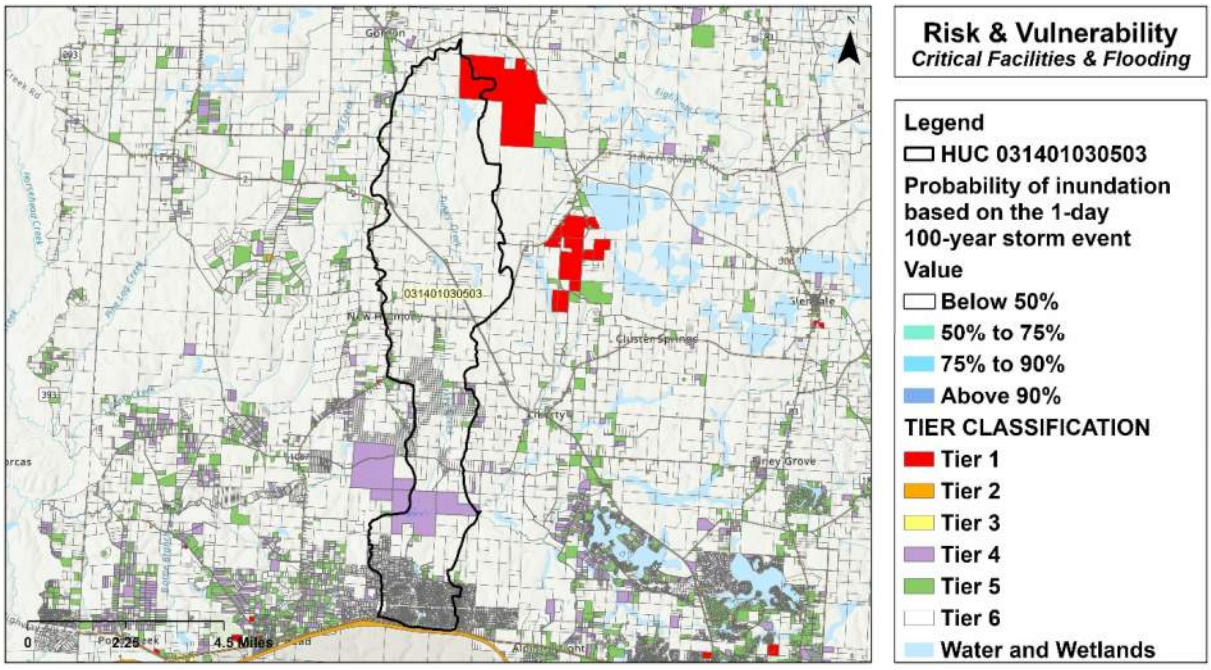

Figure 36. HUC 031401030503 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

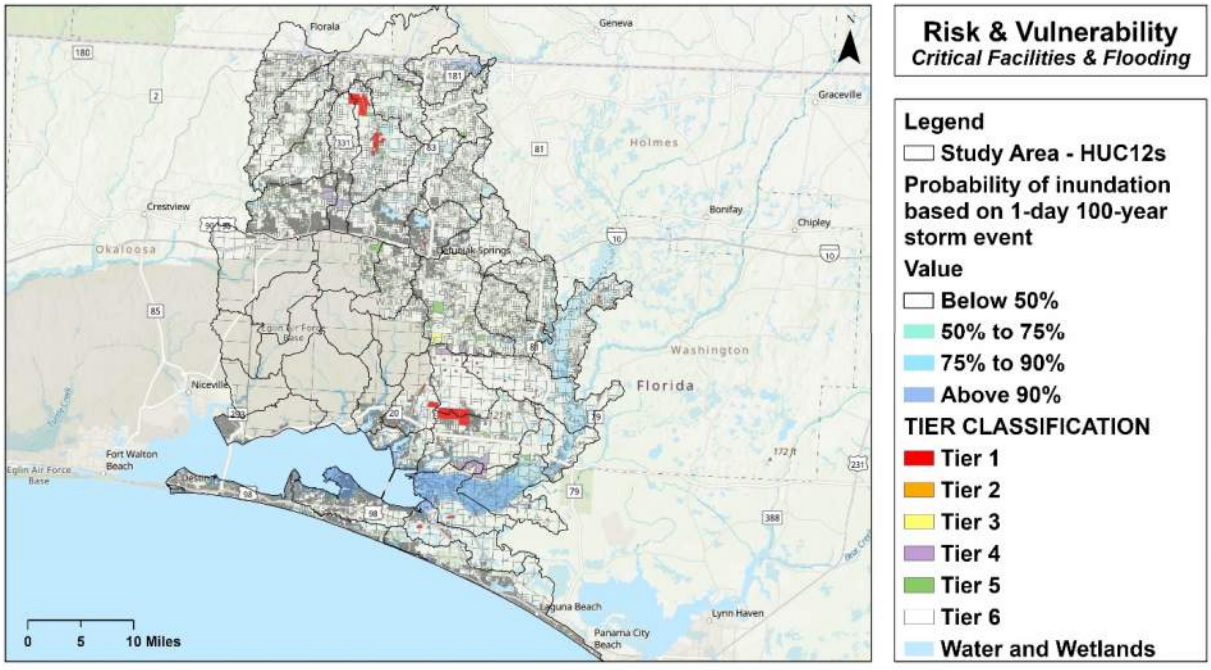

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

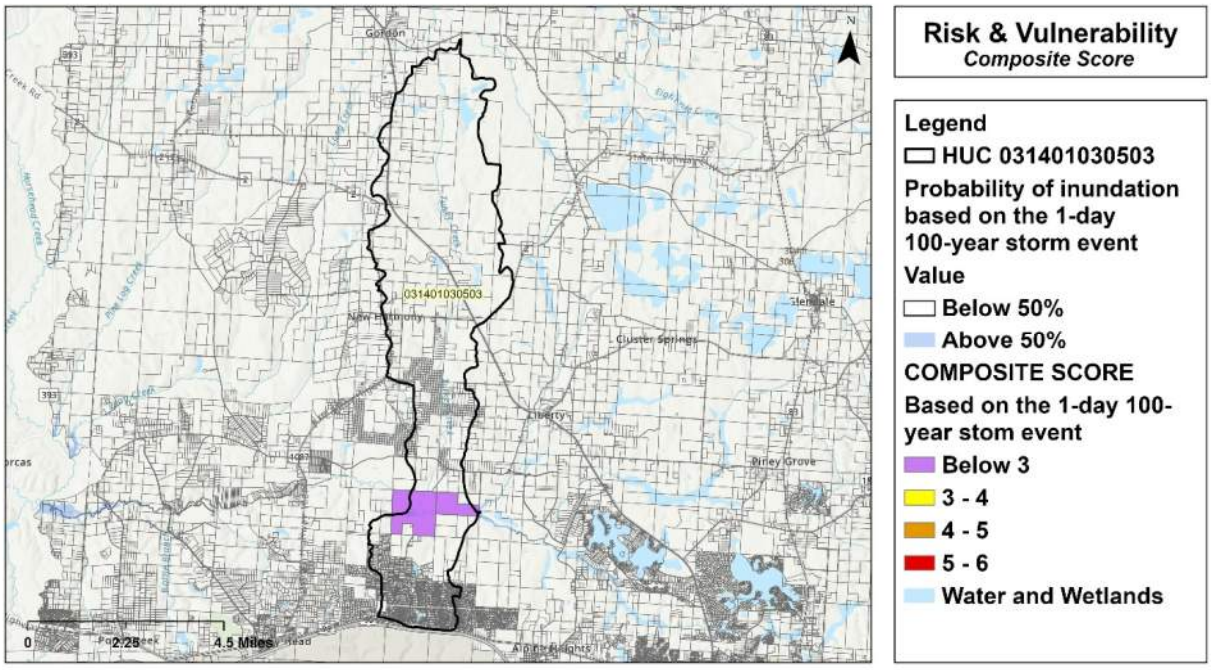

Figure 38. HUC 031401030503 sub-watershed Composite Score Risk map, with calculation based on 1-day 100-year storm event. Processed by FAU.

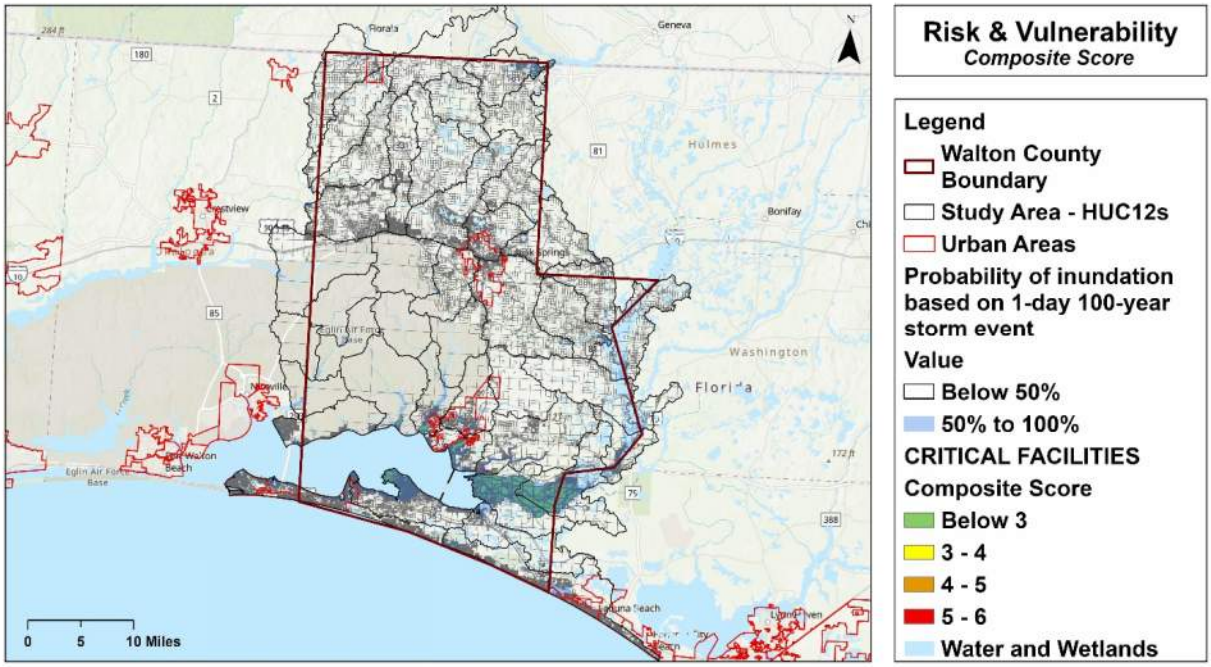

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

Please note that due to the scale of the map, the composite score layer is not properly visible in this map.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401030503. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It is important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401030503. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401030503	17000.11
All of the 1-day 100-year storm event inundation	**17.30**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	17.30
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	17.30

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. . **Error! Reference source**

not found. indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

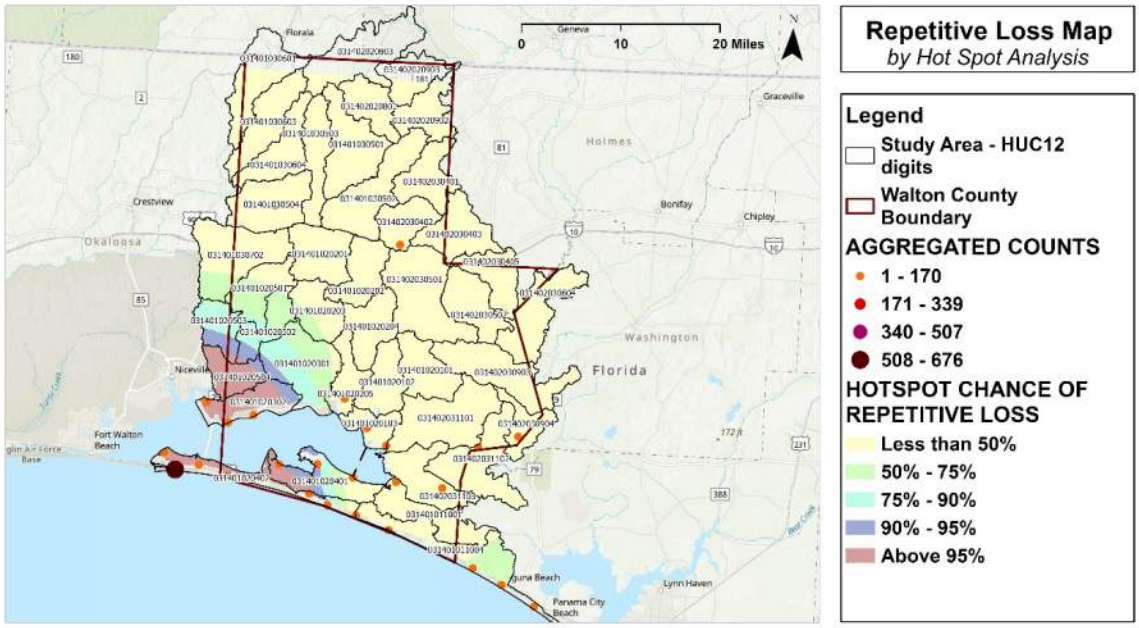

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5 Priority Projects

Although there are a few parcels falling within classification tier 1, and a good amount of parcels falling within tiers 4 and 5 of priority of land uses, only two of them are within the flooding zone, once flooding in the area is relatively minor and not alarming. Consequently, when considering the composite score, it is notable that there are only two parcels situated within the flooding zone that need some attention. They both have a score below 3, and are orphanages (DOR code 075), indicating a low priority of intervention.

APPENDIX W

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401030504

BOTTLE BRANCH-SHOAL RIVER

Principal Investigator: Frederick Bloetscher, Ph.D., P.E.

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401030504) is highlighted among all the HUCs to help identifying its location. (Figure 3).

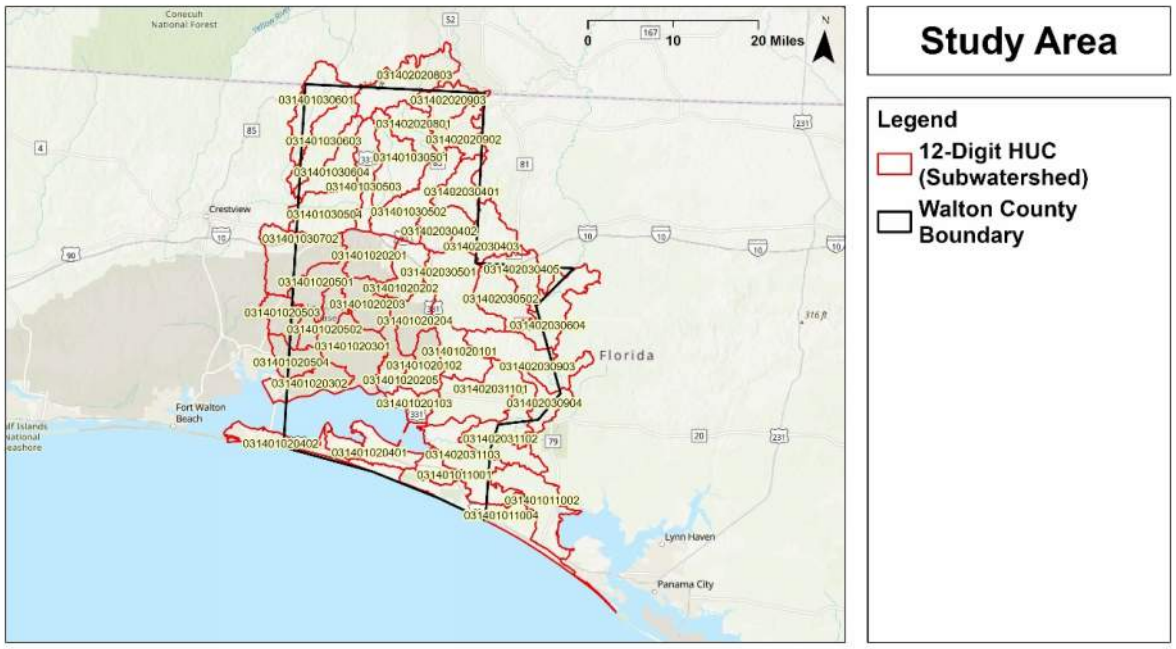

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

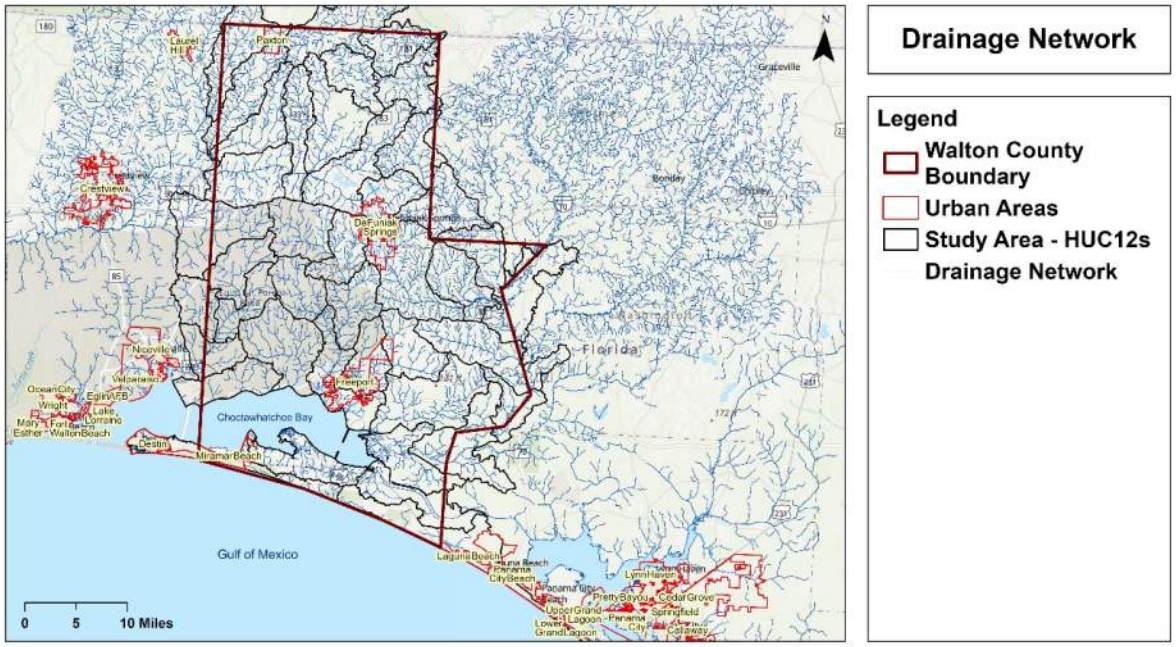

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

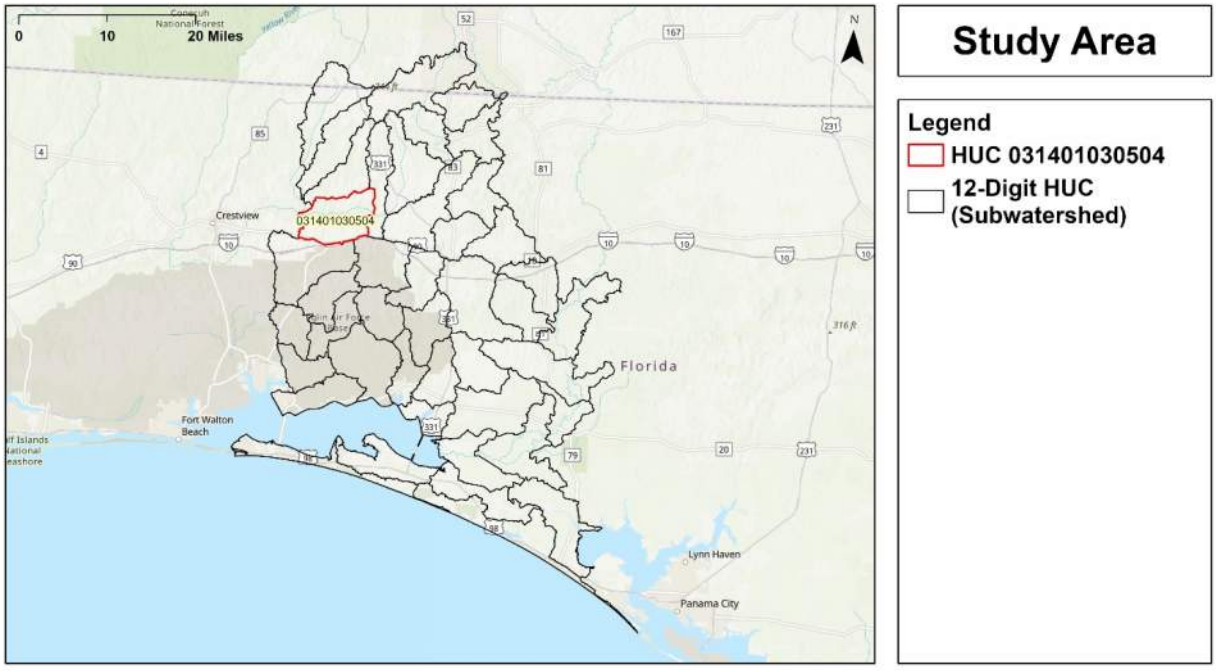

Figure 3. HUC 031401030504 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Based on the future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL))

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with

high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

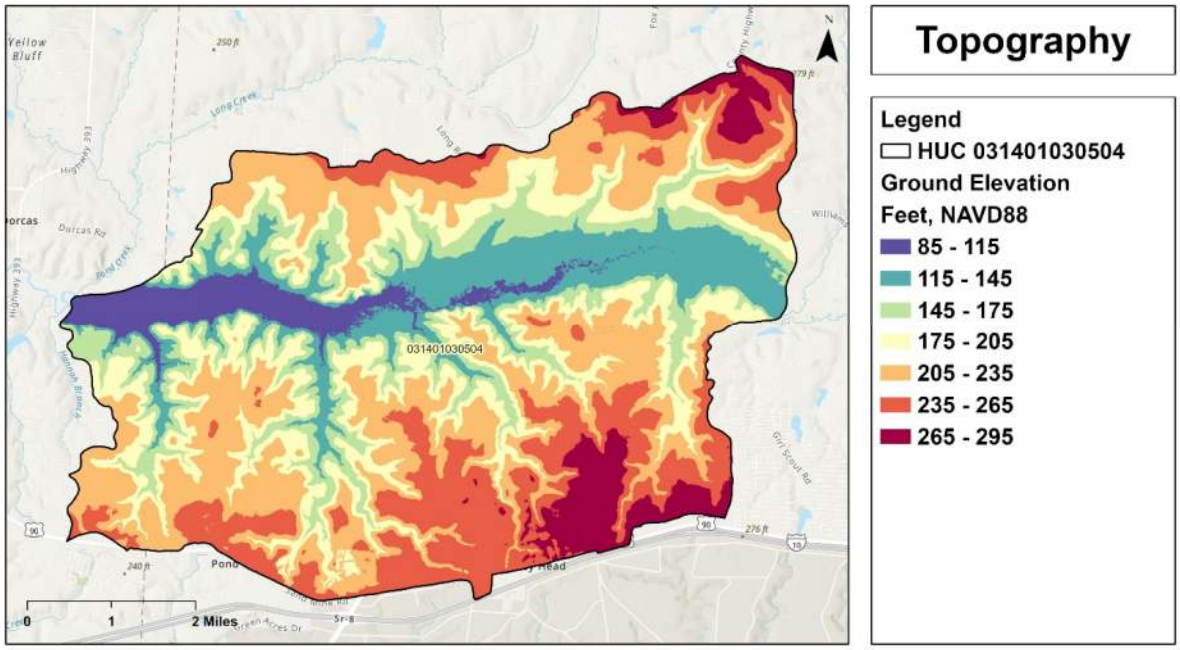

Figure 4. Topographic map of the HUC 031401030504 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of

wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology.
Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.
Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401030504 sub-watershed is shown in **Error! Reference source not found.**.

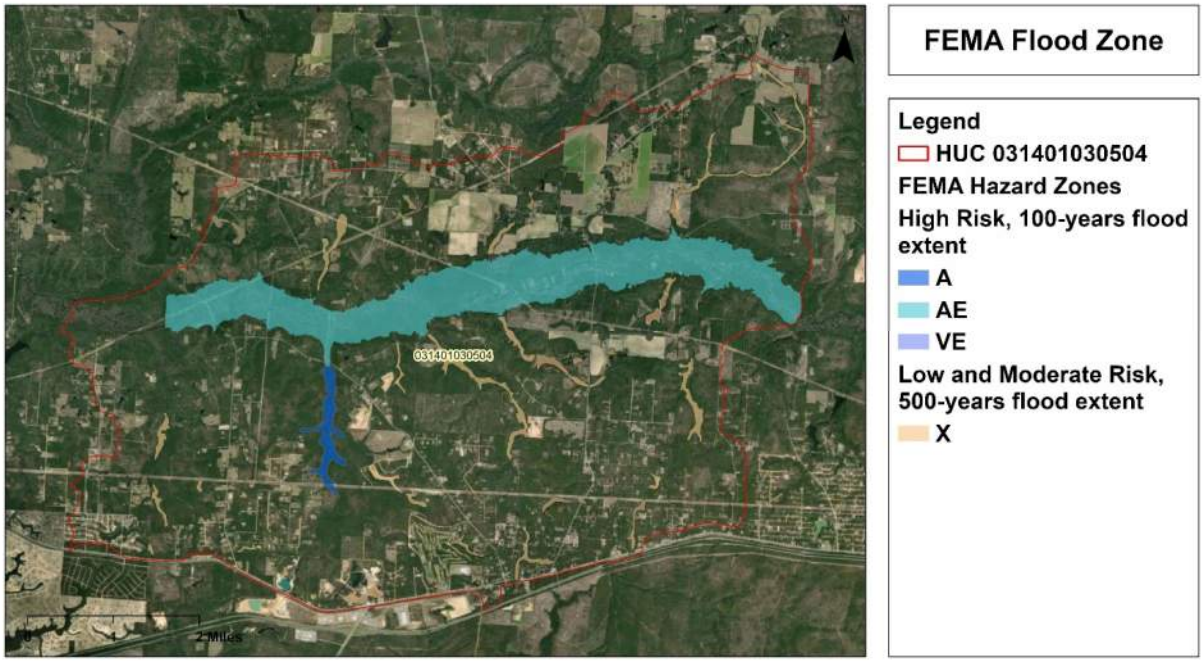

Figure 5. FEMA Flood Zone map (2020) for HUC 031401030504 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes,

including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401030504 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

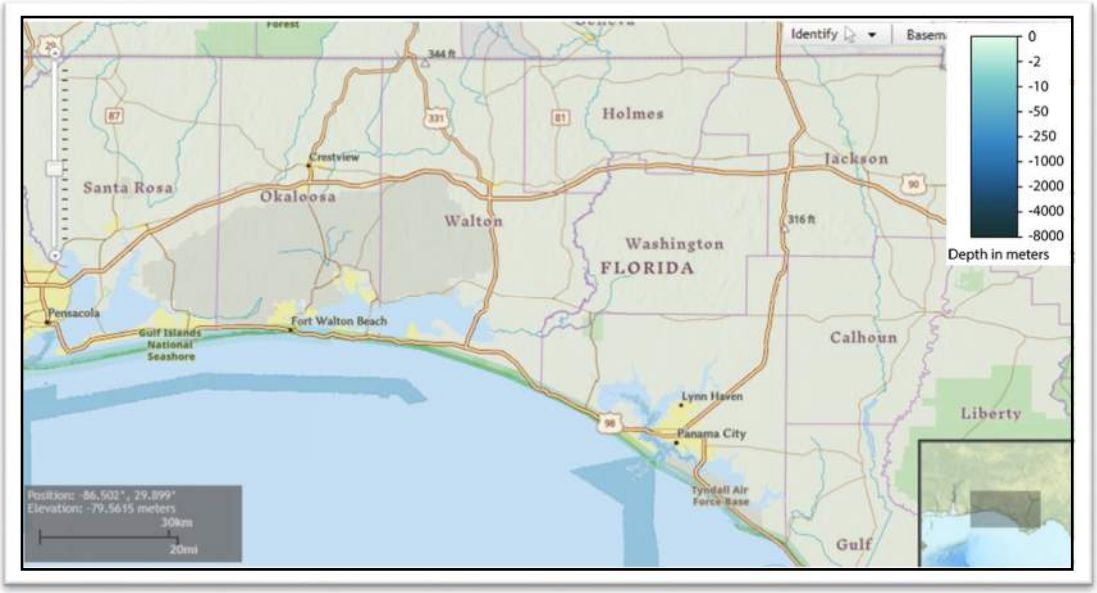

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle. Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological

conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

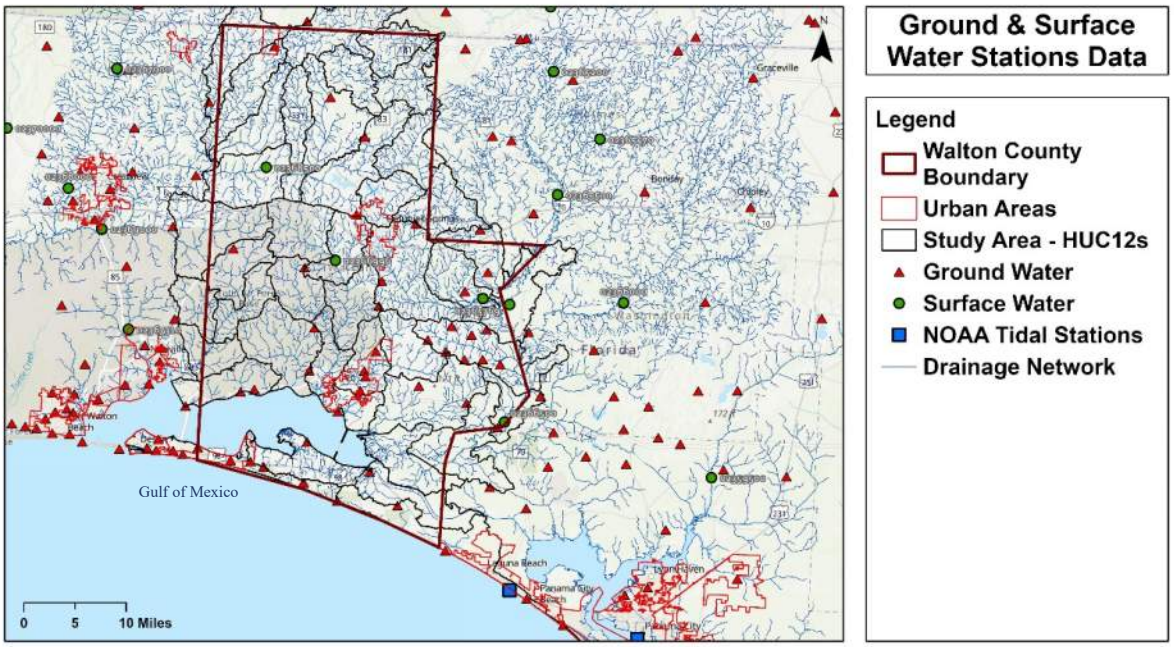

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The major water bodies in the HUC 031401030504 sub-watershed include:

- Shoal River
- Battle Creek

- Brown Branch
- Bottle Branch
- Boggy Branch
- Mill Creek
- Machine Branch
- Tan Branch
- Wolf Branch
- Tan Branch
- Laird Mill Creek

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02368500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401030503, which is USGS 02368500 Shoal River.

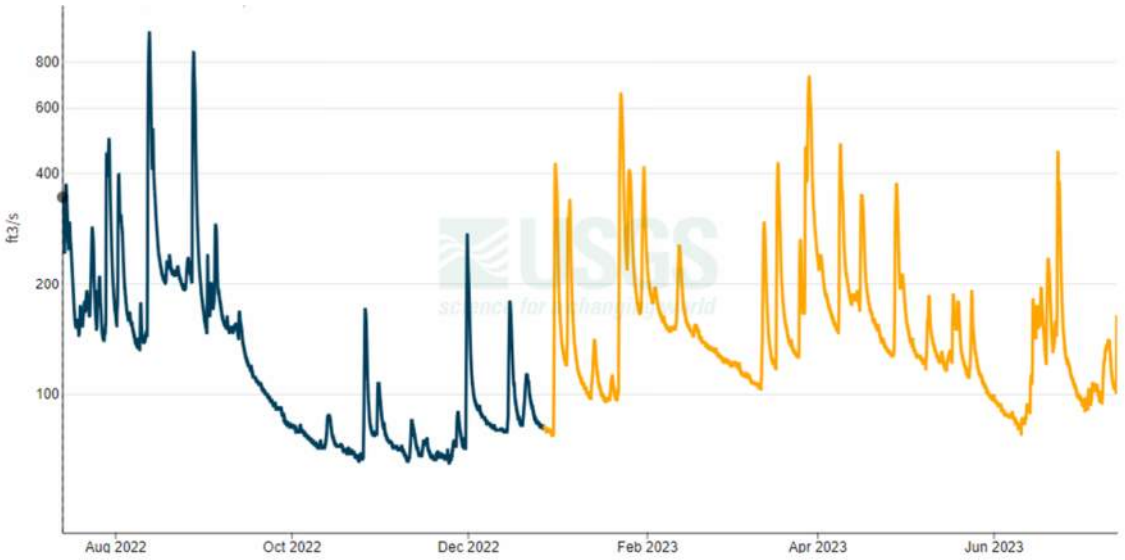

Figure 8. Average streamflow for Shoal River NR Mossy Head, Fla (USGS 02368500 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02368500/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish

a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401030504 and points out the location of the ground water station in the surroundings. A groundwater-surface layer for the HUC 031401030504 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

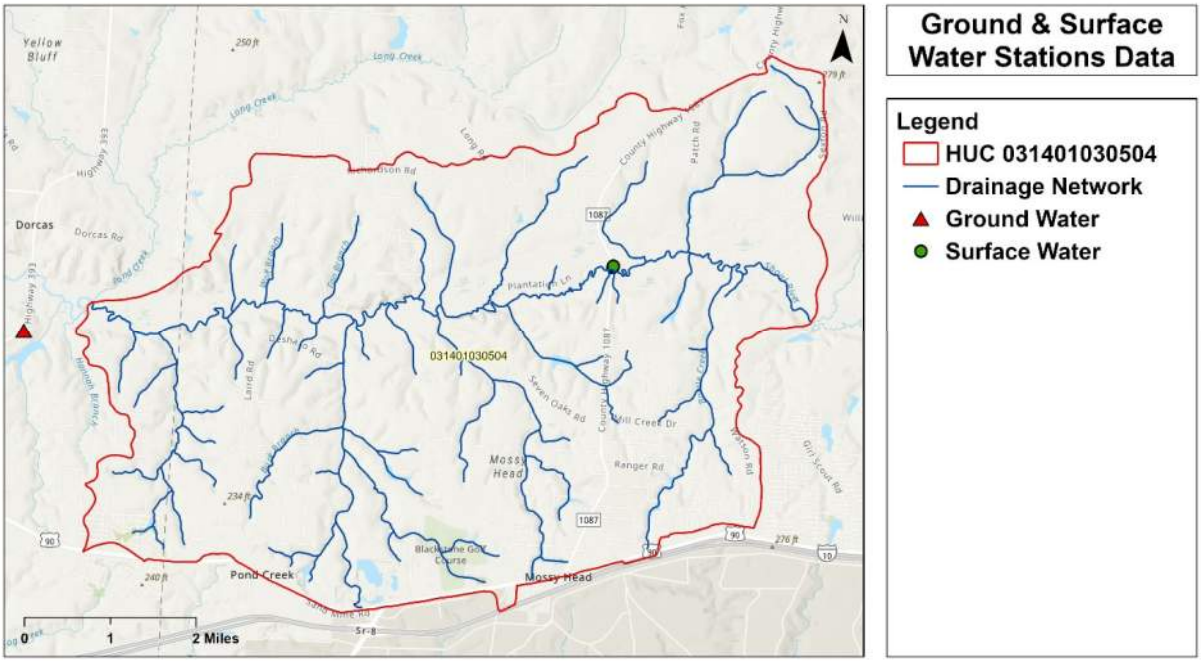

Figure 9. Ground and Surface Water Stations in the HUC 031401030504 sub-watershed, processed by FAU.

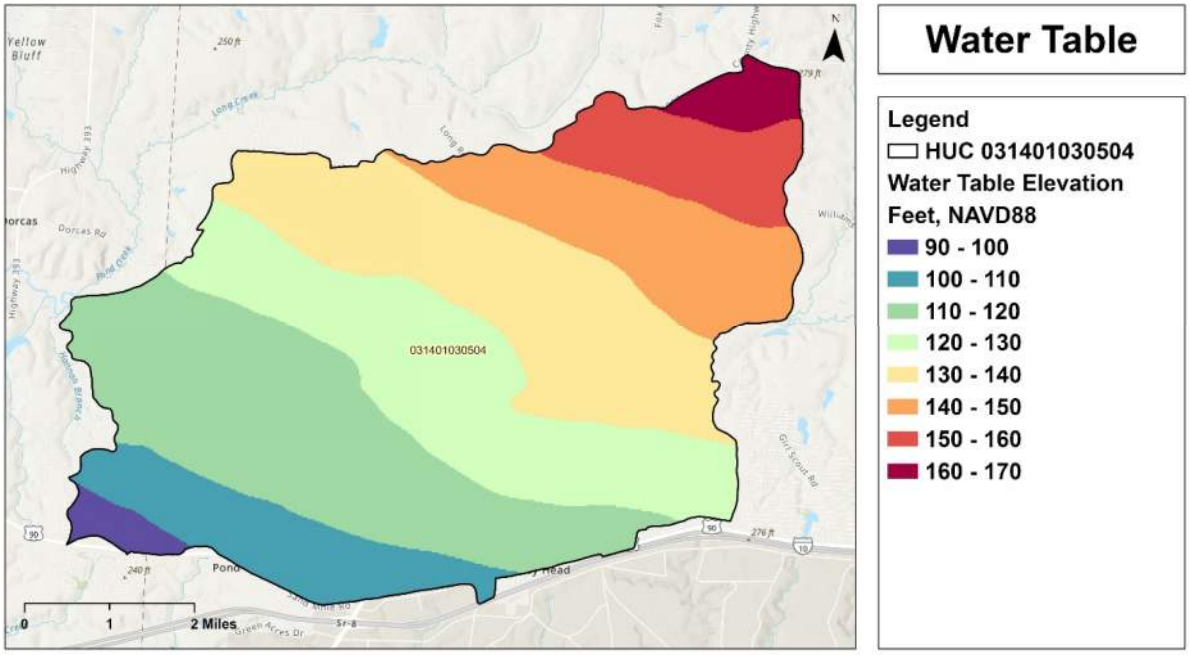

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401030504 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

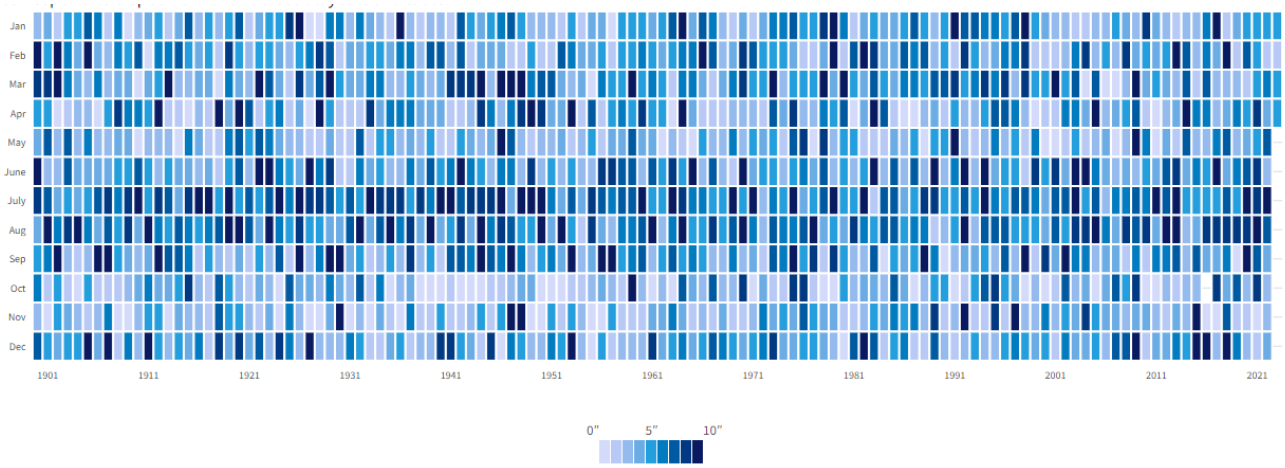

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/).

While the topography (Section 2.1) and native soil (Section 2.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is none NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

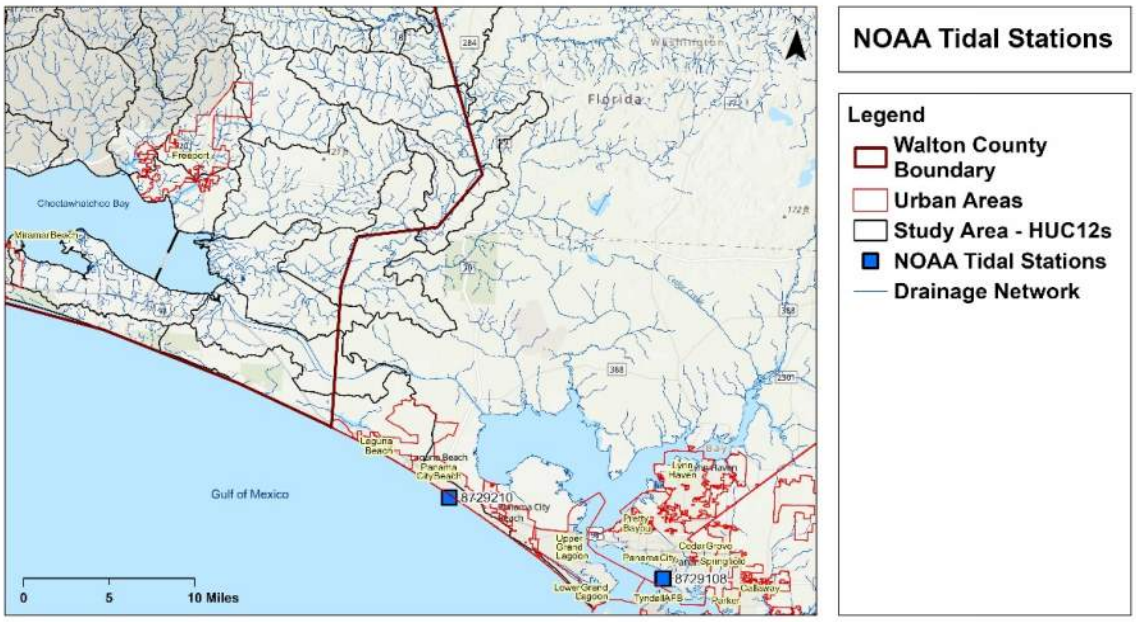

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

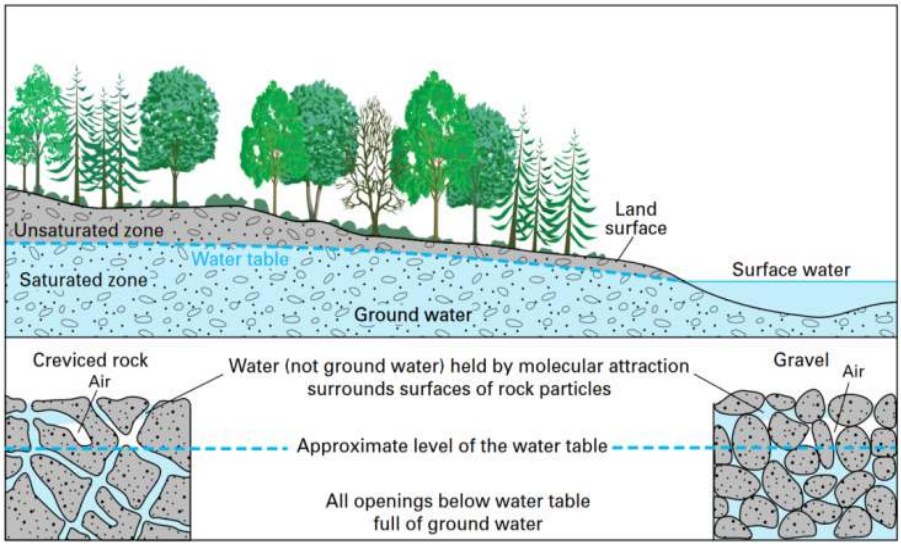

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

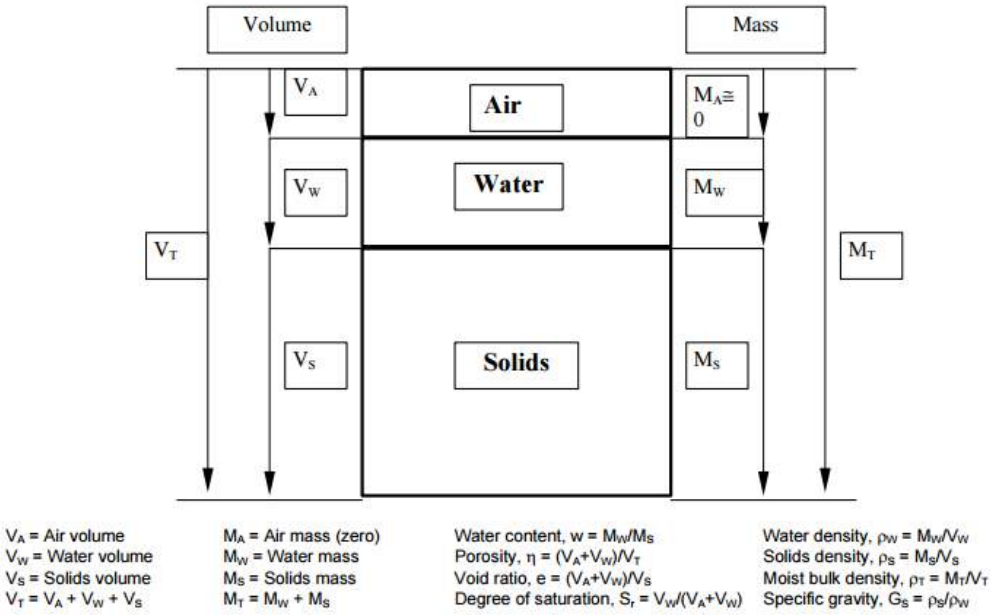

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

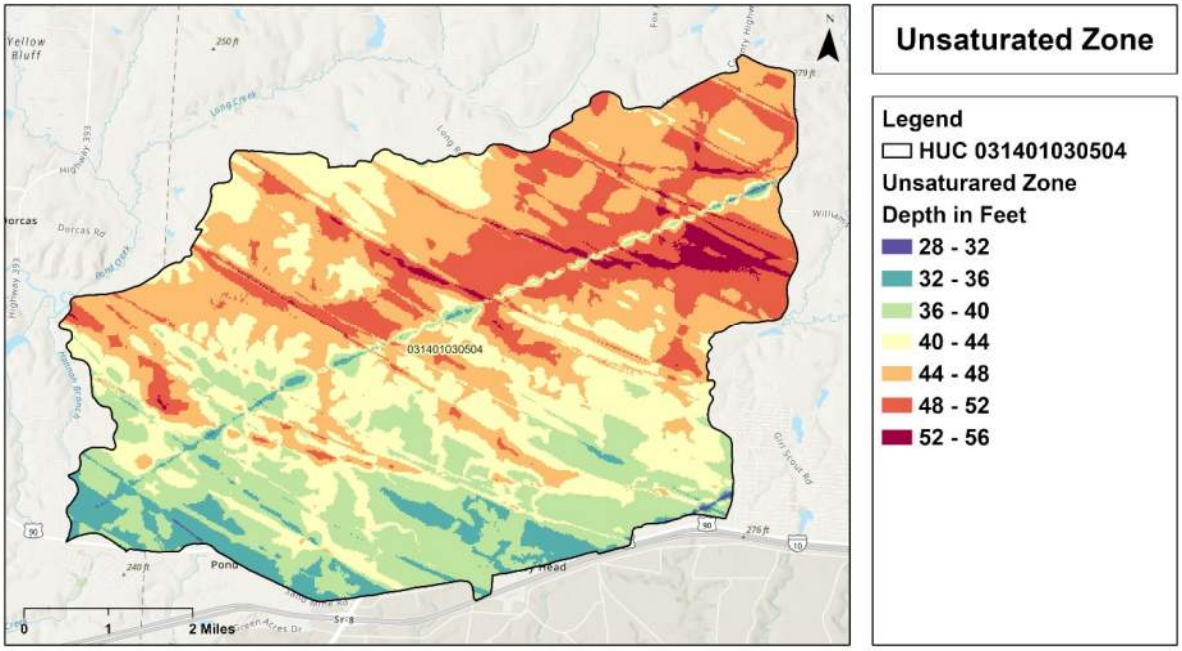

Figure 15. Unsaturated zone map for HUC 031401030504, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated.

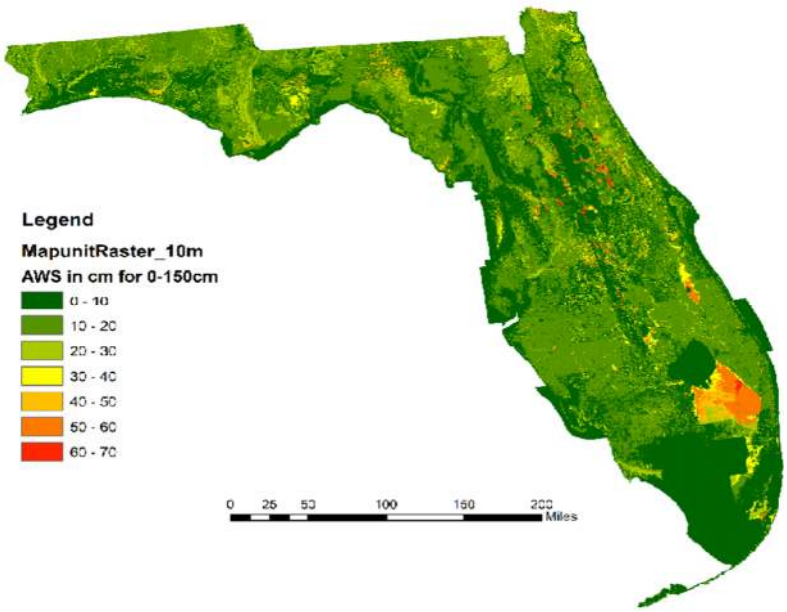

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, processed by FAU.

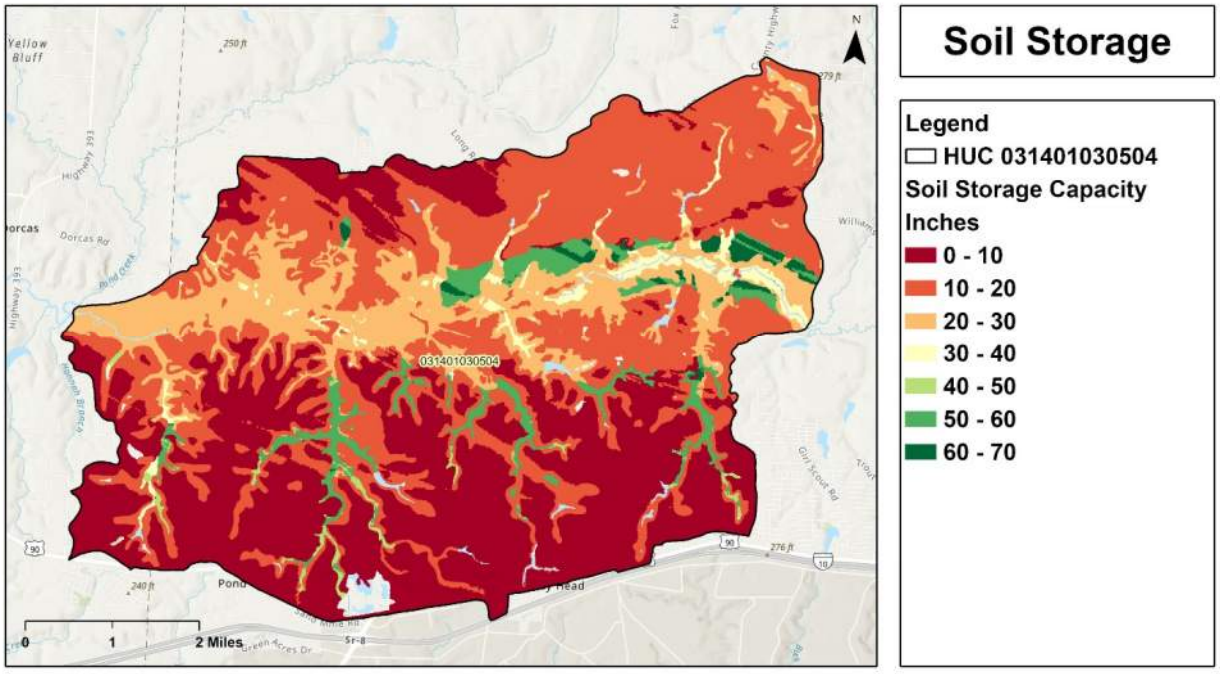

Figure 17. Water storage capacity of soil for the HUC 031401030504, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

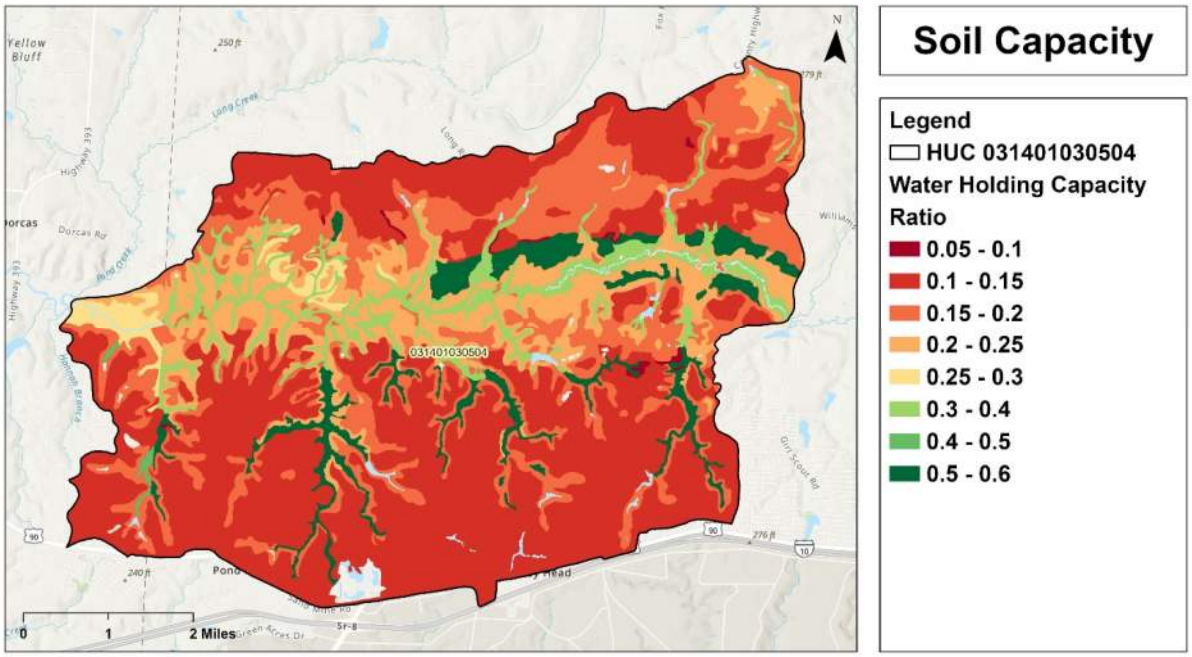

Figure 18. Water Holding Capacity (ratio) for the HUC 031401030504, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

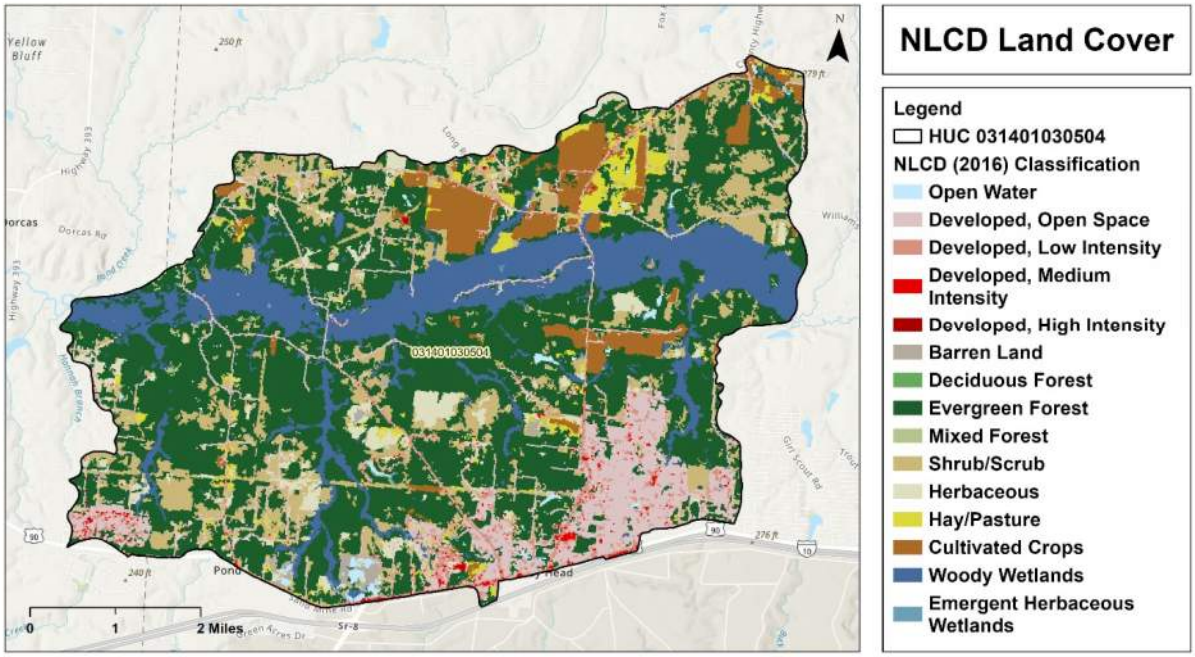

Figure 19. Land use in the HUC 031401030504 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps were used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

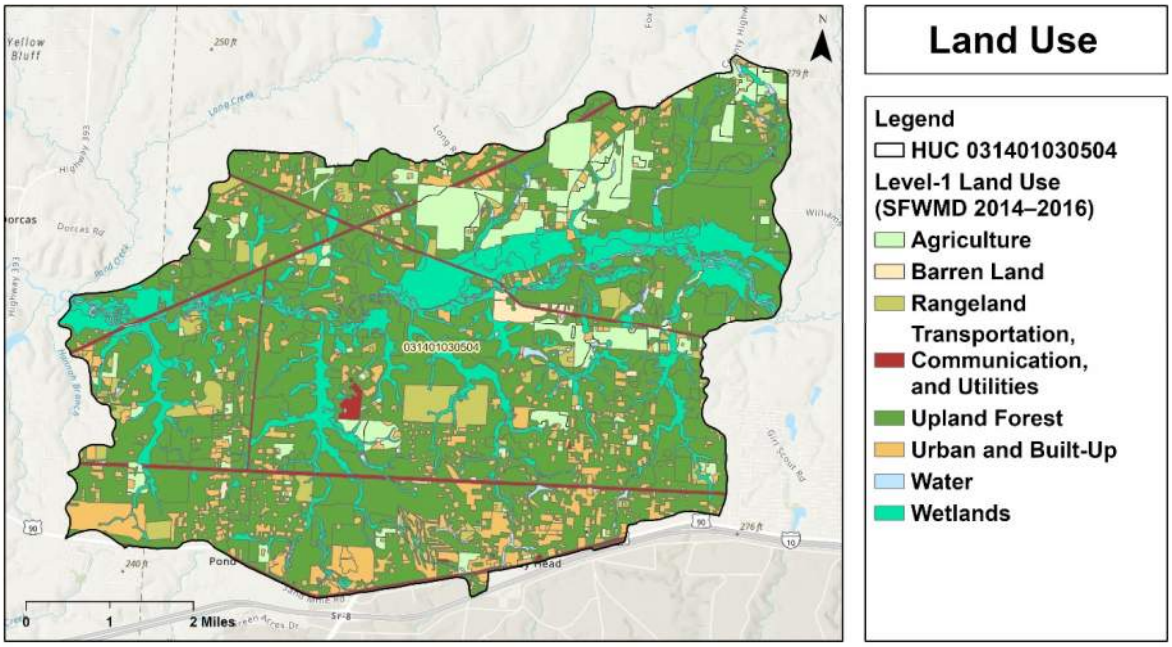

Figure 20. Land use in the HUC 031401030504 (from the 2023 Florida Geographic Data Library (FGDL) database), processed by FAU.

In the HUC 031401030502 sub-watershed, mostly of the area is upland forest, with 51.85%. The second place is wetland, with 12.95% followed by Transportation, Communication, and Utilities, with 12.14%. Urban and built-up also represent a good amount, with 10.33% of the total, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031401030502 subwatershed (from the 2023 Florida Geographic Data Library (FGDL) database).

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	2098.72	6.94%
Barren Land	165.04	0.55%
Rangeland	1102.05	3.64%
Transportation, Communication, and Utilities	3670.46	12.14%
Upland Forest	15681.31	51.85%
Urban and Built-Up	3124.41	10.33%
Water	484.09	1.60%
Wetlands	3915.29	12.95%
Grand Total:	**30241.37**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

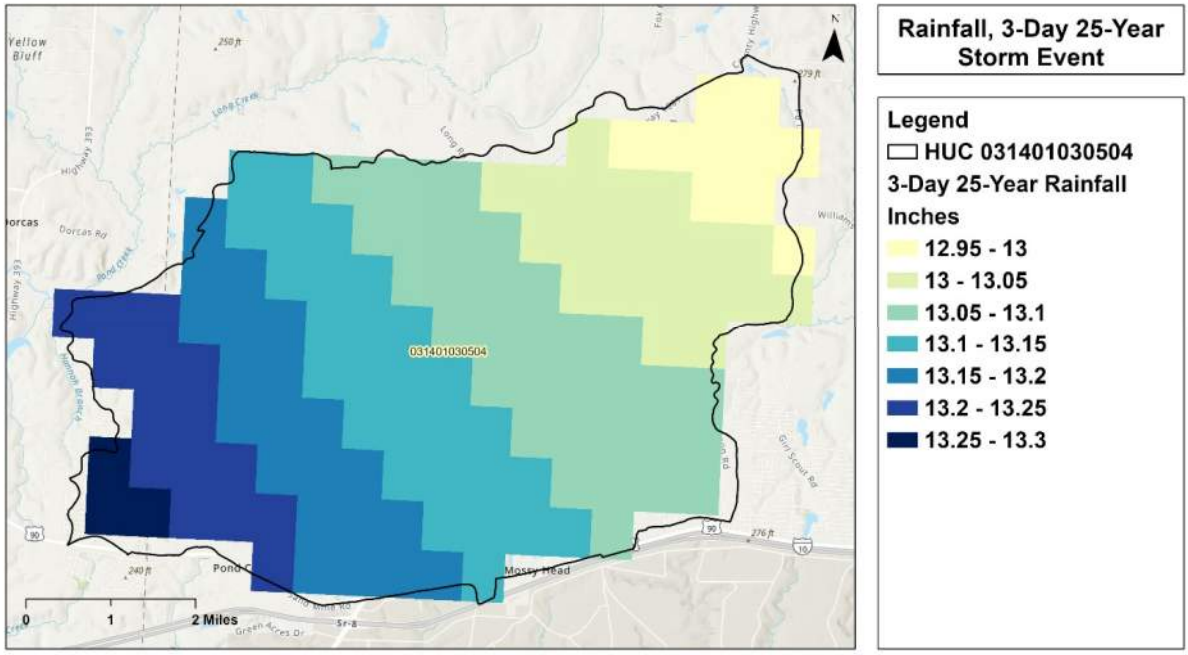

Figure 21. Rainfall distribution map across HUC 031401030504 sub-watershed, for 3-day 25-year storm event, processed by FAU.

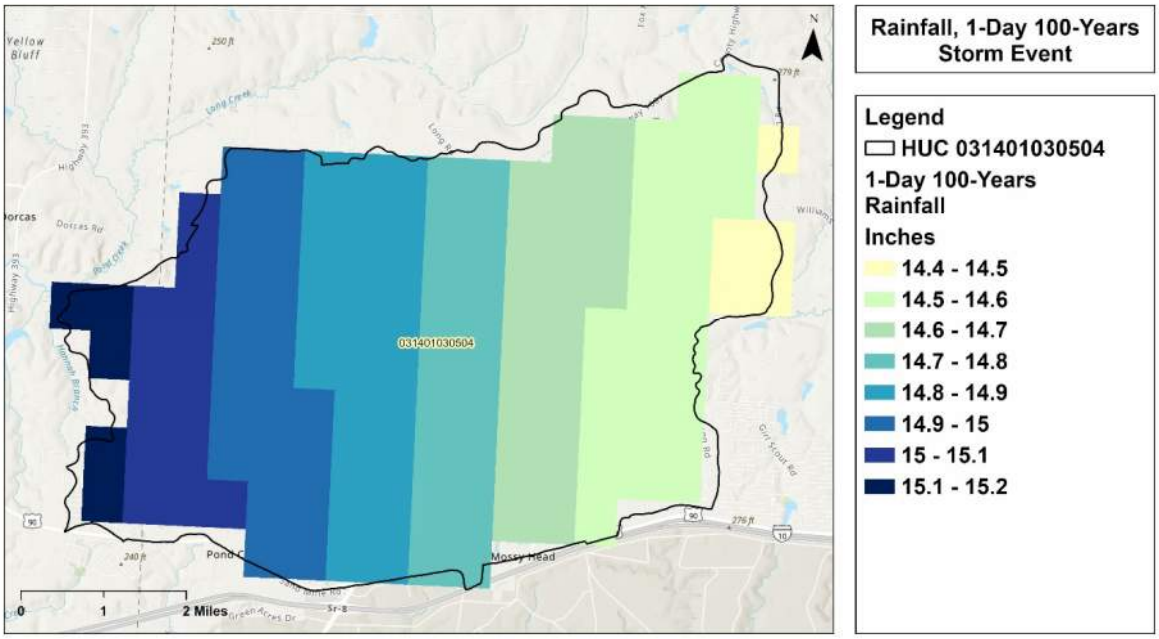

Figure 22. Rainfall distribution map across HUC 031401030504 sub-watershed, for 1-day 100-year storm event, processed by FAU.

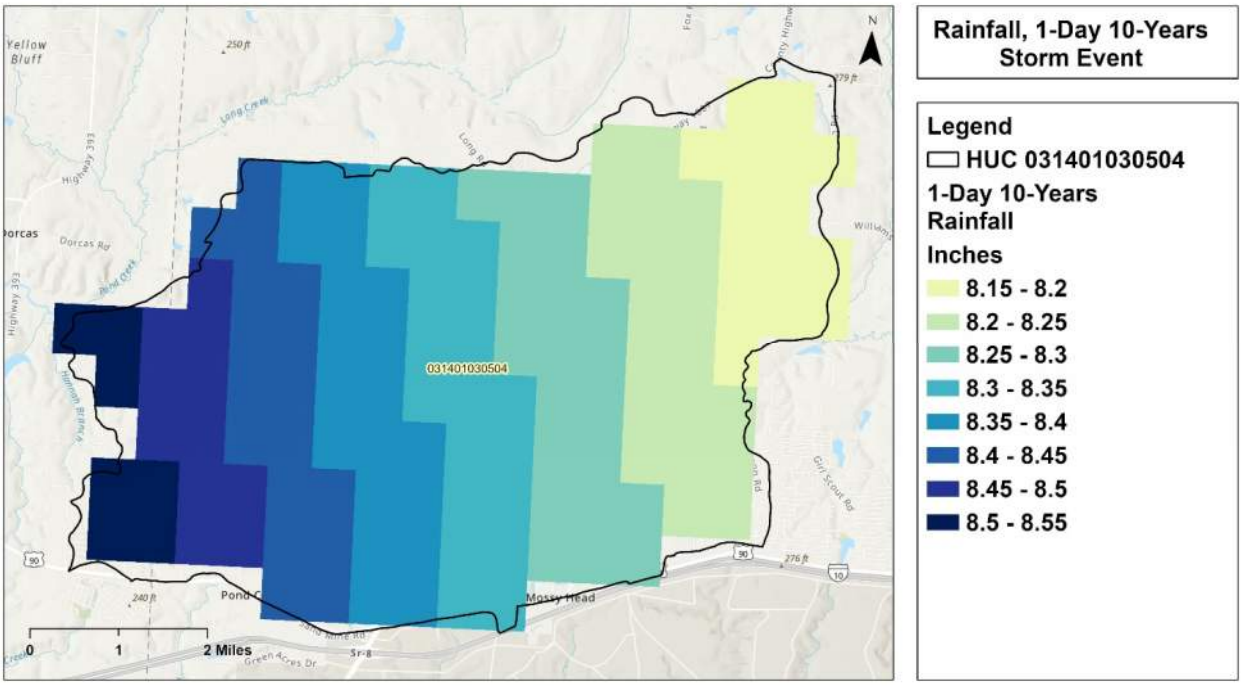

Figure 23. Rainfall distribution map across HUC 031401030504 sub-watershed, for 1-day 10-year storm event, processed by FAU.

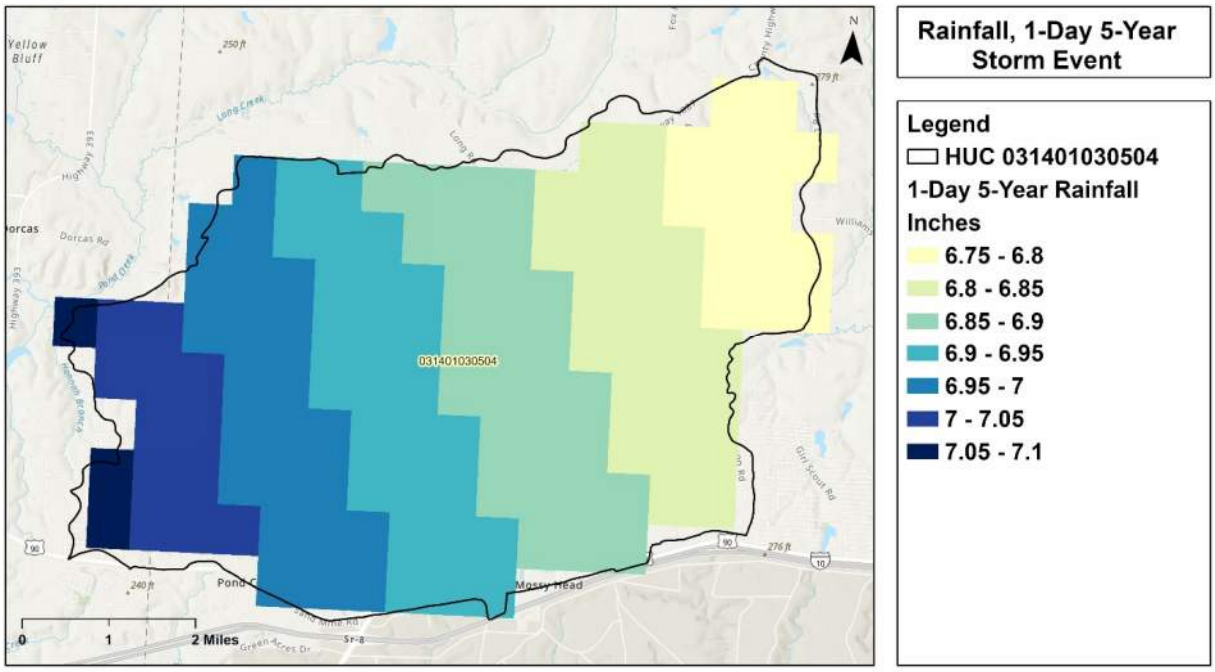

Figure 24. Rainfall distribution map across HUC 031401030504 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically

aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

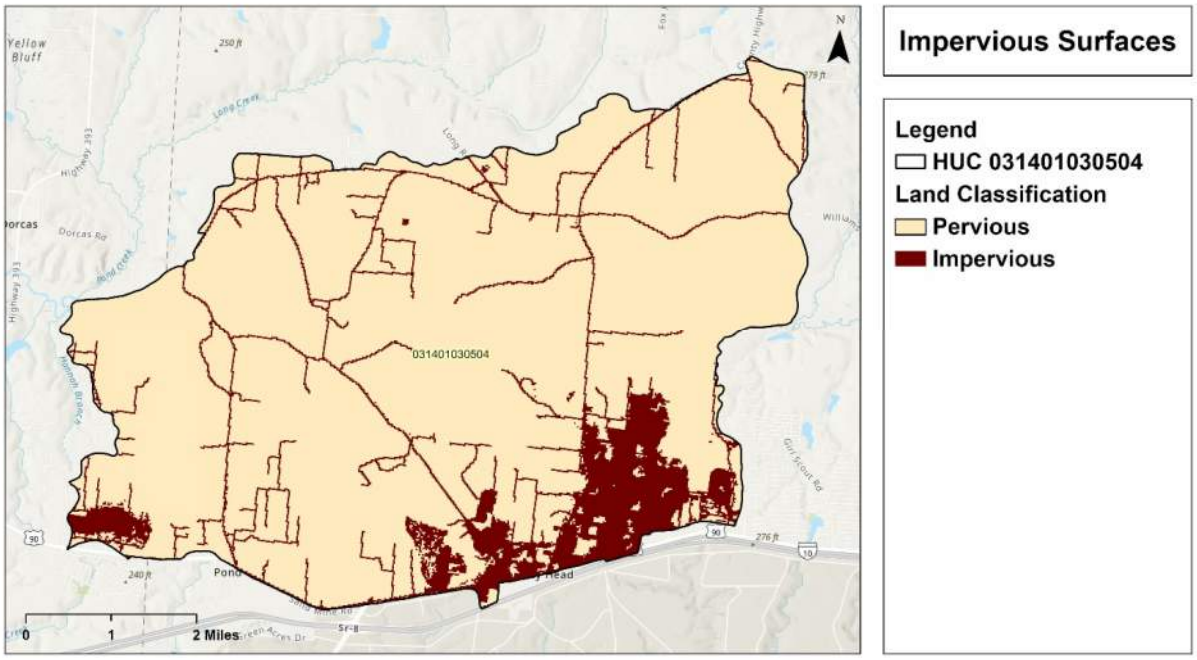

Figure 25. Impervious area map for the HUC 031401030504 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

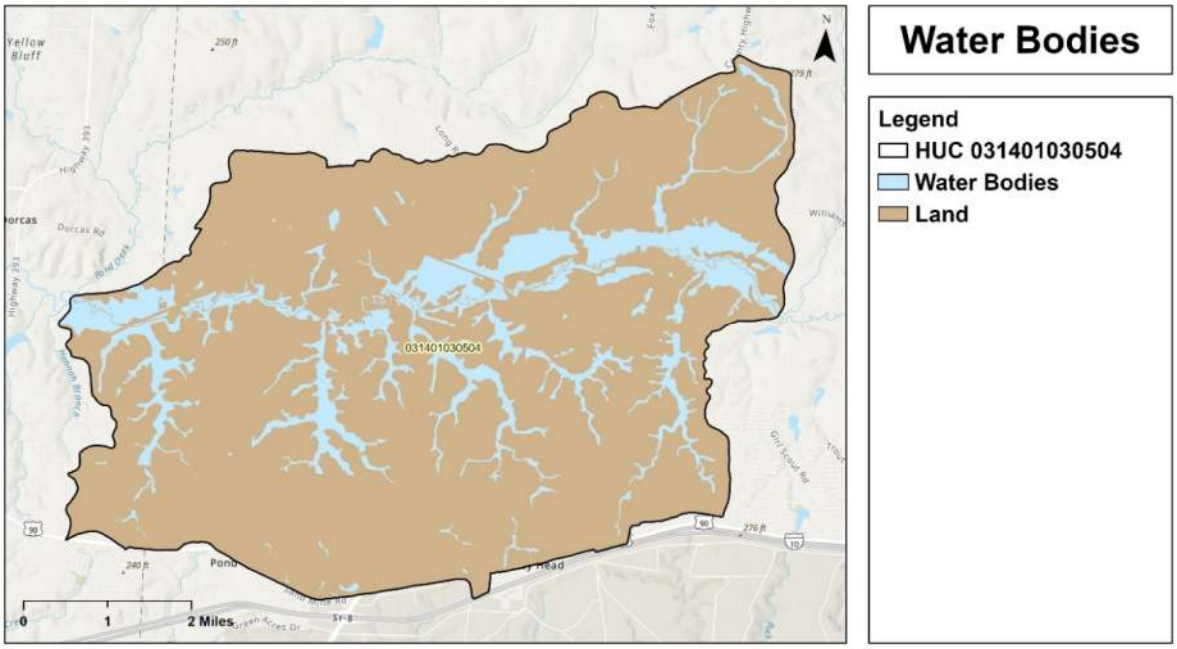

Figure 26. Water bodies map for the HUC 031401030504 sub-watershed, processed by FAU.

1.10. Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs,

property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.** respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

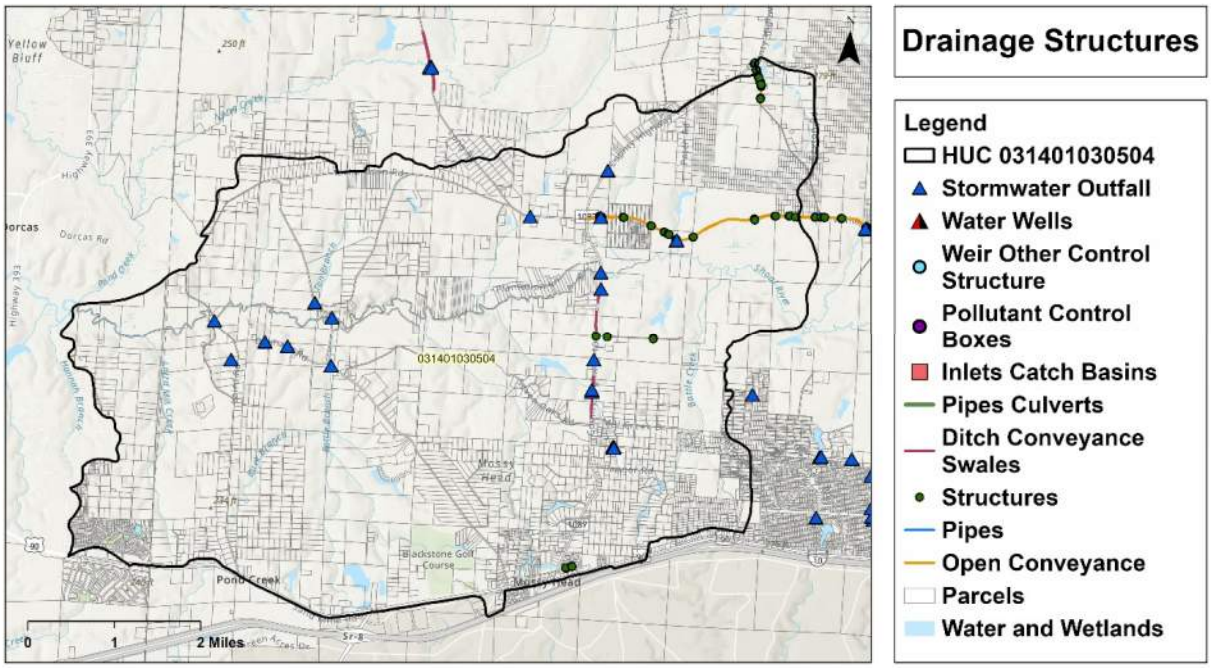

Figure 27. Stormwater Infrastructure for the HUC 031401030504. Processed by FAU.

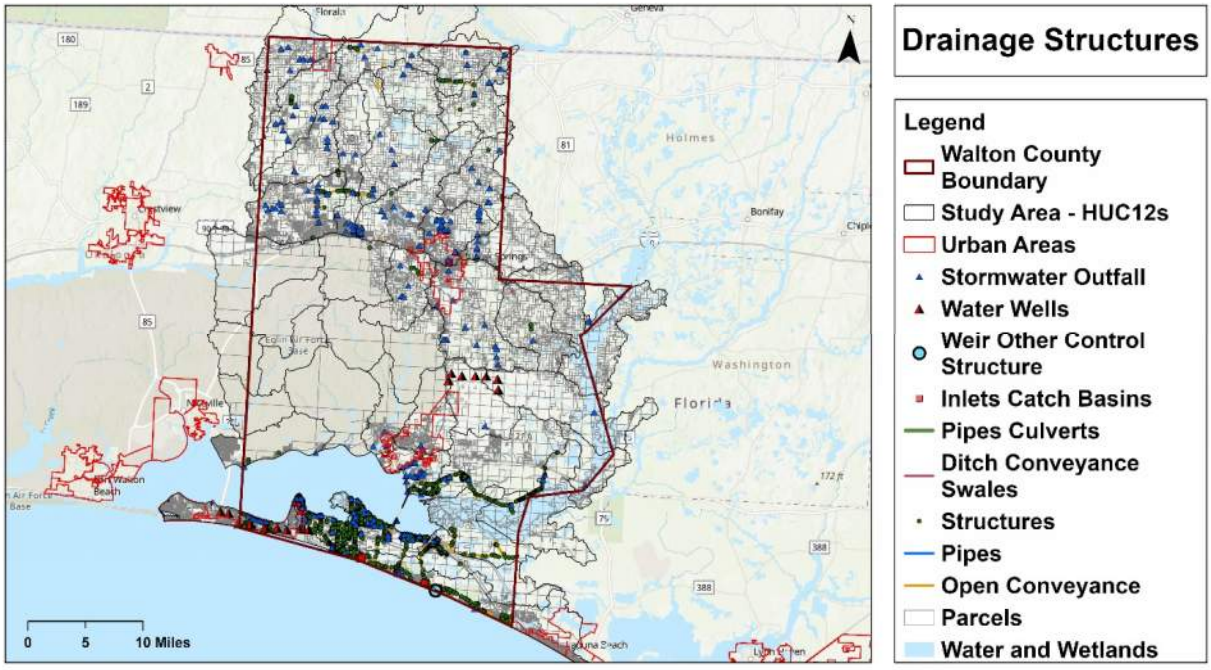

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020)

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401030504 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

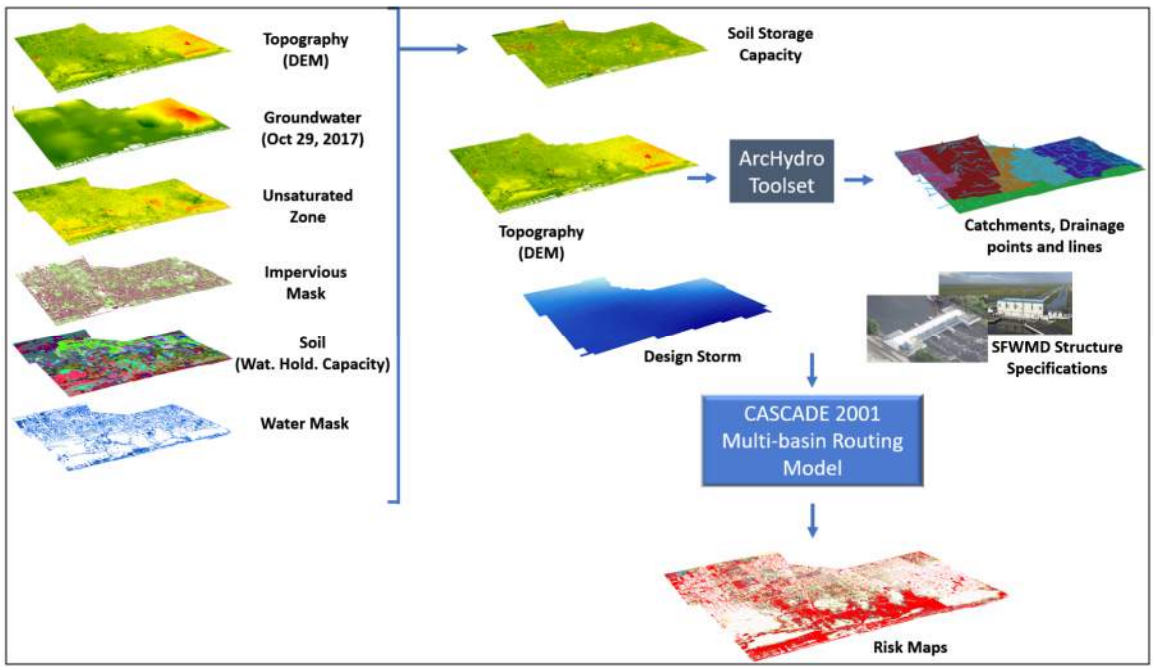

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)

= 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

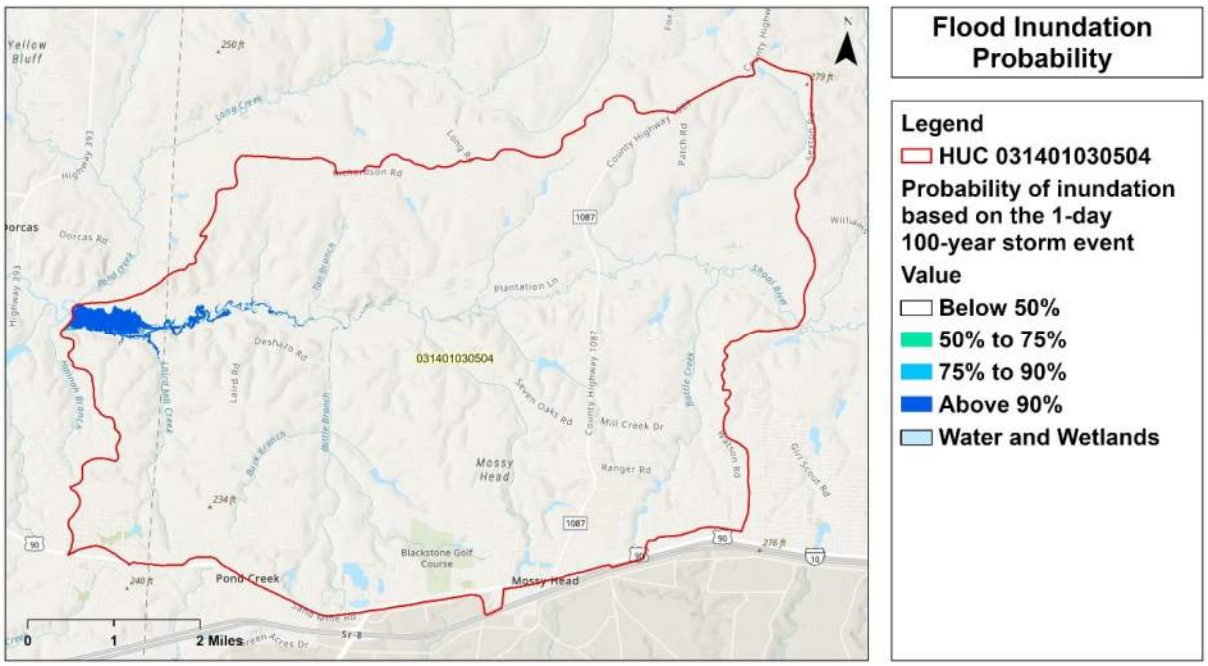

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401030504, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data

to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a small portion of flooding is noted at the entrance of Shoal River into the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, sea level rise should not impact the HUC, therefore SLR scenarios were not calculated.

The design storm simulation determined that approximately 0.8% of the HUC total area or 0.29 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 0.9% of the HUC's total area, or 0.36 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.6% of the HUC's total area, or 0.23 mi^2, would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0.4% of the HUC's total area, or 0.17 mi^2, would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401030504 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	37.69	0.29	99.2%	0.8%
1-day 100-year	37.62	0.36	99.1%	0.9%
1-day 10-year	37.75	0.23	99.4%	0.6%
1-day 5-year	37.81	0.17	99.5%	0.4%

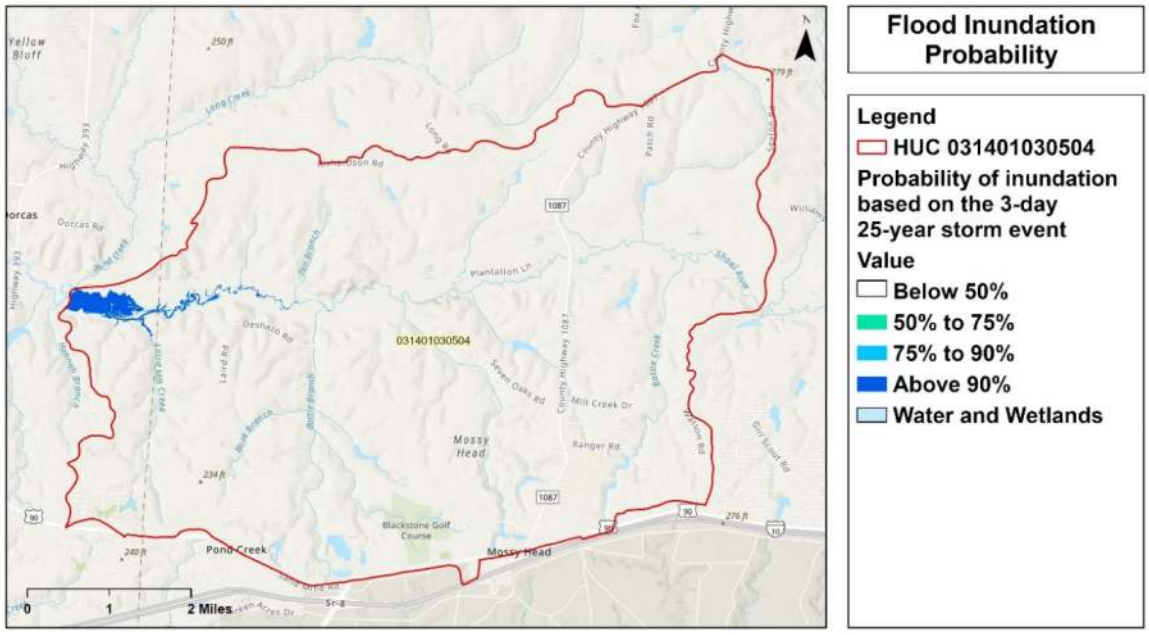

Figure 31. 3-day 25-year storm event for HUC 031401030504 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

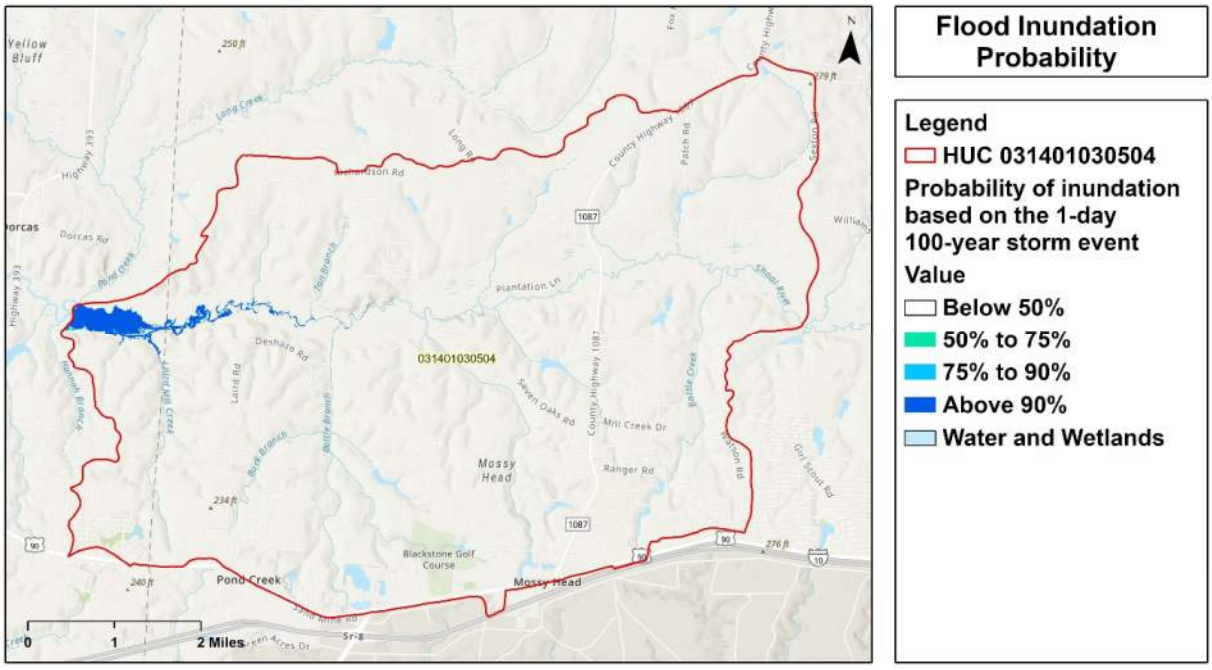

Figure 32. 1-day 100-year storm event for HUC 031401030504 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

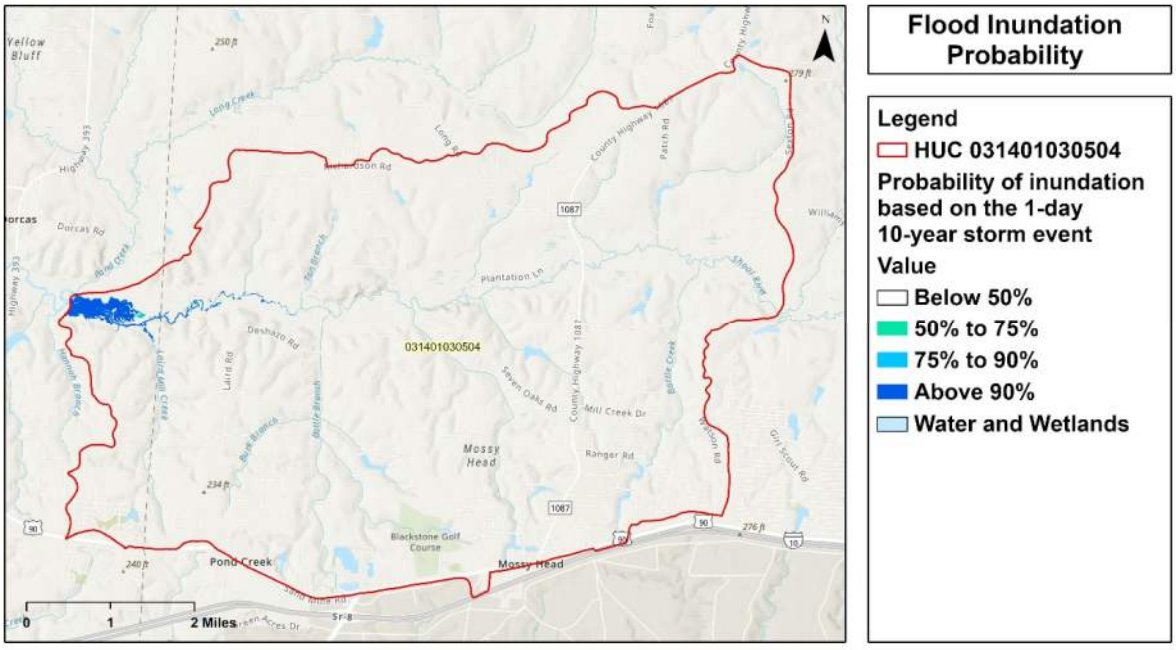

Figure 33. 1-day 10-year storm event for HUC 031401030504 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

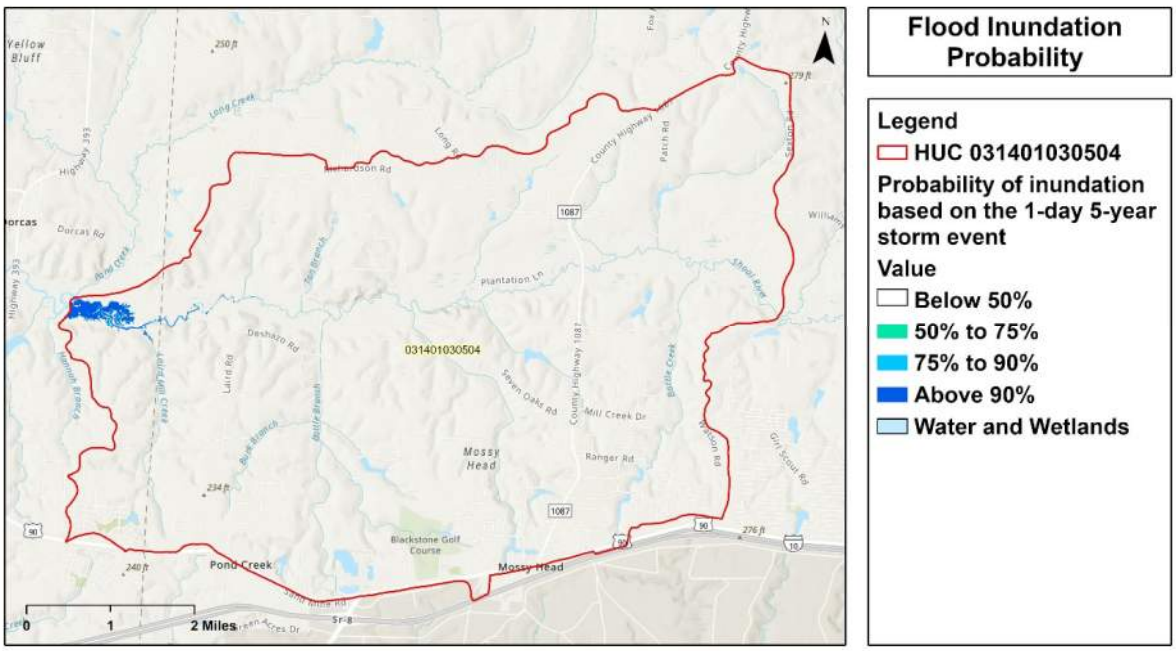

Figure 34. 1-day 5-year storm event for HUC 031401030504 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older,

poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service,	3

	Electric Repair, Laundries, Laundromats	
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6

50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1

84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031401020504 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (

Figure 36) overlays critical facilities onto the 1-day 100-year storm event scenario.

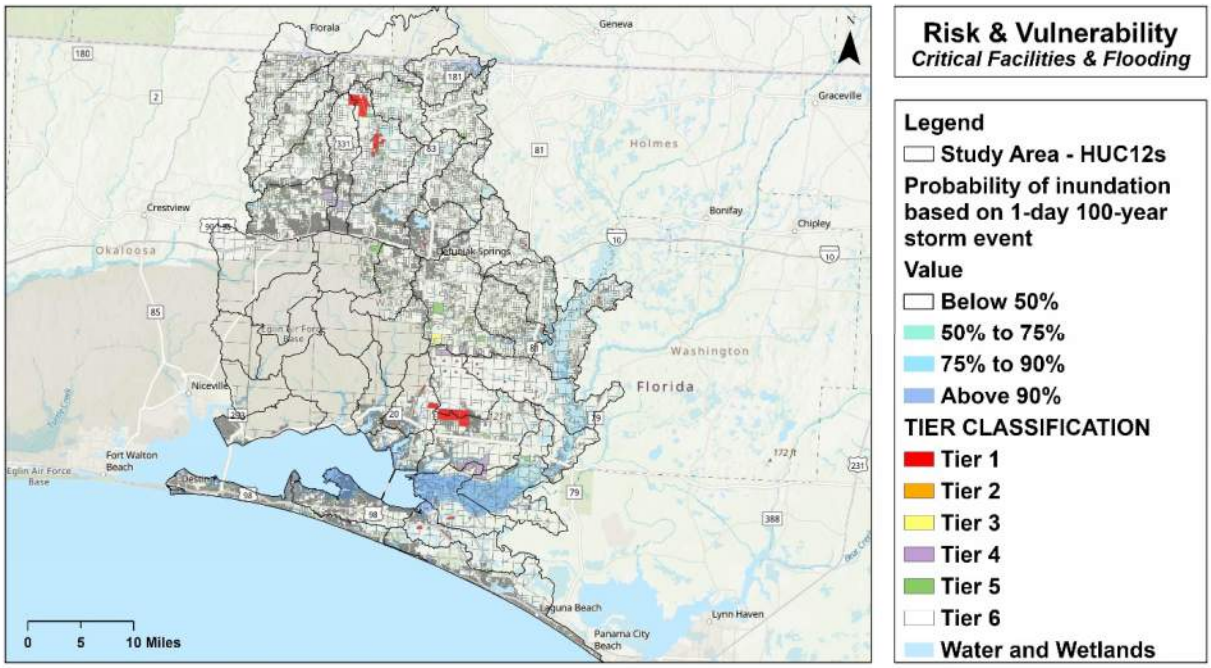

Figure 37 is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally,

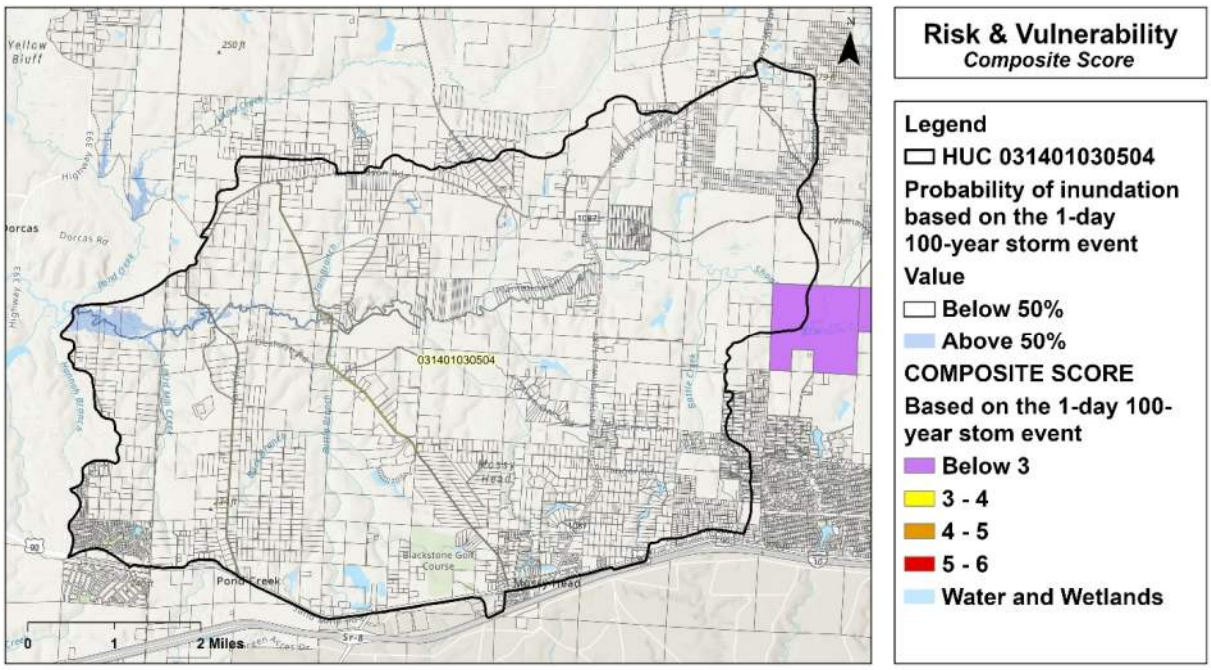

Figure 38 illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly,

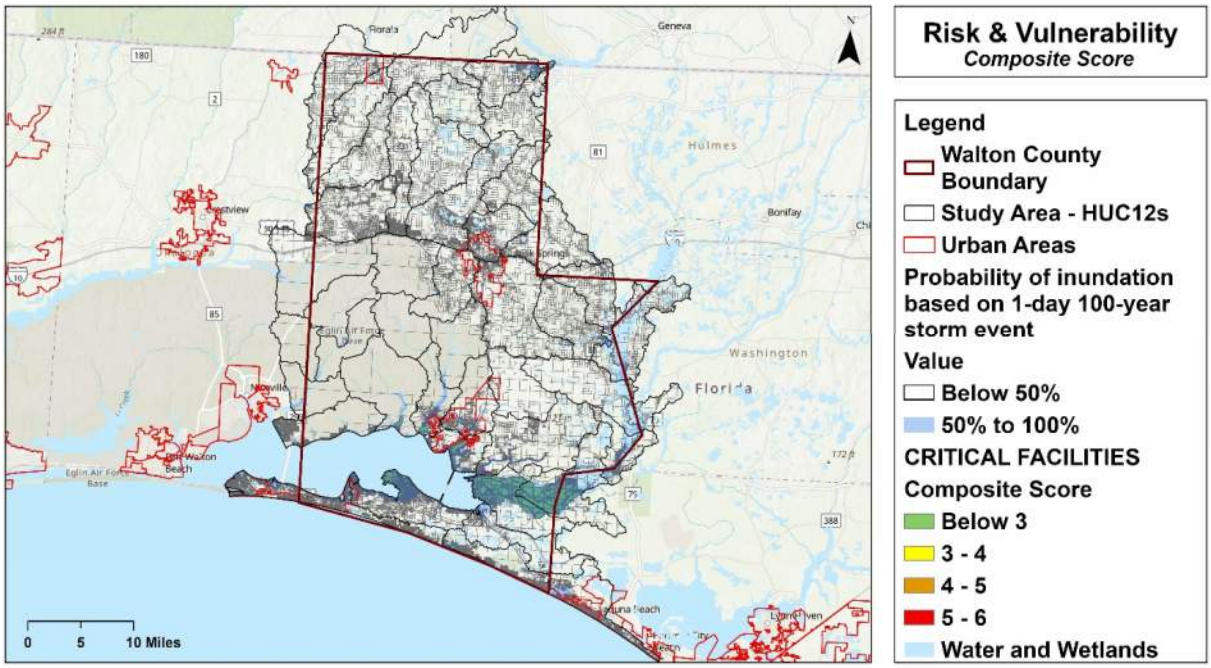

Figure 39 is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

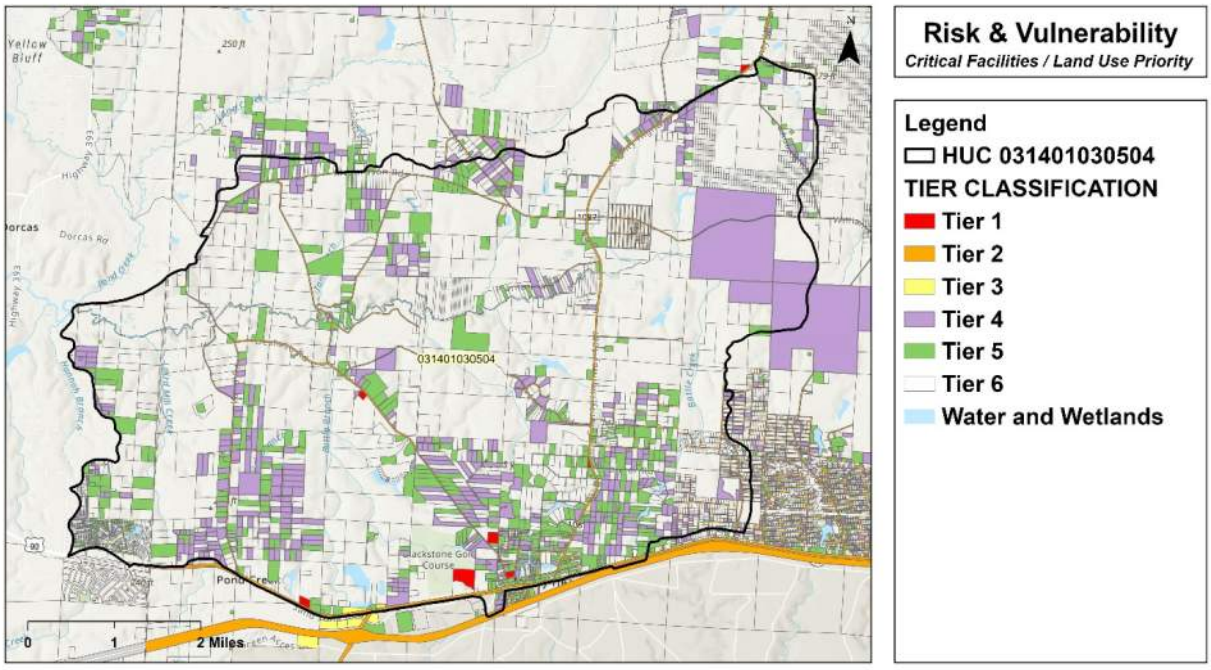

Figure 35. HUC 031401020504 sub-watershed Critical Facilities (priority of land uses) map.

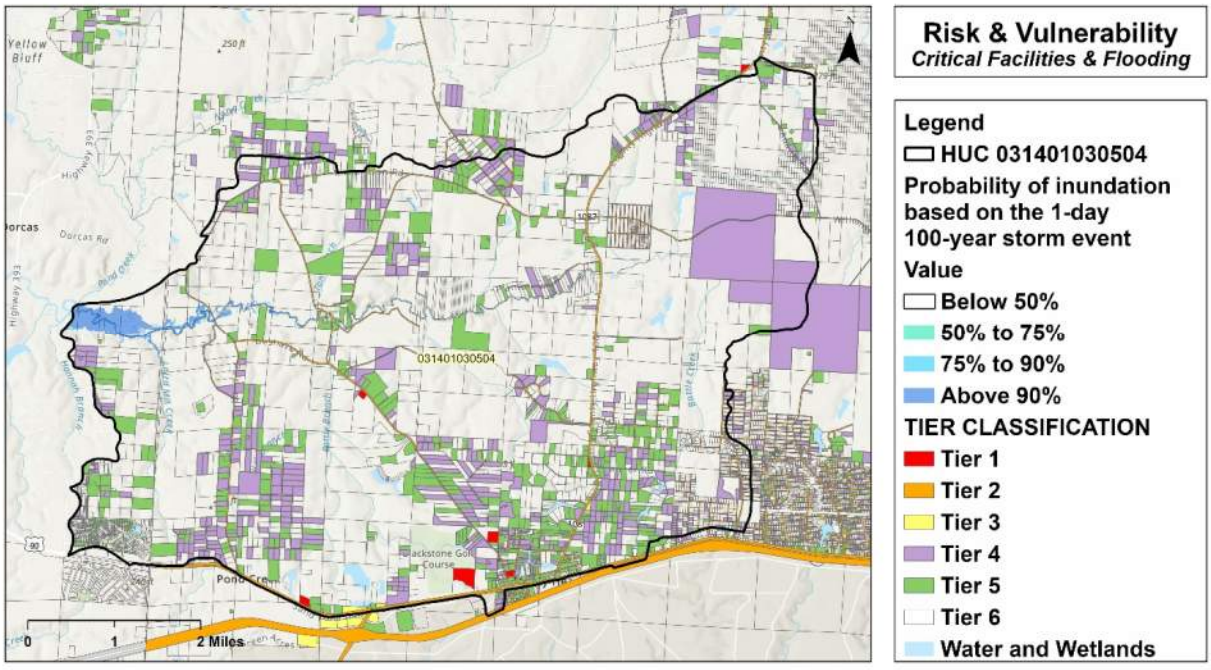

Figure 36. HUC 031401020504 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

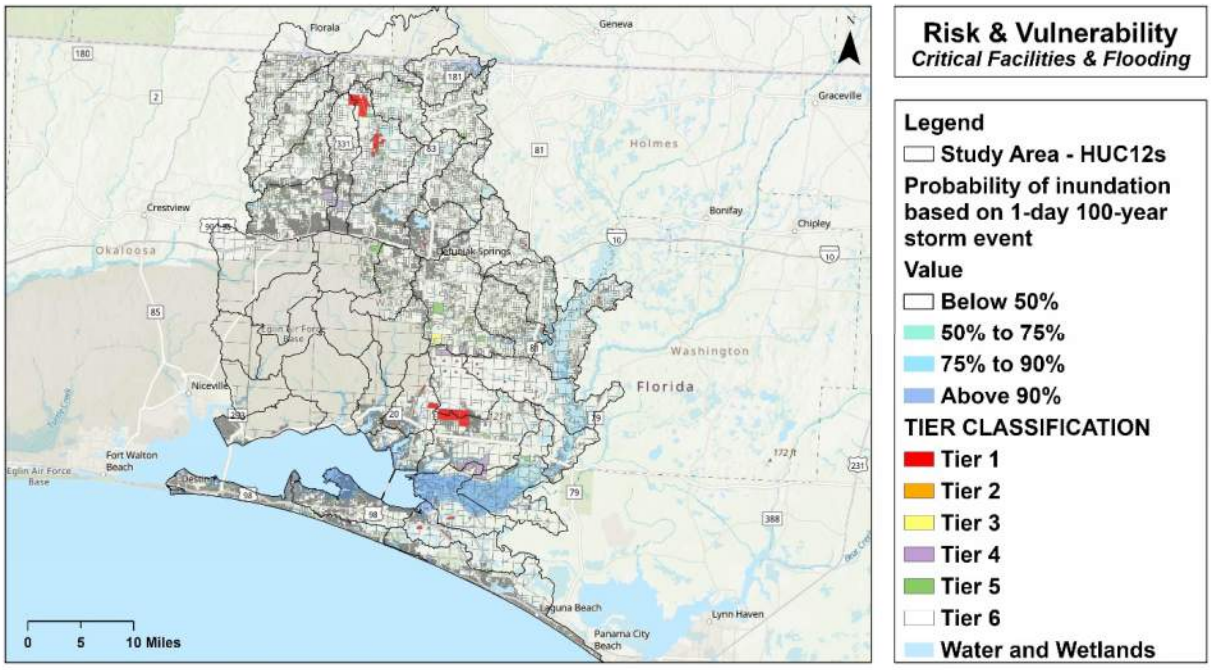

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

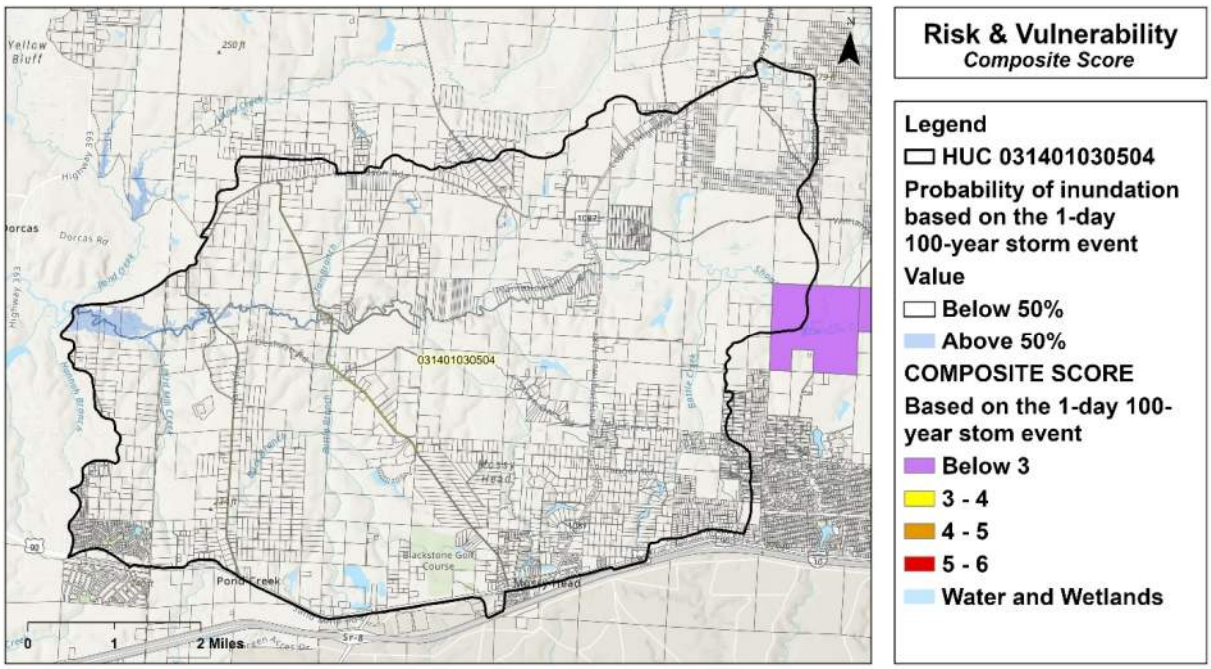

Figure 38. HUC 031401020504 sub-watershed Composite Score Risk map, with calculation based on 1-day 100-year storm event. Processed by FAU.

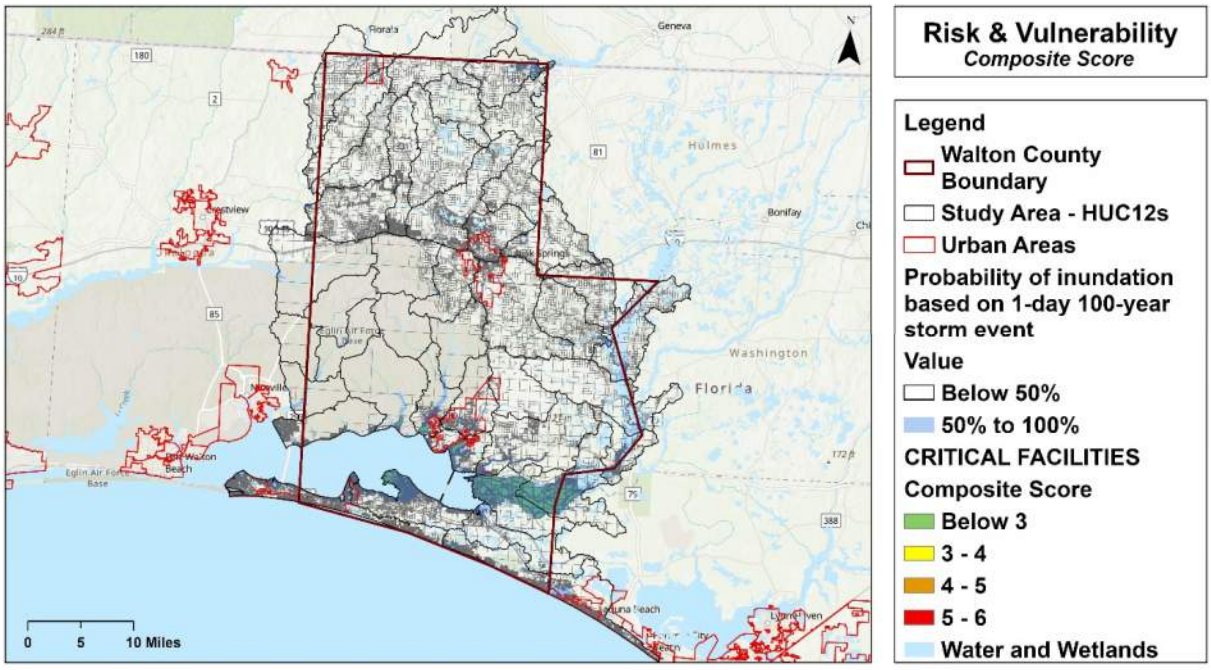

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401030504. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401030504.Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401030504	24308.00
All of the 1-day 100-year storm event inundation	**227.83**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	227.83
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	227.83

2.4.4 Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. . **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, displaying the estimated probability of repetitive loss.

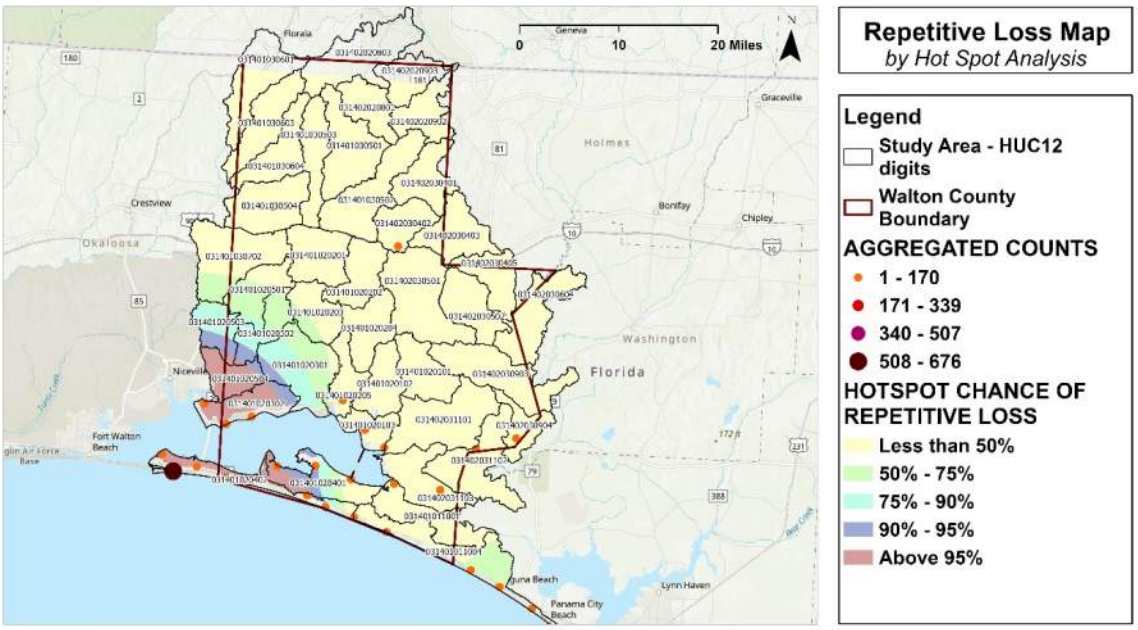

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5 Priority Projects

Although there are a few parcels falling within classification tier 1, and a good amount of parcels falling within tiers 4 and 5 of priority of land uses, only two of them are within the flooding zone, once flooding in the area is relatively minor and not alarming. Consequently, when considering the composite score, it is notable that there is only one parcel which is an orphanage or other non-profit or charitable services, situated within the flooding zone that need some attention, although it has a score below 3, indicating a low priority for intervention.

APPENDIX X

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401030601

FLEMING CREEK-POND CREEK

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Co-Principal Investigators: Weibo Liu, Ph.D., Daniel Meeroff, Ph.D., Diana Mitsova, Ph.D., S. Nagarajan, Ph.D., Hongbo Su, Ph.D., Ramesh Teegavarapu, Ph.D., Zhixiao Xie, Ph.D., Yan Yong, Ph.D., and Caiyun Zhang, Ph.D., Ahmet Urusan, Ph.D., Shannon Egger, Eva Suarez, Ph.D.

Research Assistant: Leticia Sabio

This resource was funded in part, through a grant agreement from the Florida Division of Emergency Management's (FDEM) Bureau of Mitigation, by a grant provided by through the Hazard Mitigation Grant Program (HMGP) DR-4337-004-P, as approved by FDEM and the Federal Emergency Management Agency (FEMA) to create and update Watershed Master Plans (WMP) throughout the state of Florida. The views, statements, findings, conclusions, and recommendations expressed herein are those of the authors and do not necessarily reflect the views of the State of Florida, FEMA, or any of their sub-agencies.

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day, 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401030601) is highlighted among all the HUCs to help identifying its location. (Figure 3).

A small town, Paxton, shares a portion of its boundary with the basin. Demographic data and other characteristics of Paxton, along with other cities in Walton County, will be discussed later.

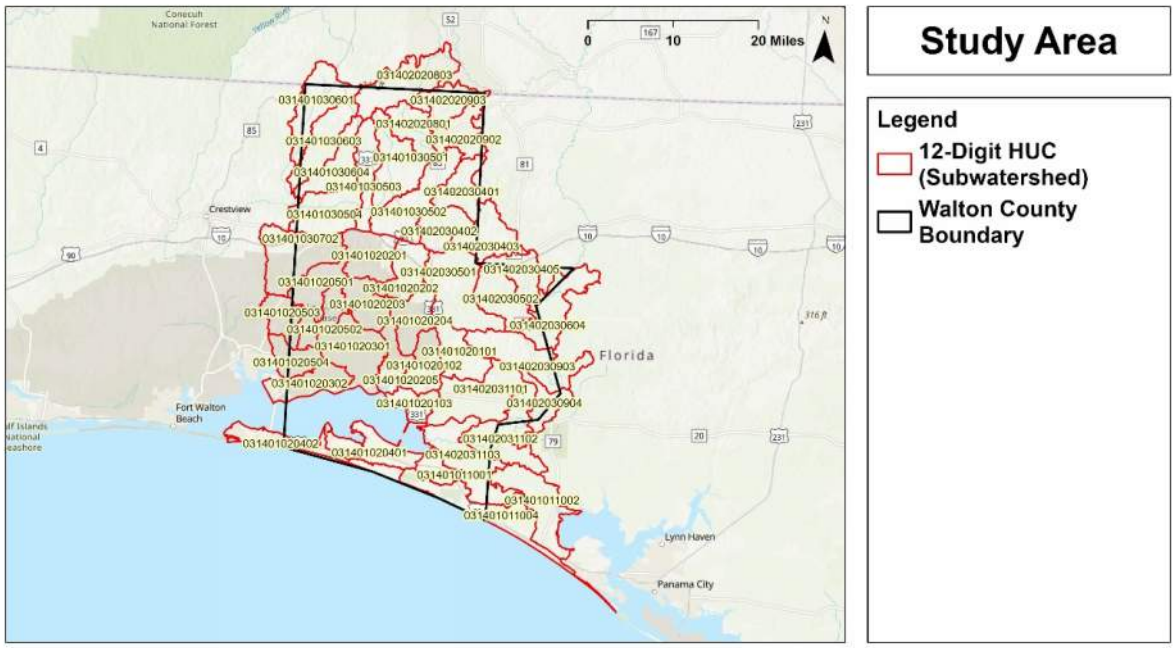

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

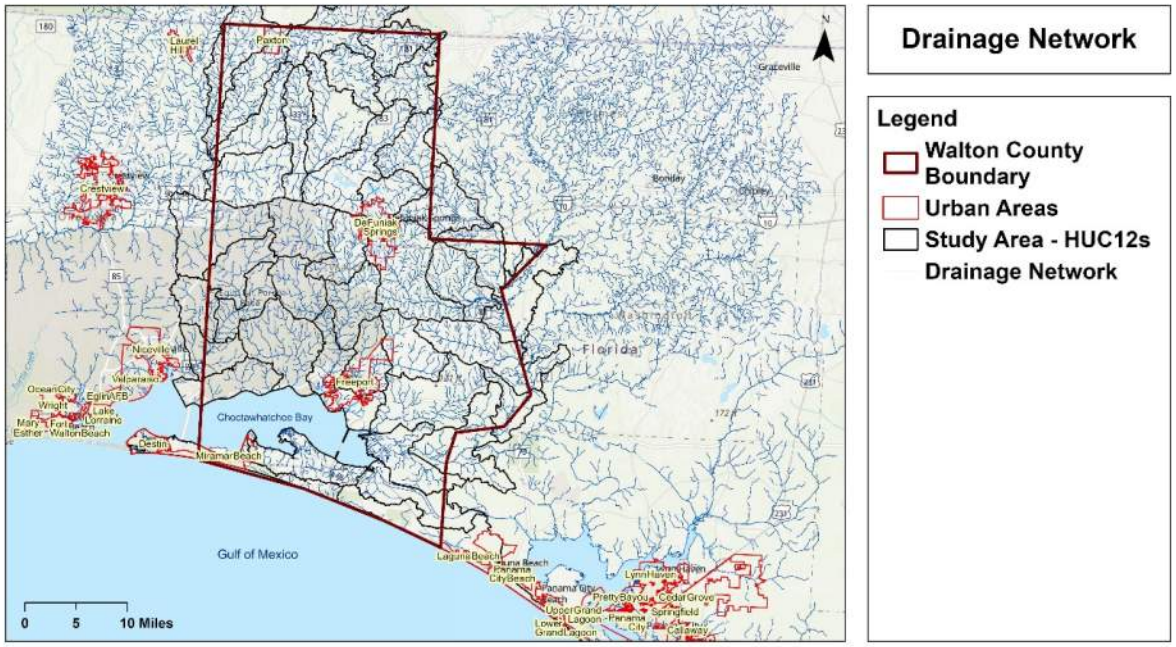

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

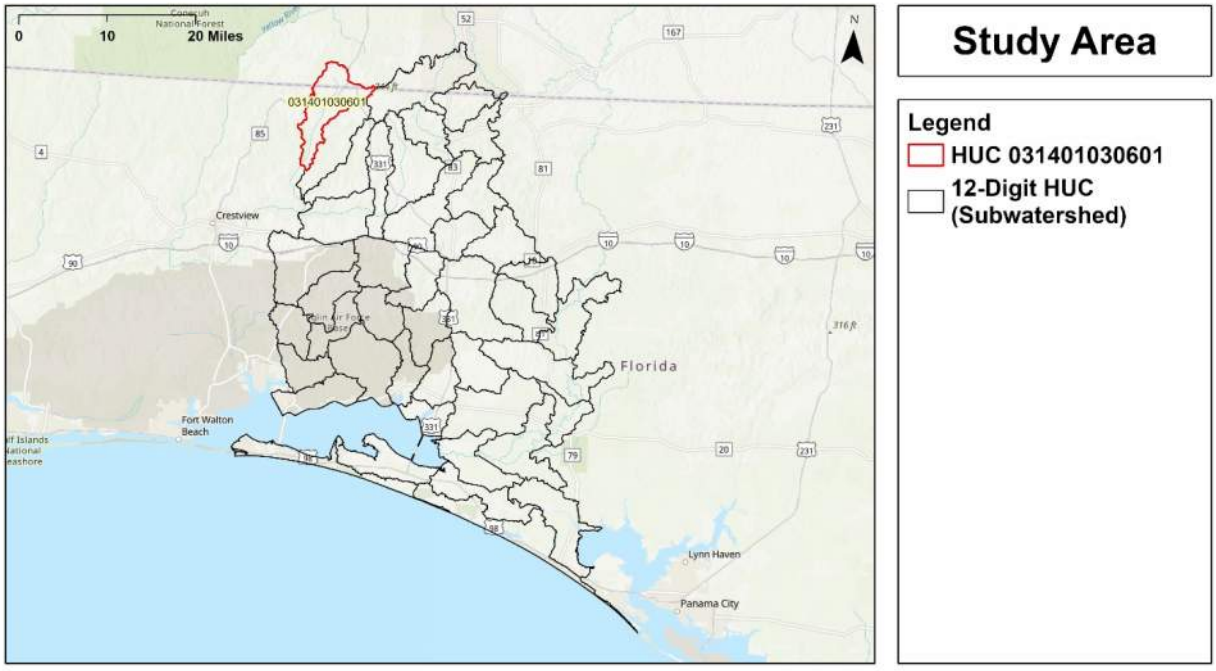

Figure 3. HUC 031401030601 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Based on the future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with

high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

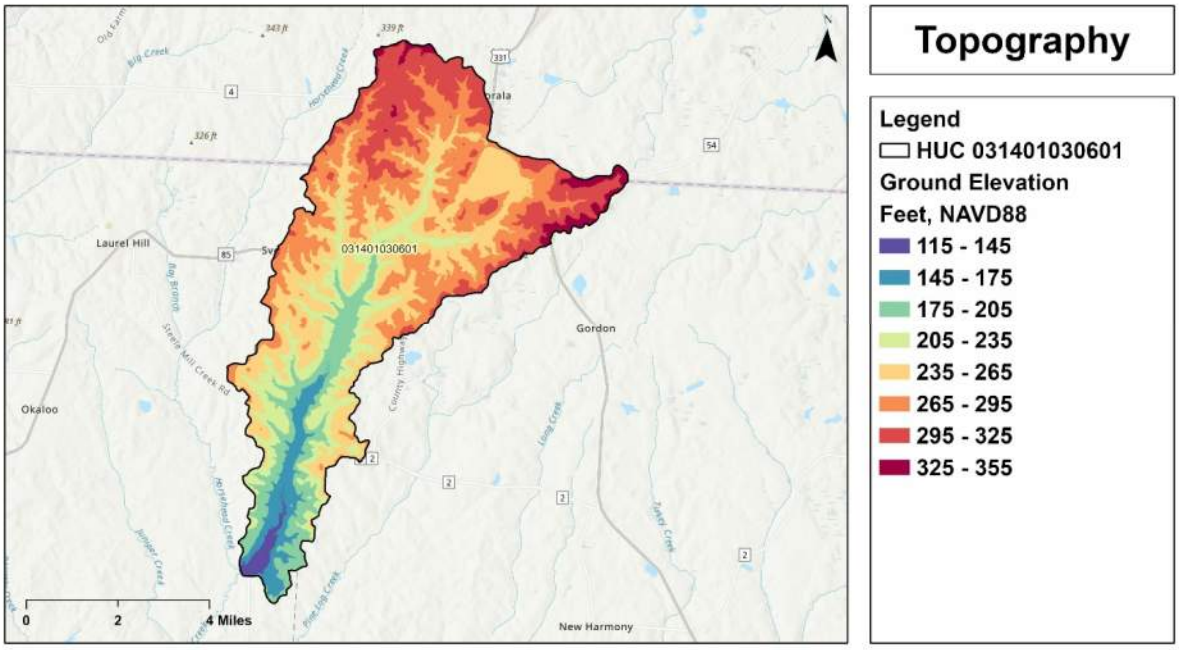

Figure 4. Topographic map of the HUC 031401030601 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of

wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401030601 sub-watershed is shown in **Error! Reference source not found.**.

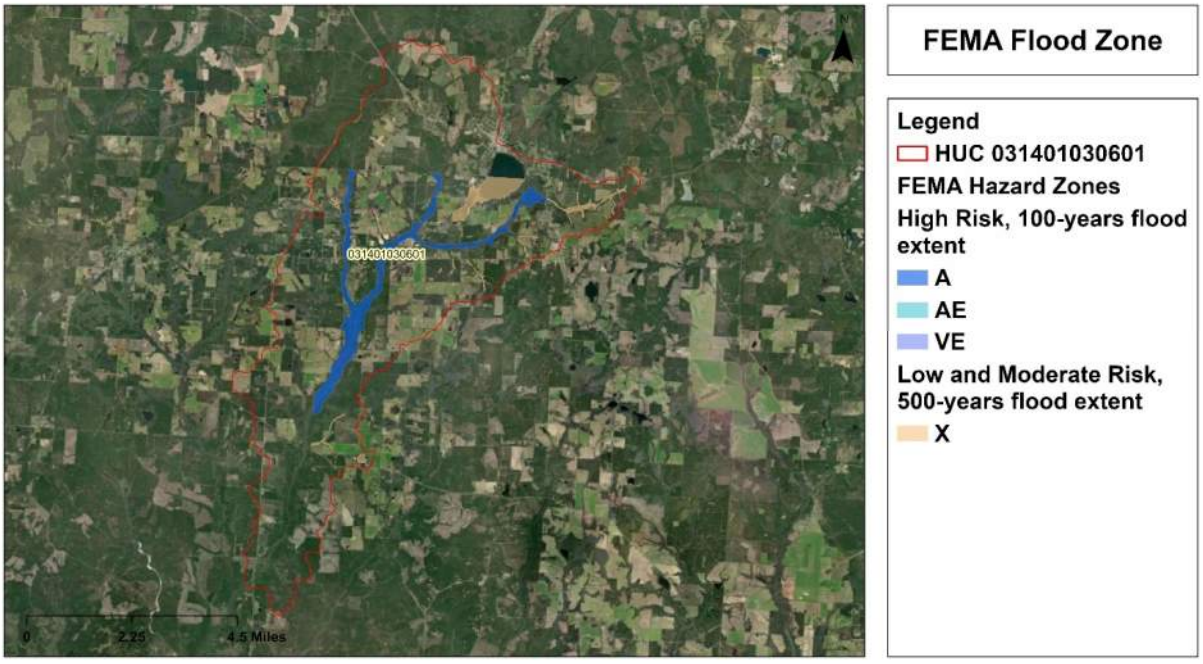

Figure 5. FEMA Flood Zone map (2020) for HUC 031401030601 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination

between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401030601 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

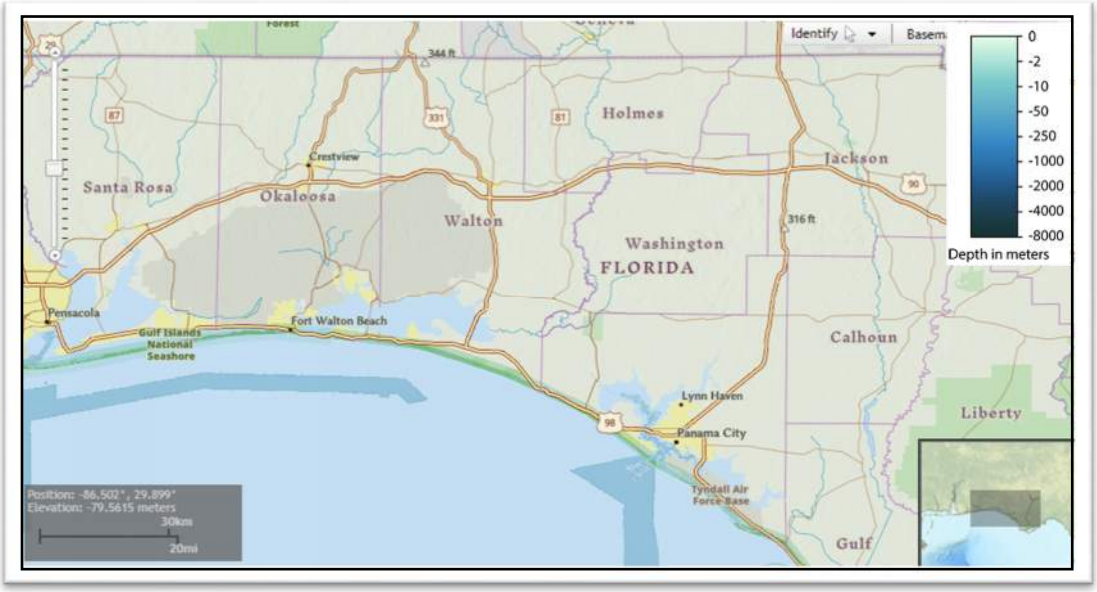

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological

conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

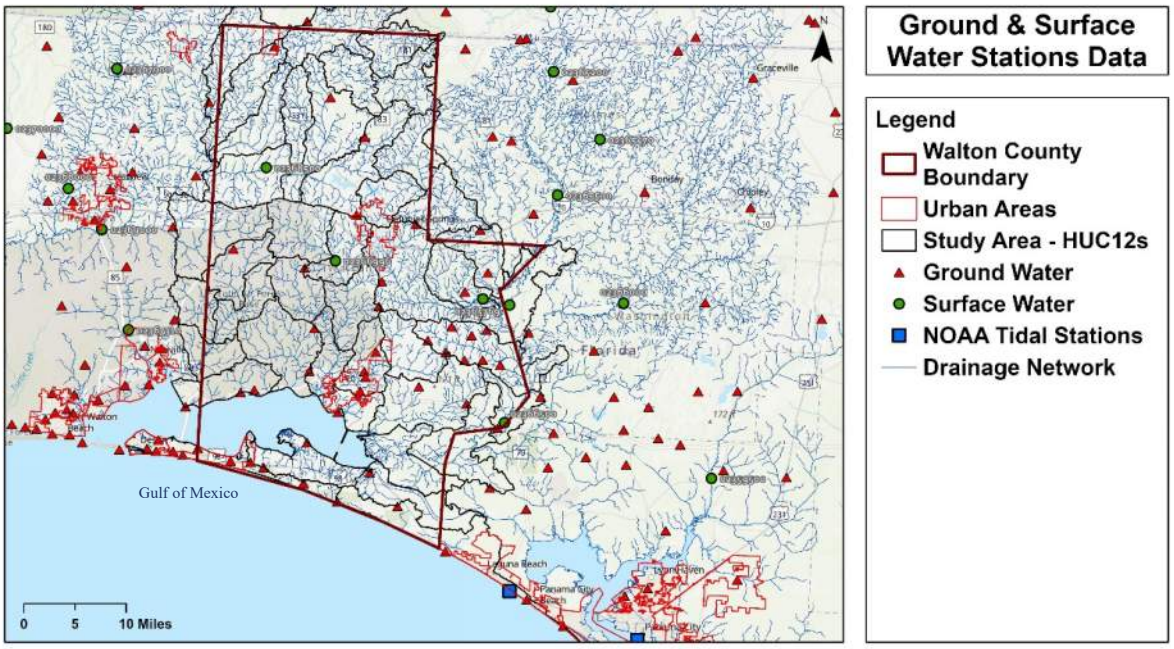

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031401030601 has no major rivers and canals, but creeks, incude:

- Pond Creek
- Fleming Creek

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02368500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401030601, which is USGS 02368500 Shoal River.

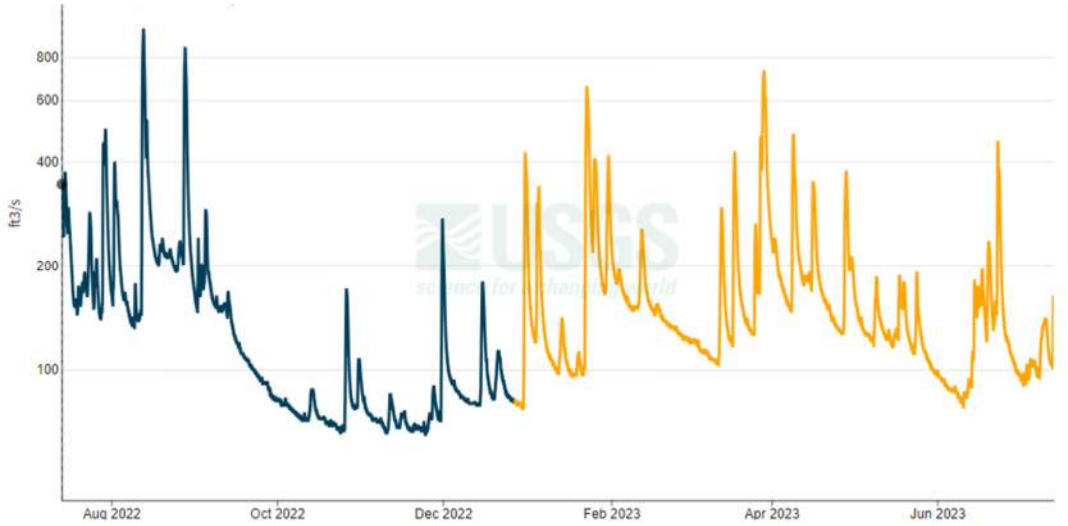

Figure 8. Average streamflow for Shoal River NR Mossy Head, Fla (USGS 02368500 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02368500/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401030601 and points out the location of the ground water station in the surroundings. A groundwater-surface layer for the HUC 031401020101 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

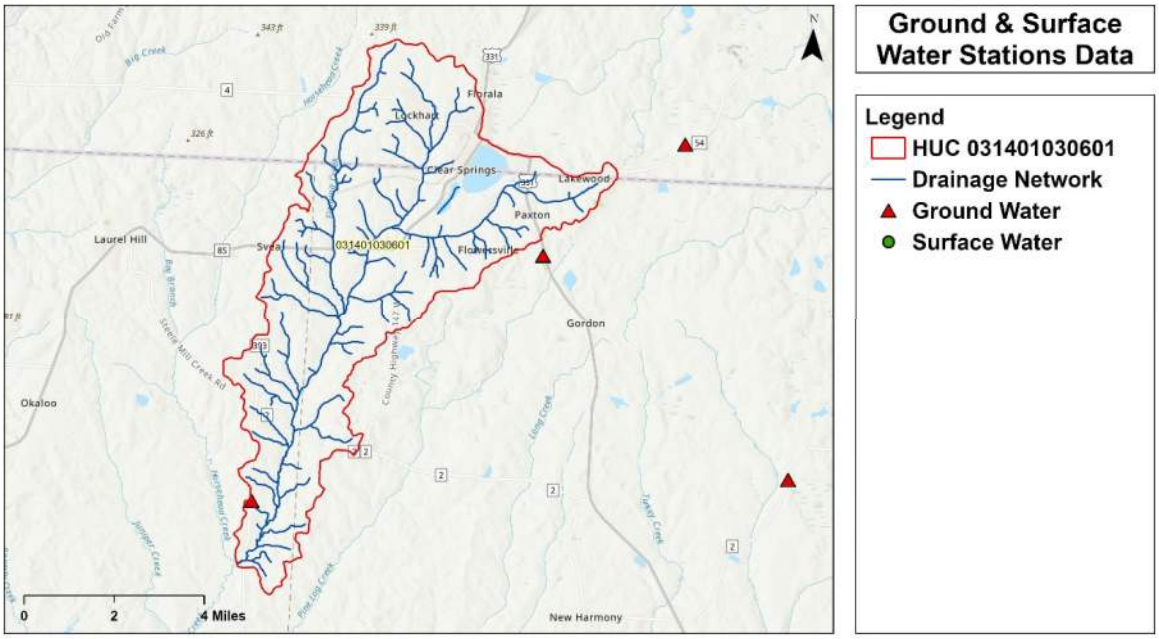

Figure 9. Ground and Surface Water Stations in the HUC 031401030601 sub-watershed, processed by FAU.

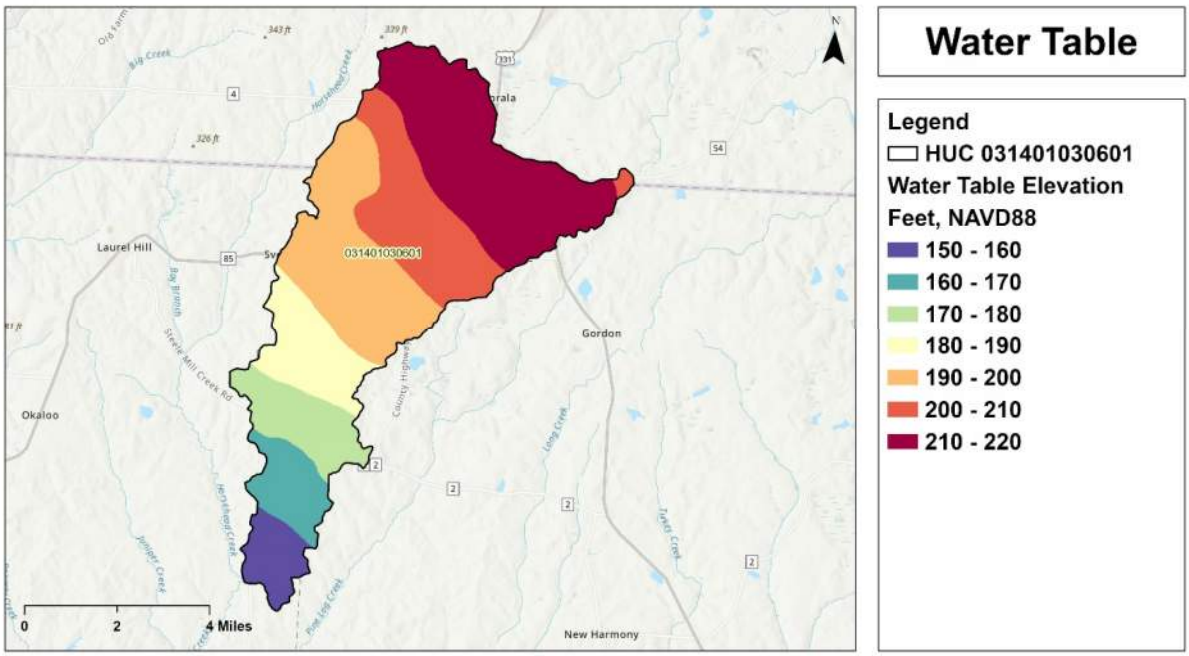

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401030601 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

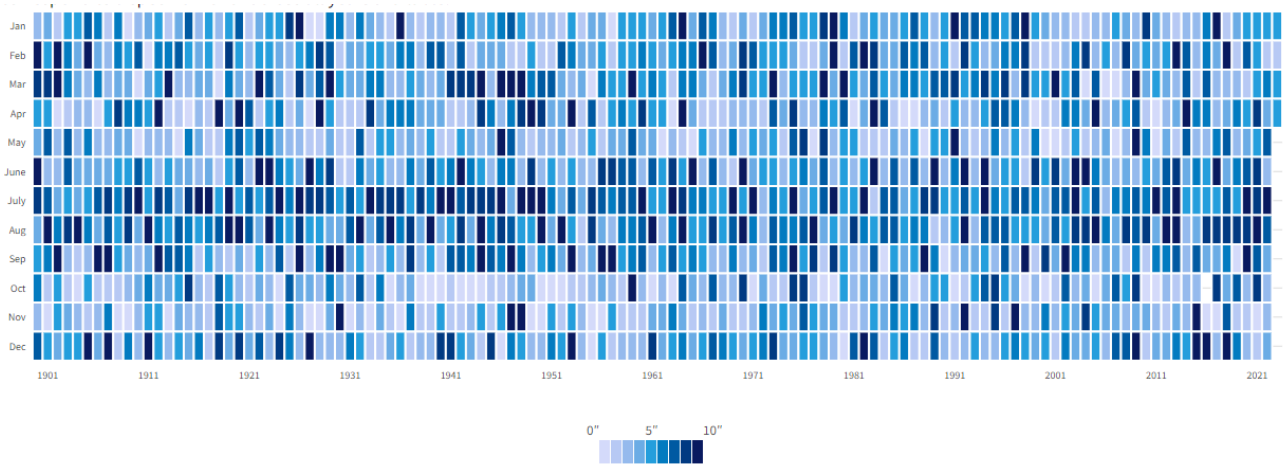

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/)

While the topography (Section 2.1) and native soil (Section 2.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there are no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

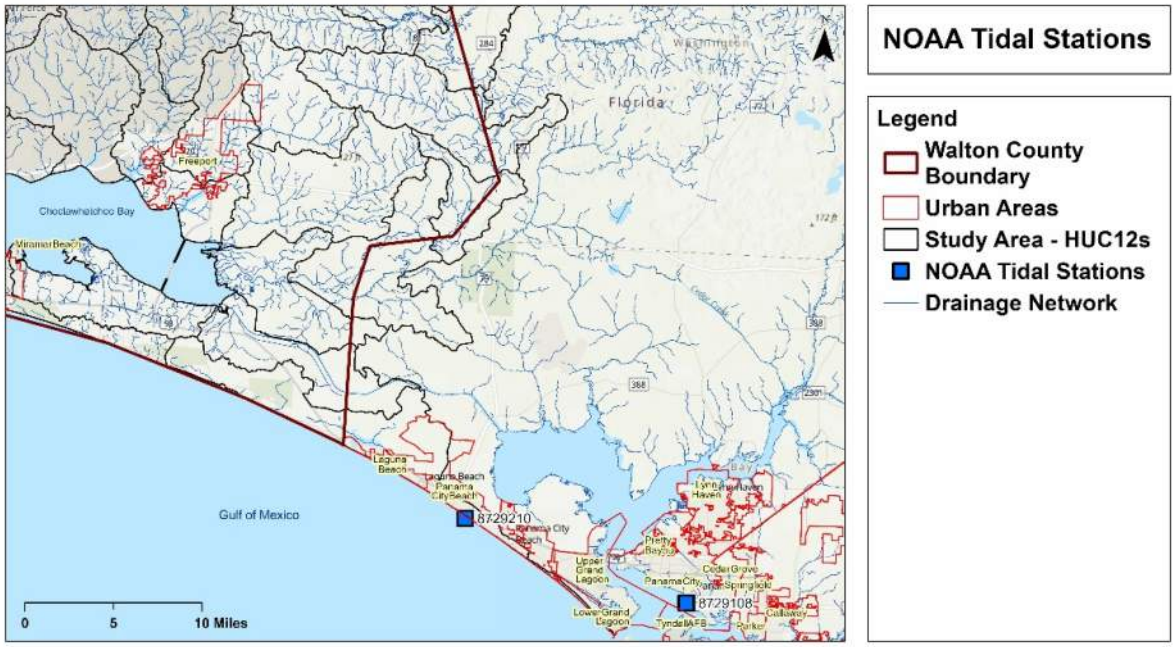

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

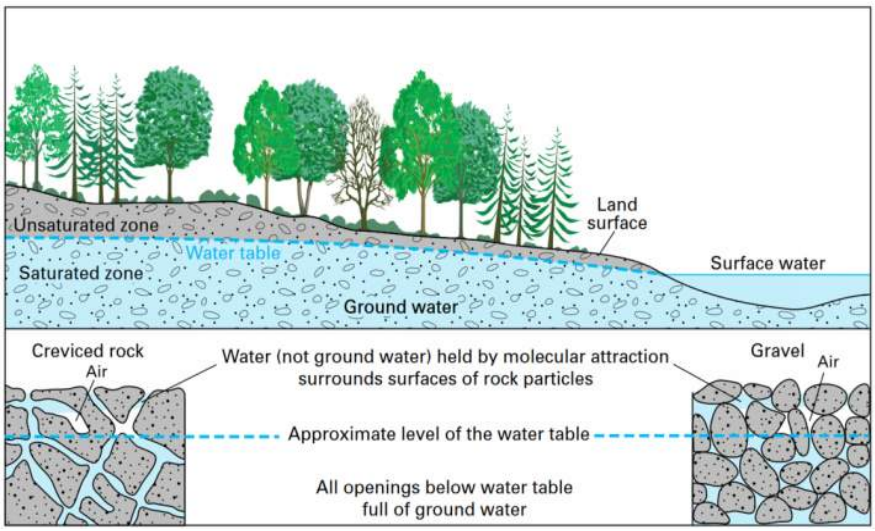

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

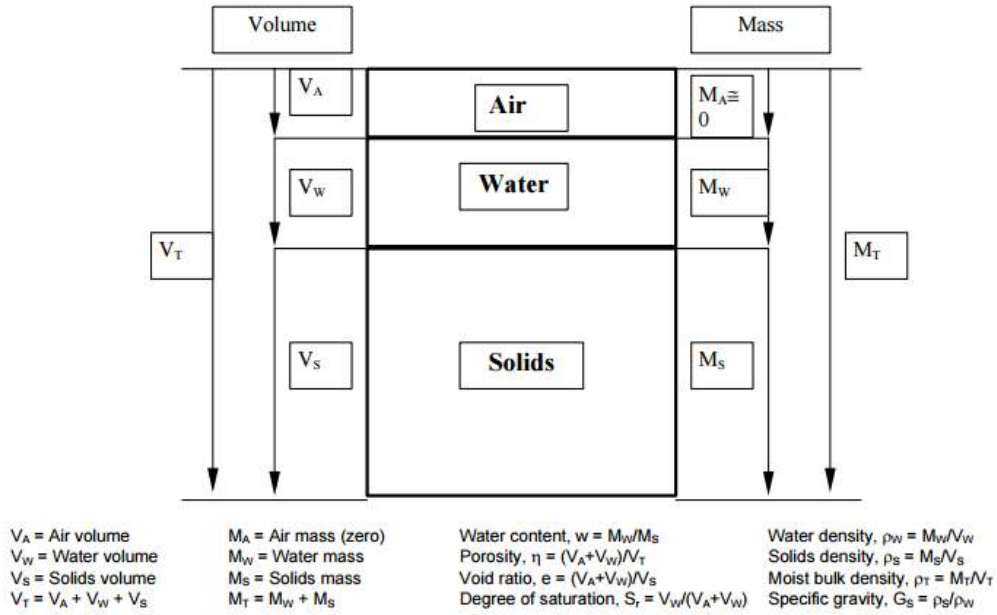

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

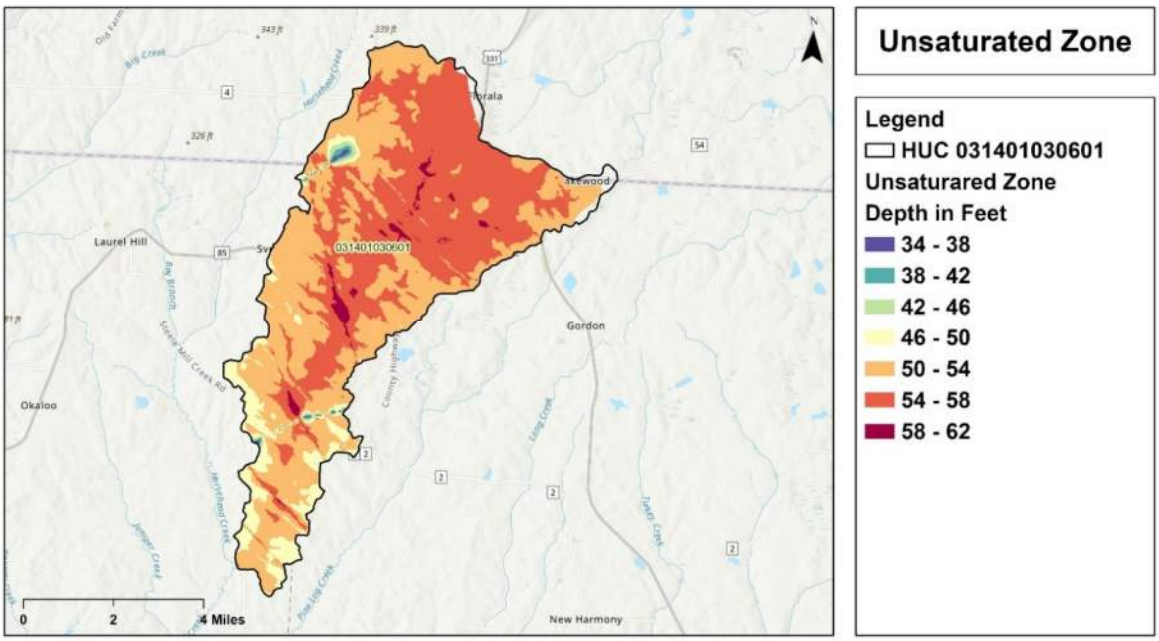

Figure 15. Unsaturated zone map for HUC 031401030601, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A great portion of the basin has enough soil storage capacity, ranging between 50 to 58 inches of capacity left.

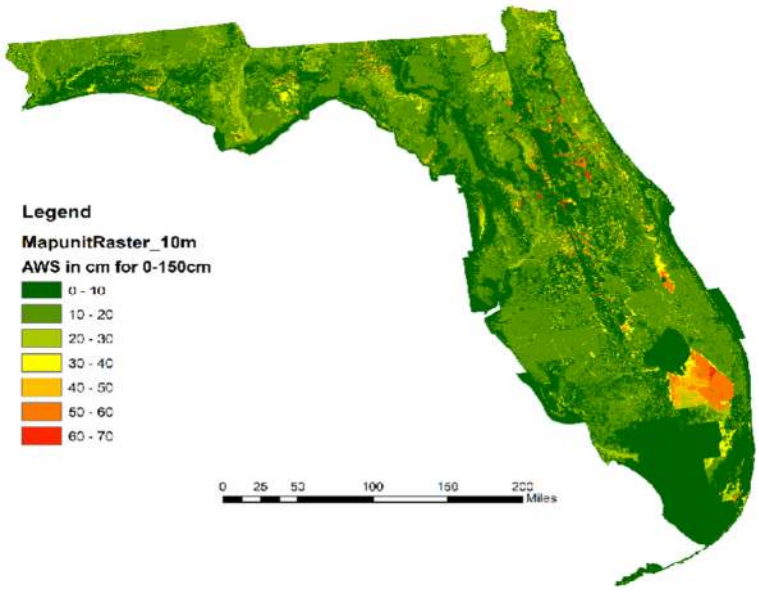

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

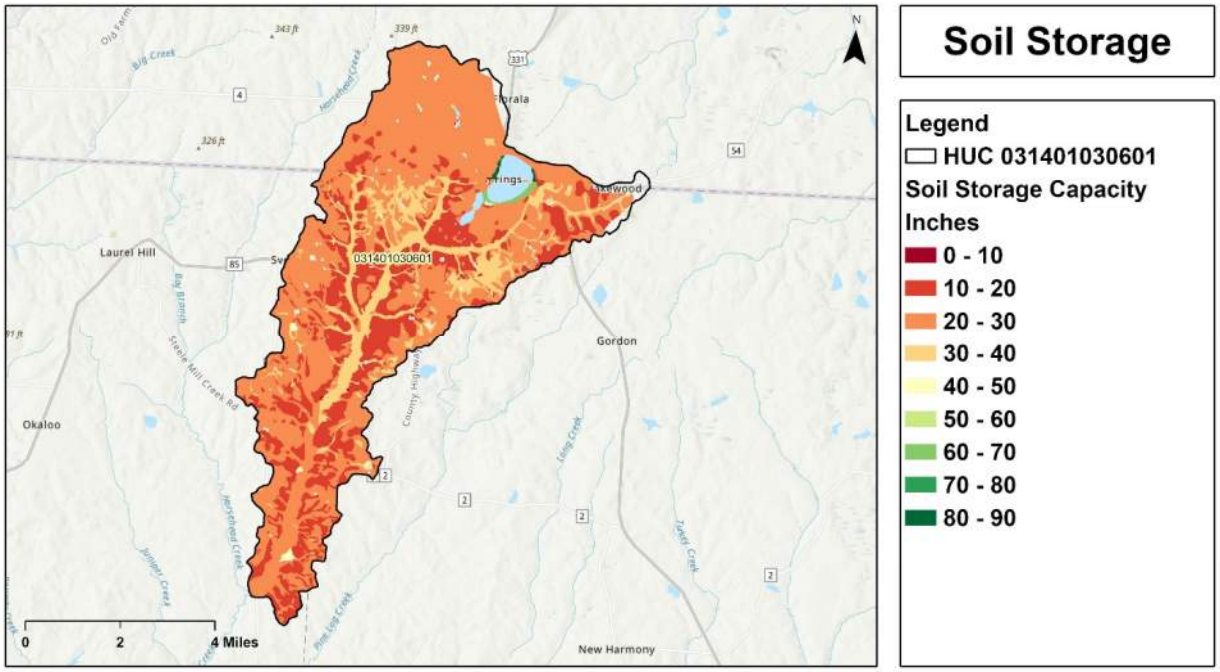

Figure 17. Water storage capacity of soil for the HUC 031401030601, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

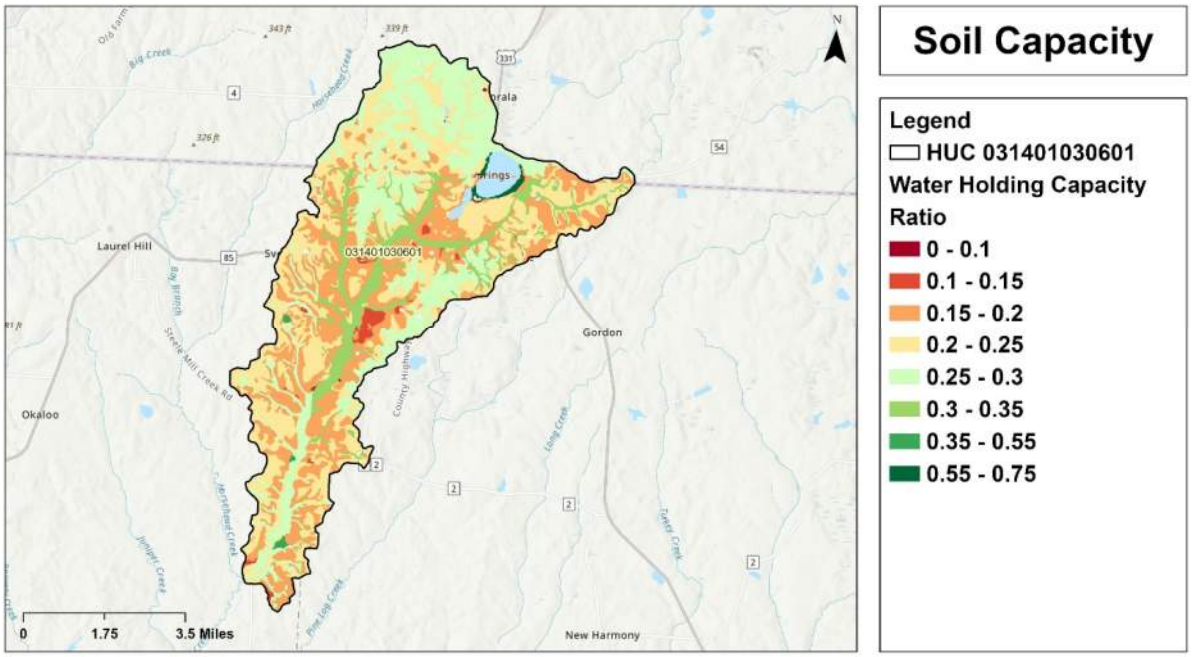

Figure 18. Water Holding Capacity (ratio) for the HUC 031401030601, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

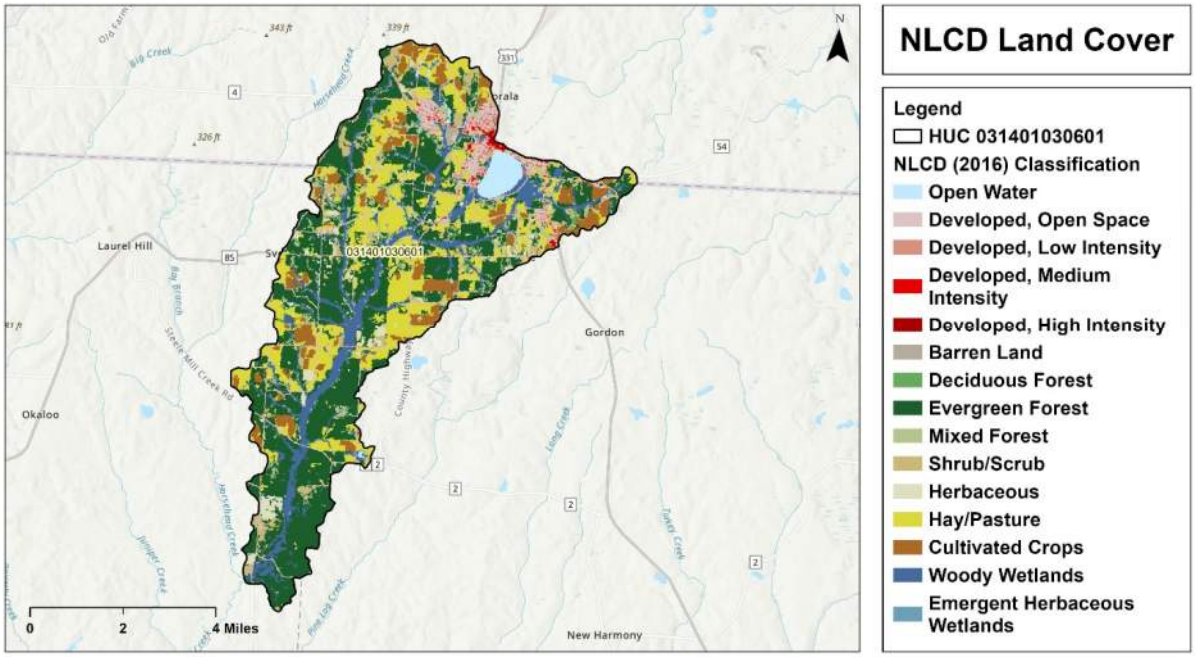

Figure 19. Land use in the HUC 031401030601 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

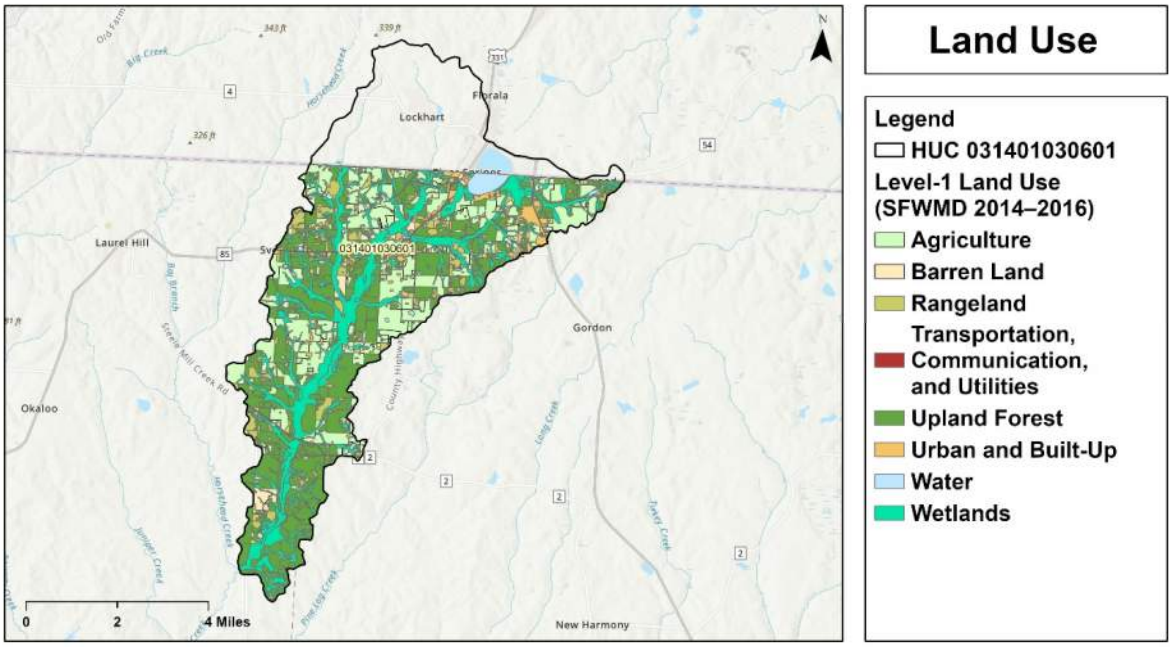

Figure 20. Land use in the HUC 031401030601 (2023 Florida Geographic Data Library (FGDL))), processed by FAU.

Please be aware that the Alabama portion of the HUC was not considered in this land use study. Consequently, the following analysis pertains solely to the Florida portion of the HUC 031401020101 sub-watershed. In this area, the predominant land cover is upland forest, accounting for 40.97% of the region. Agriculture comes in second at 24.77%, followed by wetlands at 18.85%. Developed land is limited, with only 5.16% categorized as urban and built-up, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031401030601 subwatershed (2023 Florida Geographic Data Library (FGDL))).

Level 1 Land Use Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	5403.27	24.77%
Barren Land	249.58	1.14%
Rangeland	1023.75	4.69%
Transportation, Communication, and Utilities	252.61	1.16%
Upland Forest	8937.82	40.97%
Urban and Built-Up	1125.86	5.16%
Water	712.79	3.27%
Wetlands	4111.81	18.85%
Grand Total:	**21817.49**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day, 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

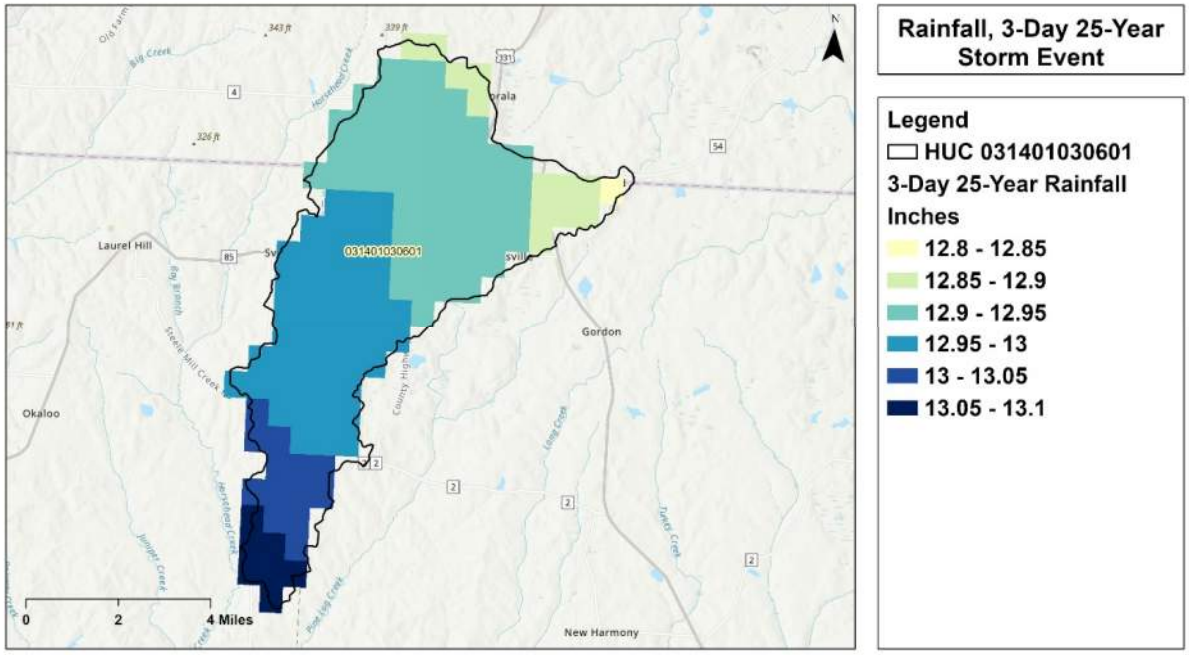

Figure 21. Rainfall distribution map across HUC 031401030601 sub-watershed, for 3-day 25-year storm event, processed by FAU.

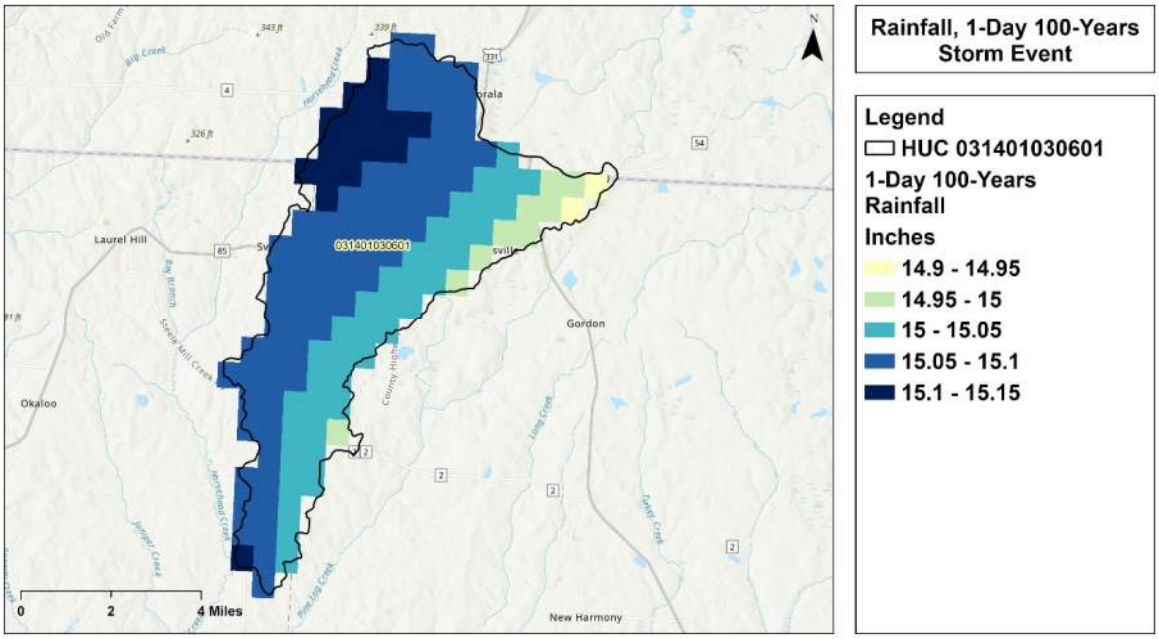

Figure 22. Rainfall distribution map across HUC 031401030601 sub-watershed, for 1-day 100-year storm event, processed by FAU.

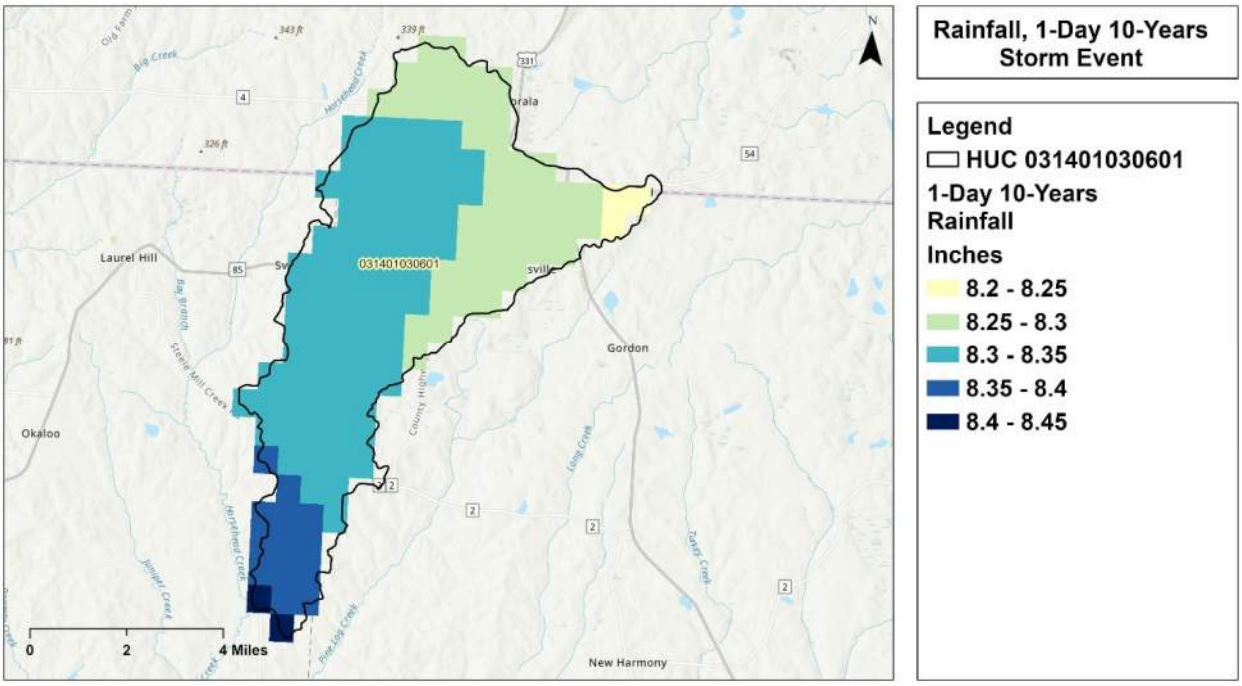

Figure 23. Rainfall distribution map across HUC 031401030601 sub-watershed, for 1-day 10-year storm event, processed by FAU.

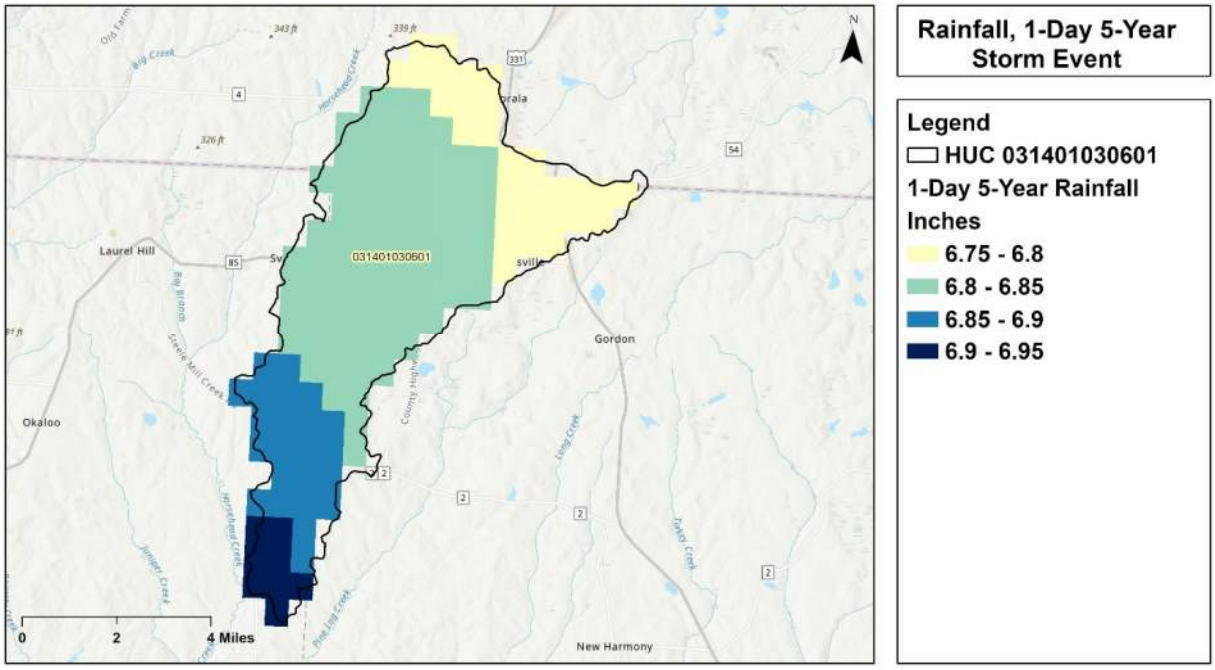

Figure 24. Rainfall distribution map across HUC 031401030601 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically

aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

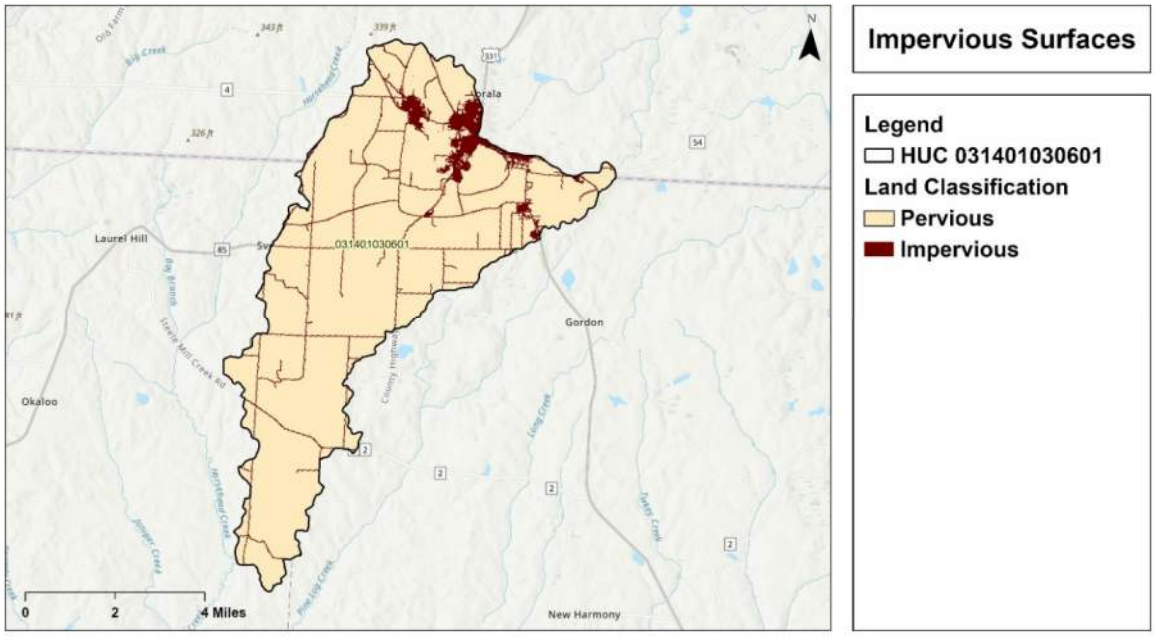

Figure 25. Impervious area map for the HUC 031401030601 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

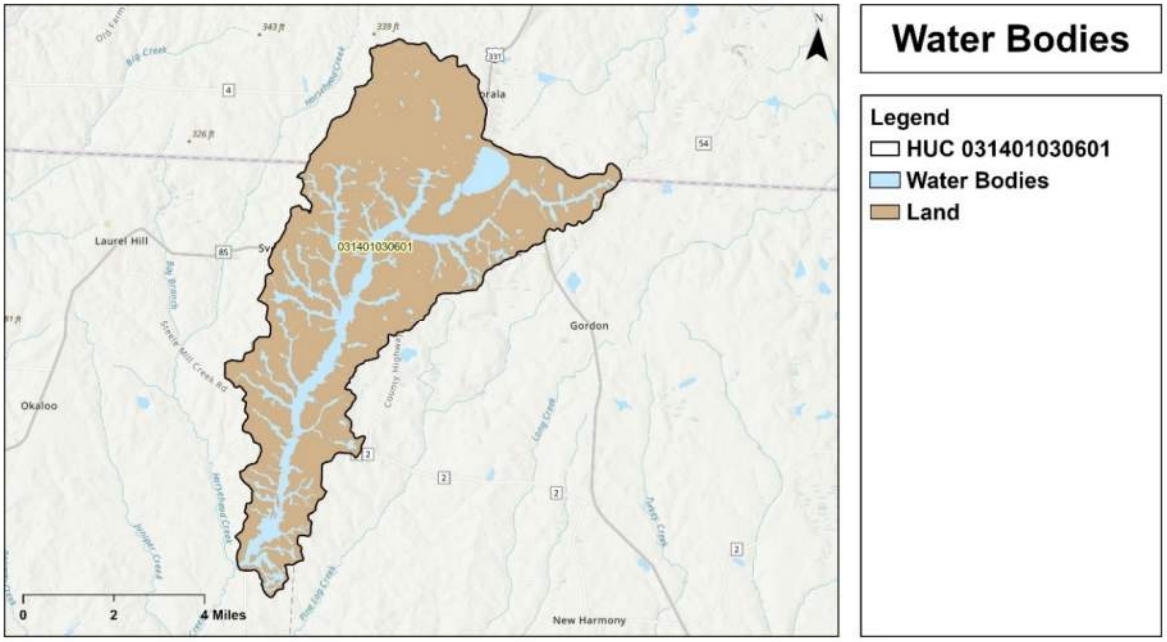

Figure 26. Water bodies map for the HUC 031401030601 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs,

property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, , such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

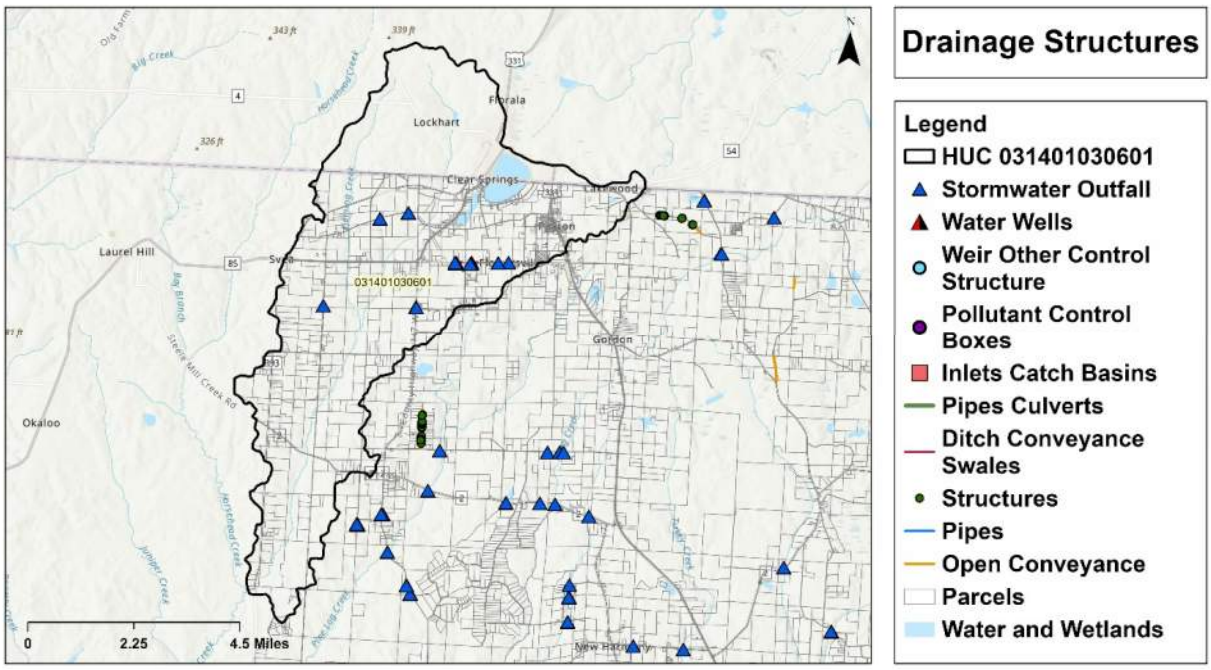

Figure 27. Stormwater Infrastructure for the HUC 031401030601. Processed by FAU.

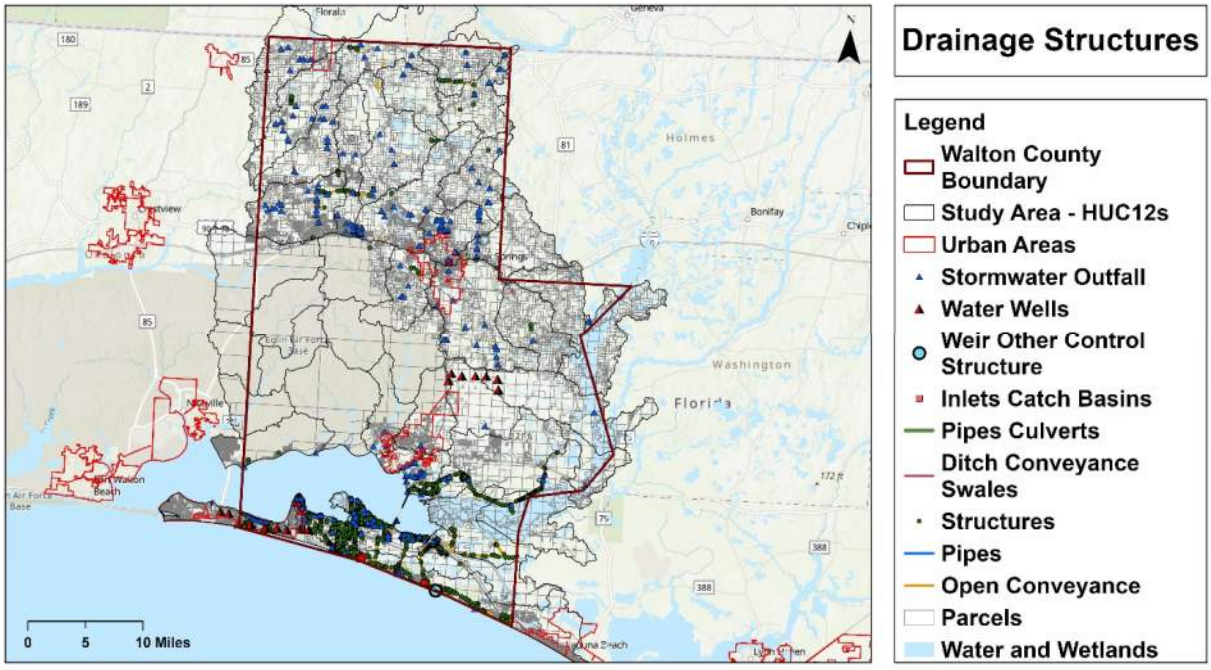

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020)

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401030601 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

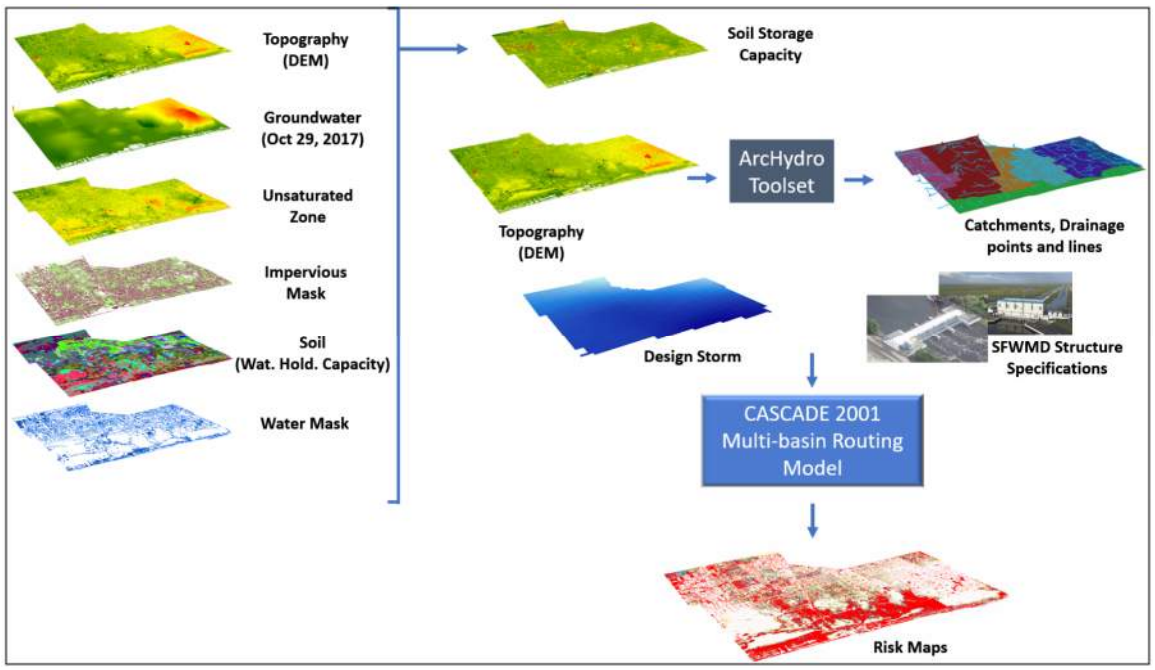

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)

= 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

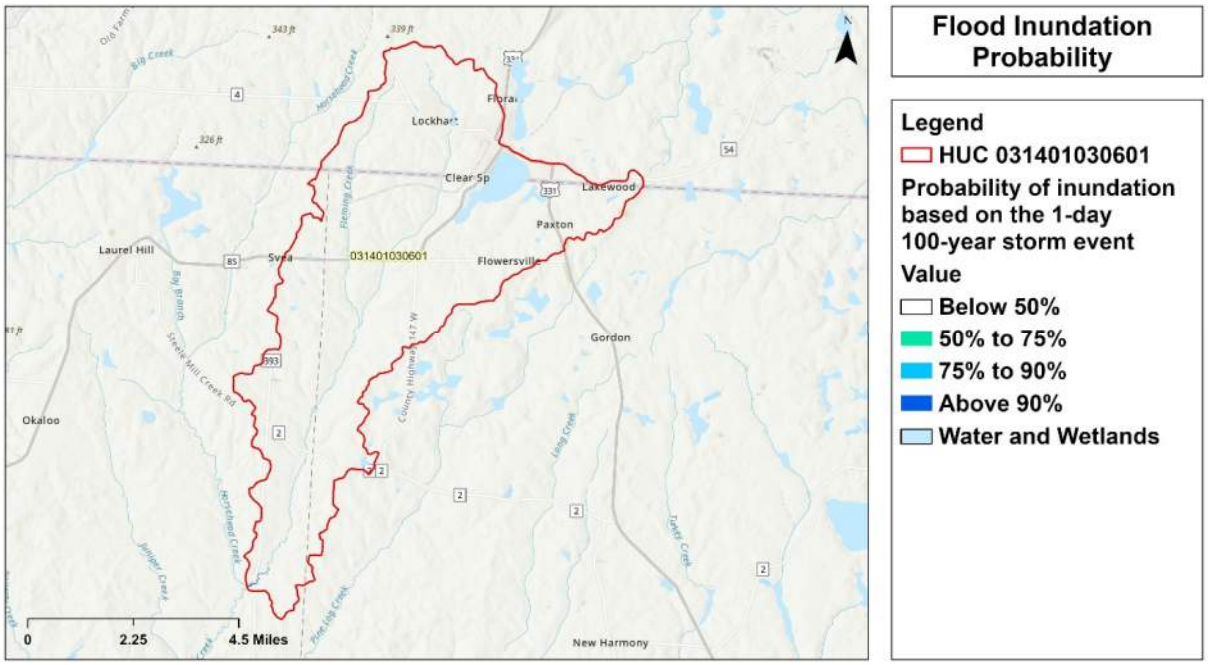

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401030601, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation

and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations,

Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:In all storm event scenarios, a small portion of flooding, almost imperceptible, is noted at the entrance to the creek into the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, sea level rise should not impact the HUC, therefore SLR scenarios were not calculated.

The design storm simulation determined that approximately 0% of the HUC total area or only 0.01 mi² has a probability of inundation above 50% for all four storm event scenarios. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401030601 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	38.28	0.01	100.0%	0.0%
1-day 100-year	38.28	0.01	100.0%	0.0%
1-day 10-year	38.28	0.01	100.0%	0.0%
1-day 5-year	38.28	0.01	100.0%	0.0%

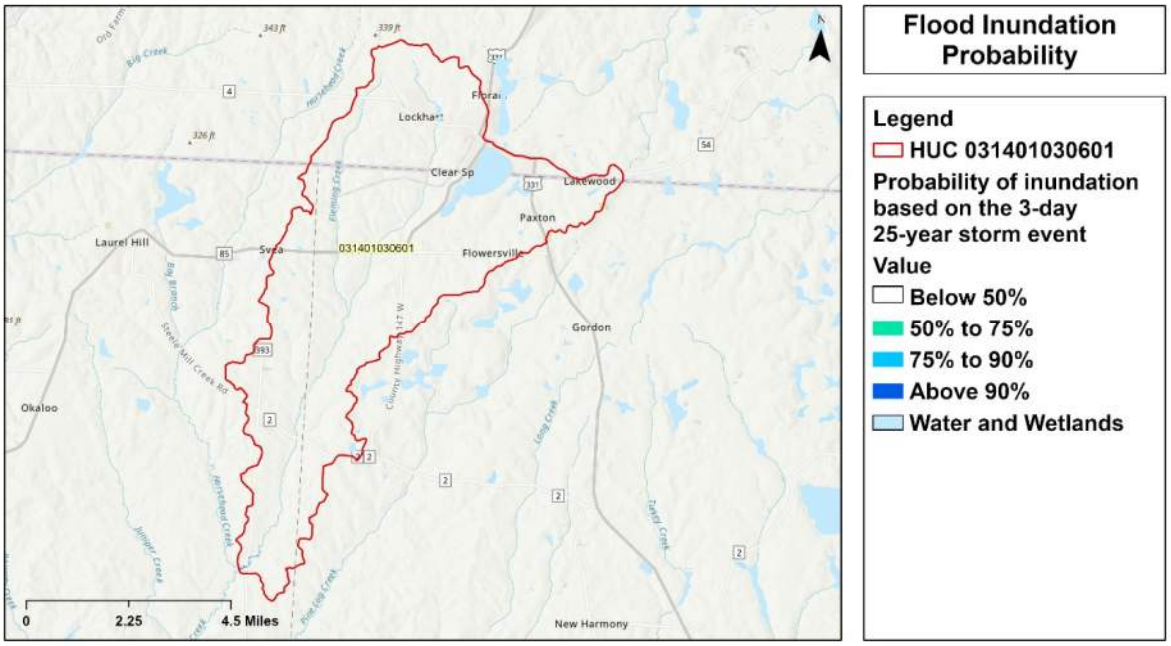

Figure 31. 3-day 25-year storm event for HUC 031401030601 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

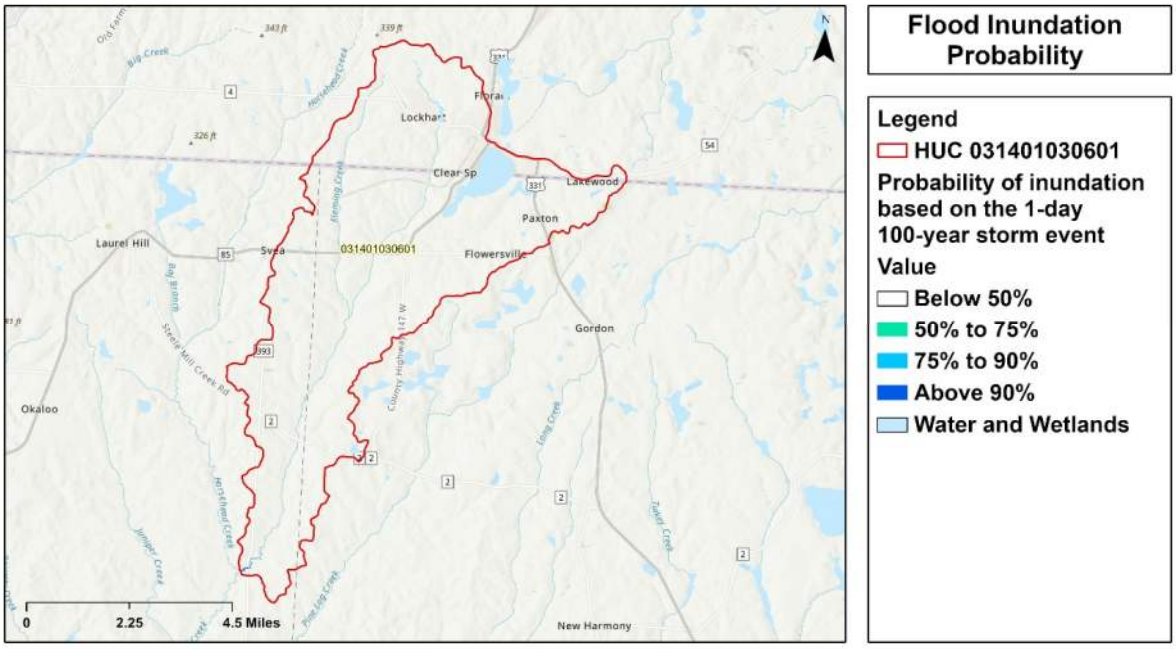

Figure 32. 1-day 100-year storm event for HUC 031401030601 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

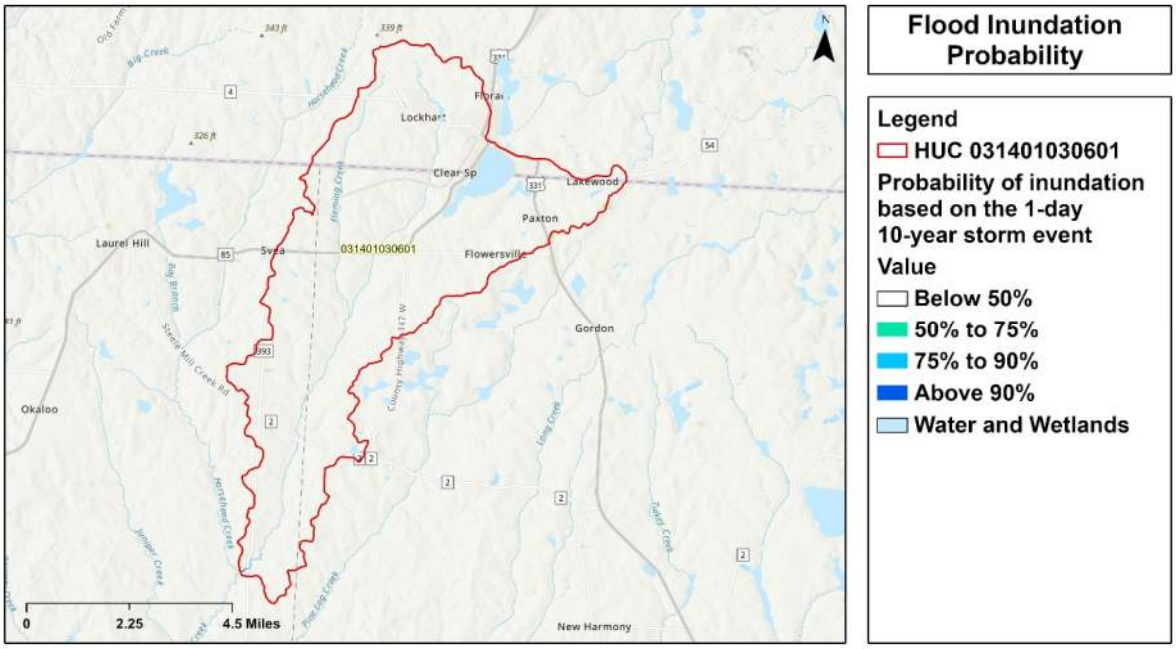

Figure 33. 1-day 10-year storm event for HUC 031401030601 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

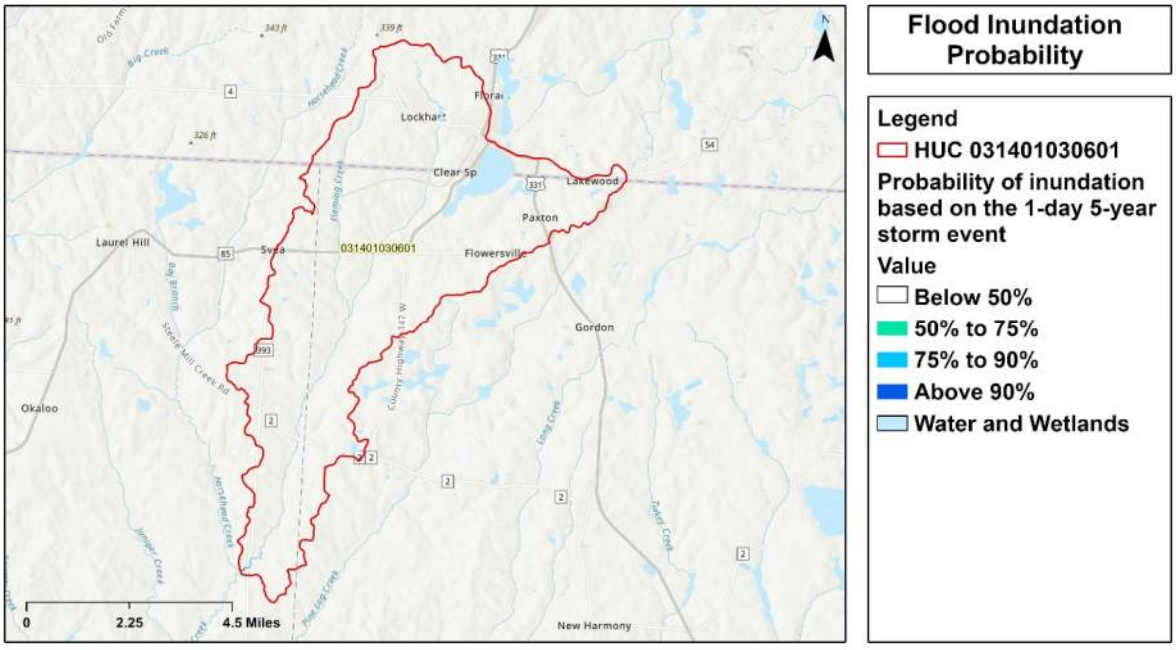

Figure 34. 1-day 5-year storm event for HUC 031401030601 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6

11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6

41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6

69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6

99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, as shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.**depict the HUC 031401030601 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

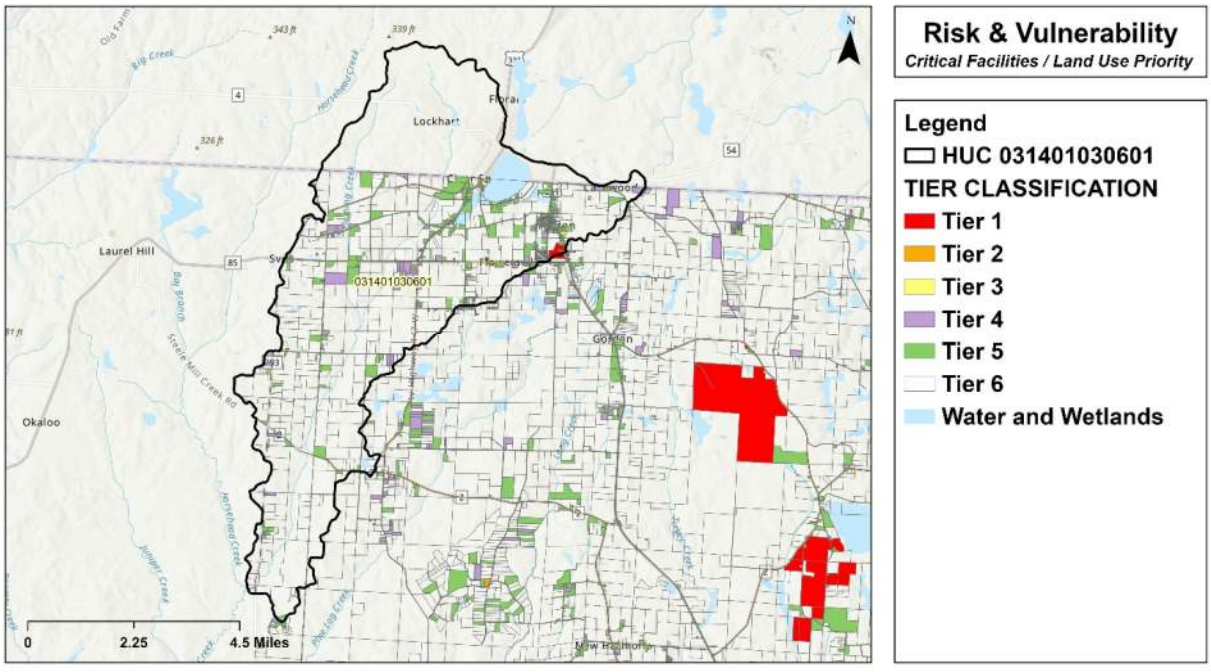

Figure 35. HUC 031401030601 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

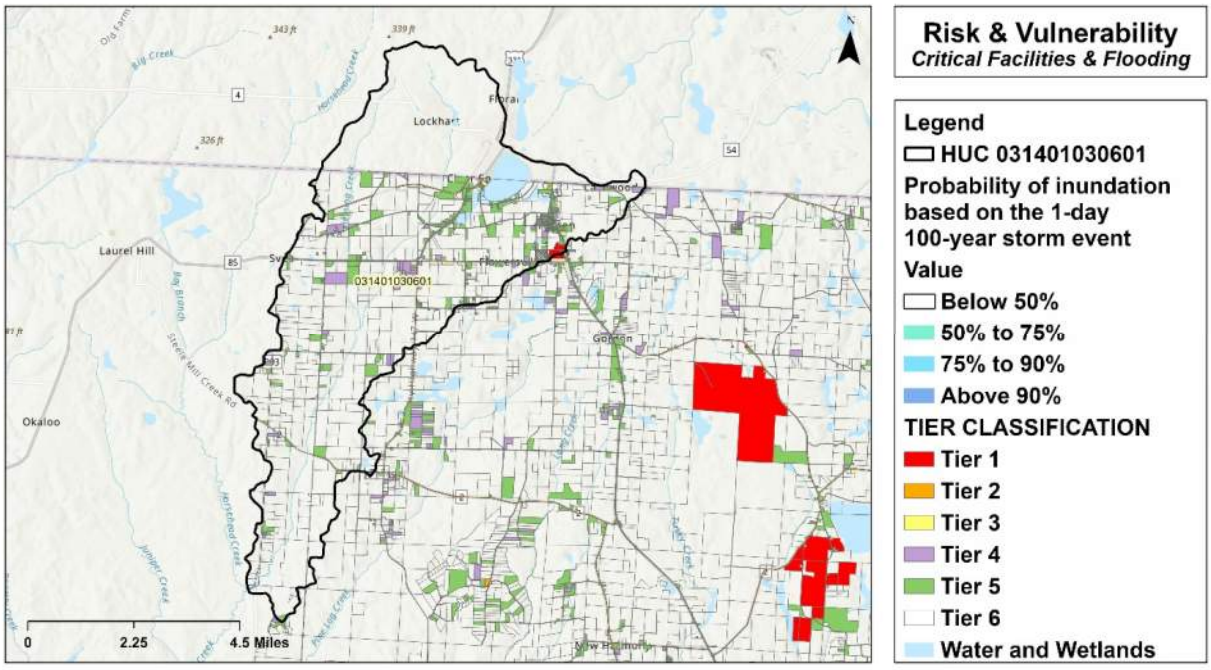

Figure 36. HUC 031401030601 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day, 100-year storm event probability of inundation. Processed by FAU.

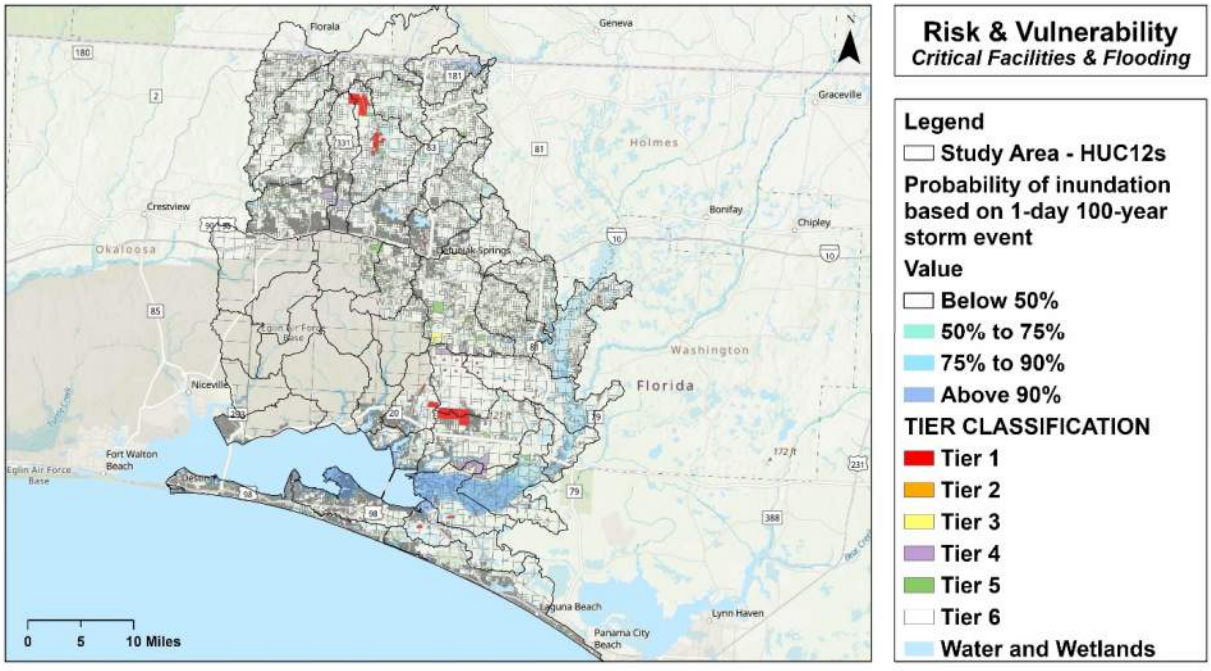

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day, 100-year storm event probability of inundation for Walton County. Processed by FAU.

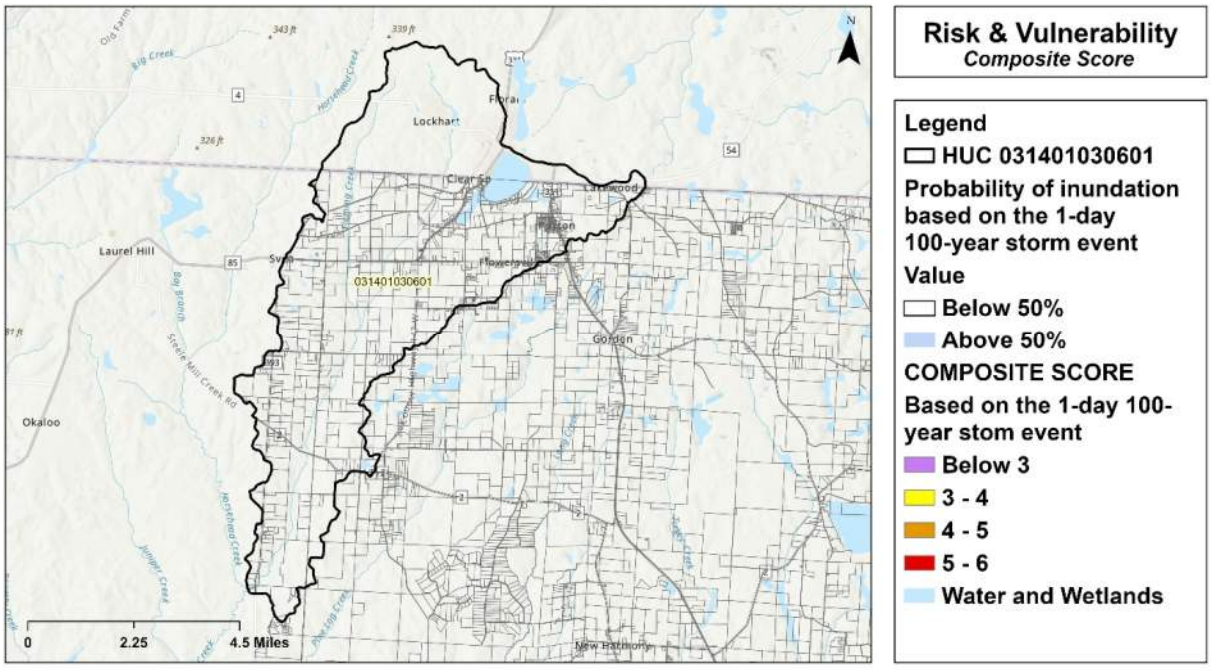

Figure 38. HUC 031401030601 sub-watershed Composite Score Risk map, with calculation based on 1-day 100-years storm event. Processed by FAU.

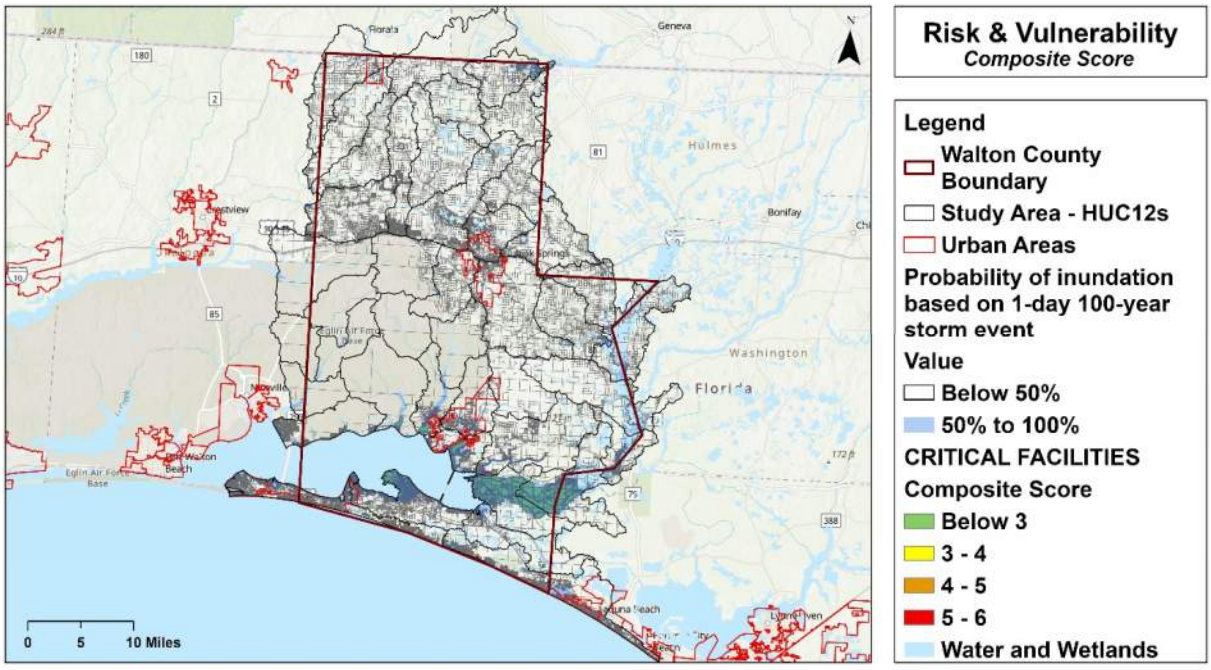

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day, 100-year storm event probability of inundation. Processed by FAU.
Please note that due to the scale of the map, the composite score layer is not properly visible in this map.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

2.4.2 Drill-down – Paxton

For enhanced visualization of the urban areas within this HUC 031401030601, **Error! Reference source not found.** to **Error! Reference source not found.** illustrate the same results for critical facilities (land use priorities) and composite scores, but on a reduced scale, which better facilitates the examination of finer details within the urban area (Paxton). These maps cover both the 1-day 100-year scenario. Sea level rise scenarios were not calculated due to the basin's non-coastal location and high elevation. The composite score results is null, since the town does not experience any flooding.

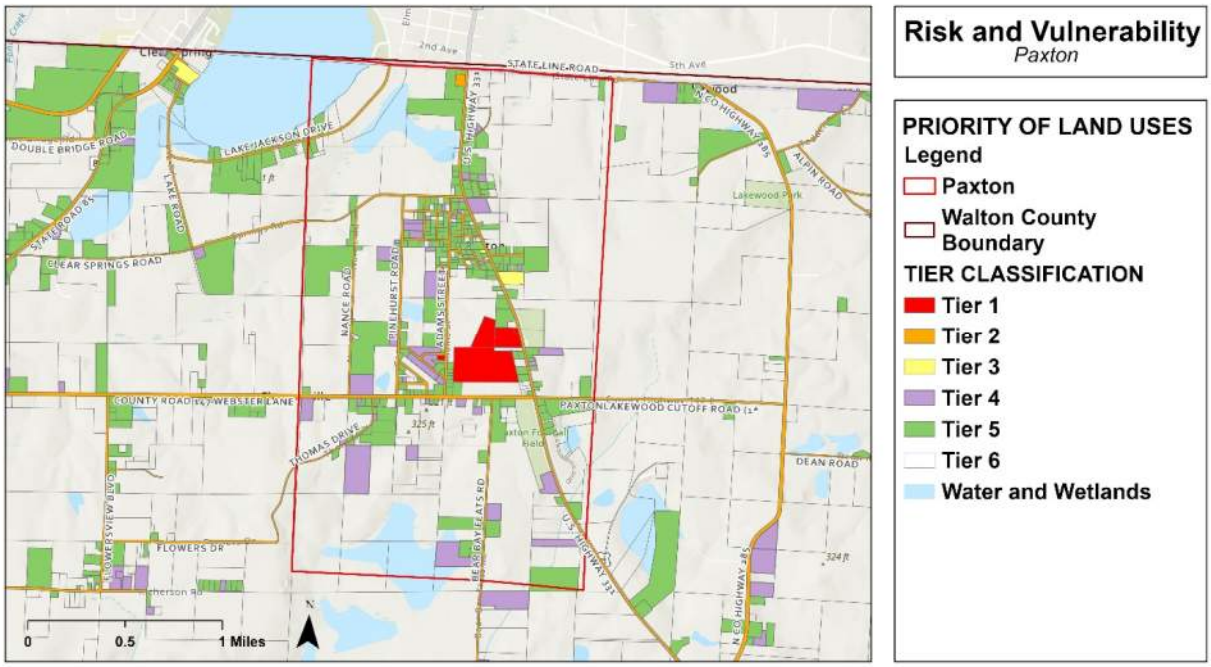

Figure 40. Critical Facilities (priority of land uses) map for Paxton. Processed by FAU.

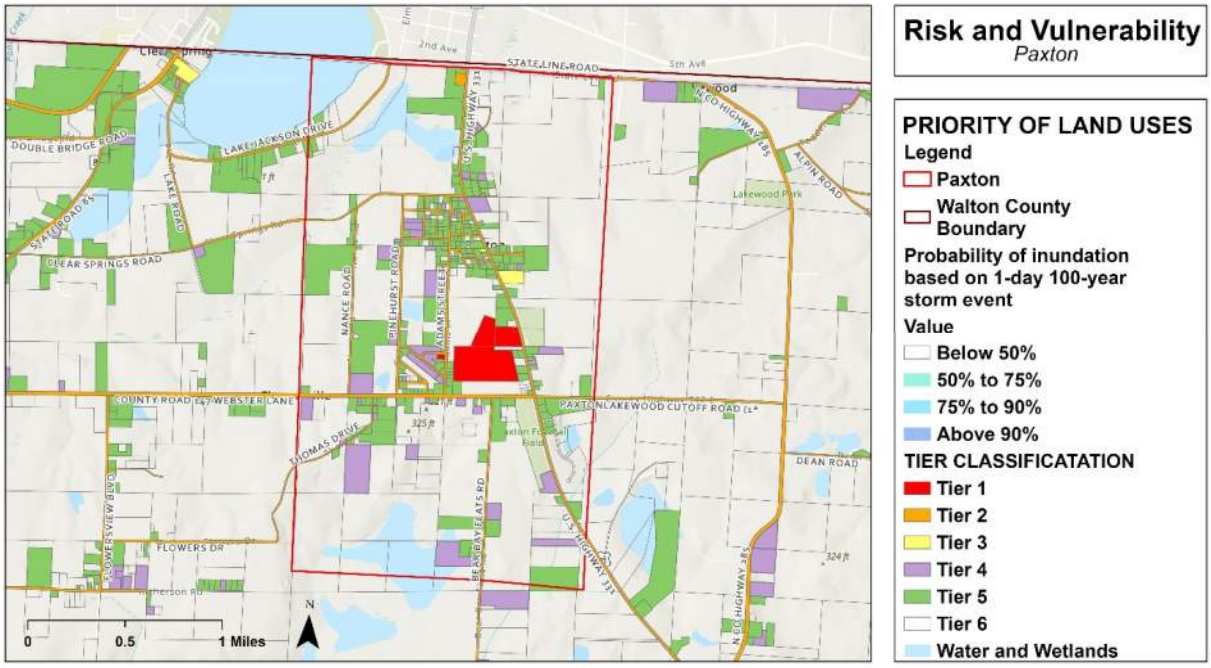

Figure 41. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-years storm event for Paxton. Processed by FAU.

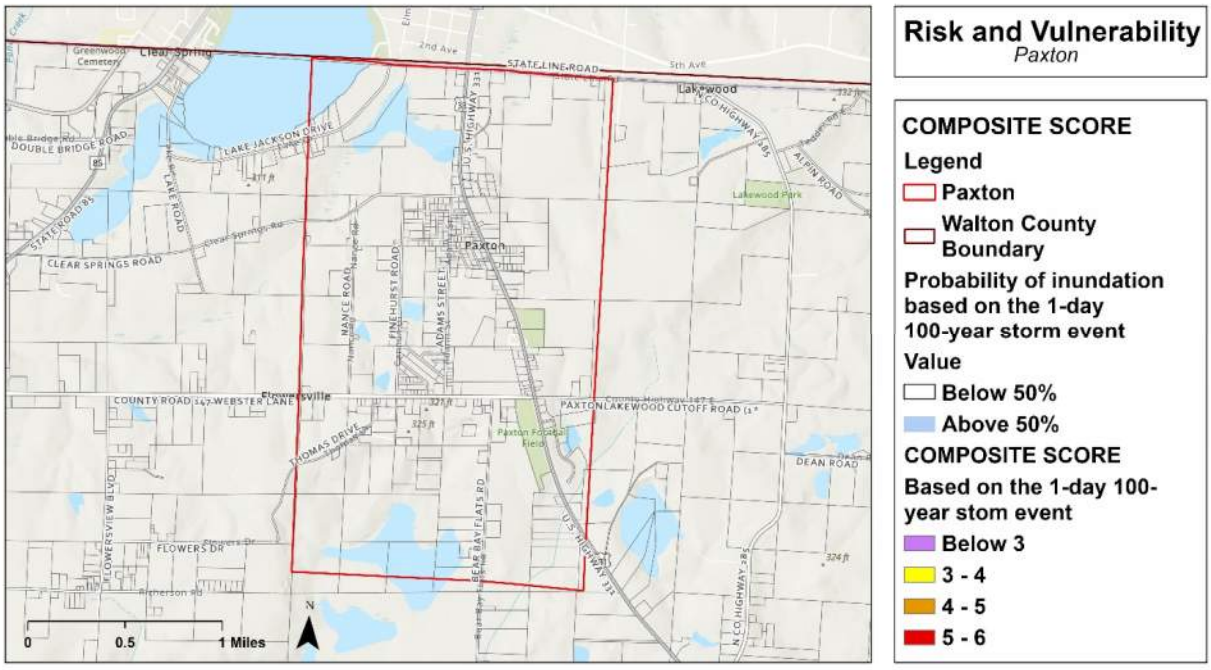

Figure 42. Composite Score map based on 1-day 100-years storm event, overlaid in flooding layer for Paxton. Processed by FAU.

2.4.3 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401030601. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.4 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It is important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-years storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-years storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401030601. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401030601	24506.97
All of the 1-day 100-years storm event inundation	**7.81**
Subtract	
A. Bodies of Water in 1-day 100-years inundation > 10 acres	0.00
B. Federal Land in 1-day 100-years inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-years inundation > 10 acres	0
D. State Land in 1-day 100-years inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-years inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-years inundation minus (A+B+C) or	7.81
With NO State Lands: All of the 1-day 100-years inundation minus (A+B+C+D+E)	7.81

2.4.5 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. Figure 43 indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

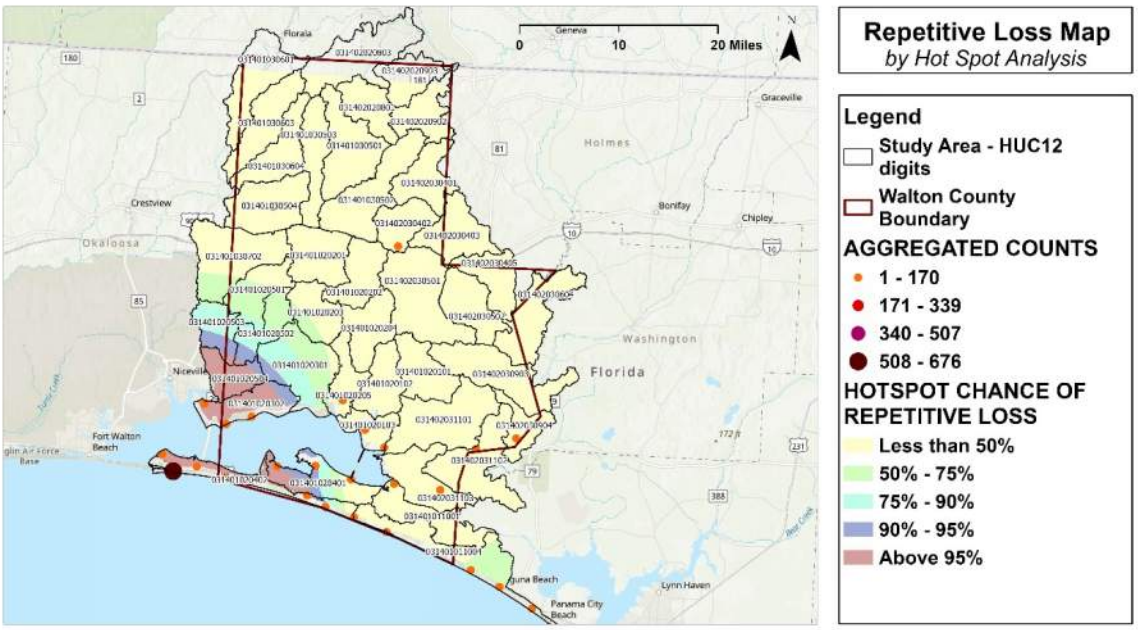

Figure 43. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.6 Priority Projects

Although there are a few parcels falling within classification tier 1, and a good amount of parcels falling within tiers 2 (roads), 4 and 5 of priority of land uses, none of them are within the flooding zone, once flooding is basically inexistent in the basin. Consequently, when considering the composite score, it is notable that the results are null, indicating no priority for intervention.

It is also important to mention that a good portion of the basin has not been included in the priority land use analysis and, consequently, in the composite score calculation. This omission is due to the project's reliance on land use data solely from Florida, and the basin has a portion on Alabama as well. The categories of land use maps in Alabama would be different, making it impossible to match the data from two different databases in different states. As a result, there is a slight possibility that there may be priority projects on the Alabama side of the basin of which we are not aware.

APPENDIX Y

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401030603

PINE LOG CREEK

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Co-Principal Investigators: Weibo Liu, Ph.D., Daniel Meeroff, Ph.D., Diana Mitsova, Ph.D., S. Nagarajan, Ph.D., Hongbo Su, Ph.D., Ramesh Teegavarapu, Ph.D., Zhixiao Xie, Ph.D., Yan Yong, Ph.D., and Caiyun Zhang, Ph.D., Ahmet Urusan, Ph.D., Shannon Egger, Eva Suarez, Ph.D.

Research Assistant: Leticia Sabio

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401030603) is highlighted among all the HUCs to help identifying its location. (Figure 3).

A small town, Paxton, shares a portion of its boundary with the basin. Demographic data and other characteristics of Paxton, along with other cities in Walton County, will be discussed later.

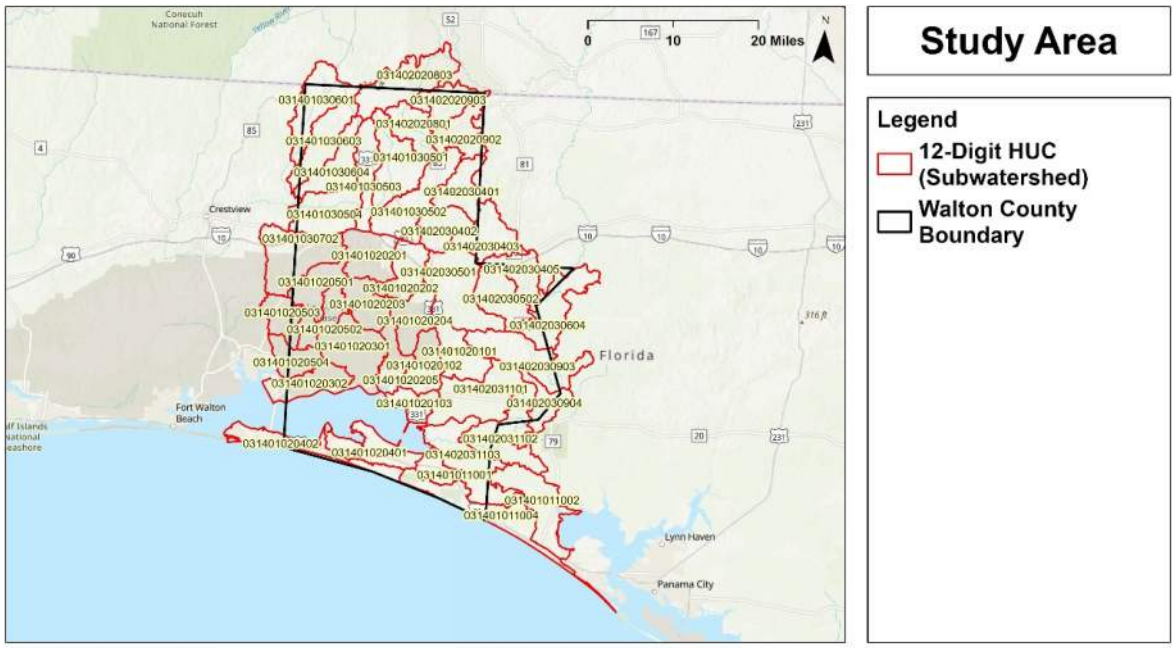

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

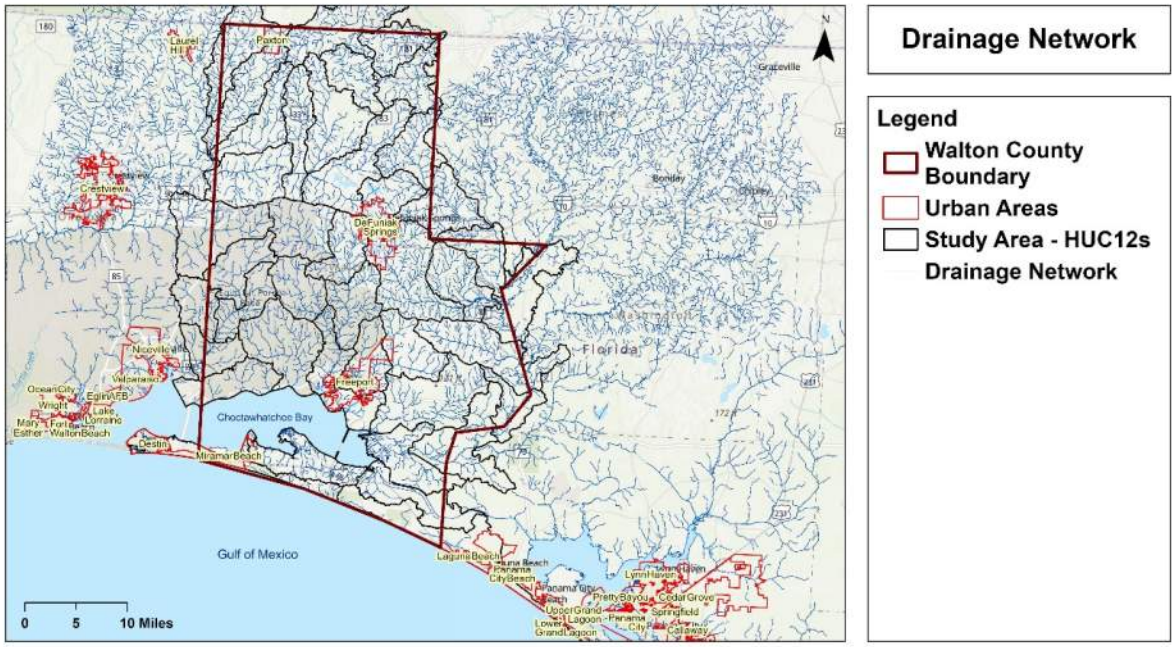

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

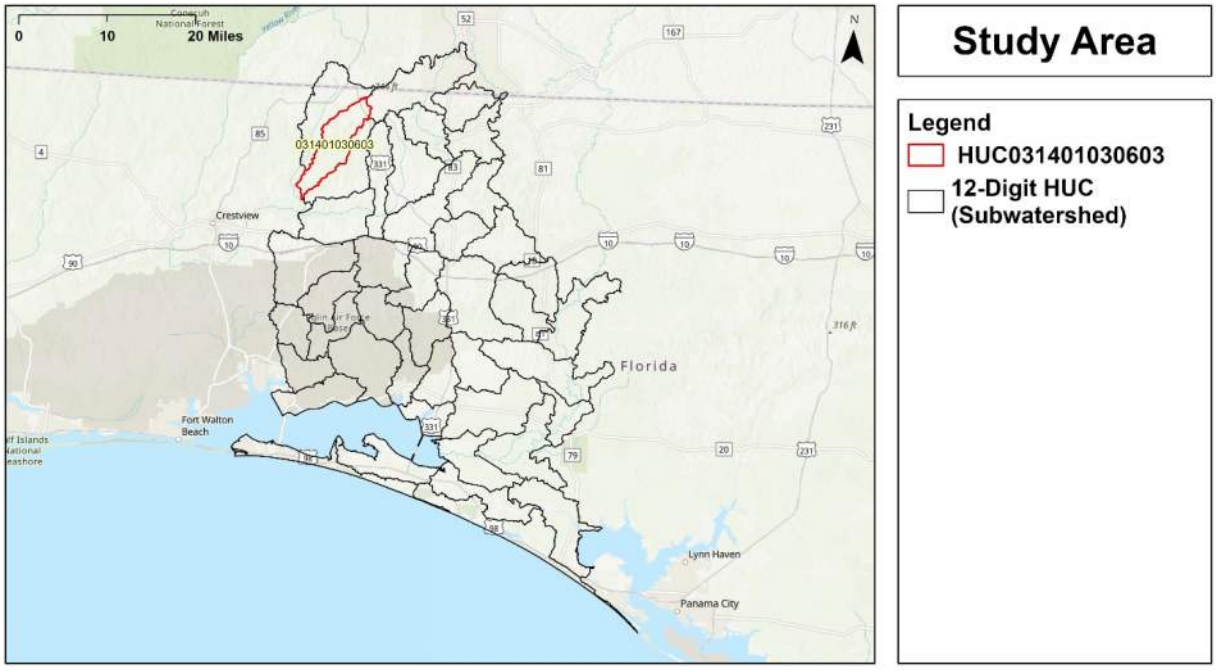

Figure 3. HUC 031401030603 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Based on the future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with

high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

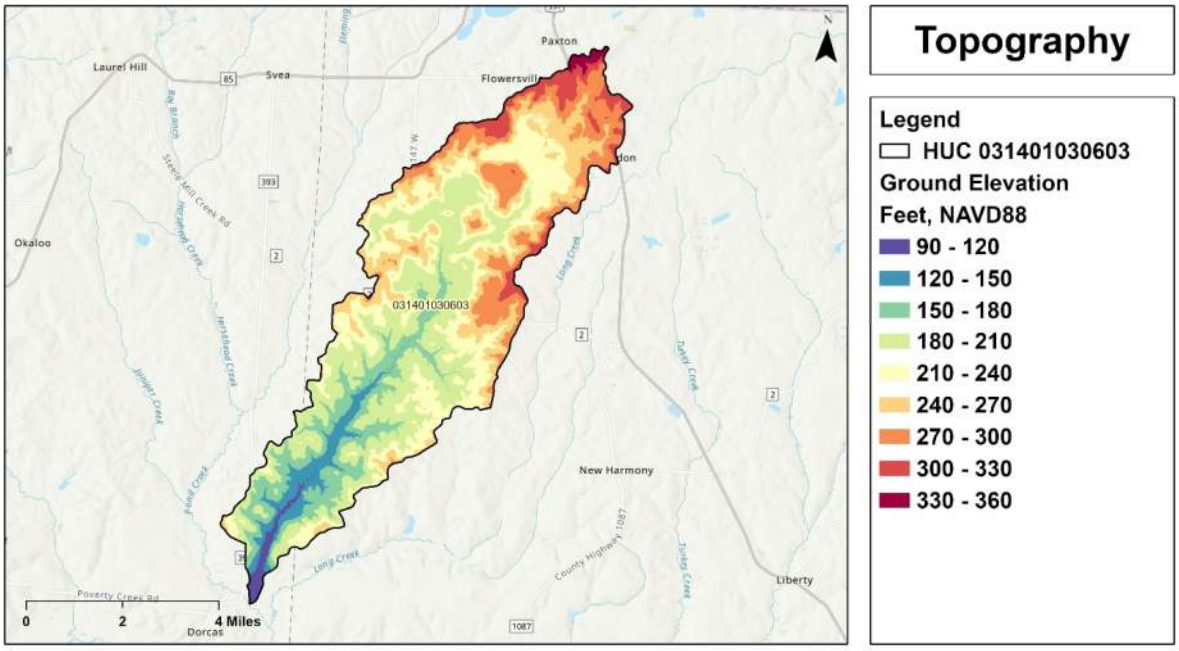

Figure 4. Topographic map of the HUC 031401030603 sub-watershed, processed by FAU

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of

wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401030603 sub-watershed is shown in **Error! Reference source not found.**.

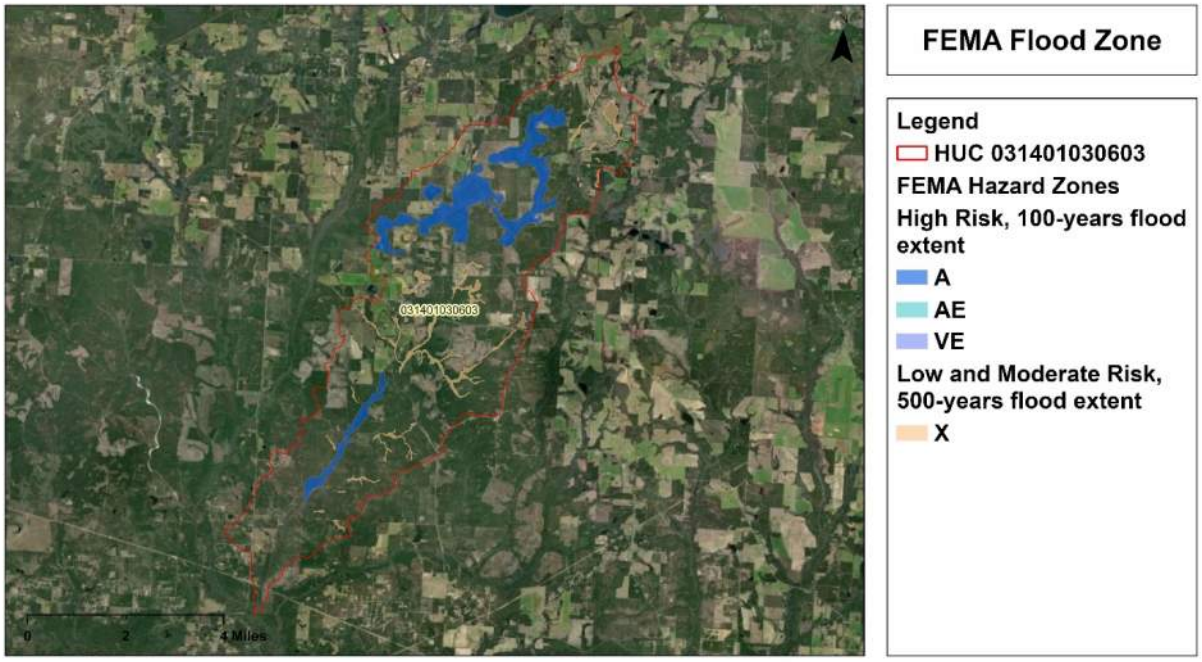

Figure 5. FEMA Flood Zone map (2020) for HUC 031401030603 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination

between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401030603 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

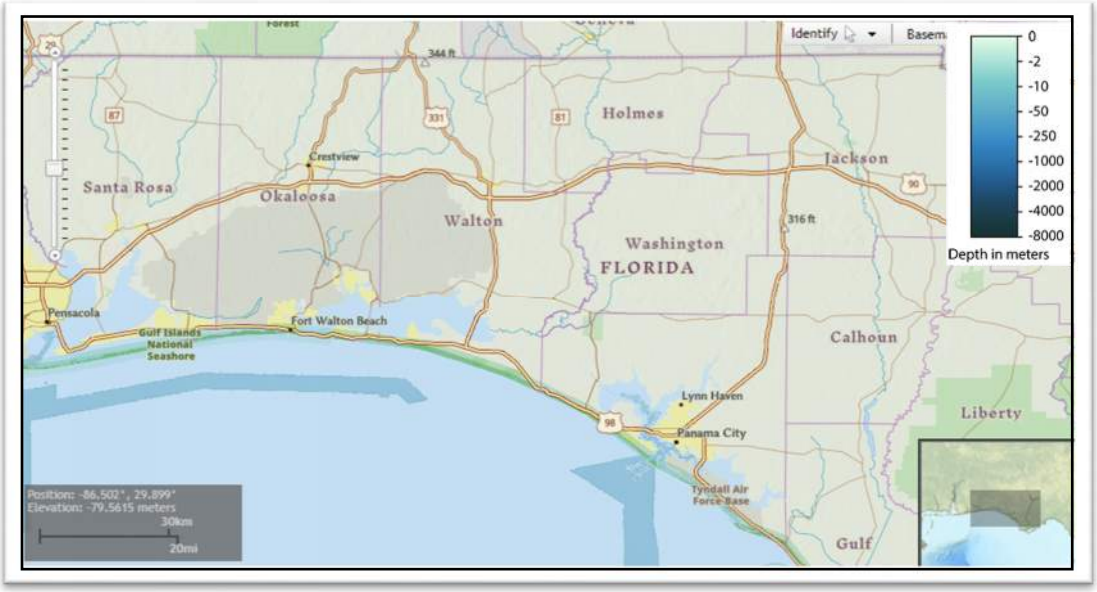

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological

conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

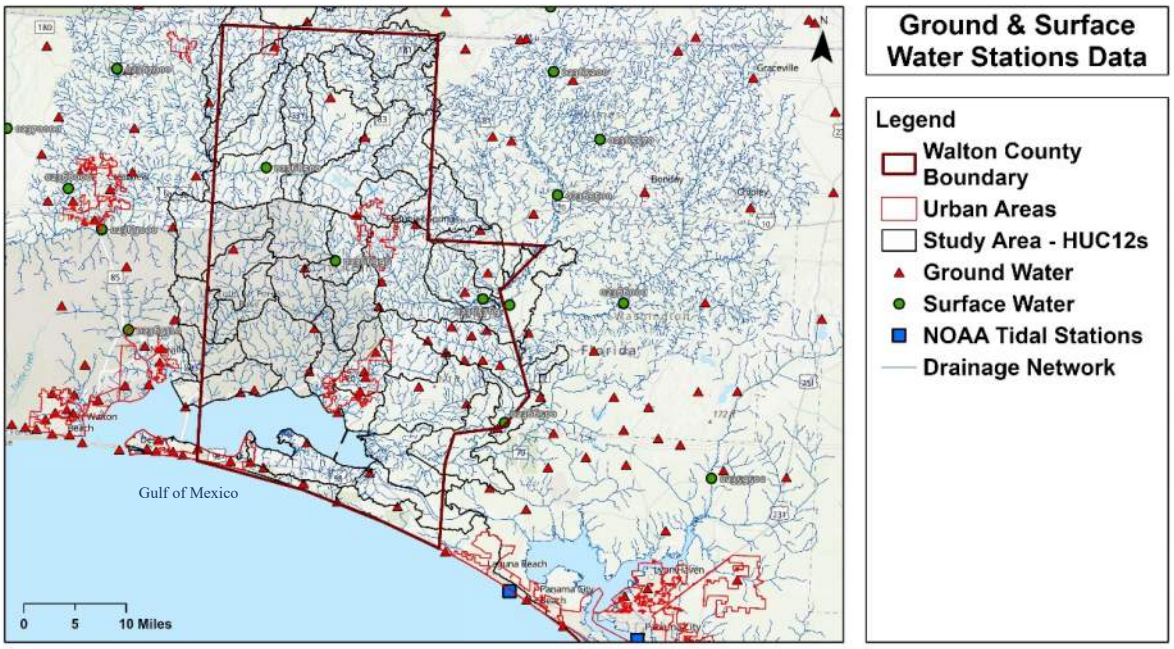

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031401030603 has no major rivers and canals, but creeks, include:

- Pine Log Creek
- East Branch Pine Log Creek

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02368500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401030603, which is USGS 02368500 Shoal River.

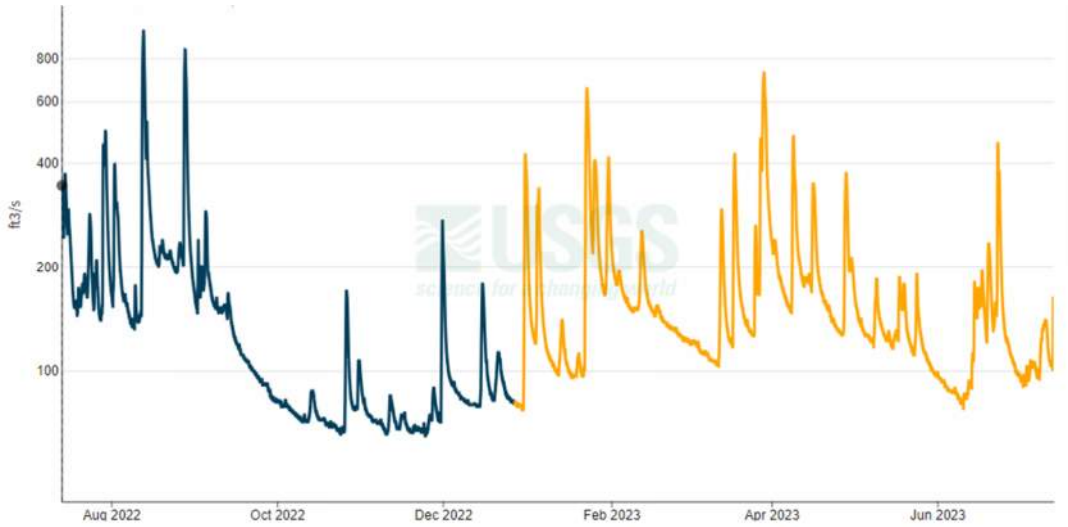

Figure 8. Average streamflow for Shoal River NR Mossy Head, Fla (USGS 02368500 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02368500/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station

(or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401030603 and points out the location of the ground water station in the surroundings. A groundwater-surface layer for the HUC 031401030603 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

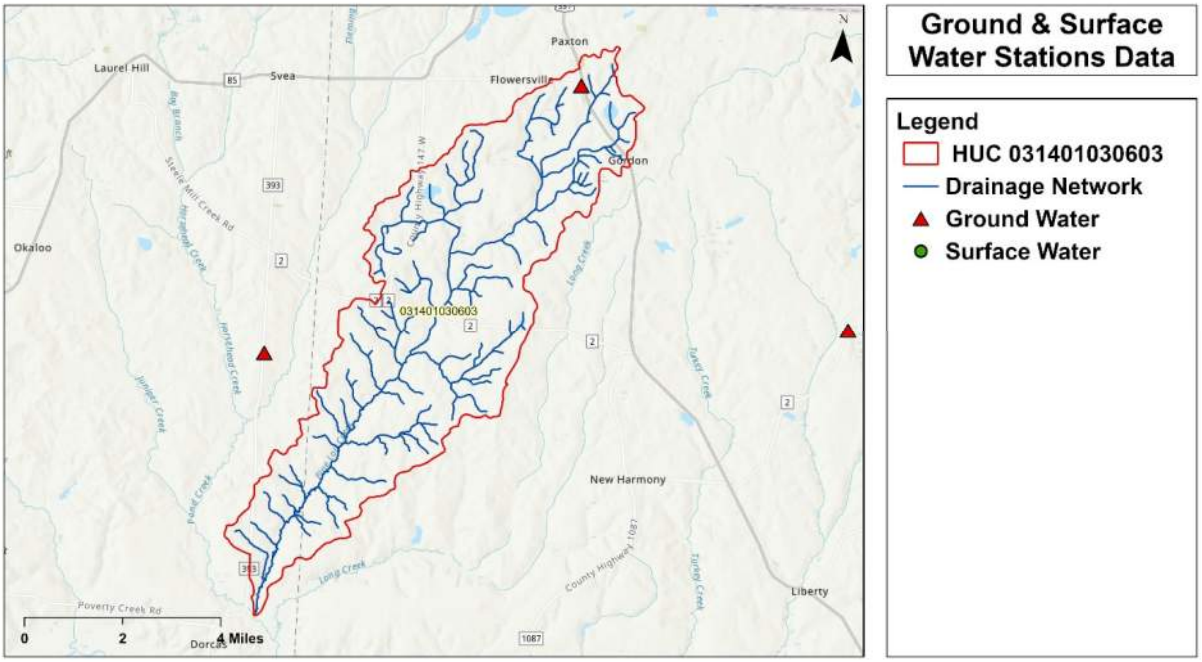

Figure 9. Ground and Surface Water Stations in the HUC 031401030603 sub-watershed, processed by FAU.

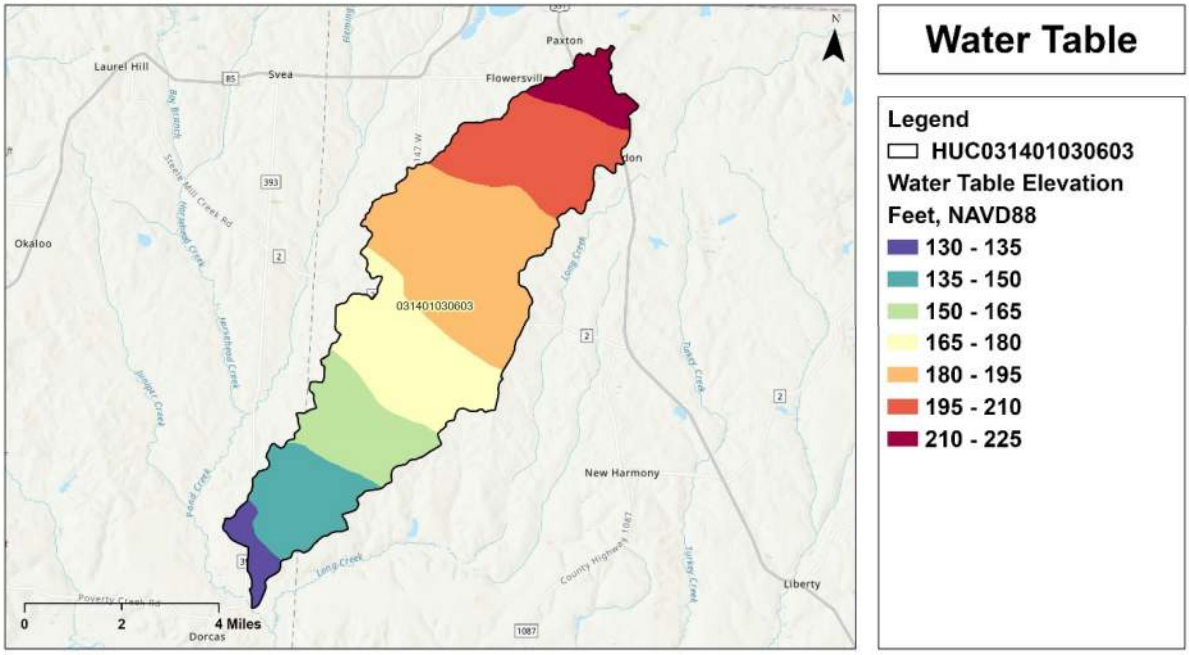

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401030603 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

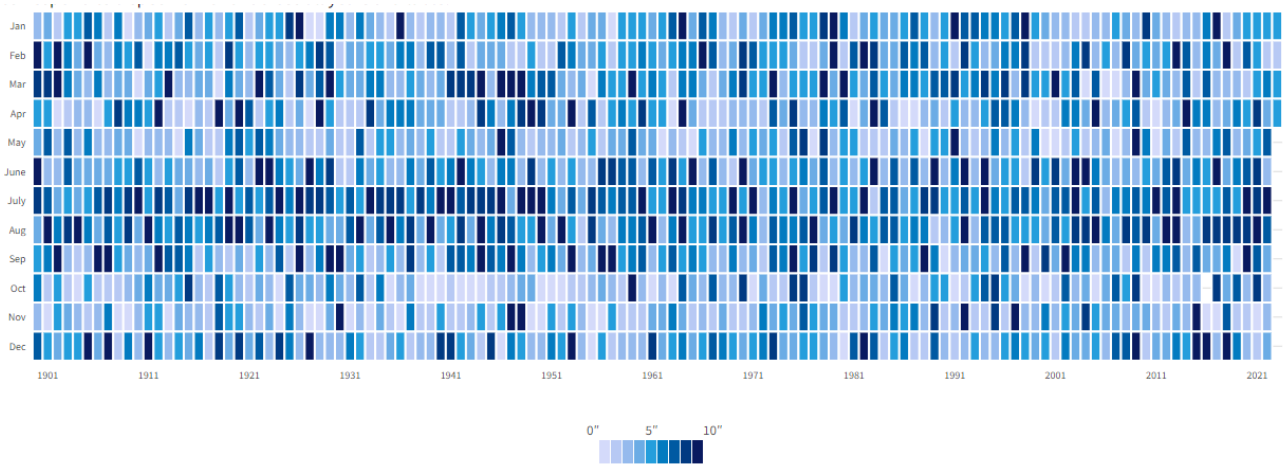

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/)

While the topography (Section 2.1) and native soil (Section 2.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there are no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

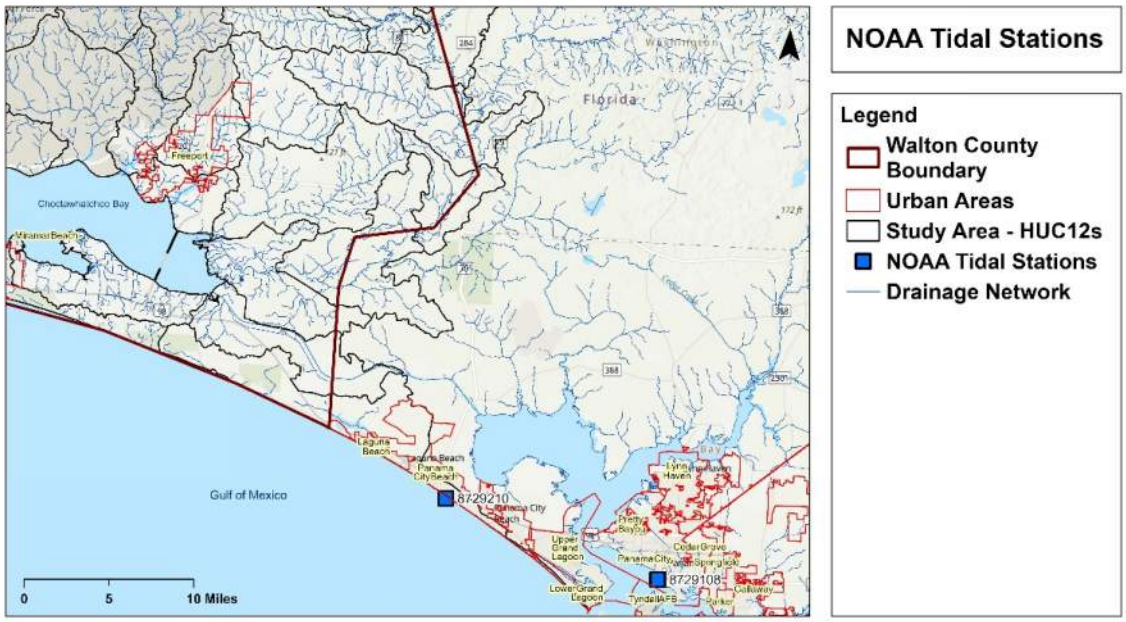

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

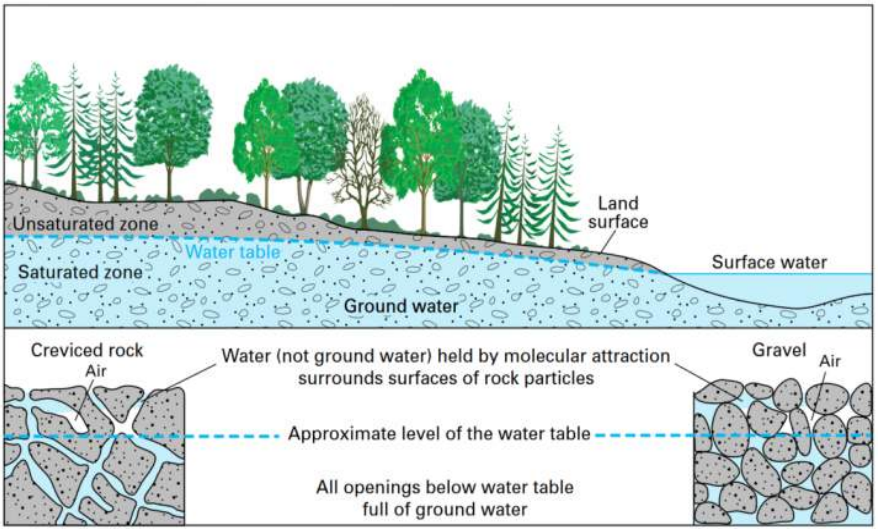

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

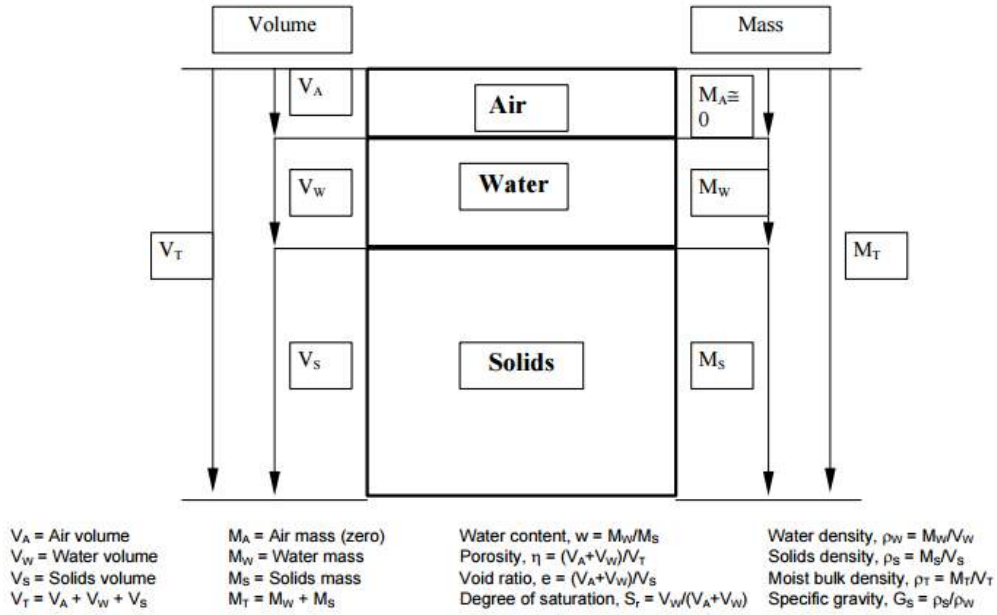

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

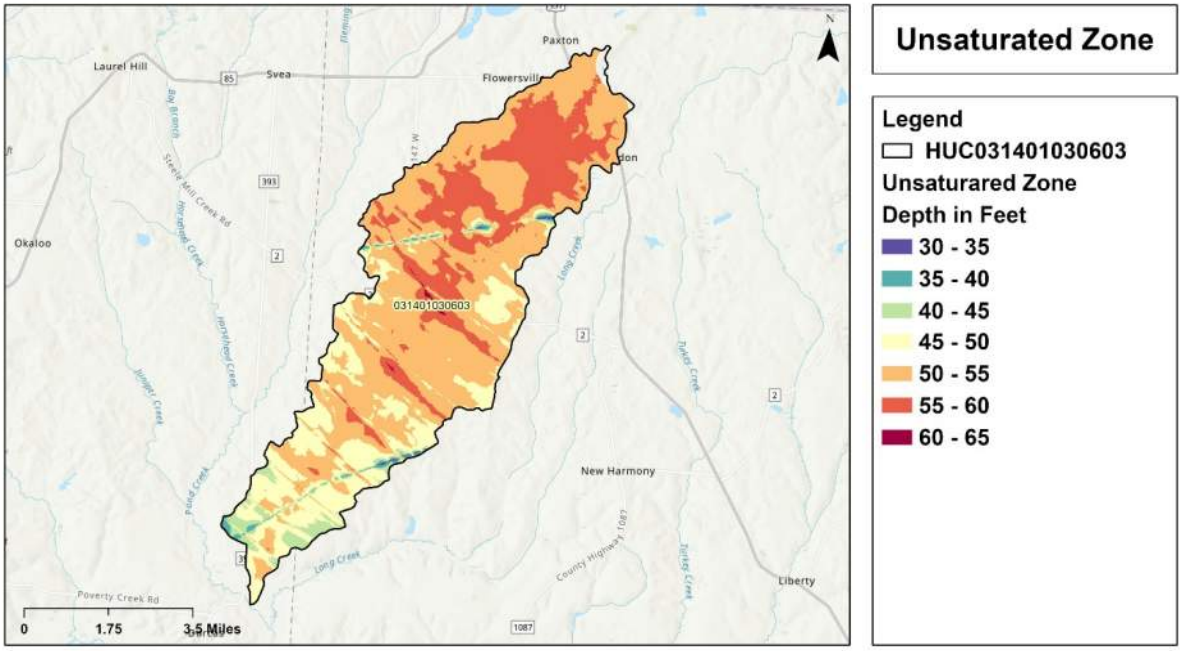

Figure 15. Unsaturated zone map for HUC 031401030603, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A great portion of the basin has enough soil storage capacity, ranging between 45 to 60 inches of capacity left.

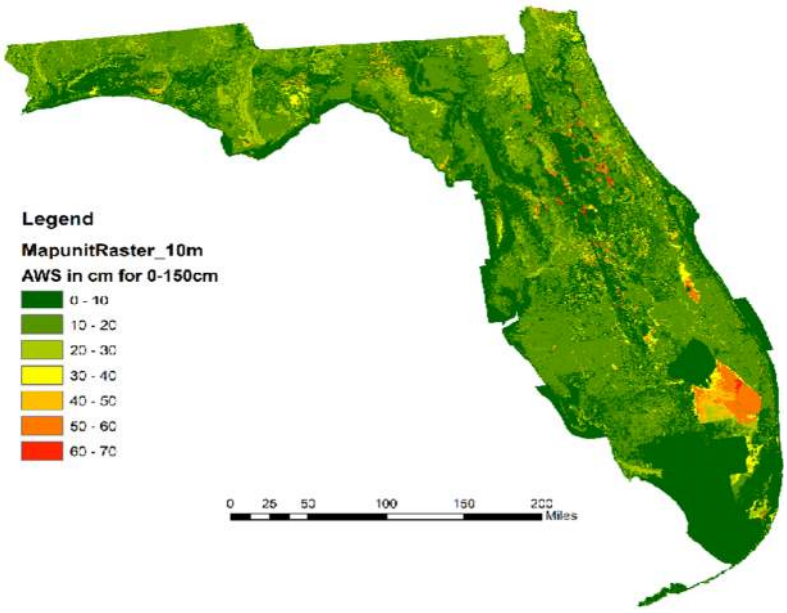

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

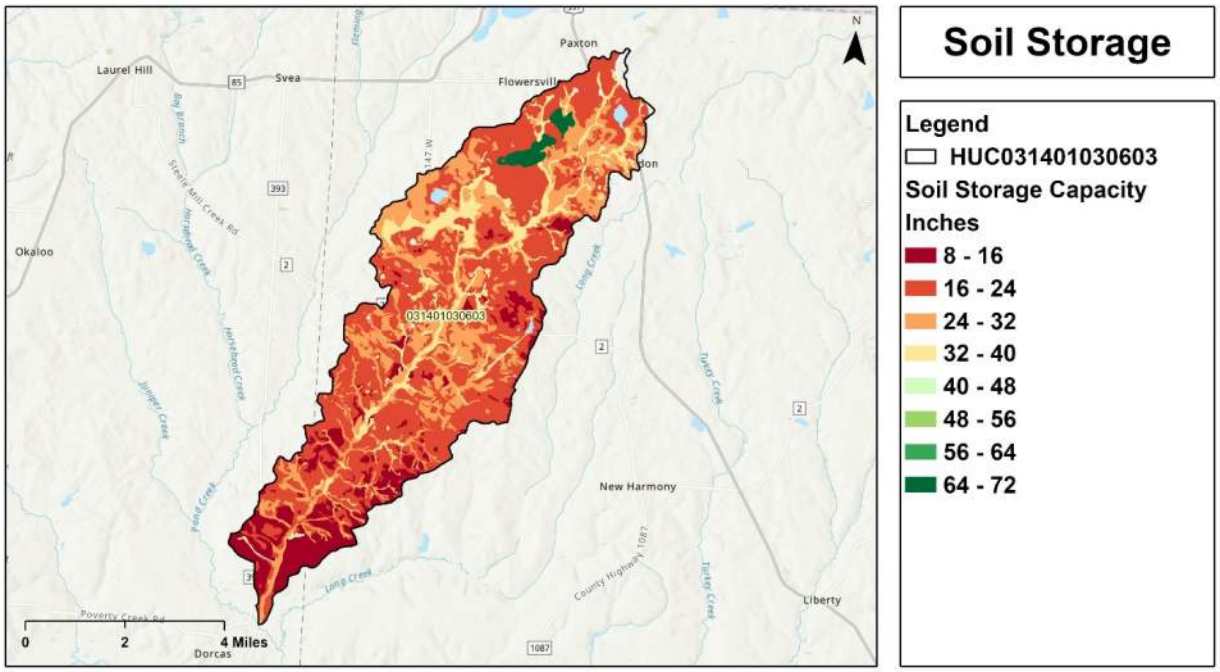

Figure 17. Water storage capacity of soil for the HUC 031401030603 (inches), processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

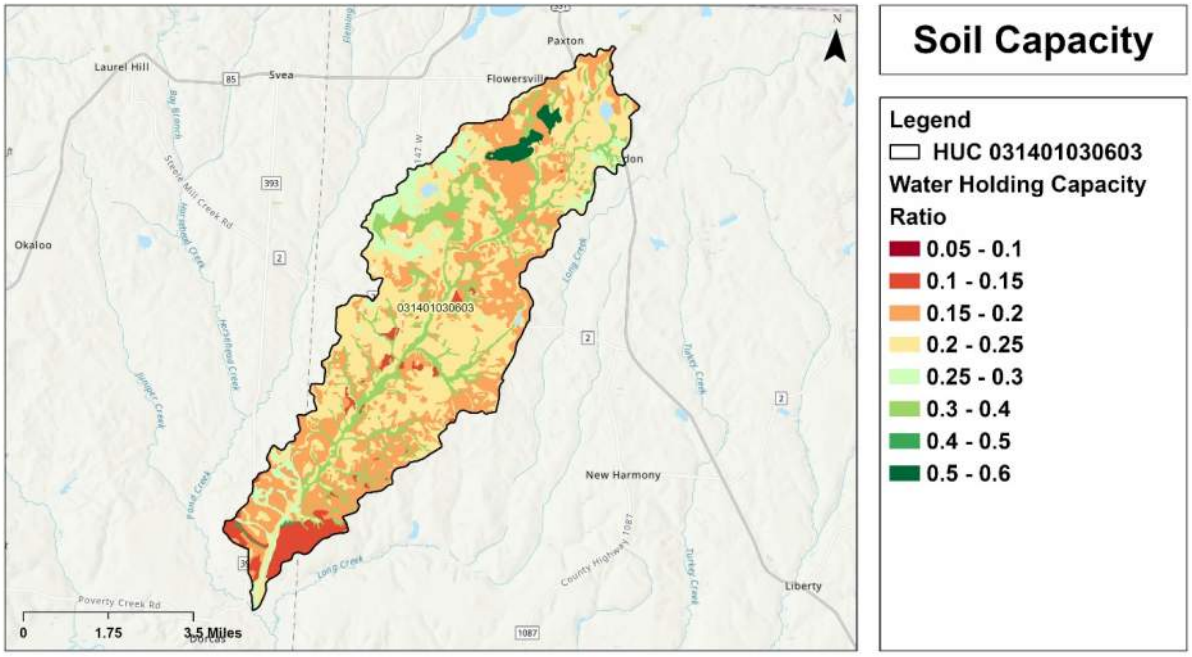

Figure 18. Water Holding Capacity (ratio) for the HUC 031401030603, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

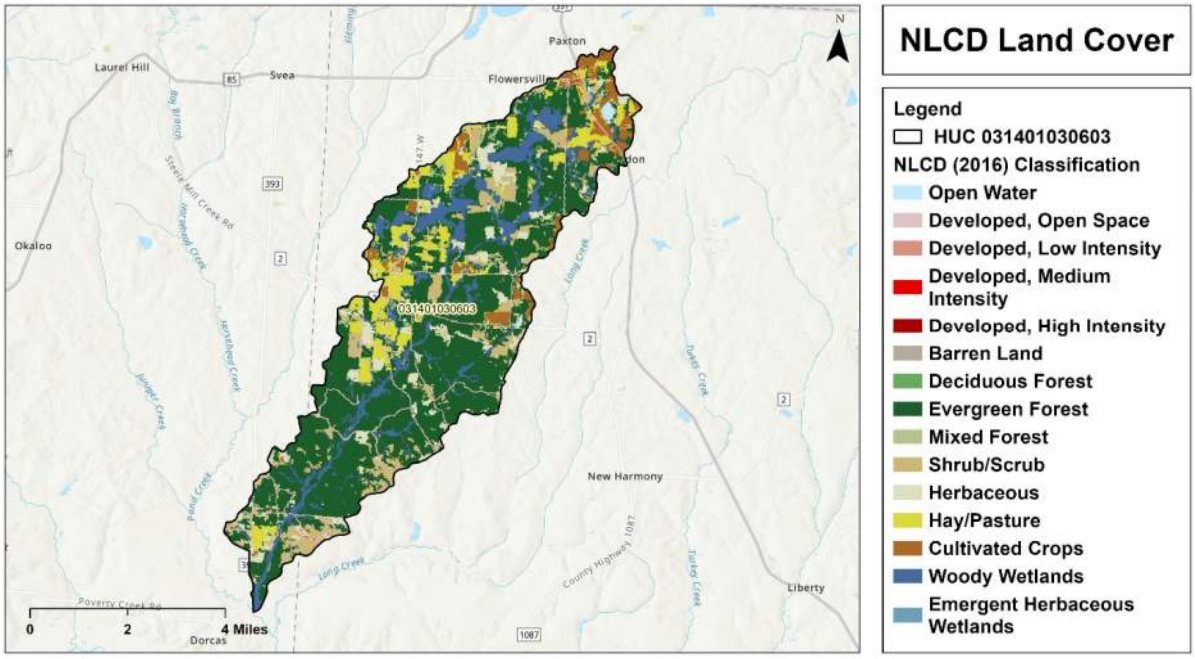

Figure 19. Land use in the HUC 031401030603 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

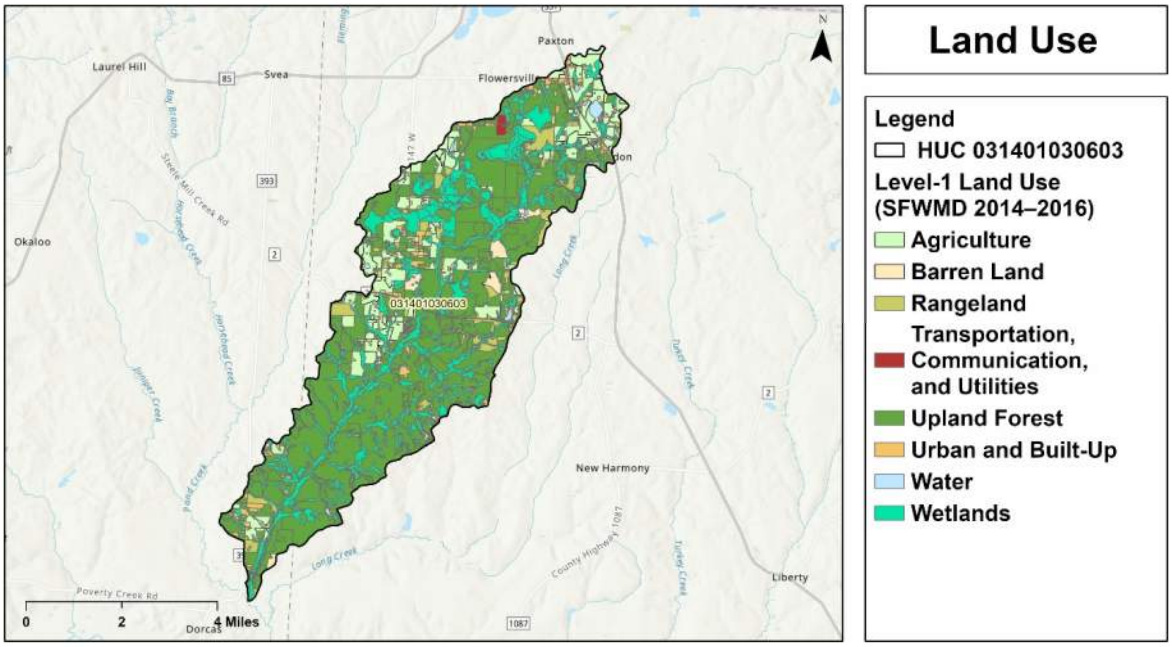

Figure 20. Land use in the HUC 031401030603 (2023 Florida Geographic Data Library (FGDL))), processed by FAU.

In the HUC 031401030603 sub-watershed, mostly of the area is upland forest, with 57.91%. The second place is wetlands, with 16.82%, followed by agriculture, with 13.92%. There is no much developed land in the HUC – only 2.86% is urban and built-up and only 1.08% is Transportation, Communication, and Utilities, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031401030603 subwatershed (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	3752.82	13.92%
Barren Land	355.57	1.32%
Rangeland	1115.40	4.14%
Transportation, Communication, and Utilities	291.86	1.08%
Upland Forest	15615.50	57.91%
Urban and Built-Up	771.94	2.86%
Water	524.25	1.94%
Wetlands	4536.08	16.82%
Grand Total:	**26963.42**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

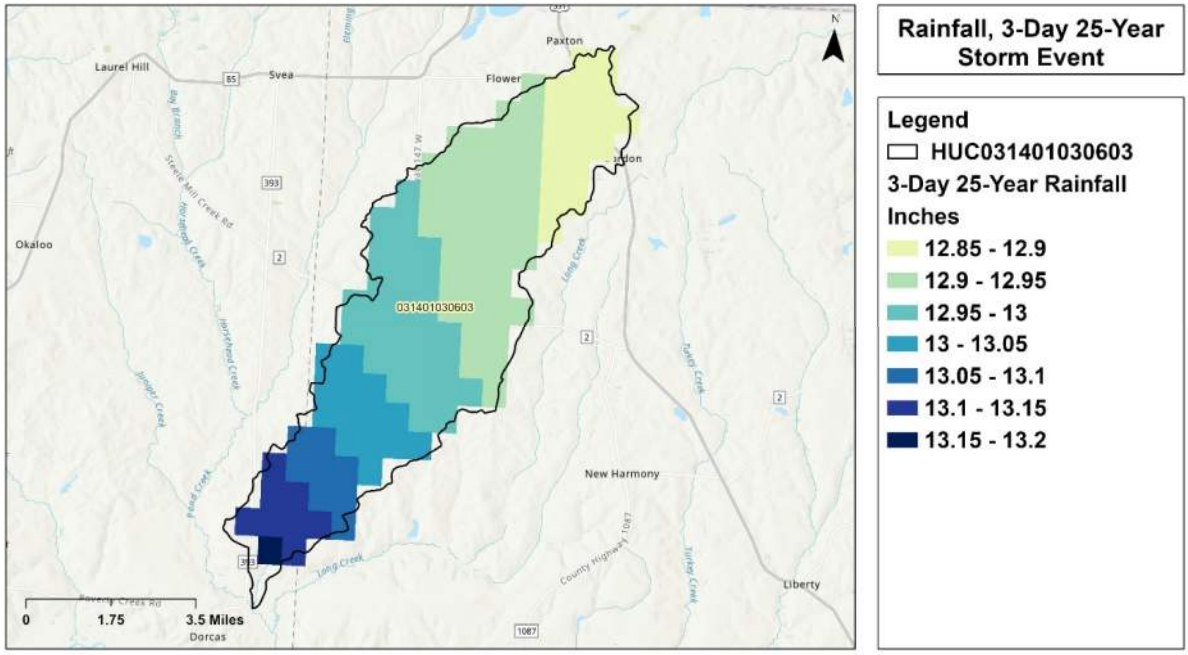

Figure 21. Rainfall distribution map across HUC 031401030603 sub-watershed, for 3-day 25-year storm event, processed by FAU.

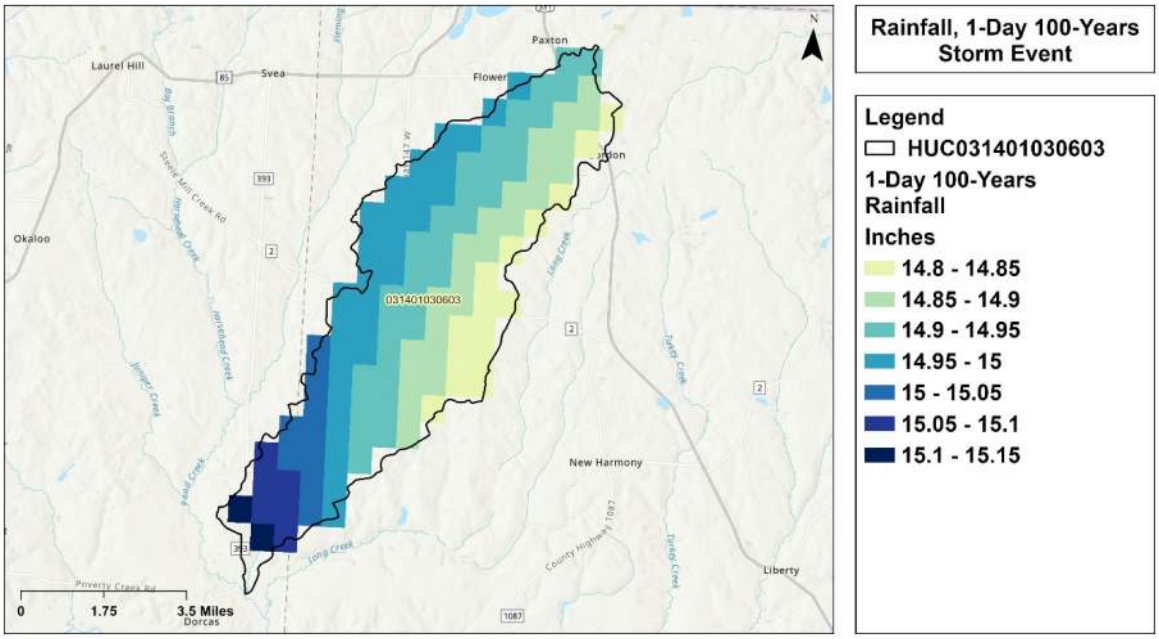

Figure 22. Rainfall distribution map across HUC 031401030603 sub-watershed, for 1-day 100-year storm event, processed by FAU.

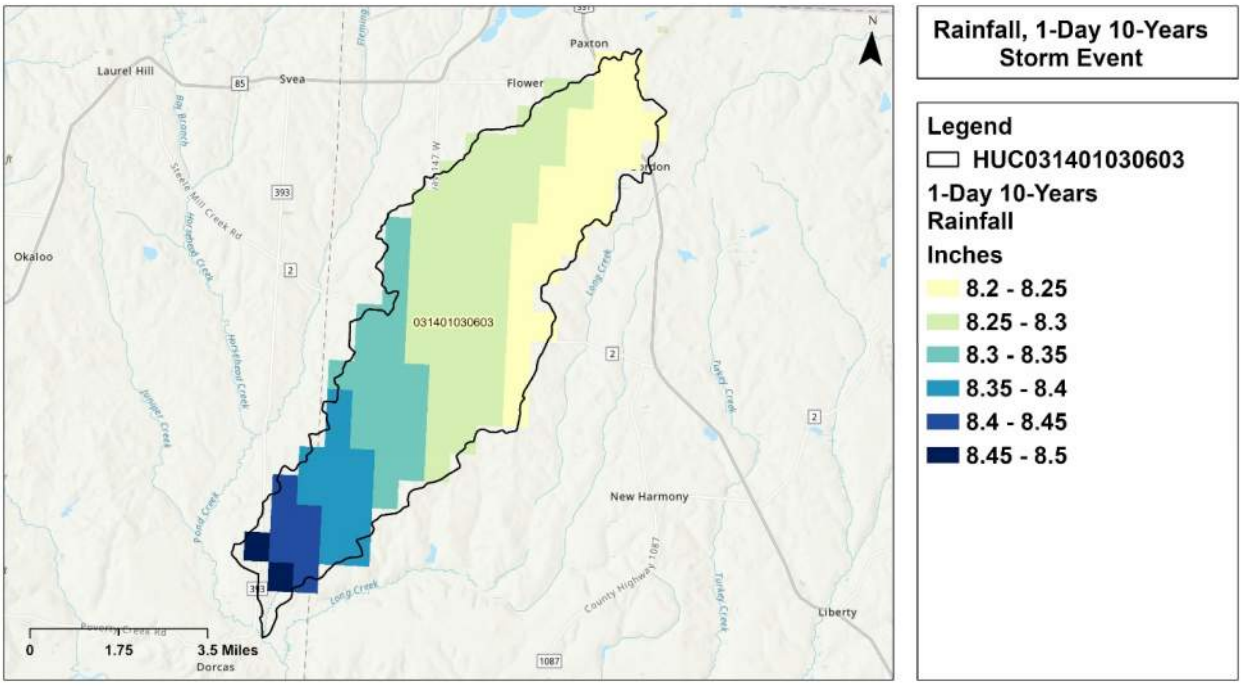

Figure 23. Rainfall distribution map across HUC 031401030603 sub-watershed, for 1-day 10-year storm event, processed by FAU.

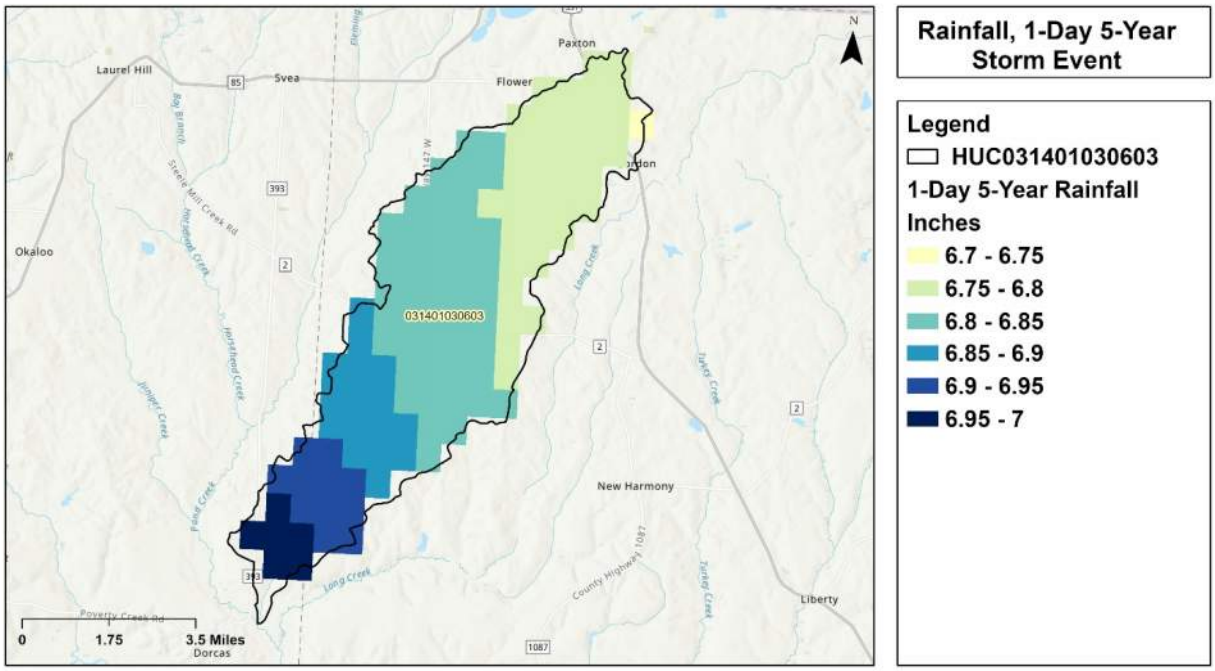

Figure 24. Rainfall distribution map across HUC 031401030603 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically

aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

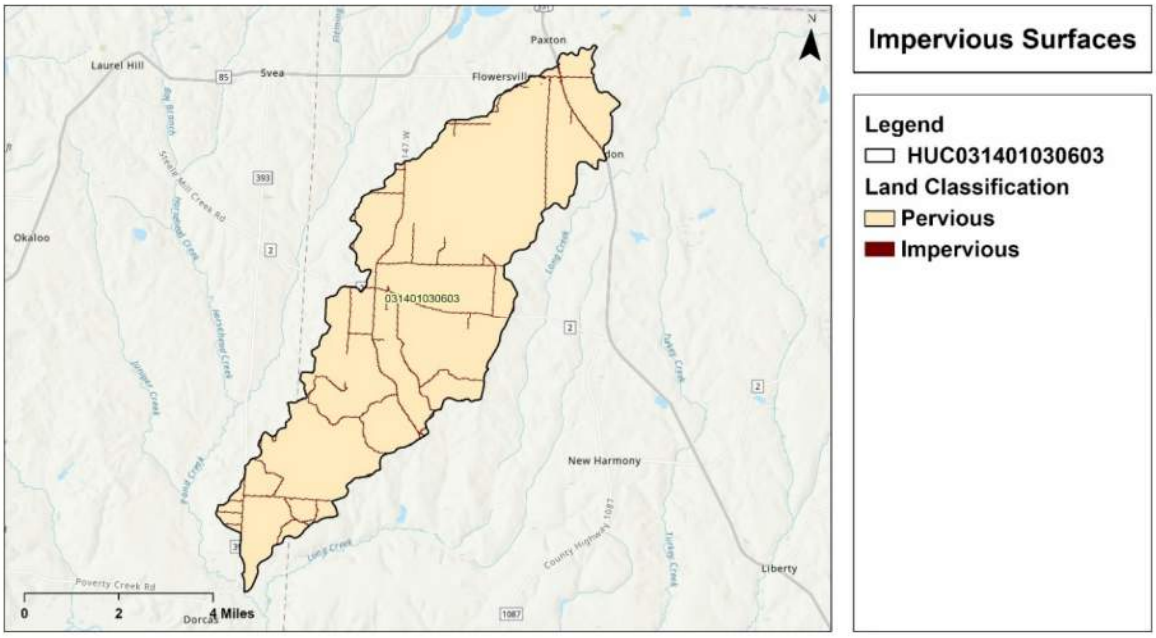

Figure 25. Impervious area map for the HUC 031401030603 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

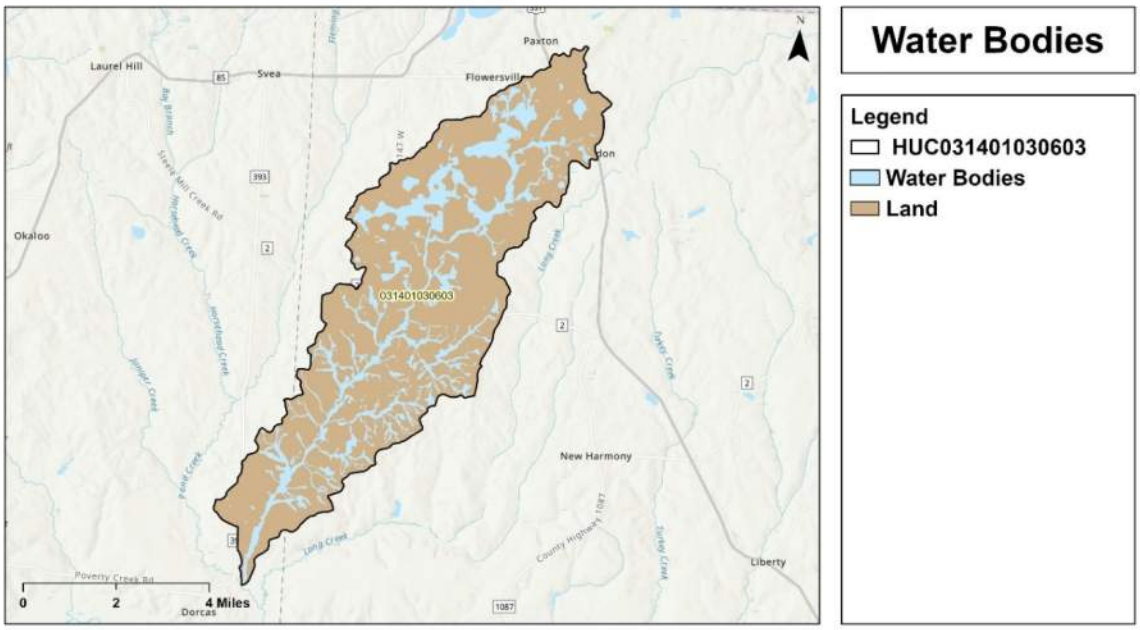

Figure 26. Water bodies map for the HUC 031401030603 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, Table 5 outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, , such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

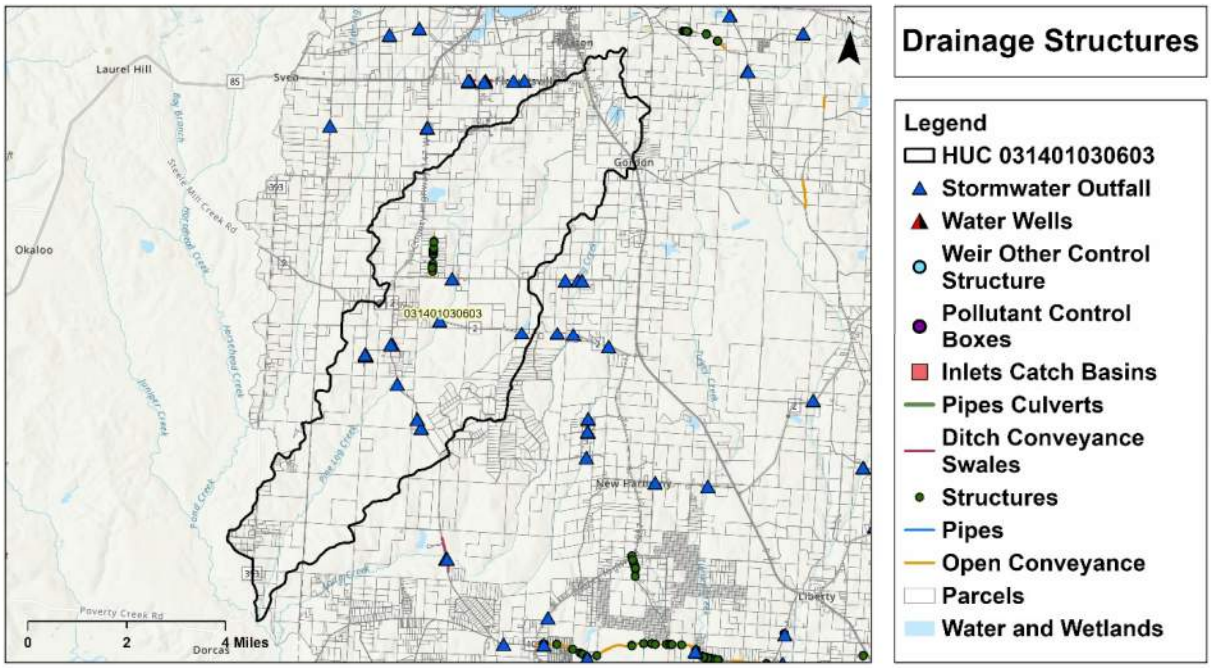

Figure 27. Stormwater Infrastructure for the HUC 031401030603. Processed by FAU.

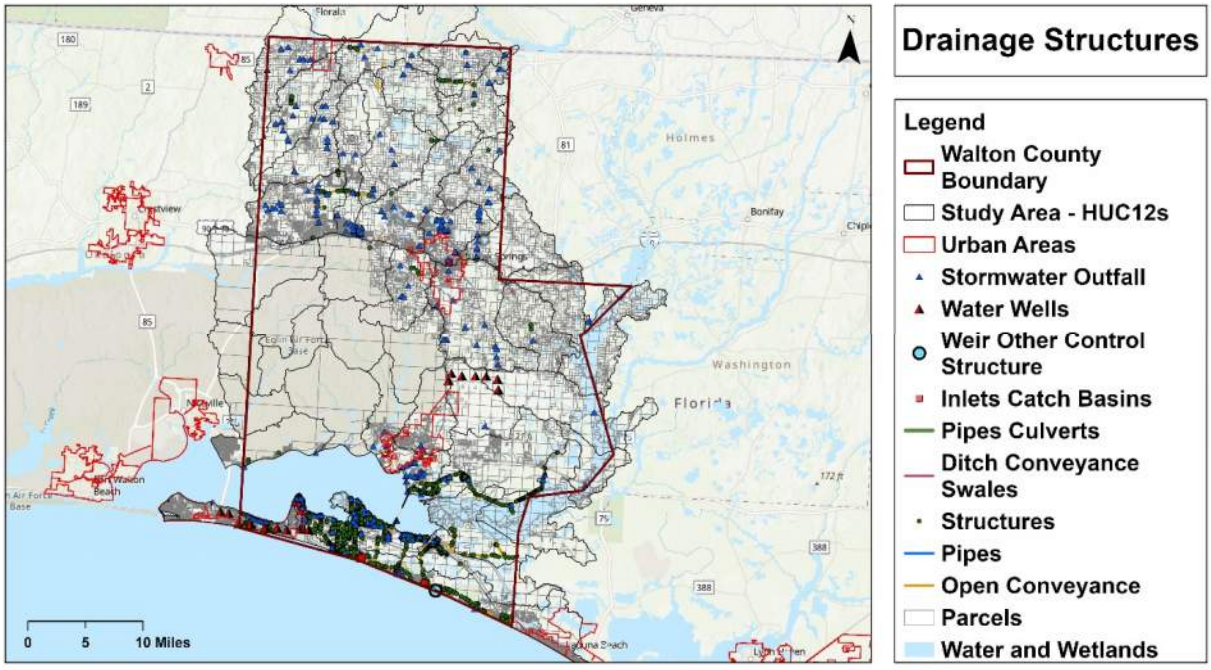

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020)

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401030603 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

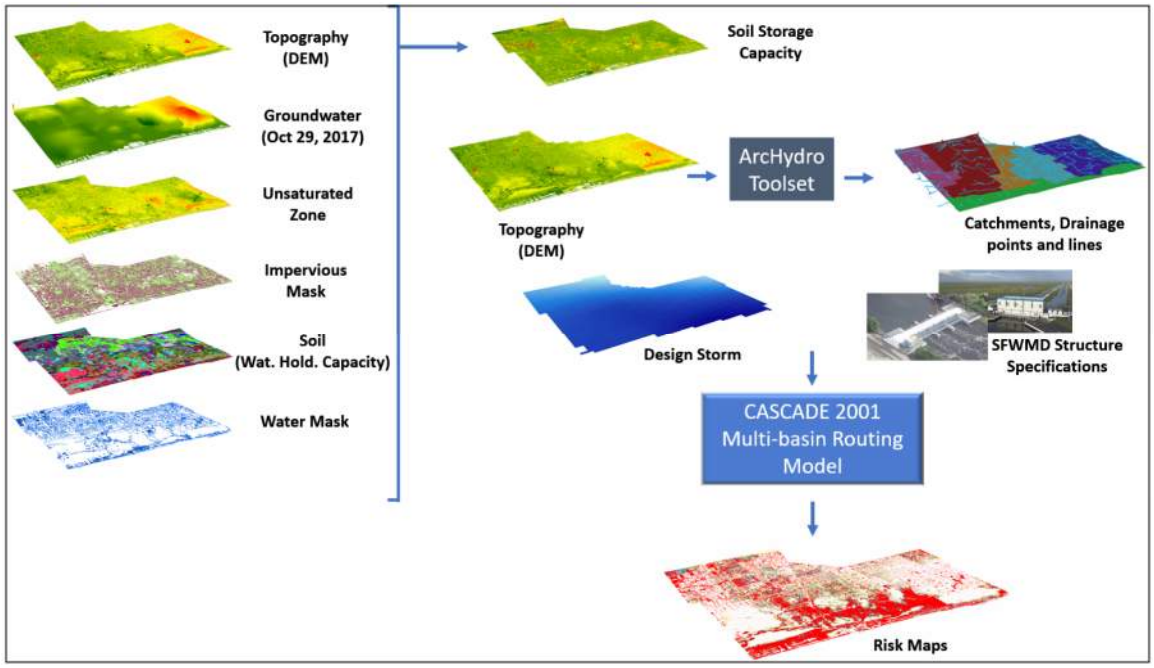

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)

= 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

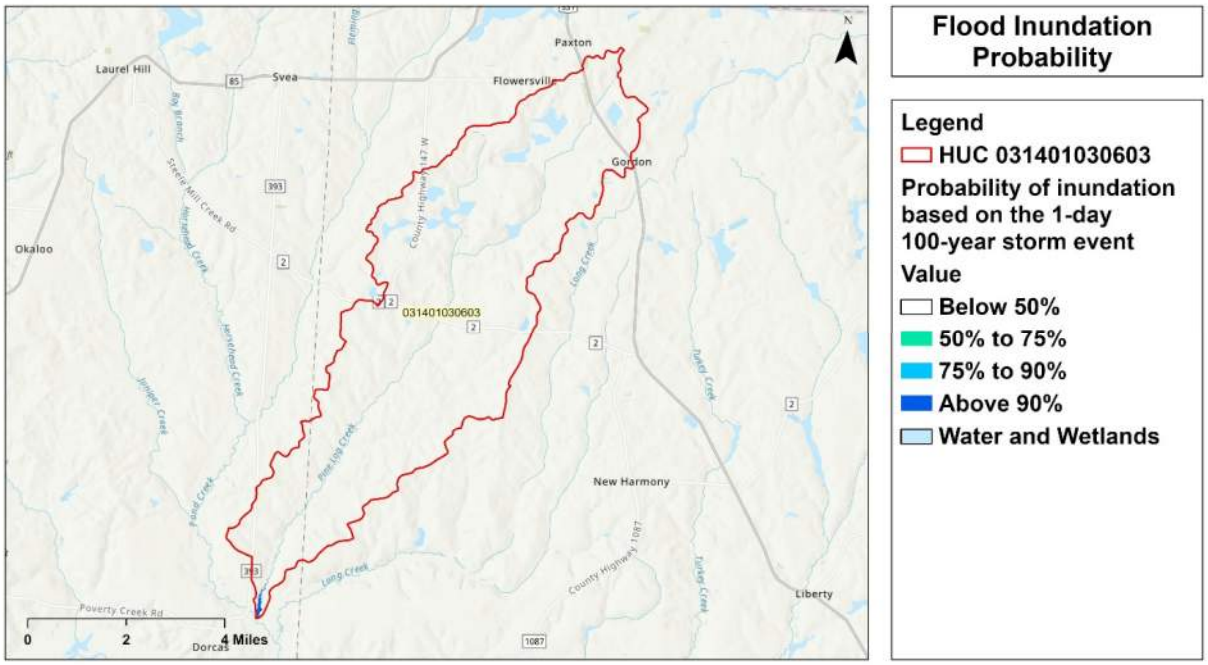

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401030603, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation

and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations,

Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a small portion of flooding, almost imperceptible is noted at the entrance to the creek into the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, sea level rise should not impact the HUC, therefore SLR scenarios were not calculated.

The design storm simulation determined that approximately 0.1% of the HUC total area or only 0.033 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 0.12% of the HUC's total area, or 0.038 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.09% of the HUC's total area, or 0.029 mi^2, would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0.09% of the HUC's total area, or 0.029 mi^2, would be expected to be inundated

during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401030603 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	32.791	0.033	99.90%	0.10%
1-day 100-year	32.786	0.038	99.88%	0.12%
1-day 10-year	32.795	0.029	99.91%	0.09%
1-day 5-year	32.795	0.029	99.91%	0.09%

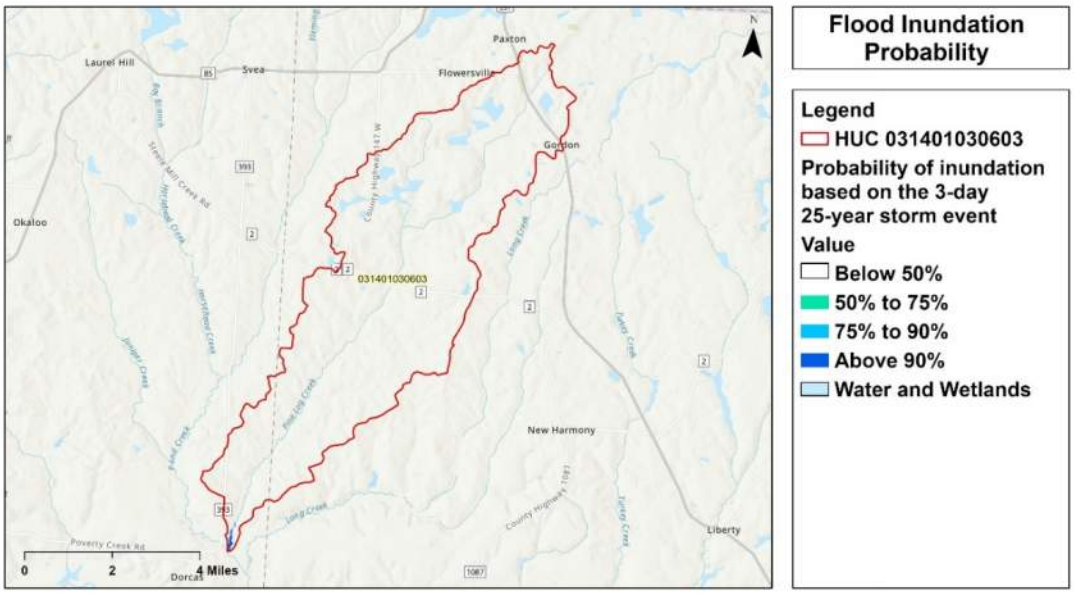

Figure 31. 3-day 25-year storm event for HUC 031401030603 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

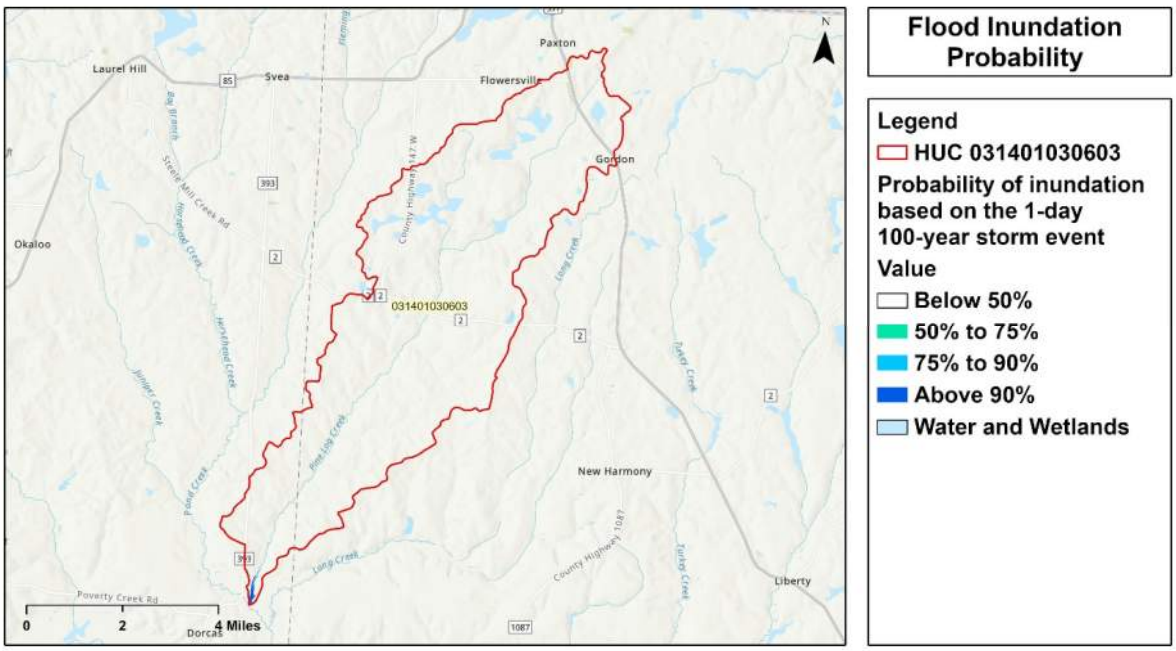

Figure 32. 1-day 100-year storm event for HUC 031401030603 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

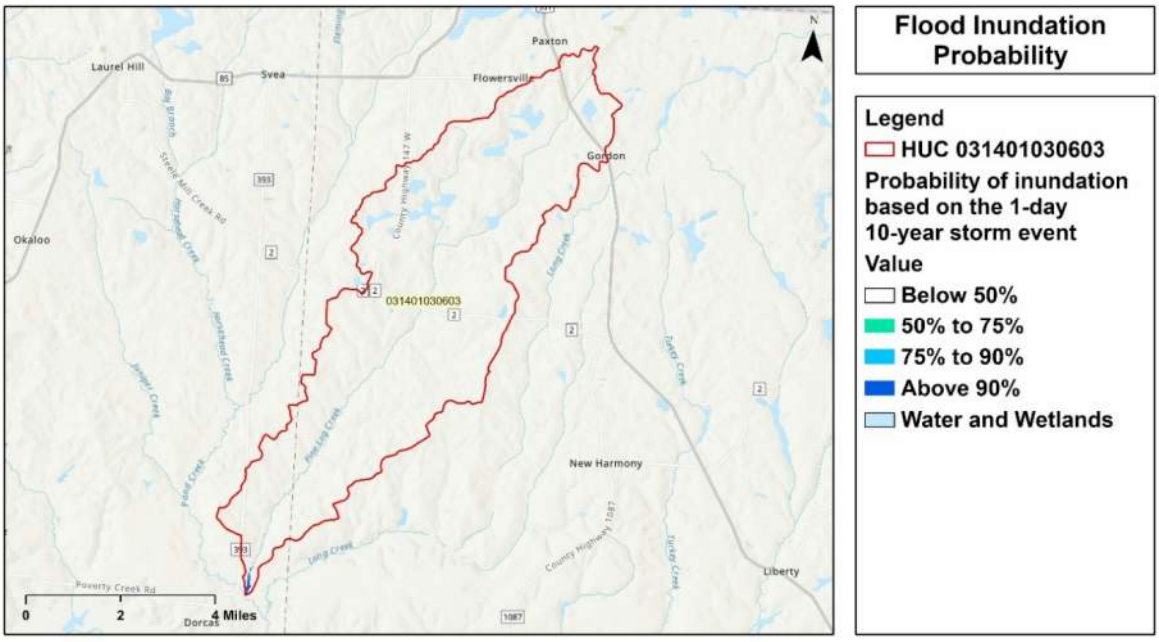

Figure 33. 1-day 10-year storm event for HUC 031401030603 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

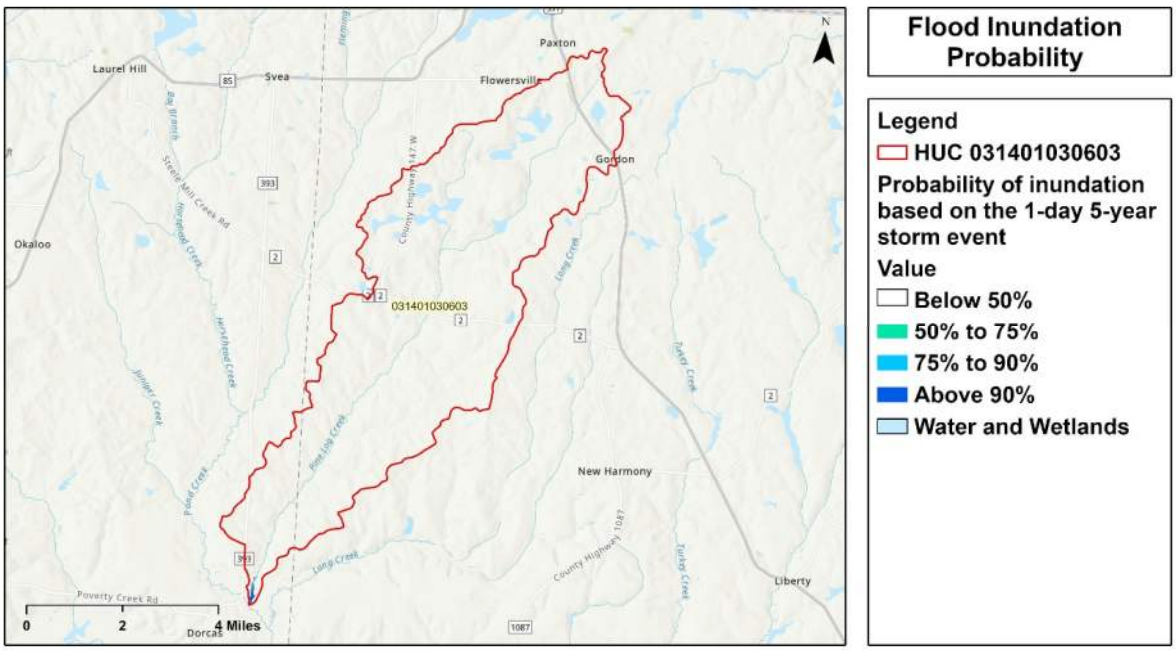

Figure 34. 1-day 5-year storm event for HUC 031401030603 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have

lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3

26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6

53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6

87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is

converted to a 6-point scale termed as the Flood Risk Factor, as shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.**depict the HUC 031401030603 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

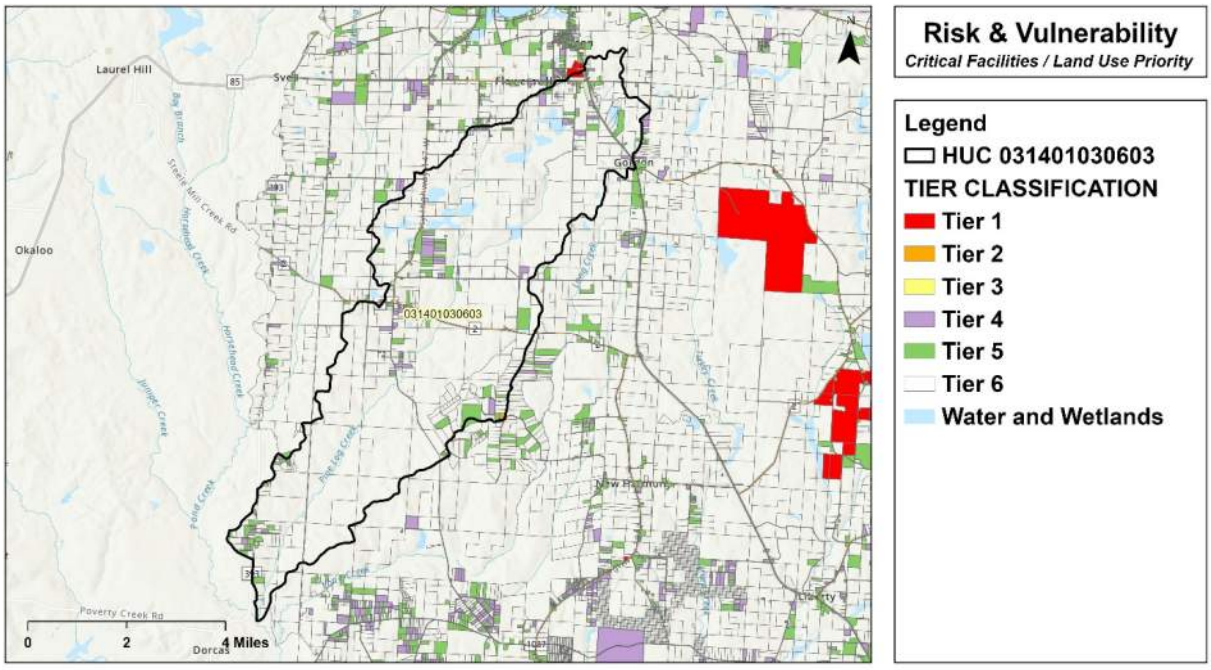

Figure 35. HUC 031401030603 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

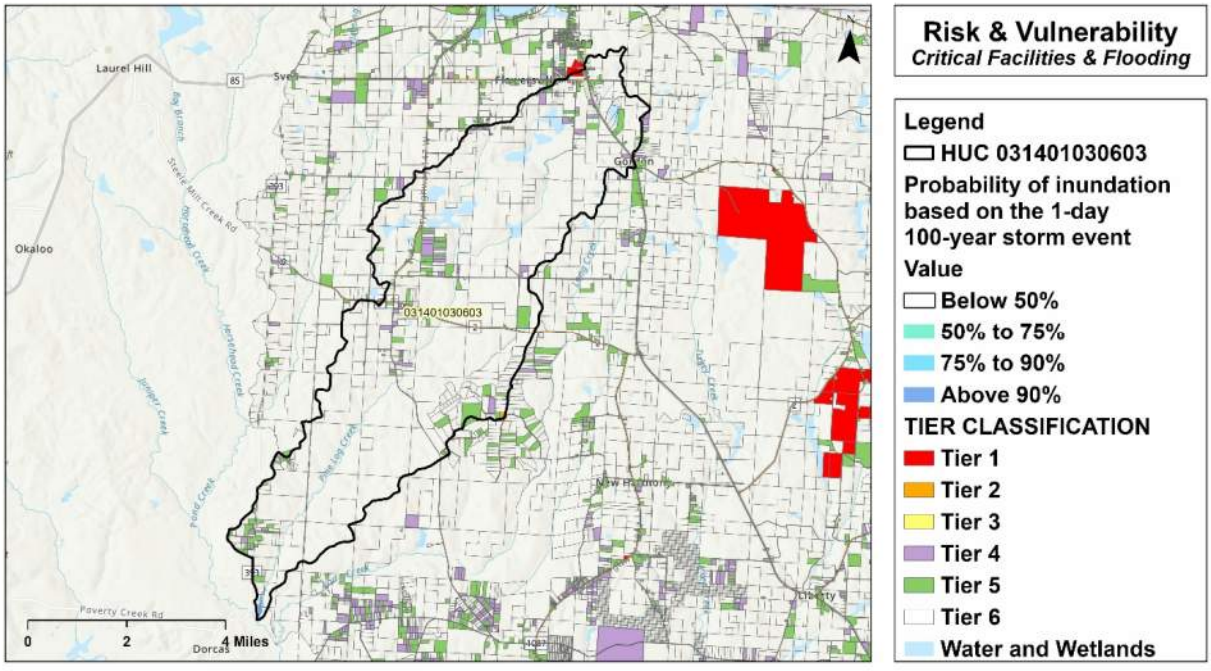

Figure 36. HUC 031401030603 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

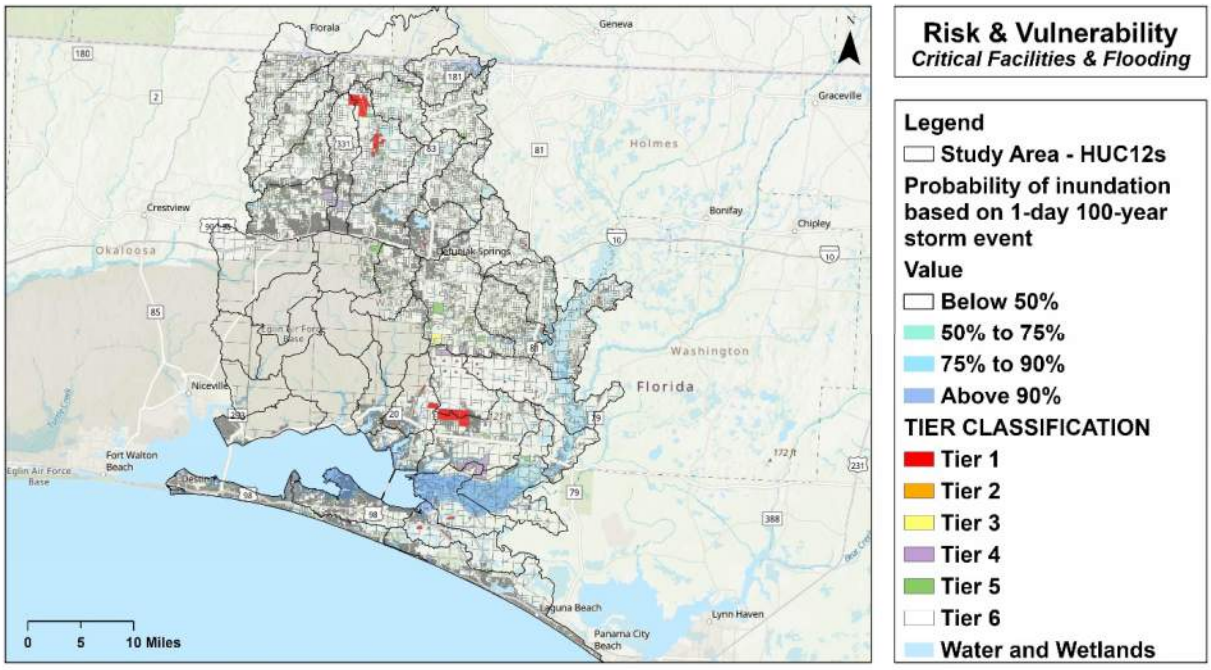

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

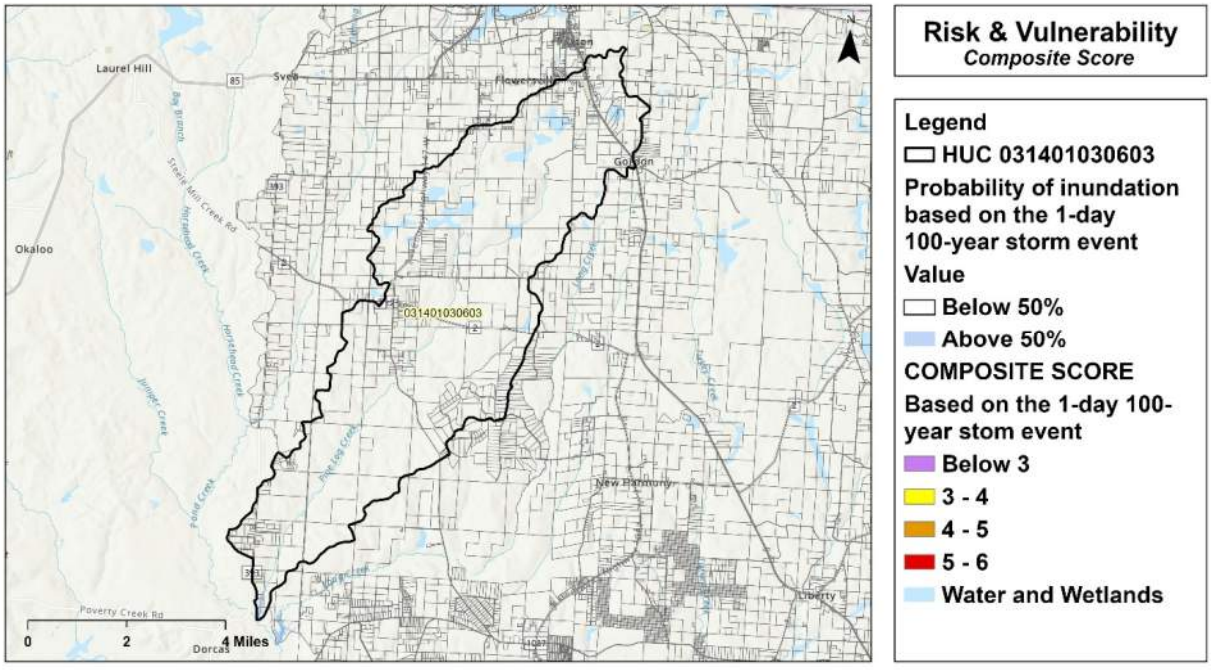

Figure 38. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

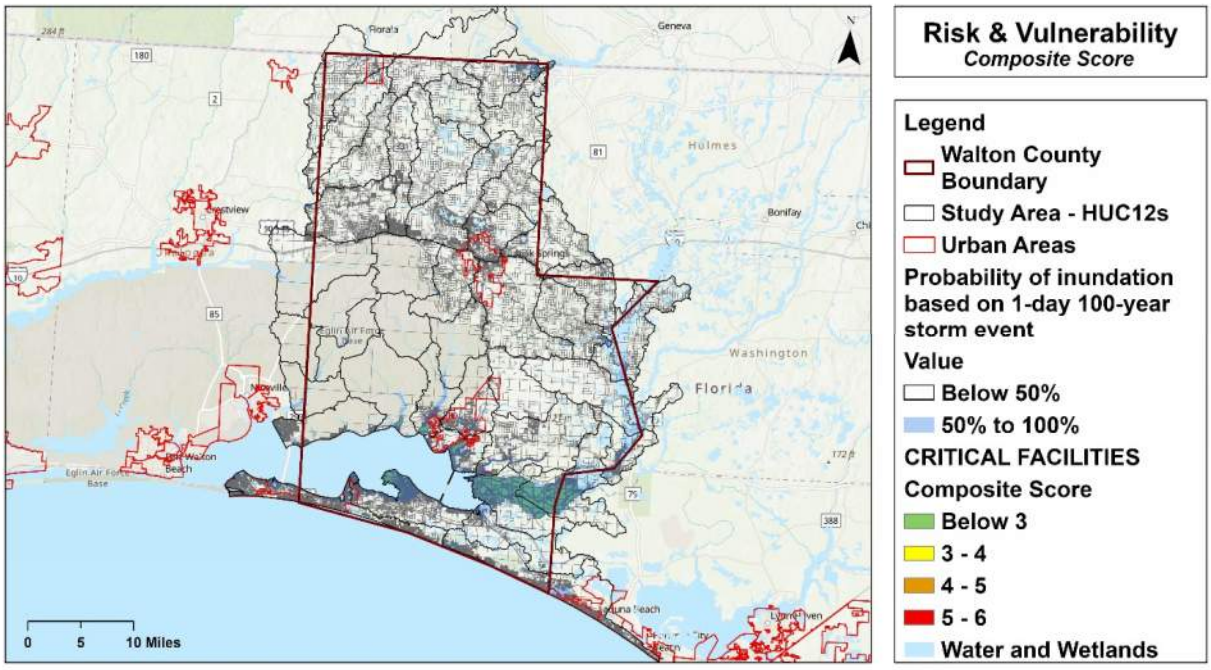

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.
Please note that due to the scale of the map, the composite score layer is not properly visible in this map.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

2.4.2 Drill-down – Paxton

For enhanced visualization of the urban areas within this HUC 031401030603, Figure 40 to Figure 42 illustrate the same results for critical facilities (land use priorities) and composite scores, but on a reduced scale, which better facilitates the examination of finer details within the urban area (Paxton). These maps cover both the 1-day 100-year scenario. Sea level rise scenarios were not calculated due to the basin's non-coastal location and high elevation. The composite score results is null, since the town does not experience any flooding.

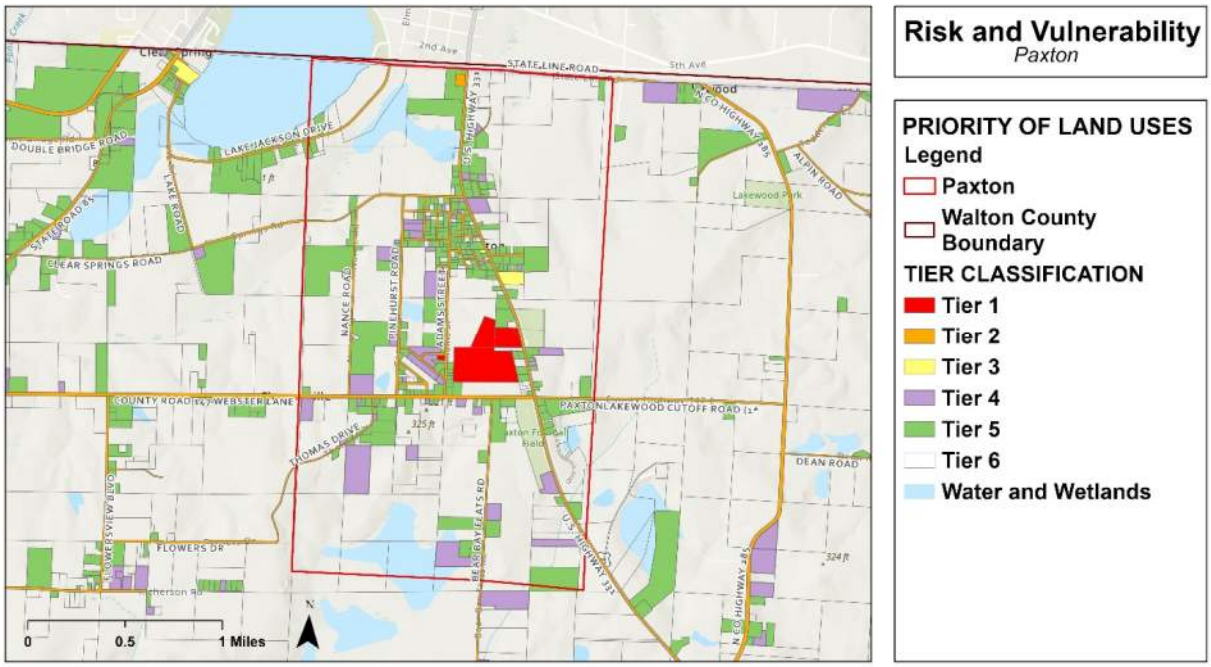

Figure 40. Critical Facilities (priority of land uses) map for Paxton. Processed by FAU.

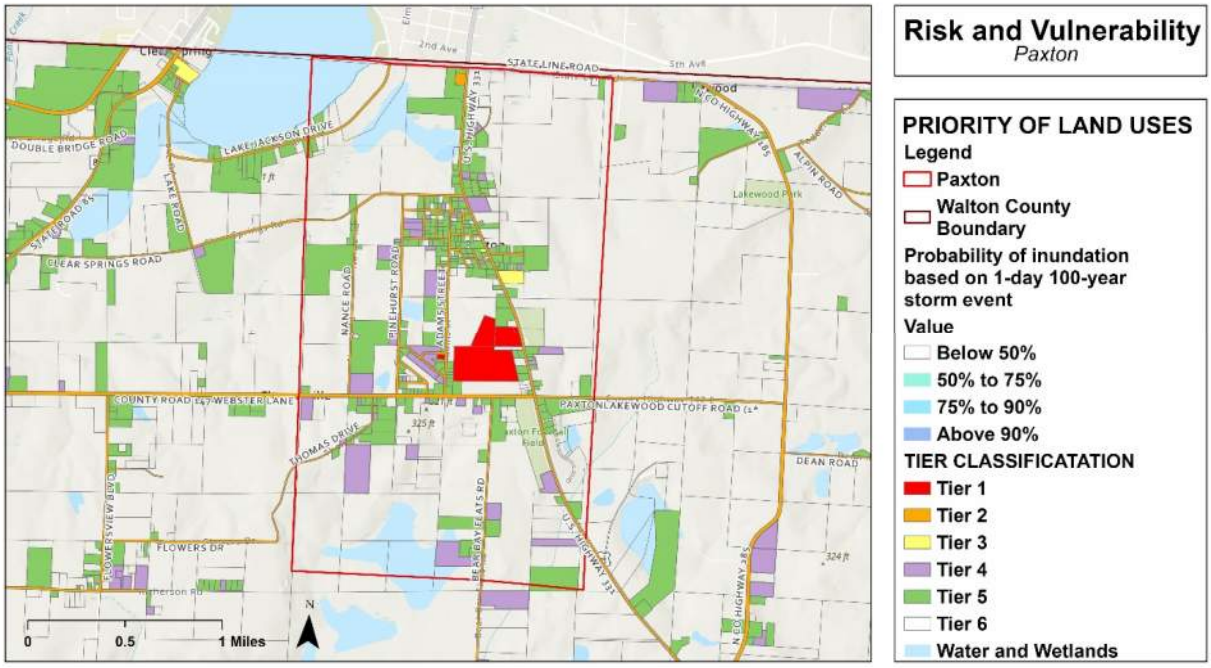

Figure 41. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event for Paxton. Processed by FAU.

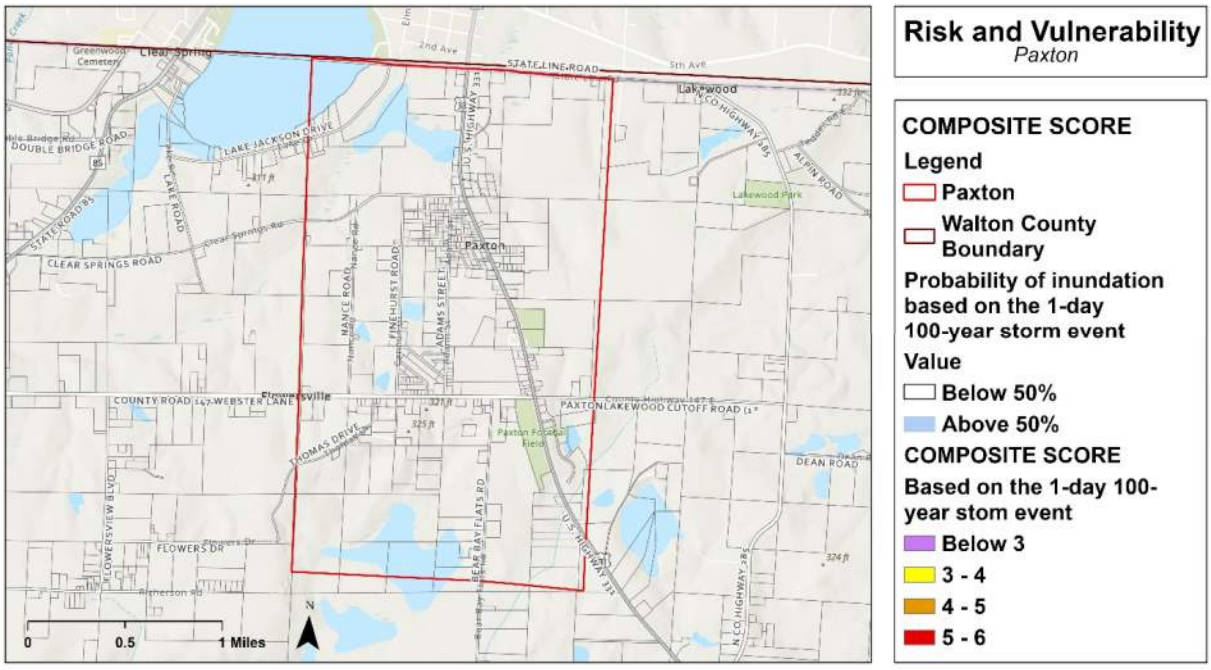

Figure 42. Composite Score map based on 1-day 100-year storm event, overlaid in flooding layer for Paxton. Processed by FAU.

2.4.3 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401030603. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.4 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands: This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands: In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401030603. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401030603	21007.62
All of the 1-day 100-year storm event inundation	**24.47**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	24.47
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	24.47

2.4.5 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

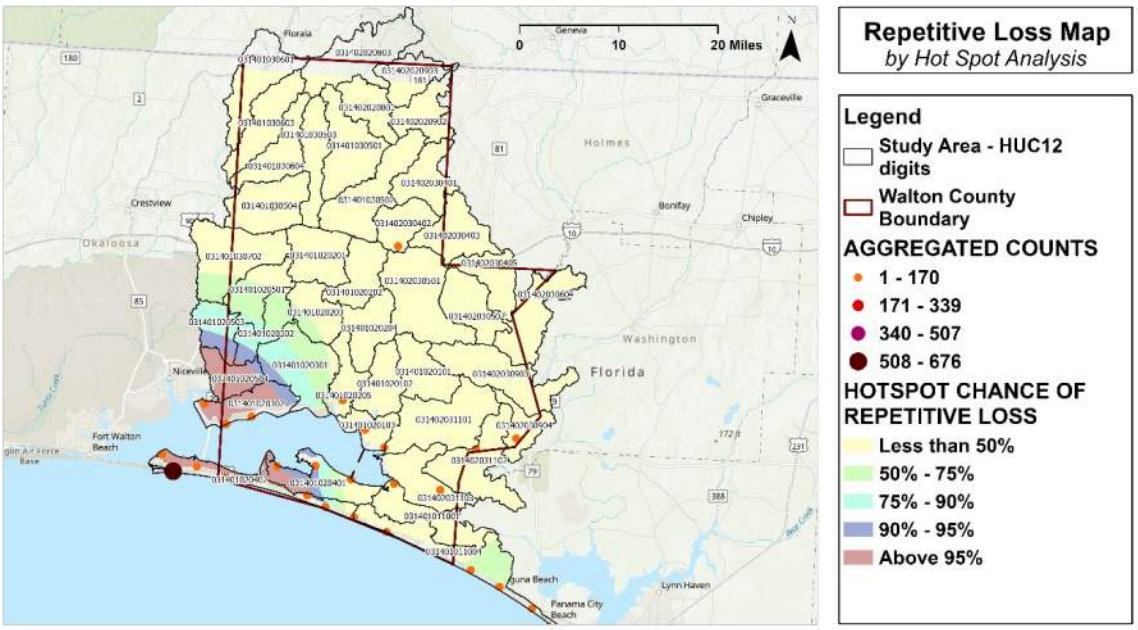

Figure 43. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.6. Priority Projects

Although there is one parcel falling within classification tier 1, and some parcels falling within tiers 2 (roads), 4 and 5 of priority of land uses, none of them are within the flooding zone, once flooding in the area is minor and not alarming. Consequently, when considering the composite score, it is notable that the results are null, indicating no priority for intervention within the basin.

APPENDIX Z

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401030604

LONG CREEK

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Research Assistant: Leticia Sabio

This resource was funded in part, through a grant agreement from the Florida Division of Emergency Management's (FDEM) Bureau of Mitigation, by a grant provided by through the Hazard Mitigation Grant Program (HMGP) DR-4337-004-P, as approved by FDEM and the Federal Emergency Management Agency (FEMA) to create and update Watershed Master Plans (WMP) throughout the state of Florida. The views, statements, findings, conclusions, and recommendations expressed herein are those of the authors and do not necessarily reflect the views of the State of Florida, FEMA, or any of their sub-agencies.

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401030604) is highlighted among all the HUCs to help identifying its location. (Figure 3).

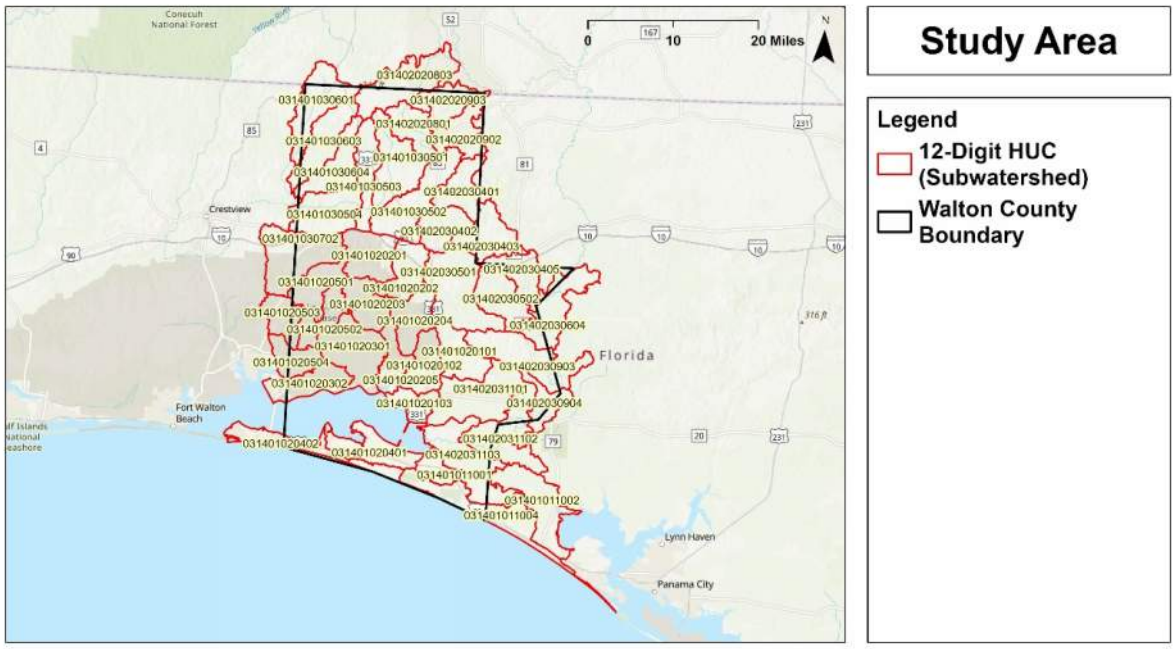

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

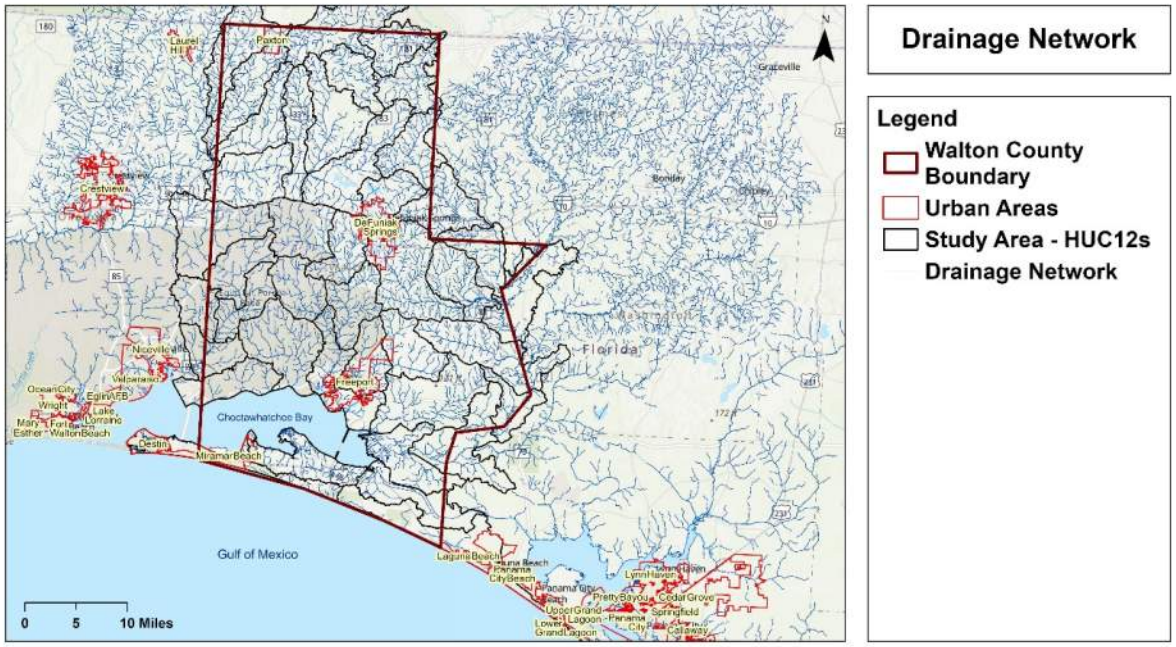

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

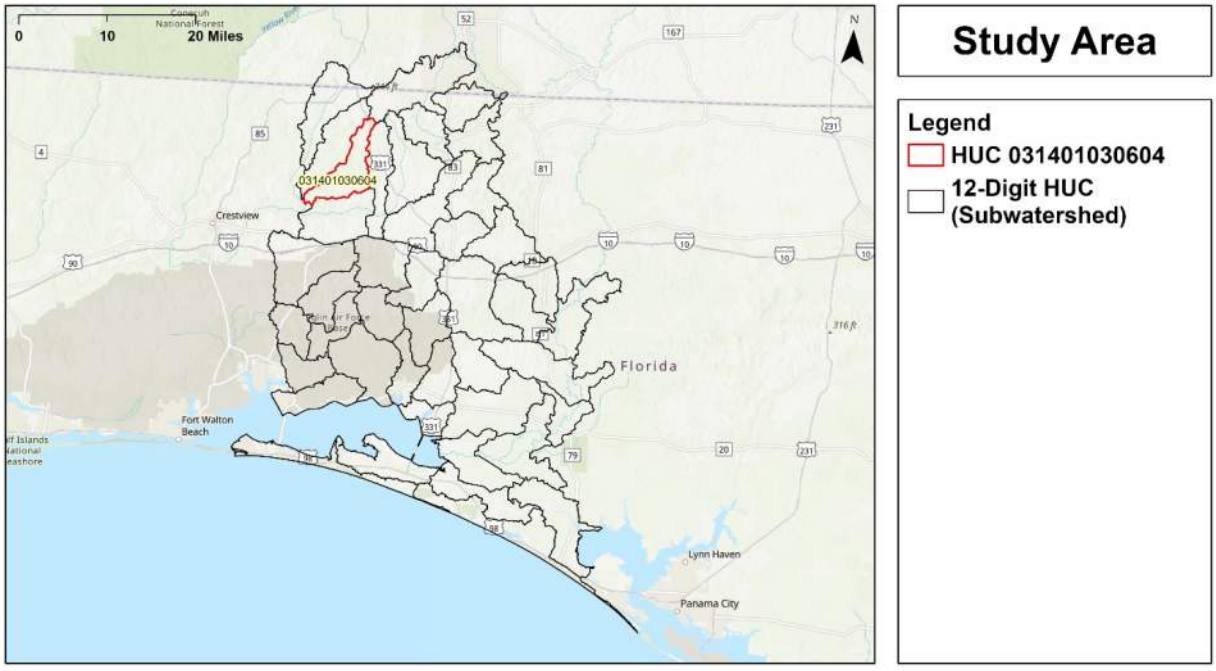

Figure 3. HUC 031401030604 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Based on the future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL))

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with

high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

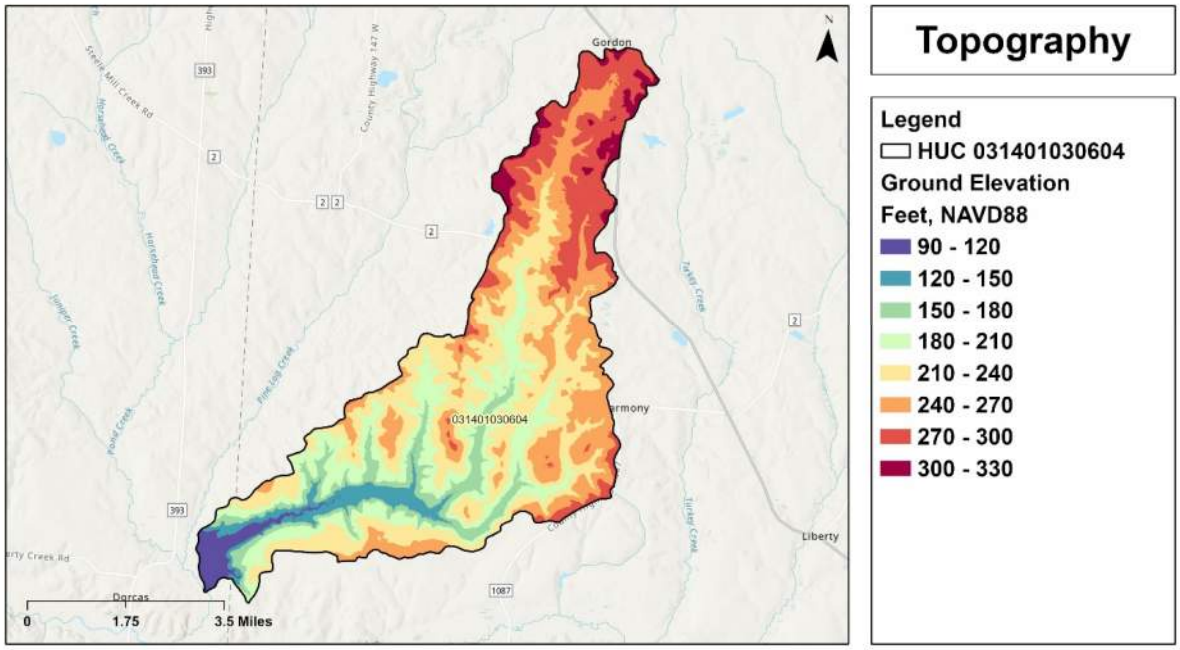

Figure 4. Topographic map of the HUC 031401030604 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of

wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology.
Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.
Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401030604 sub-watershed is shown in **Error! Reference source not found.**.

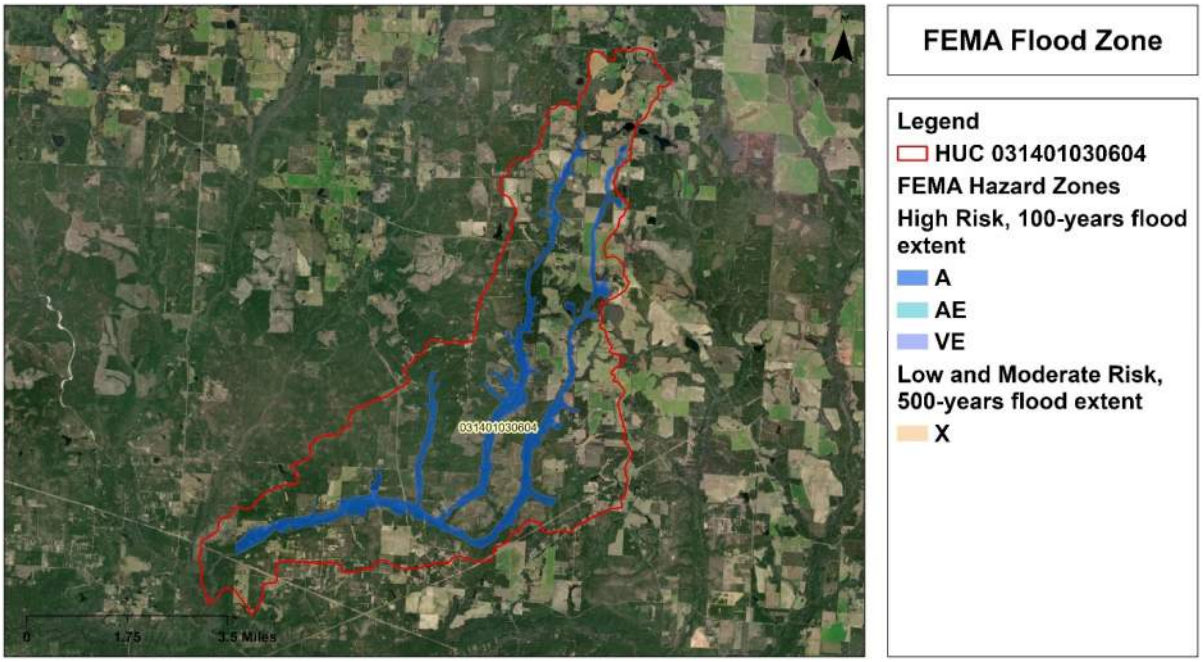

Figure 5. FEMA Flood Zone map (2020) for HUC 031401030604 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal

area, including the sub-watershed 031401030604 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

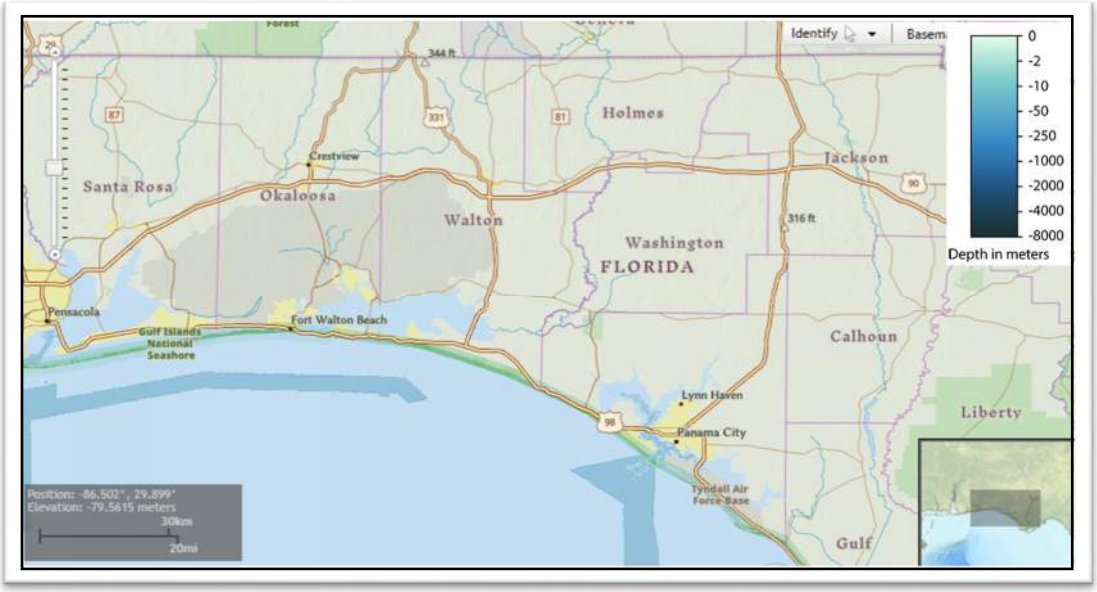

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological

conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

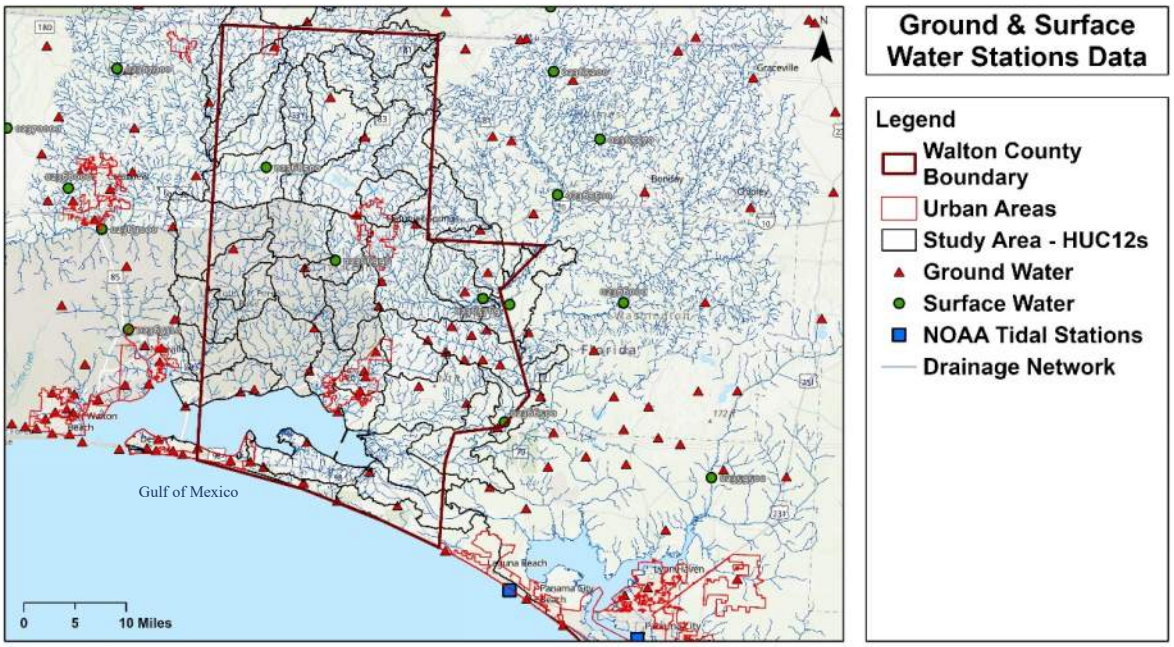

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031401030604 has no major rivers and canals, but creeks, include:

- Long Creek
- Little Creek
- Beech Tree Creek

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02368500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401030604, which is USGS 02368500 Shoal River.

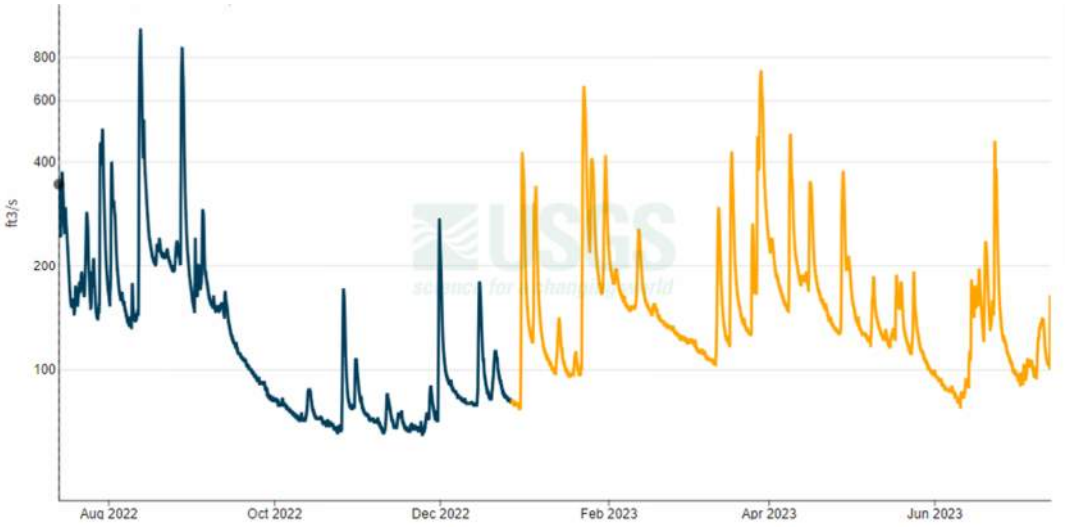

Figure 8. Average streamflow for Shoal River NR Mossy Head, Fla (USGS 02368500 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02368500/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station

(or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401030604 and points out the location of the ground water station in the surroundings. A groundwater-surface layer for the HUC 031401030604 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

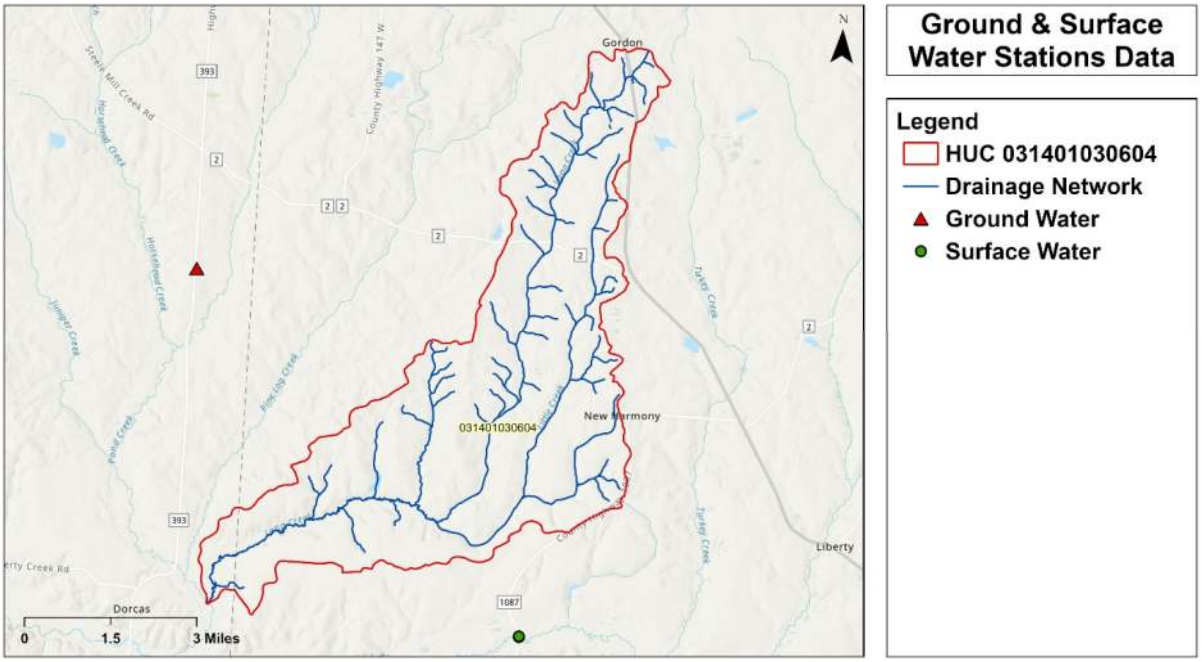

Figure 9. Ground and Surface Water Stations in the HUC 031401030604 sub-watershed, processed by FAU.

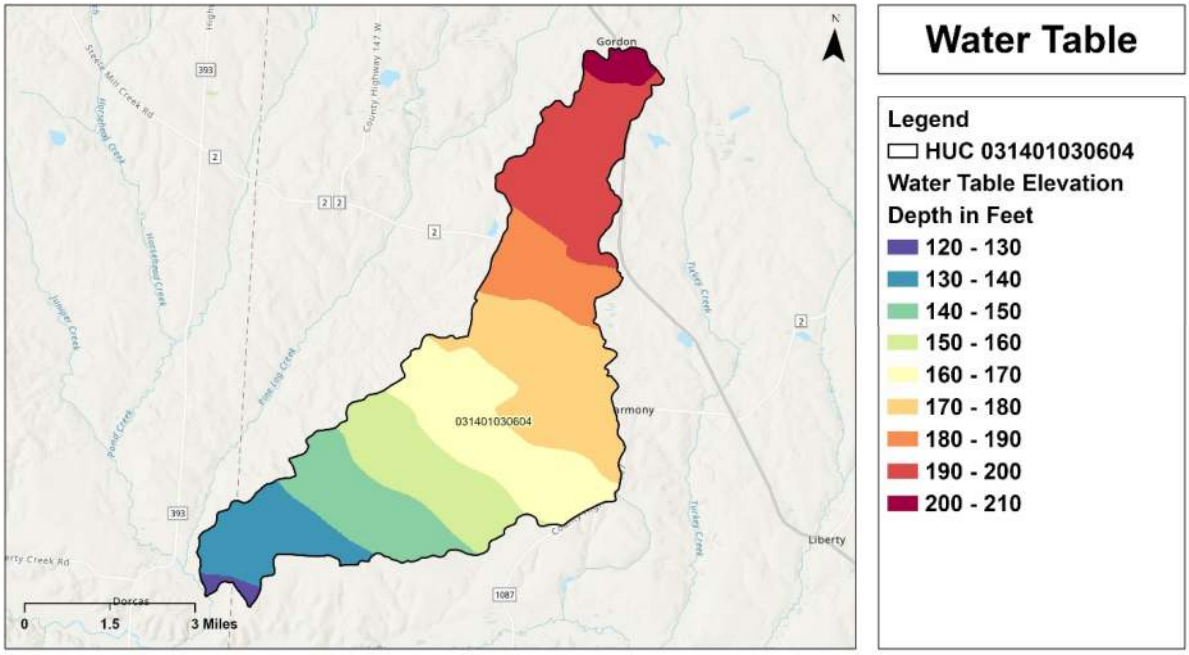

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401030604 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

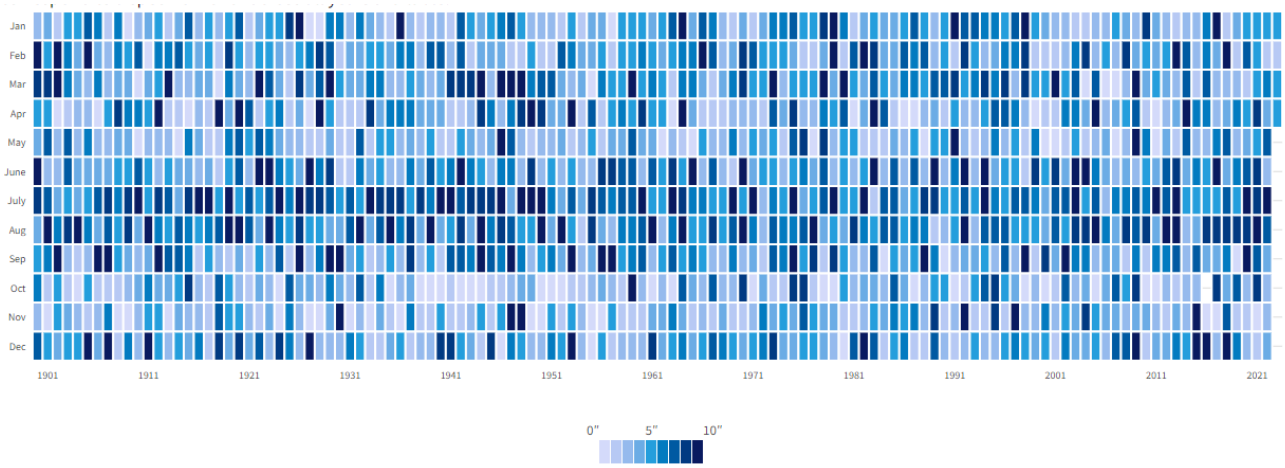

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/)

While the topography (Section 2.1) and native soil (Section 2.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is none NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

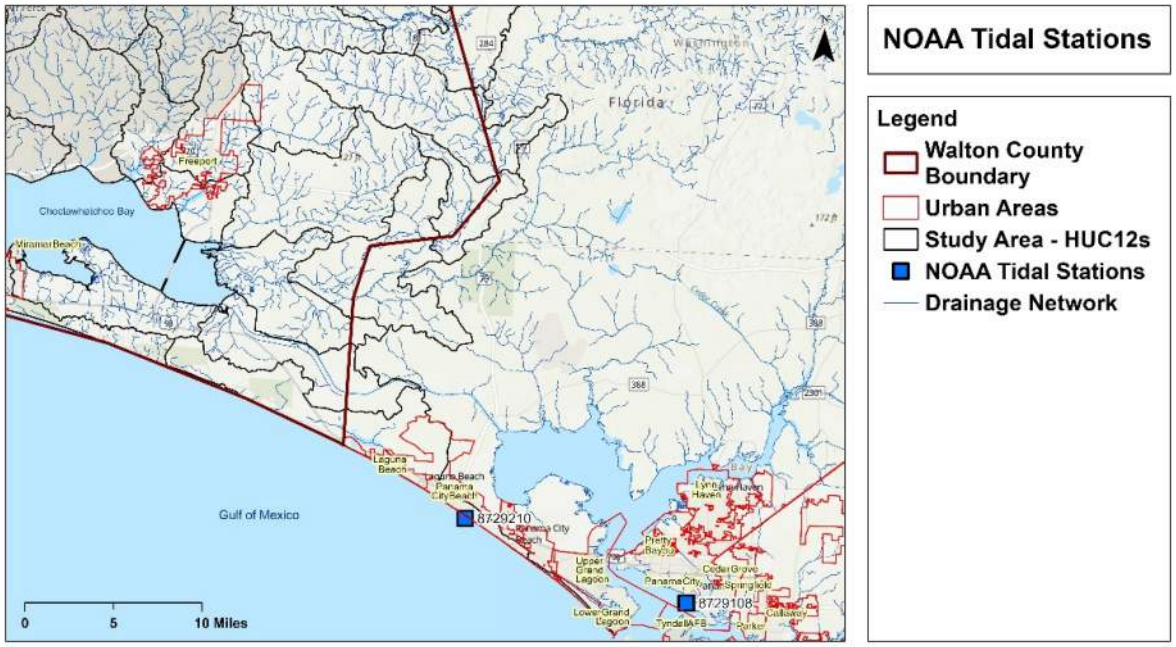

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

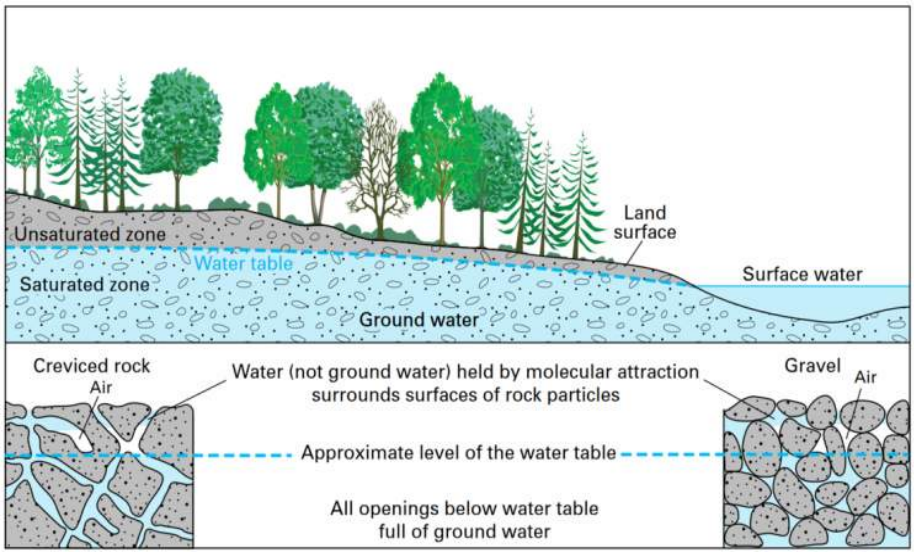

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

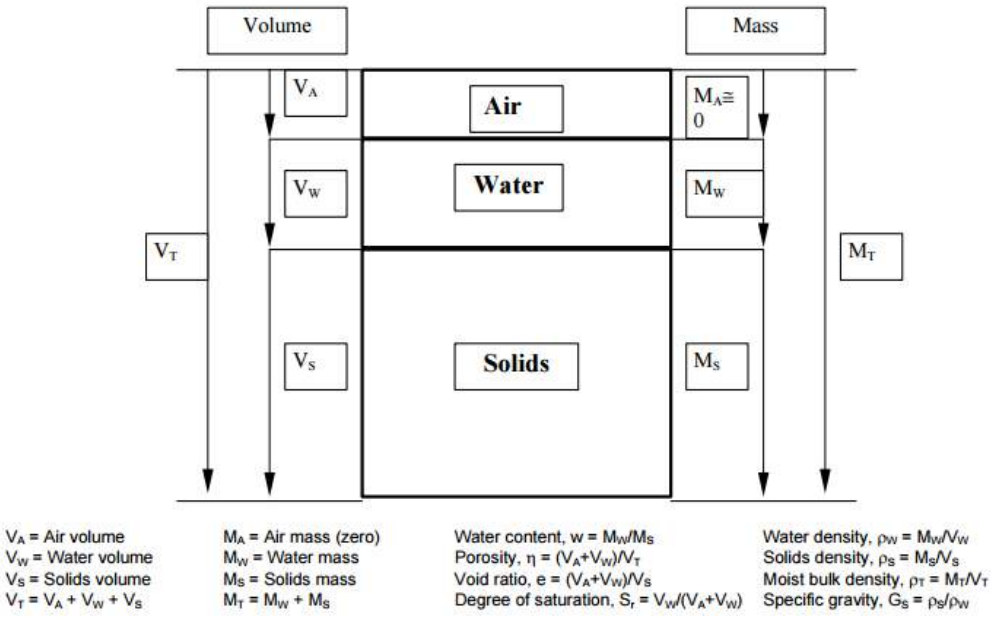

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

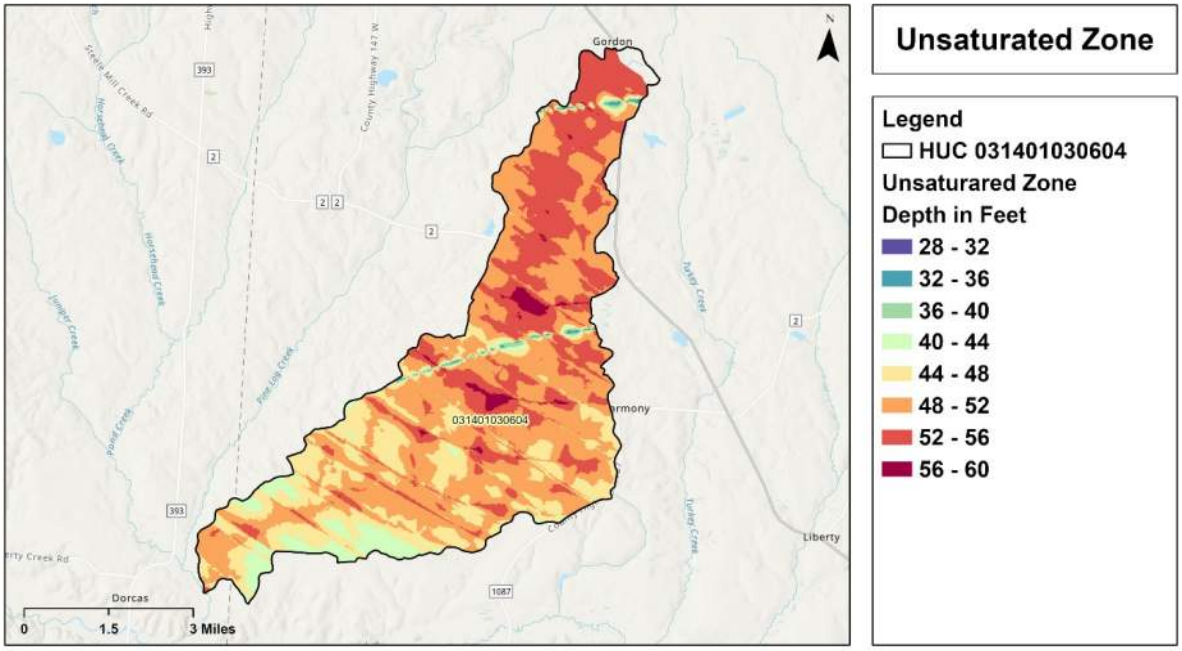

Figure 15. Unsaturated zone map for HUC 031401030604, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A great portion of the basin has enough soil storage capacity, ranging between 44 to 60 inches of capacity left.

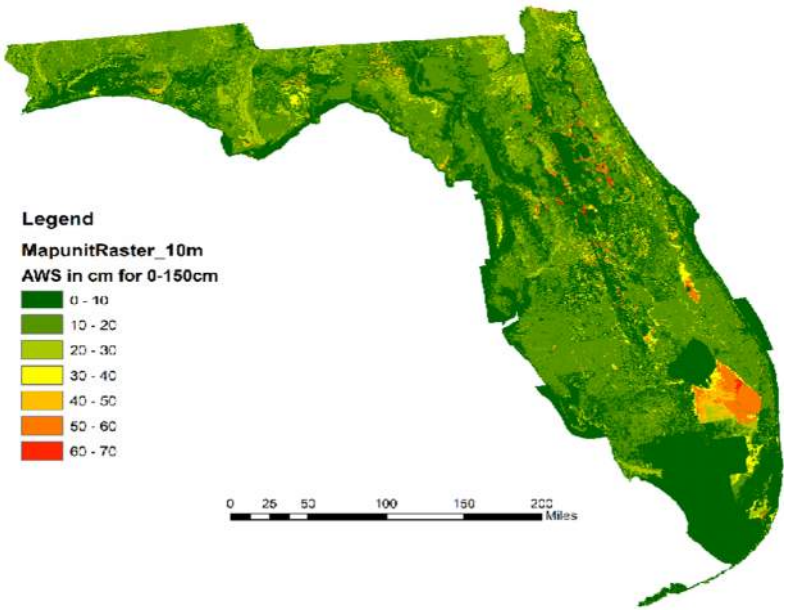

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, processed by FAU.

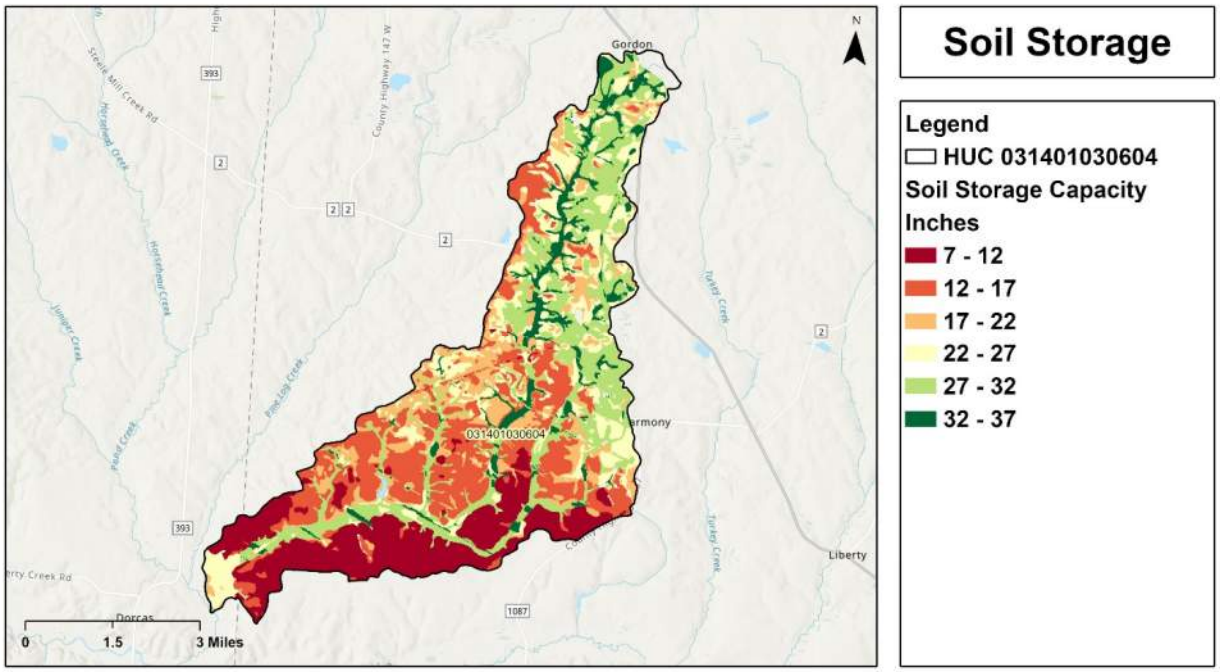

Figure 17. Water storage capacity of soil for the HUC 031401030604, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

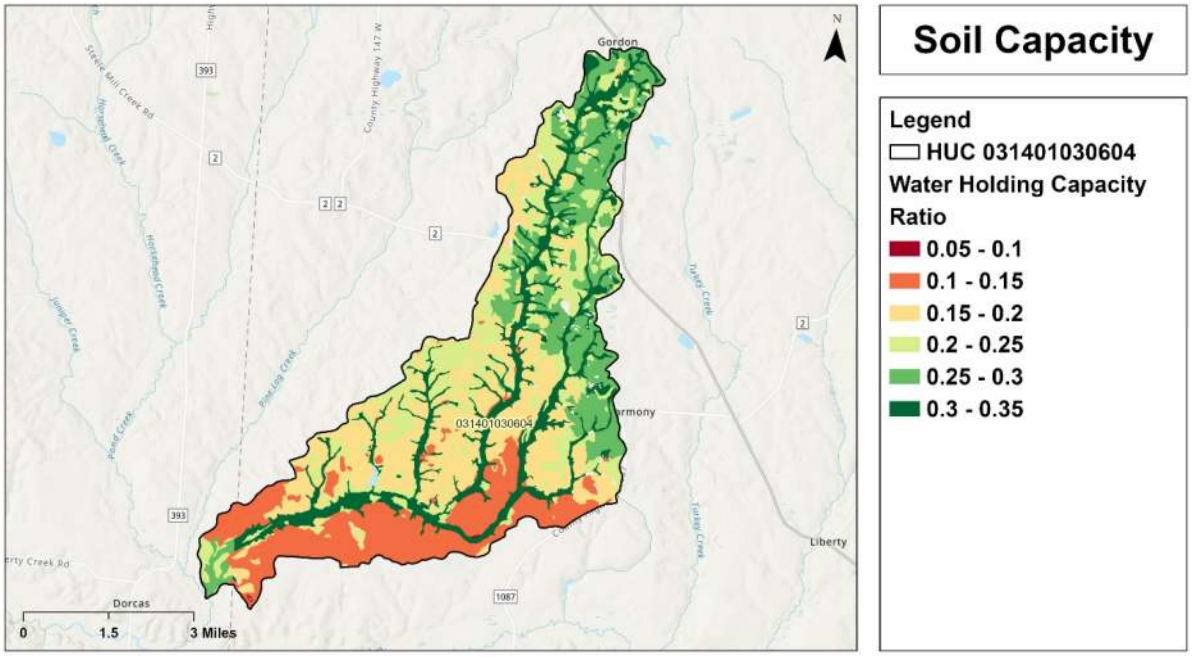

Figure 18. Water Holding Capacity (ratio) for the HUC 031401030604, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

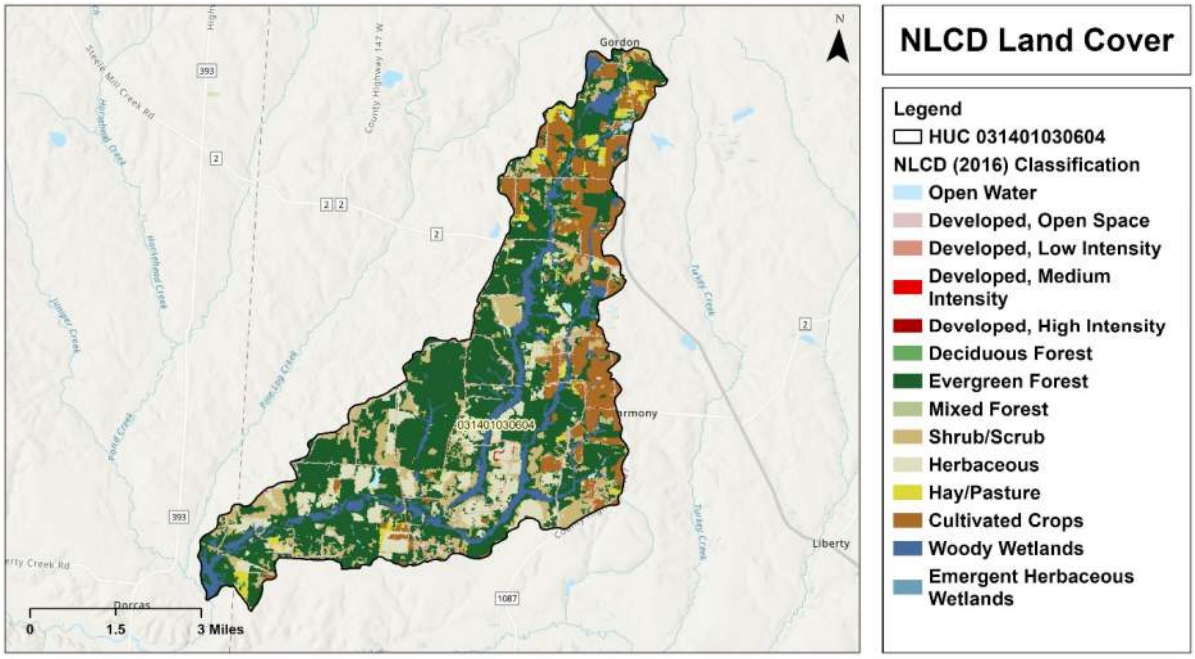

Figure 19. Land use in the HUC 031401030604 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps were used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

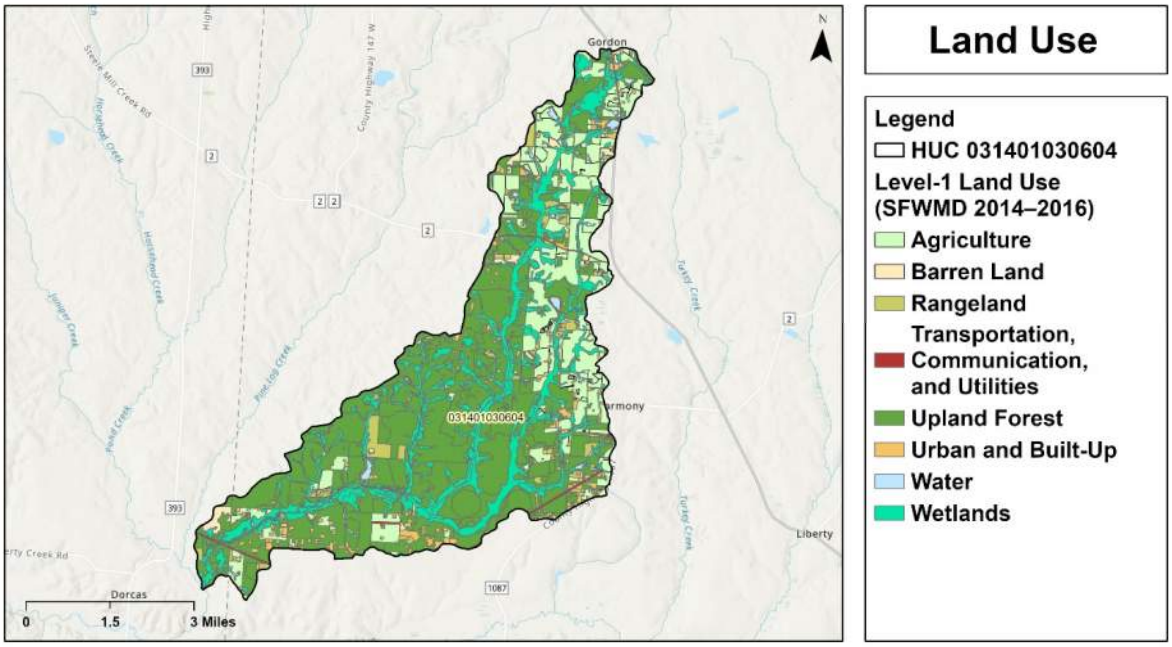

Figure 20. Land use in the HUC 031401030604 (023 Florida Geographic Data Library (FGDL)), processed by FAU.

In the HUC 031401030604 sub-watershed, mostly of the area is upland forest, with 55.30%. The second place is agriculture, with 18.32%, followed by wetlands, with 15.45%. There is no much developed land in the HUC – only 3.32% is urban and built-up and 1.45% is Transportation, Communication, and Utilities, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031401030604 subwatershed (023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	4428.75	18.32%
Barren Land	252.68	1.05%
Rangeland	690.51	2.86%
Transportation, Communication, and Utilities	350.85	1.45%
Upland Forest	13368.33	55.30%
Urban and Built-Up	802.06	3.32%
Water	545.24	2.26%
Wetlands	3735.38	15.45%
Grand Total:	**24173.81**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

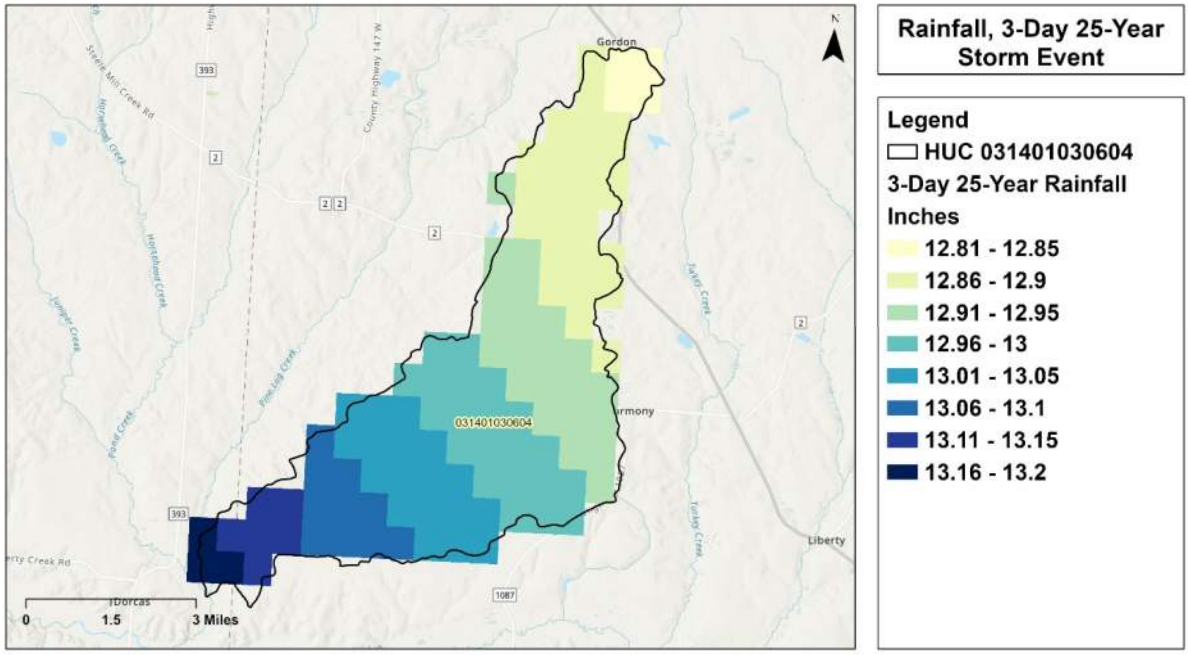

Figure 21. Rainfall distribution map across HUC 031401030604 sub-watershed, for 3-day 25-year storm event, processed by FAU.

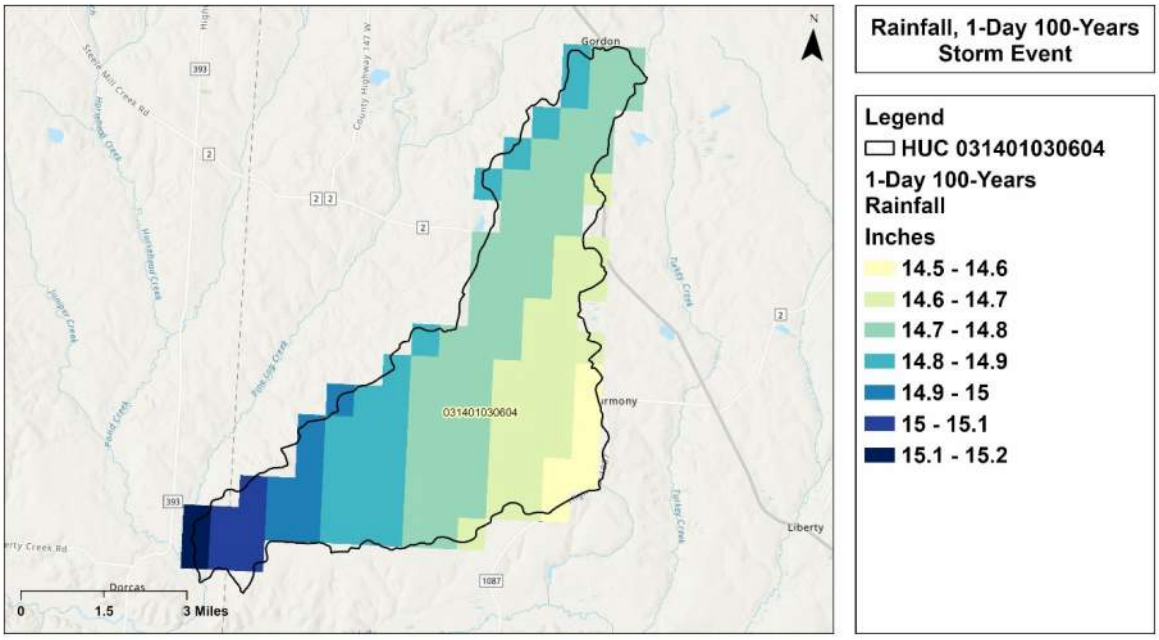

Figure 22. Rainfall distribution map across HUC 031401030604 sub-watershed, for 1-day 100-year storm event, processed by FAU.

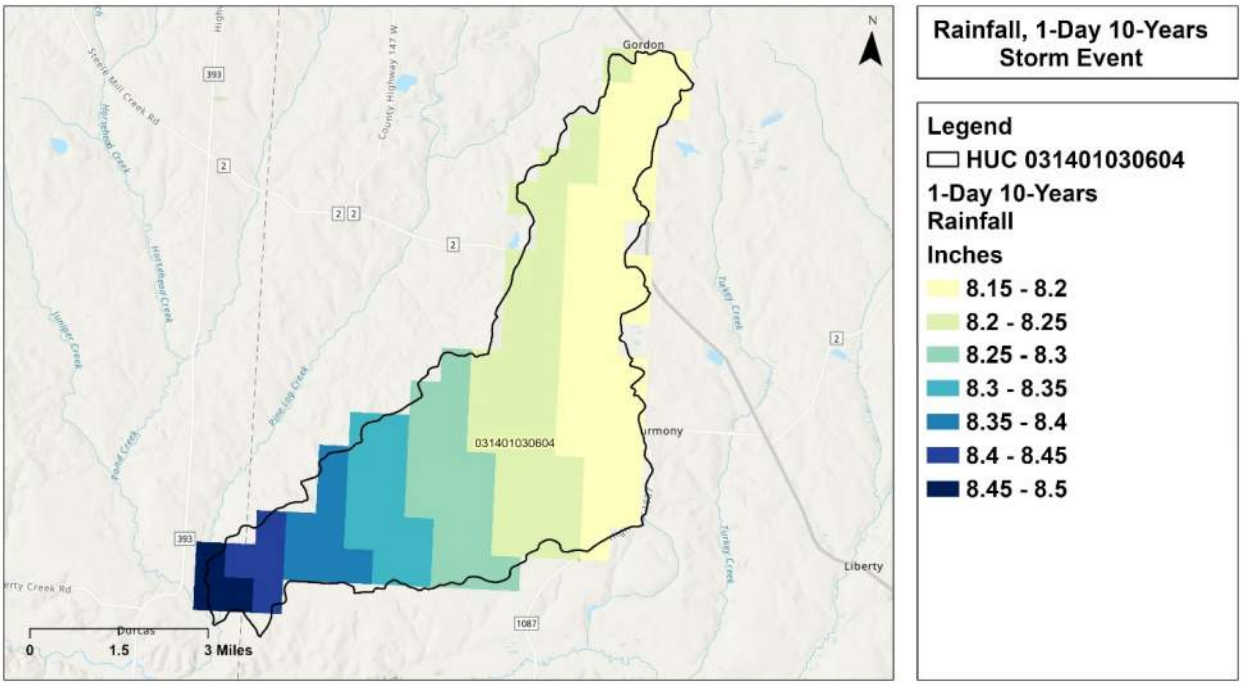

Figure 23. Rainfall distribution map across HUC 031401030604 sub-watershed, for 1-day 10-year storm event, processed by FAU.

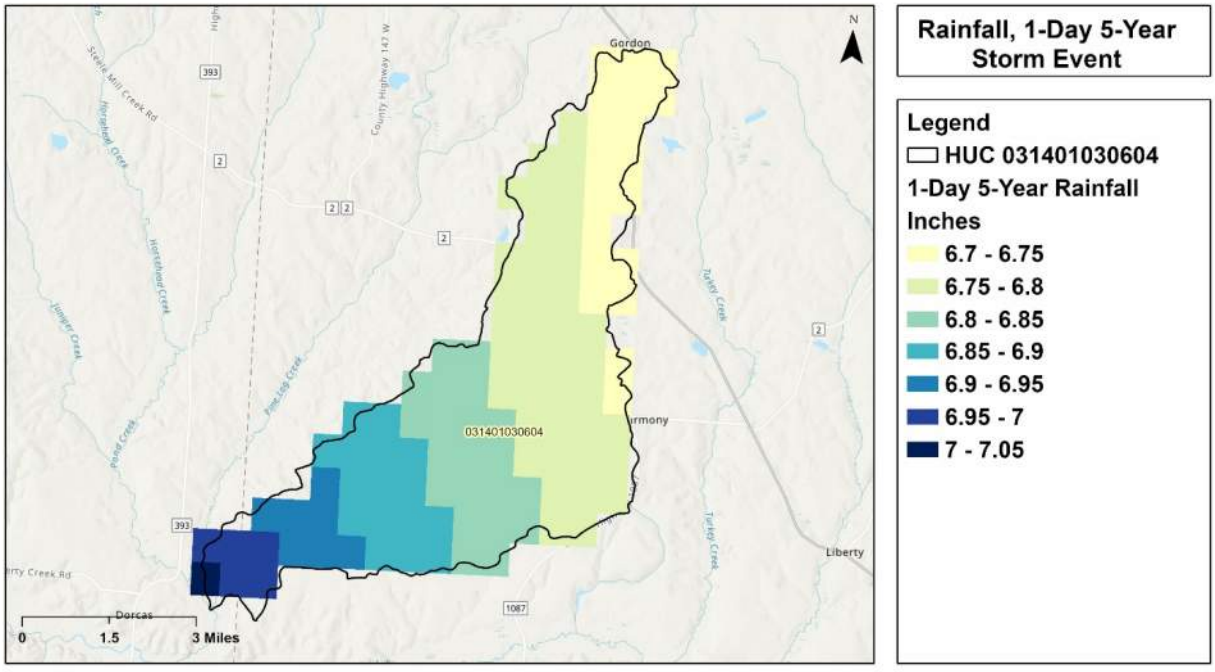

Figure 24. Rainfall distribution map across HUC 031401030604 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

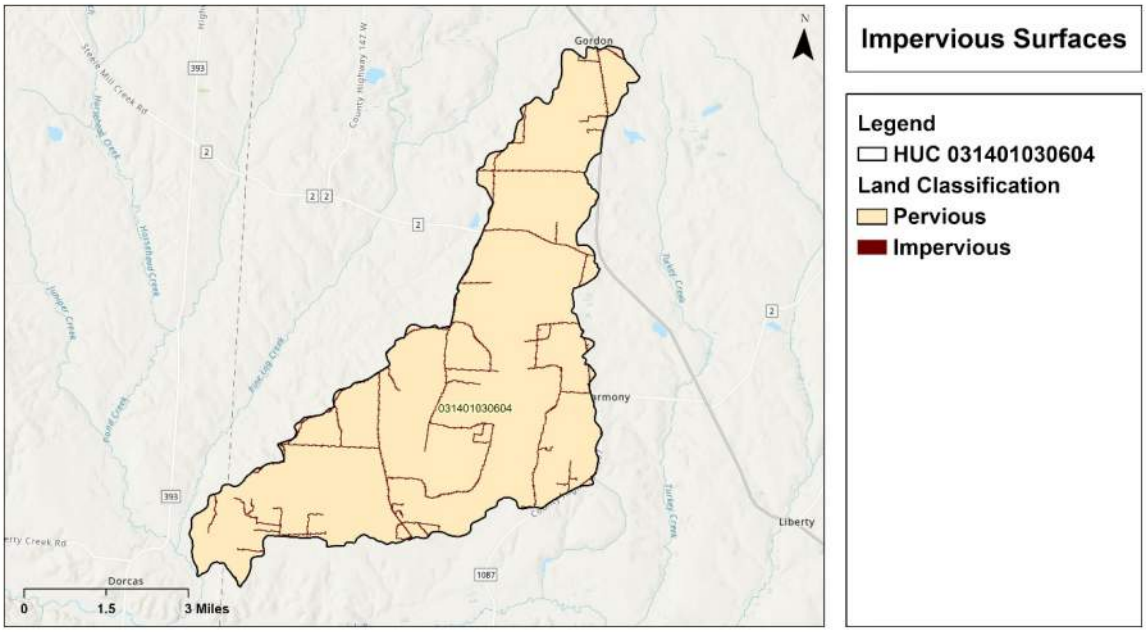

Figure 25. Impervious area map for the HUC 031401030604 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

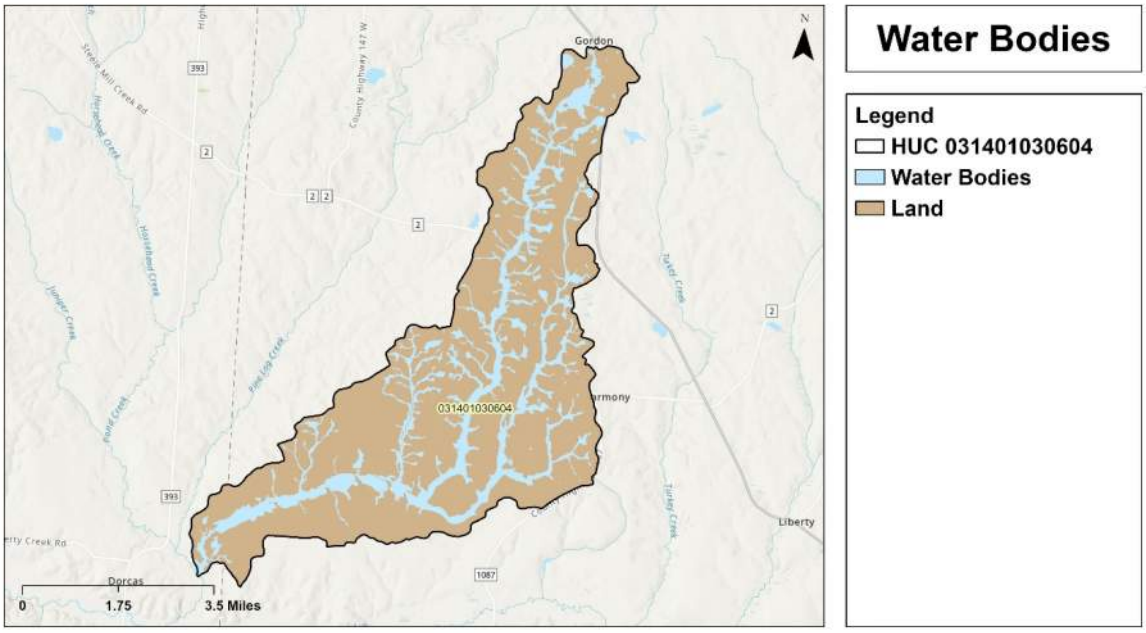

Figure 26. Water bodies map for the HUC 031401030604 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs,

property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.

- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

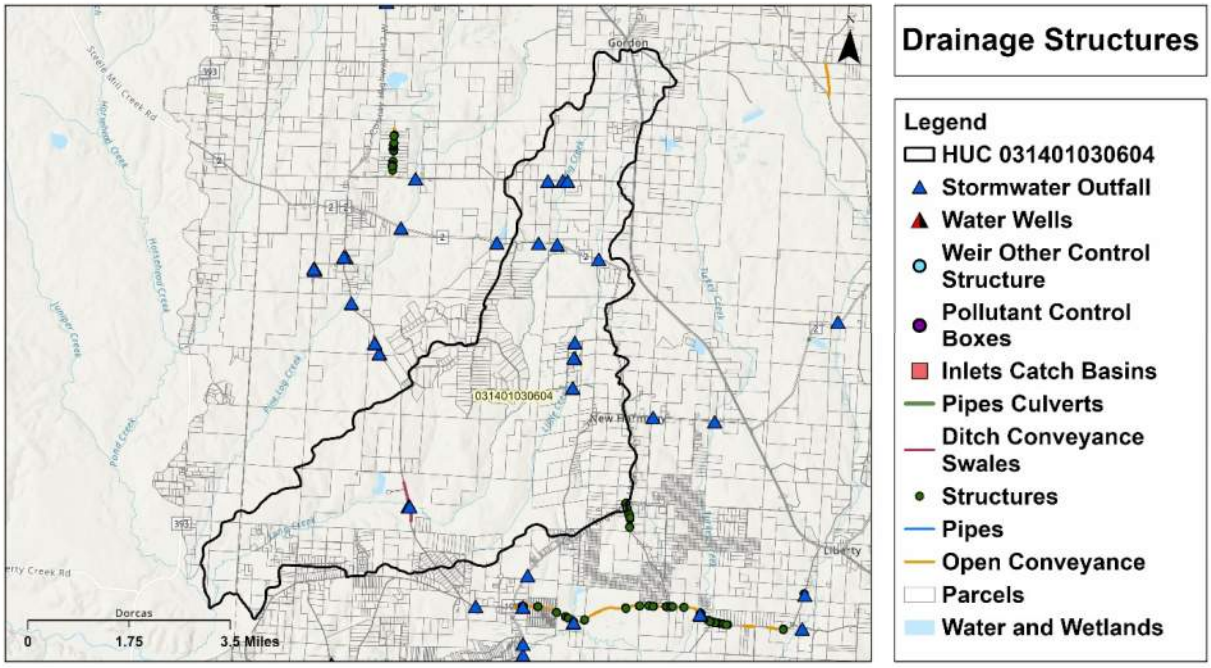

Figure 27. Stormwater Infrastructure for the HUC 031401030604. Processed by FAU.

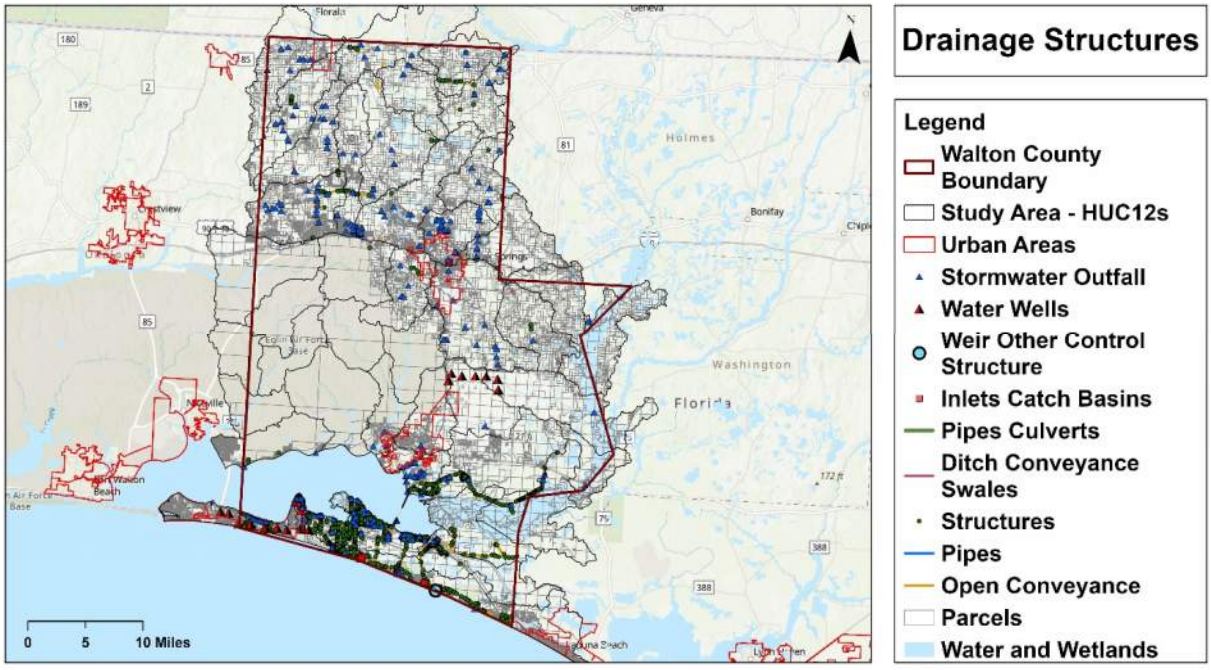

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401030604 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

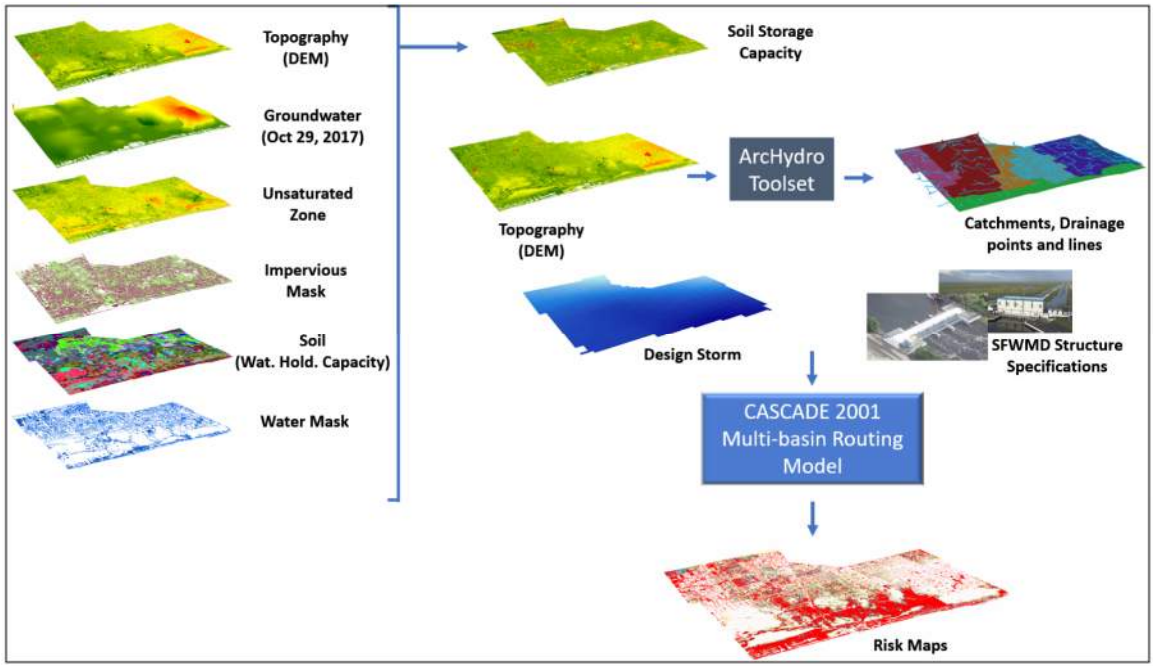

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)

= 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

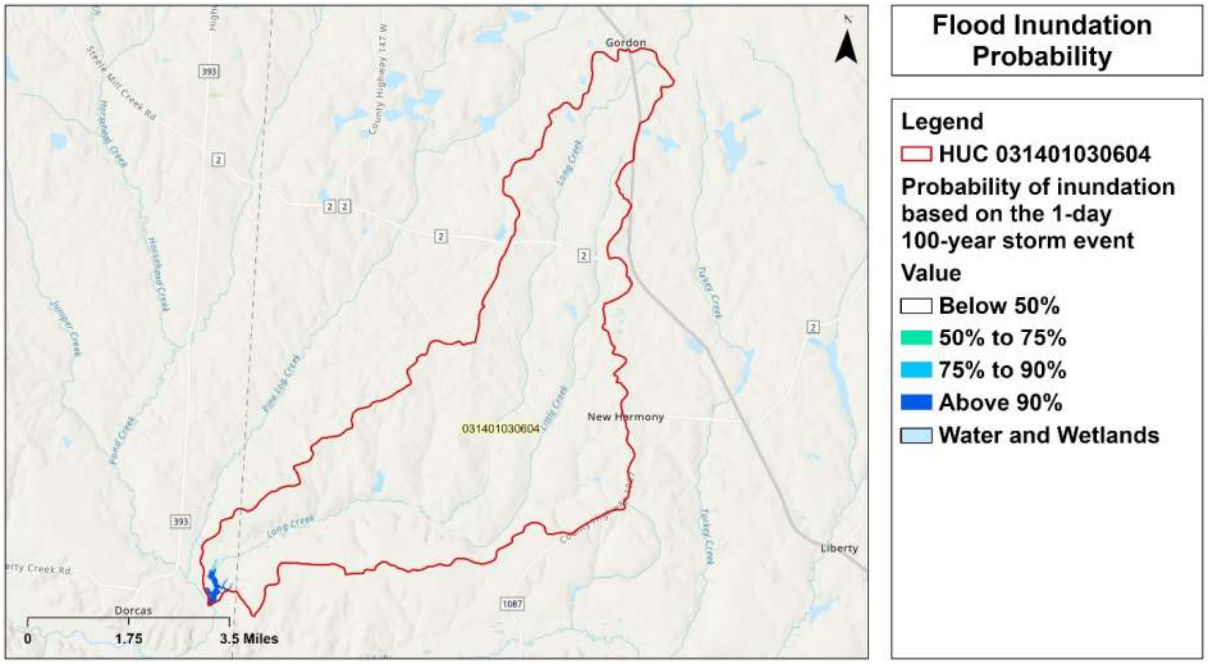

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401030604, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

fter this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees

and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a small portion of flooding, almost imperceptible, is noted at the creek entrance to the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, the HUC is expected to remain unaffected by sea level rise, therefore SLR scenarios were not computed.

The design storm simulation determined that approximately 0.28% of the HUC total area or only 0.082 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, 0.32% of the HUC's total area, or 0.094 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.26% of the HUC's total area, or 0.075 mi^2, would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0.25% of the HUC's total area, or 0.074 mi^2, would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401030604 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	29.146	0.082	99.72%	0.28%
1-day 100-year	29.134	0.094	99.68%	0.32%
1-day 10-year	29.153	0.075	99.74%	0.26%
1-day 5-year	29.154	0.074	99.75%	0.25%

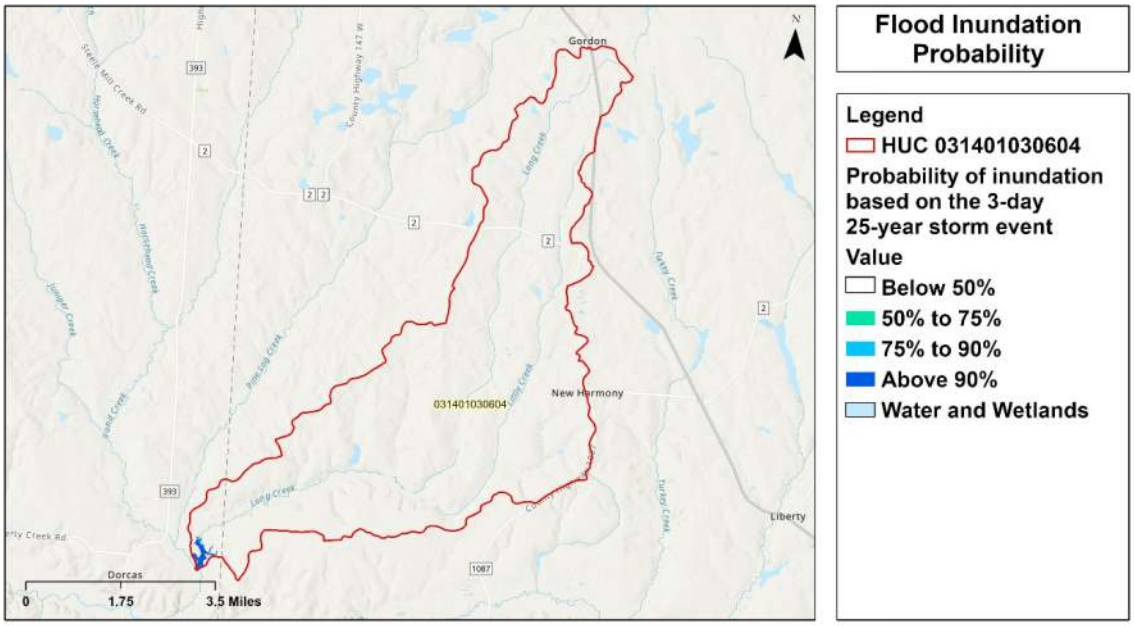

Figure 31. 3-day 25-year storm event for HUC 031401030604 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

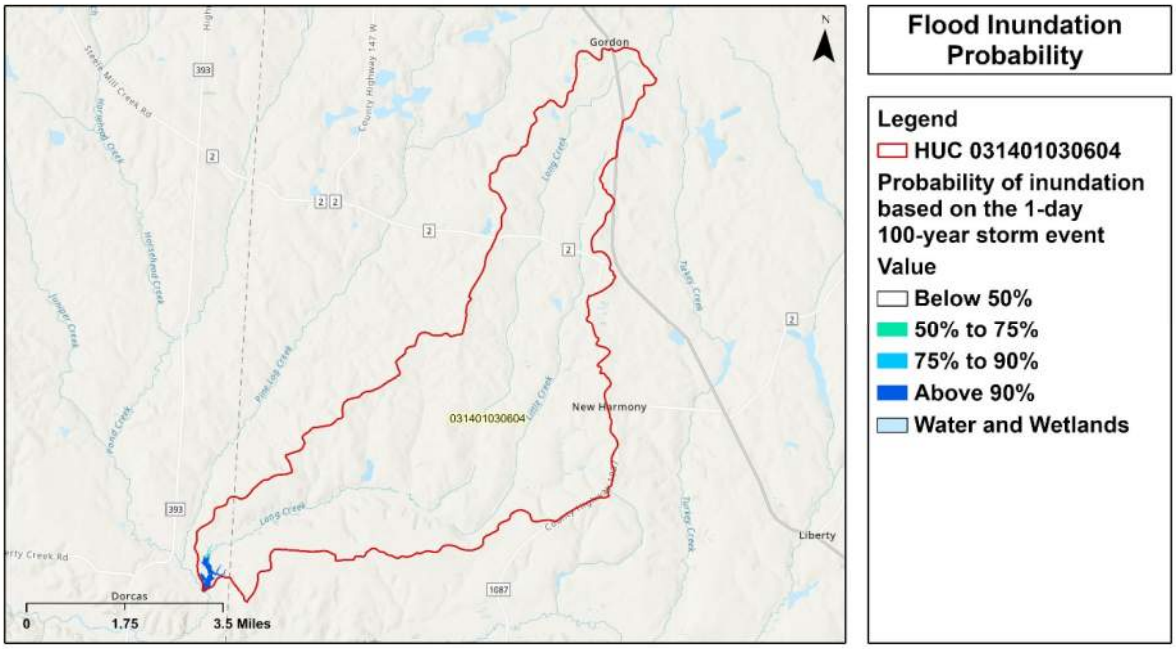

Figure 32. 1-day 100-year storm event for HUC 031401030604 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

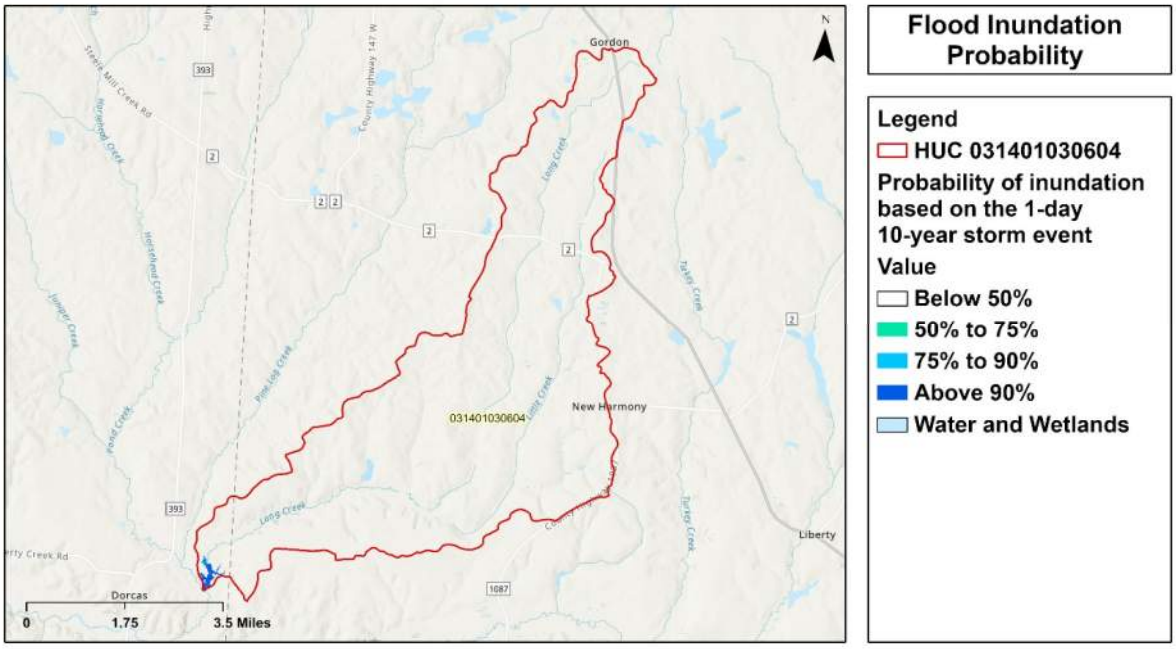

Figure 33. 1-day 10-year storm event for HUC 031401030604 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

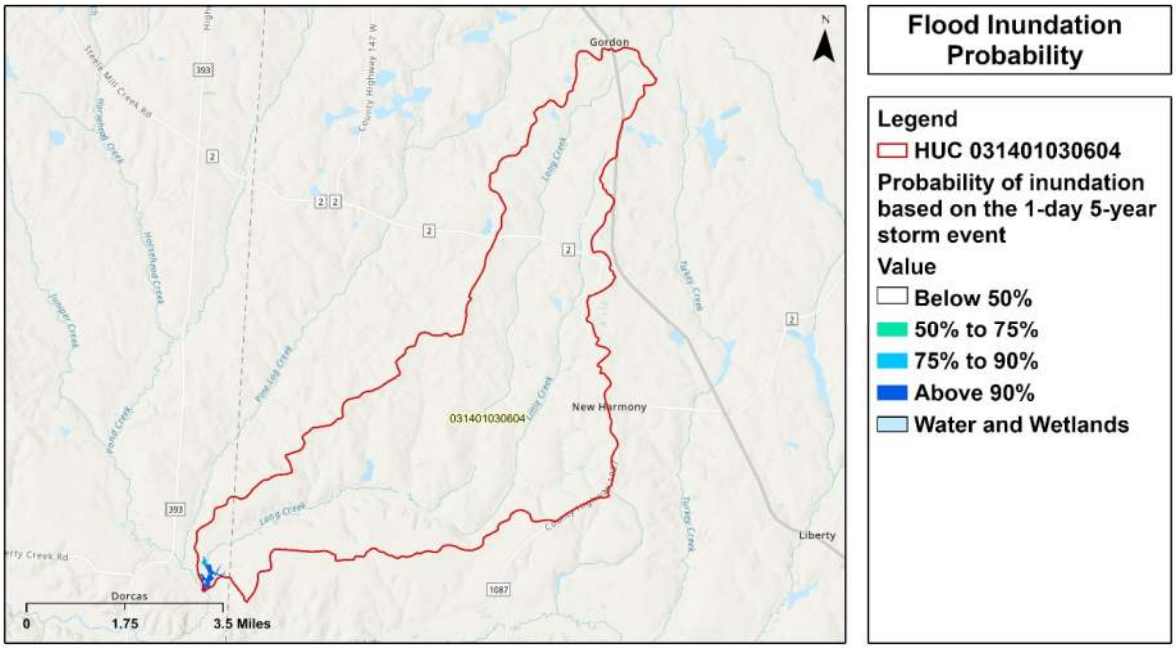

Figure 34. 1-day 5-year storm event for HUC 031401030604 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have

lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3

26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6

53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6

87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is

converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031401030604 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

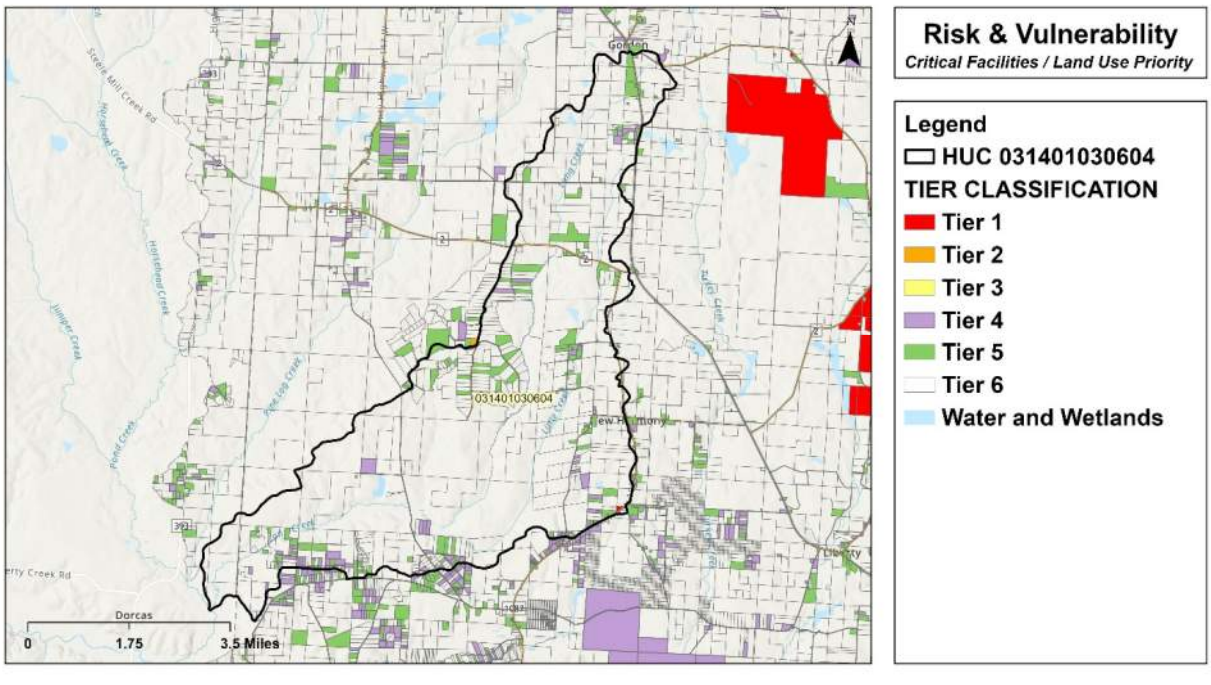

Figure 35. HUC 031401030604 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

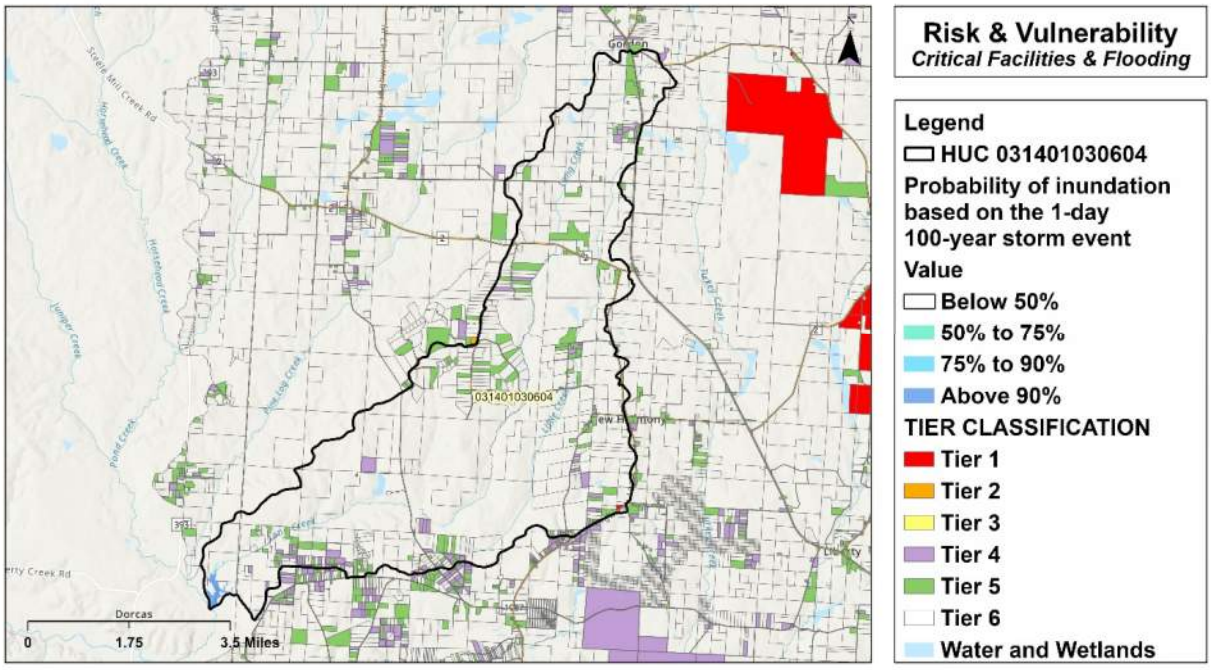

Figure 36. HUC 031401030604 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

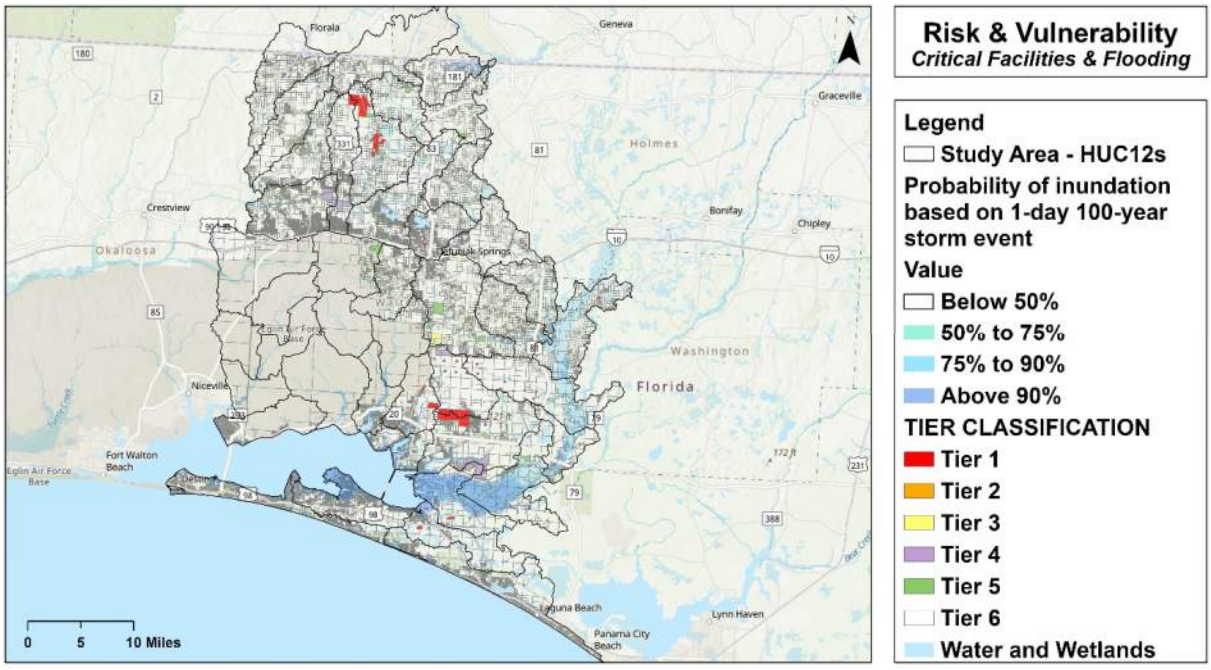

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

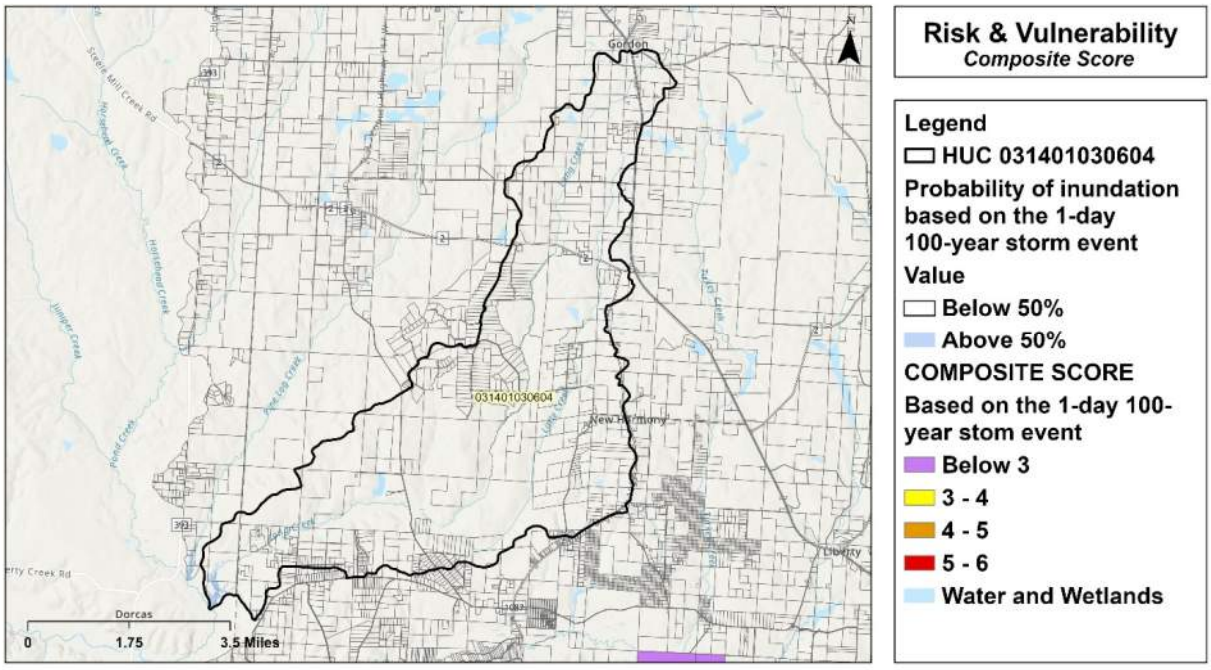

Figure 38. HUC 031401030604 sub-watershed Composite Score Risk map, with calculation based on 1-day 100-year storm event. Processed by FAU.

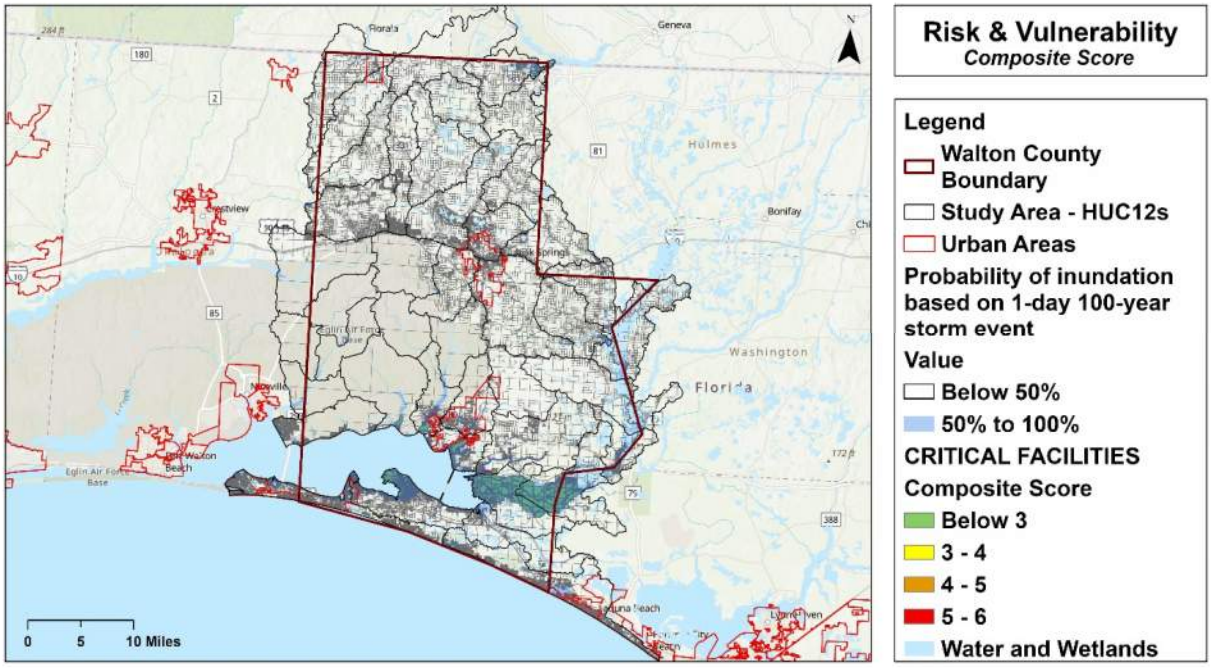

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

Please note that due to the scale of the map, the composite score layer is not properly visible in this map.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401030604. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It is important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands: This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands: In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401030604. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401030604	18706.20
All of the 1-day 100-year storm event inundation	**60.16**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	60.16
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	60.16

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. . **Error! Reference source**

not found. indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

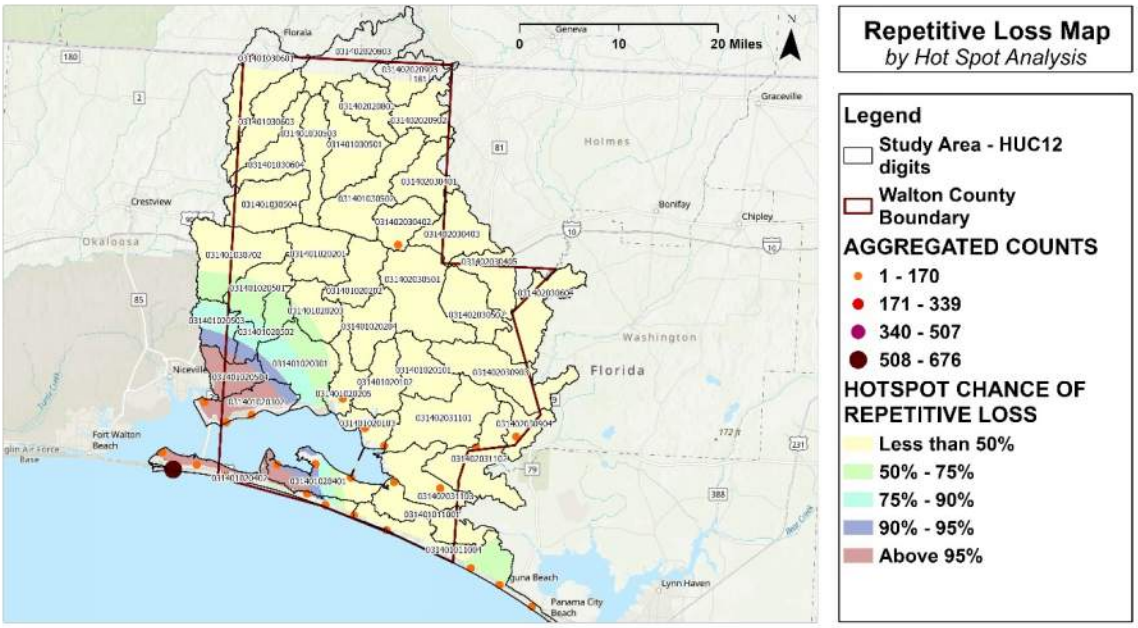

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5 Priority Projects

Although there are some parcels falling within tiers 2 (roads), 4 and 5 of priority of land uses, none of them are within the flooding zone, once flooding in the area is minor and not alarming. Consequently, when considering the composite score, it is notable that the results are null, indicating no priority for intervention within the basin.

APPENDIX AA

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031401030702

UPPER TITI CREEK

Principal Investigator: Frederick Bloetscher, Ph.D., P.E.

Co-Principal Investigators: Weibo Liu, Ph.D., Daniel Meeroff, Ph.D., Diana Mitsova, Ph.D., S. Nagarajan, Ph.D., Hongbo Su, Ph.D., Ramesh Teegavarapu, Ph.D., Zhixiao Xie, Ph.D., Yan Yong, Ph.D., and Caiyun Zhang, Ph.D., Ahmet Urusan, Ph.D., Shannon Egger, Eva Suarez, Ph.D.

Research Assistant: Leticia Sabio

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 sub-watershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031401030702) is highlighted among all the HUCs to help identify its location. (Figure 3).

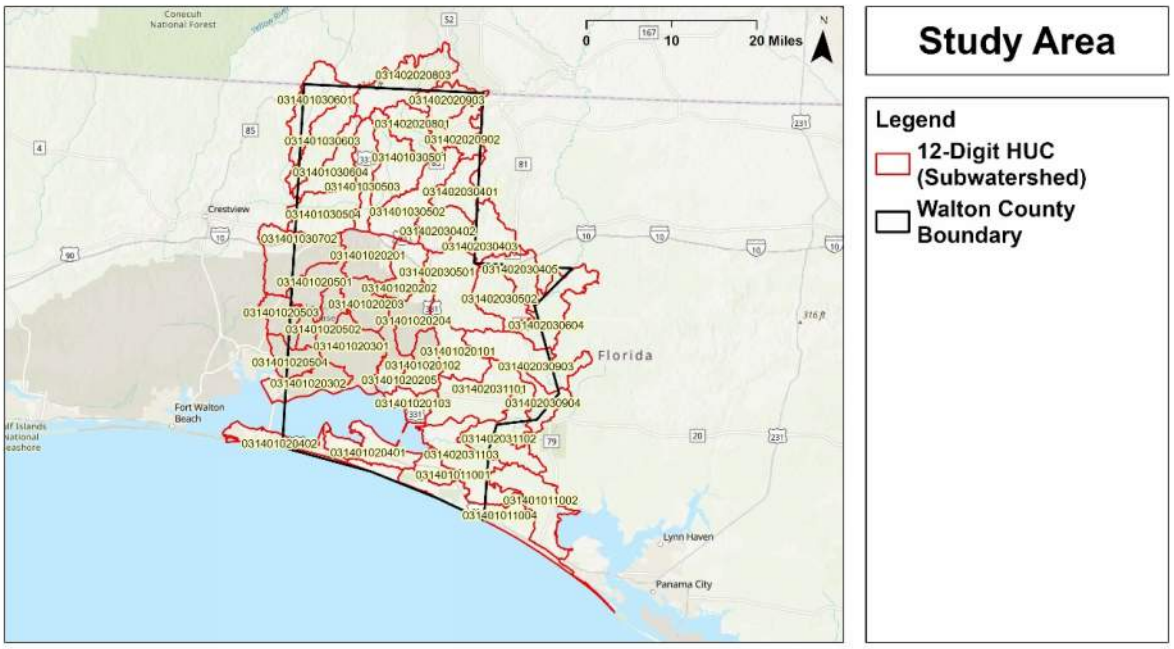

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

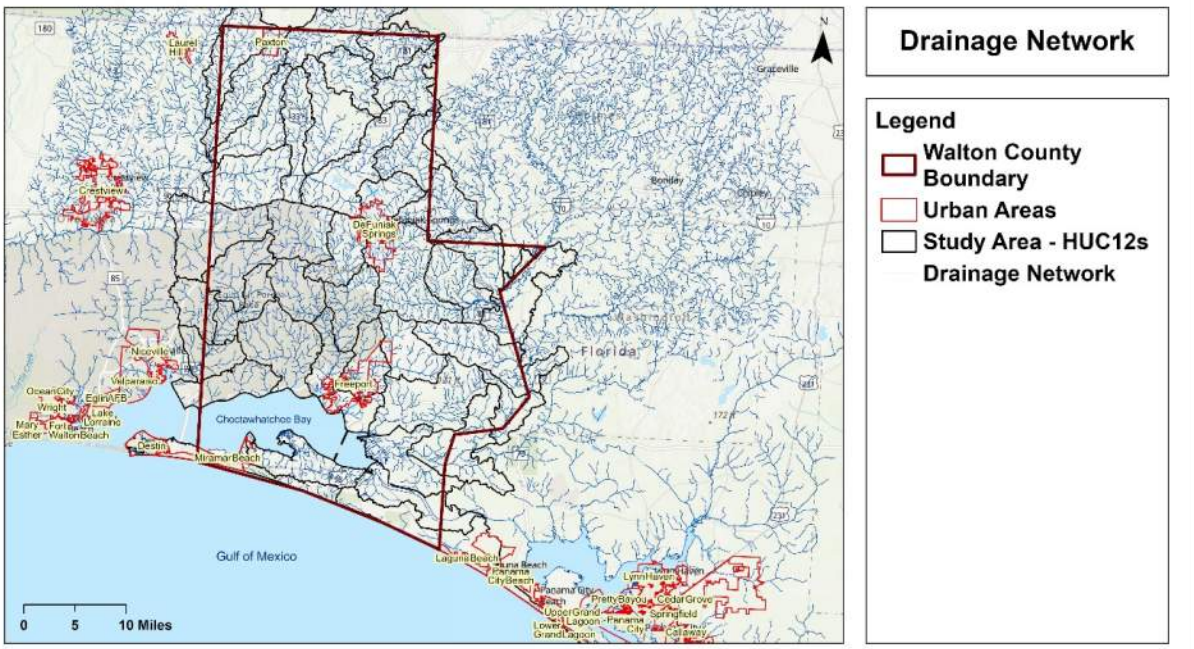

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

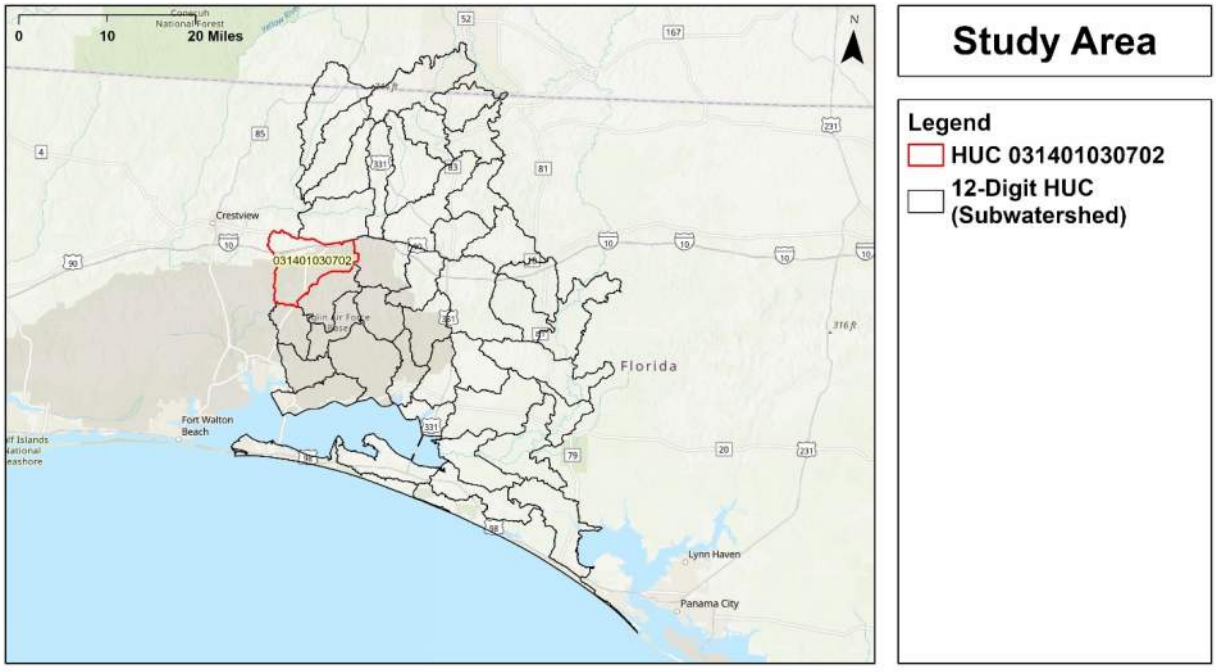

Figure 3. HUC 031401030702 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state,

with a height of 345 feet in its northern end. With a population of 75,305 residents according to the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife

management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

(Source Data: FEMA)

Figures 12 and 13 is the county-wide report show the current and projected land use for the County. Based on the 2017 future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land Use in Walton County (Prepared by FAU from future land use map) versus land use in the entire watershed (2023 Florida Geographic Data Library (FGDL))

Level 1 Land Use-Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 1.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.

- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

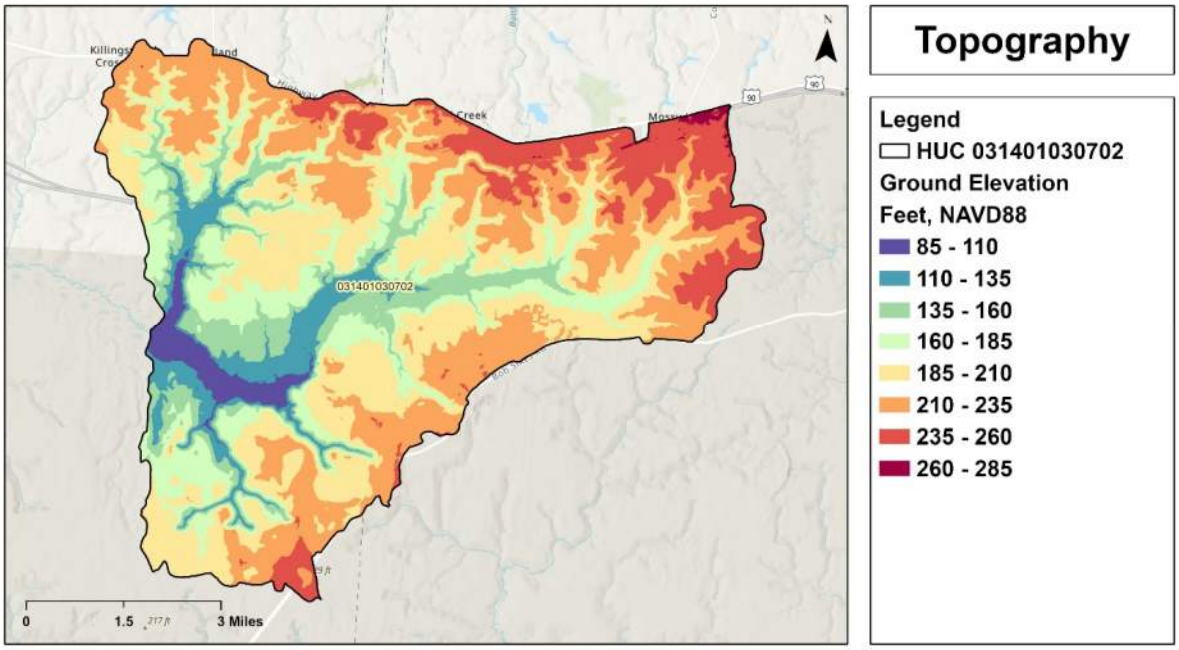

Figure 4. Topographic map of the HUC 031401030702 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031401030702 sub-watershed is shown in **Error! Reference source not found.**.

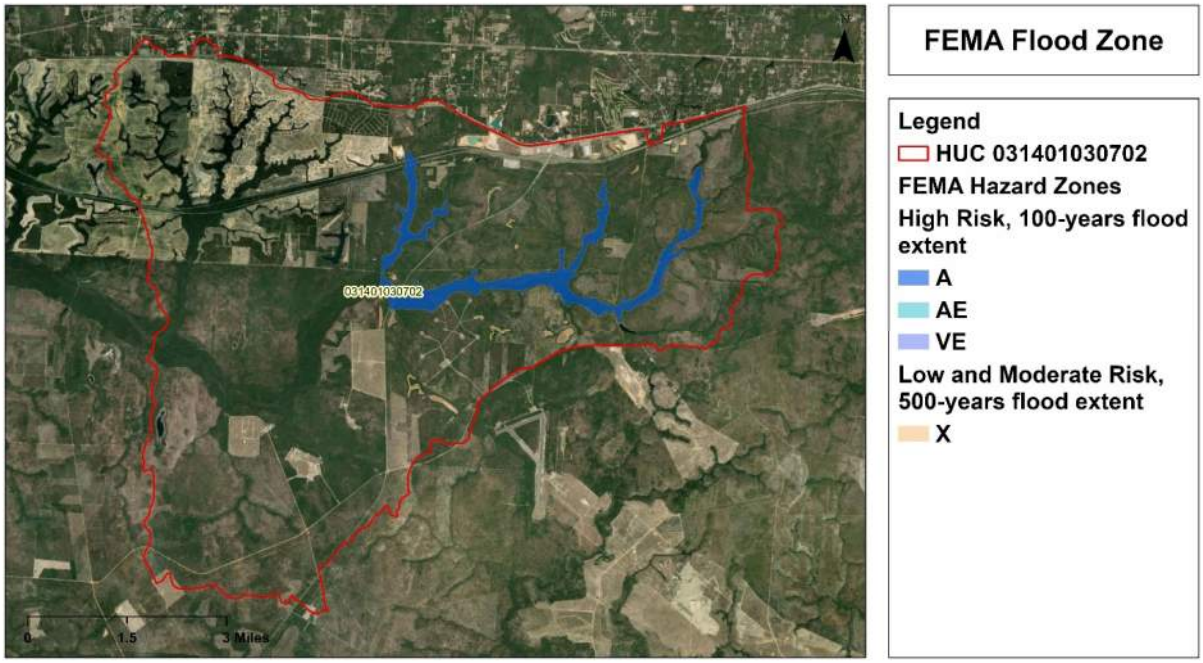

Figure 5. FEMA Flood Zone map (2020) for HUC 031401030702 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031401030702 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including

various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

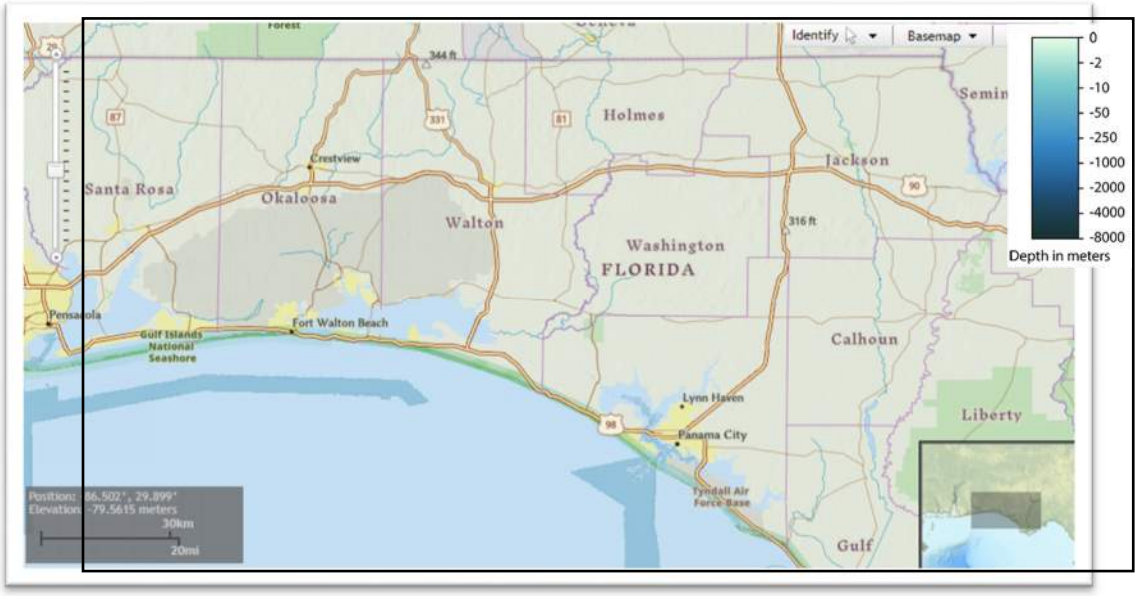

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

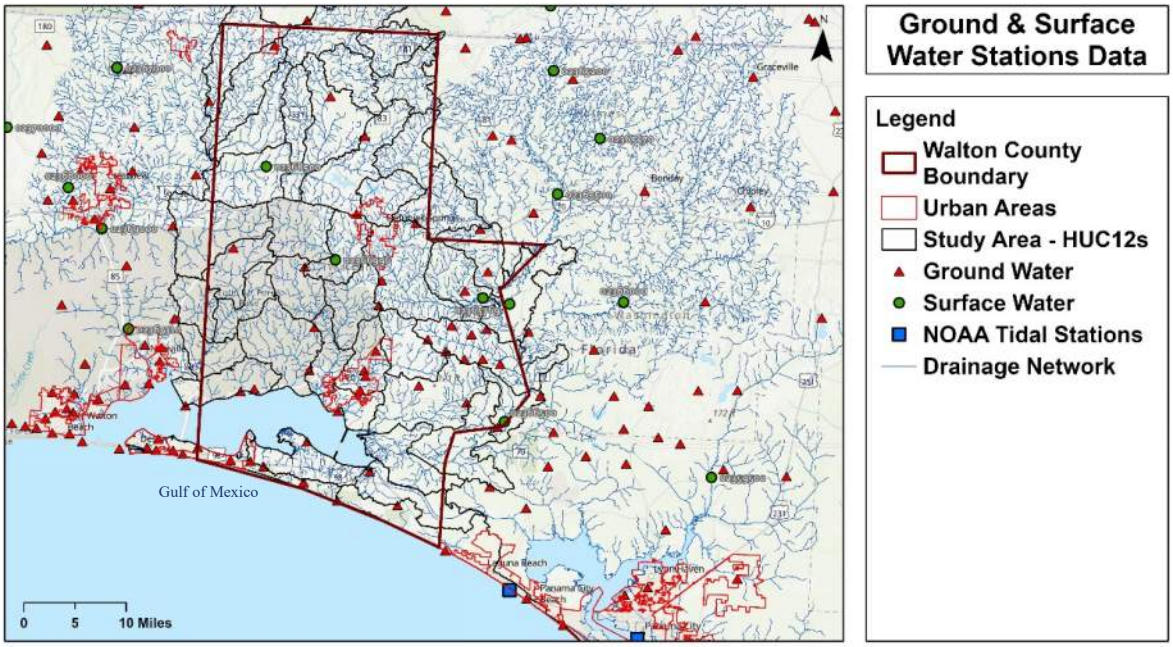

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031401030702 has no major rivers and canals, but creeks and branches, include:

- Titi Creek
- Big Fork
- Cawthon Branch

- Cowpen Branch
- Gum Creek
- East Dog Creek
- Deerland Branch
- West Dog Creek
- Bull Creek
- Ramer Creek
- Deserter Creek
- Wildcat Branch
- Indigo Branch
- Horseshoe Branch
- Wise Creek
- Hog Creek
- Gum Creek

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02368500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031401030702, which is USGS 02368500 Shoal River.

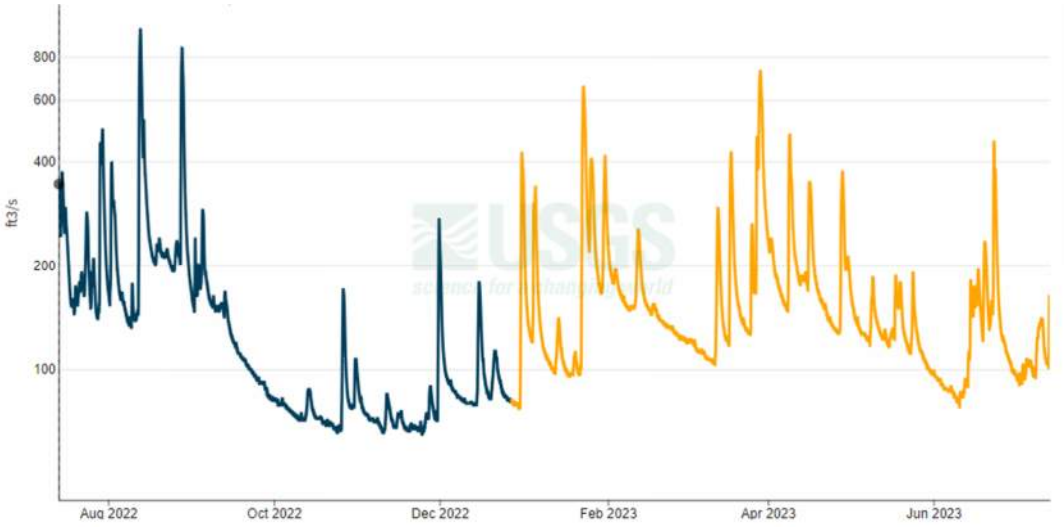

Figure 8. Average streamflow for Shoal River NR Mossy Head, Fla (USGS 02368500 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02368500/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99^{th}- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98^{th} - 100^{th} percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031401030702 and points out the location of the ground water station in the surroundings. A groundwater-surface layer for the HUC 031401030702 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

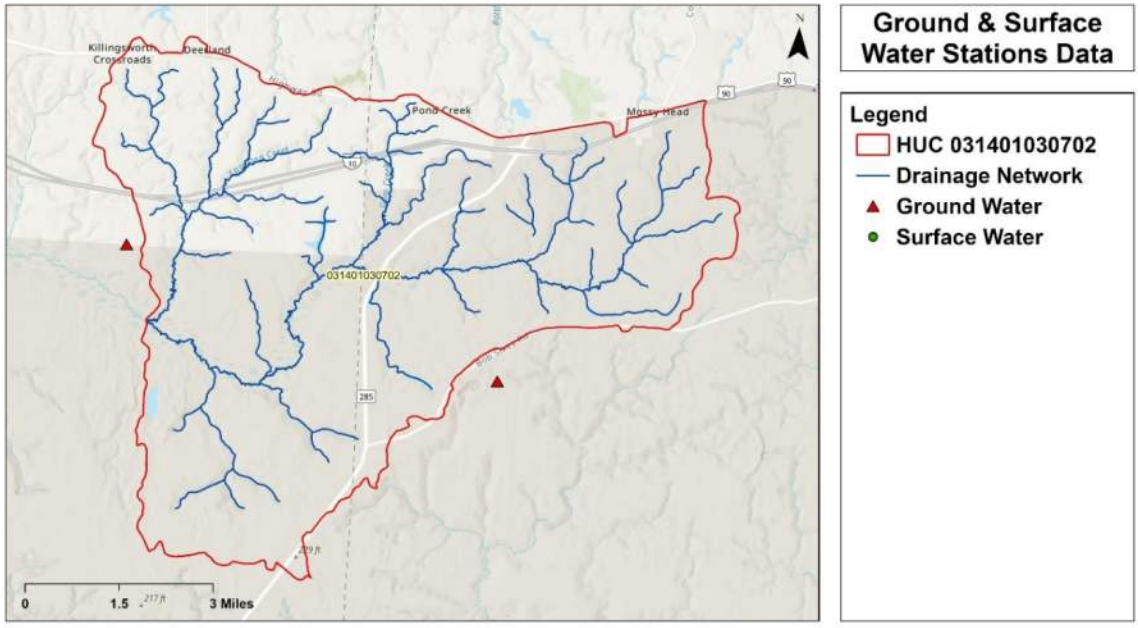

Figure 9. Ground and Surface Water Stations in the HUC 031401030702 sub-watershed, processed by FAU.

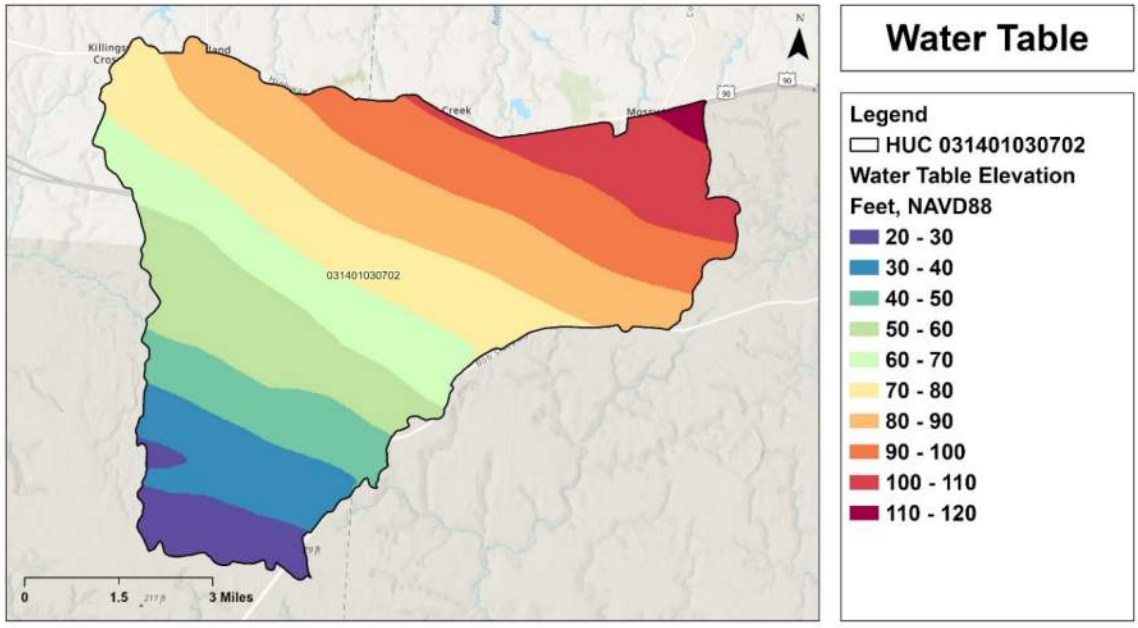

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031401030702 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the average precipitation over Walton County for every month of the year between 2011 and 2023.

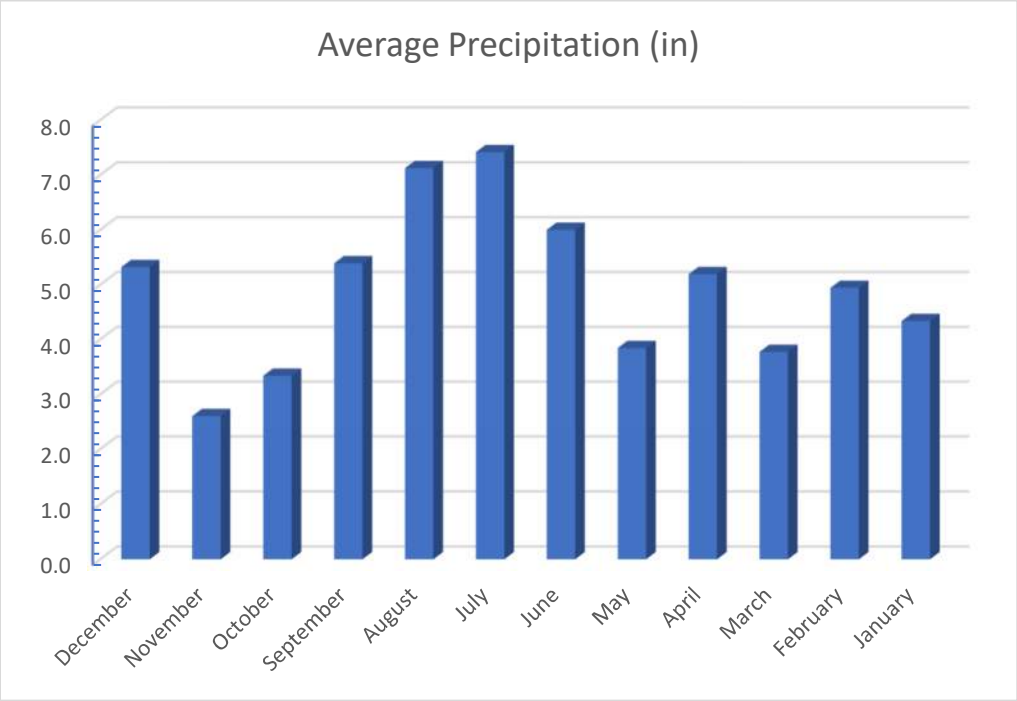

Figure 11. Monthly precipitation in Walton County, FL (2011-2023).
(Data Source: Florida Weather Data, available at https://data.usatoday.com/weather-data/walton-county/12131/1975-04-01/Table/)

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows

the two closest tide stations to Walton County. Since there is none NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

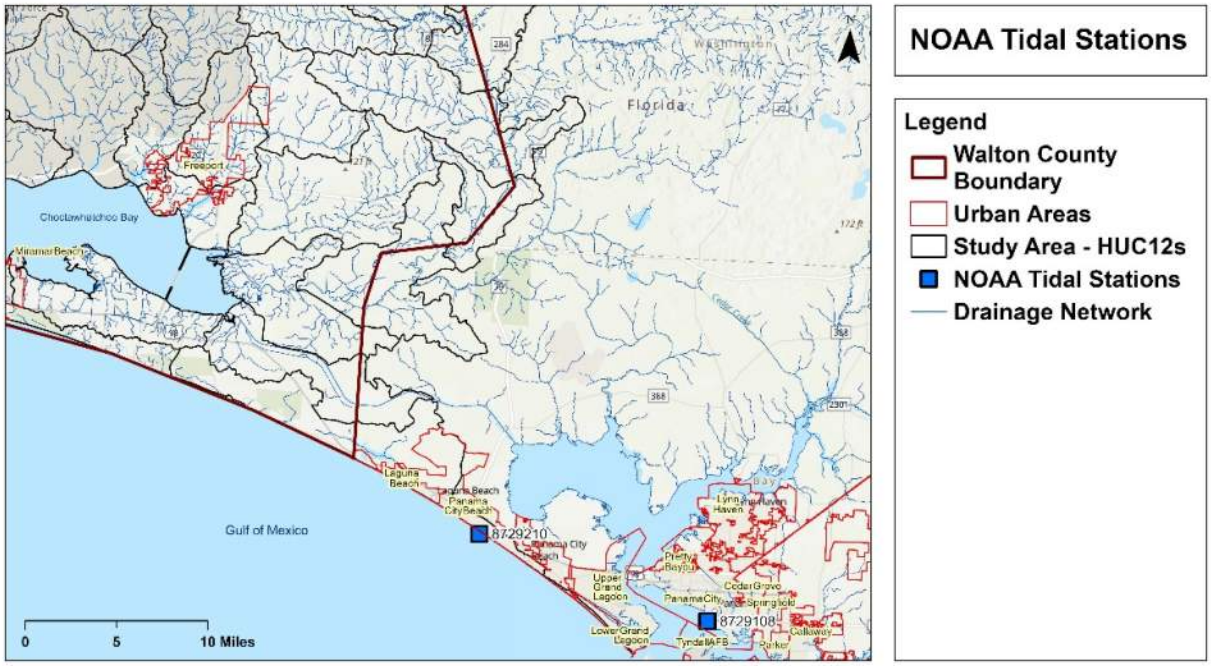

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

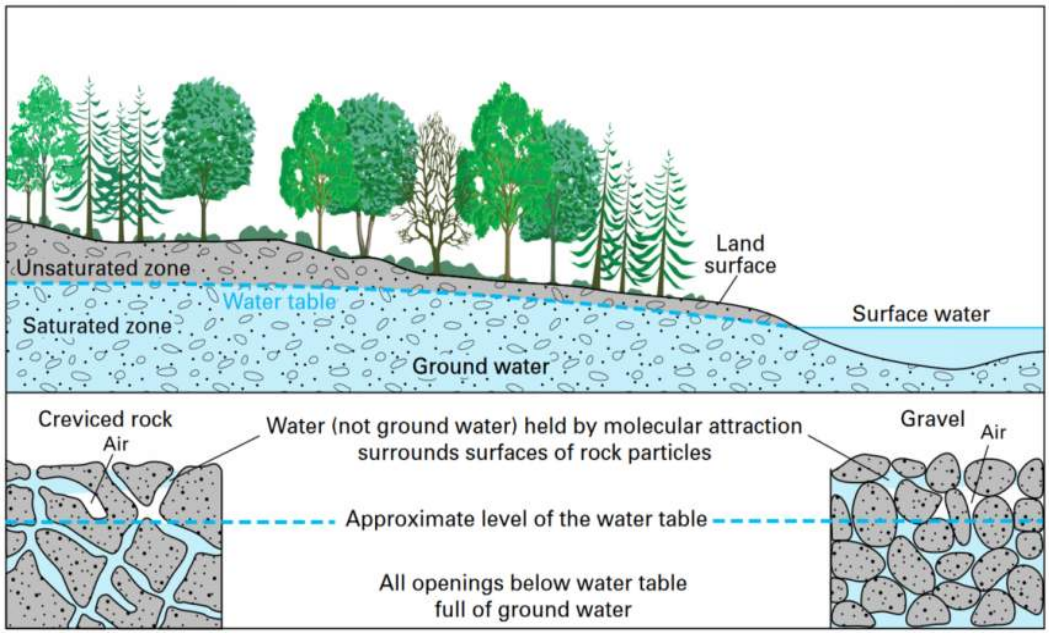

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

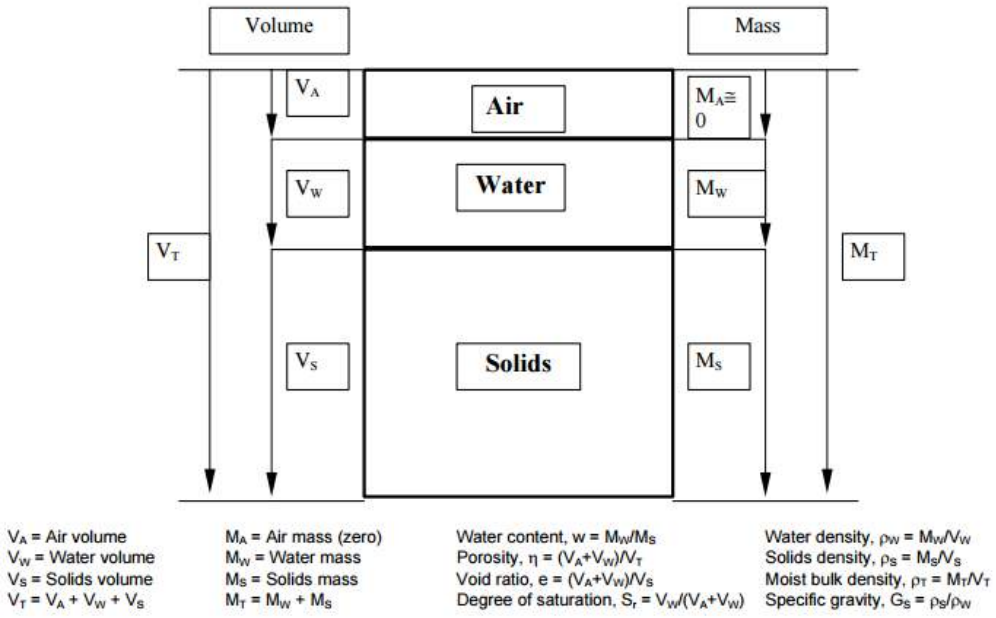

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

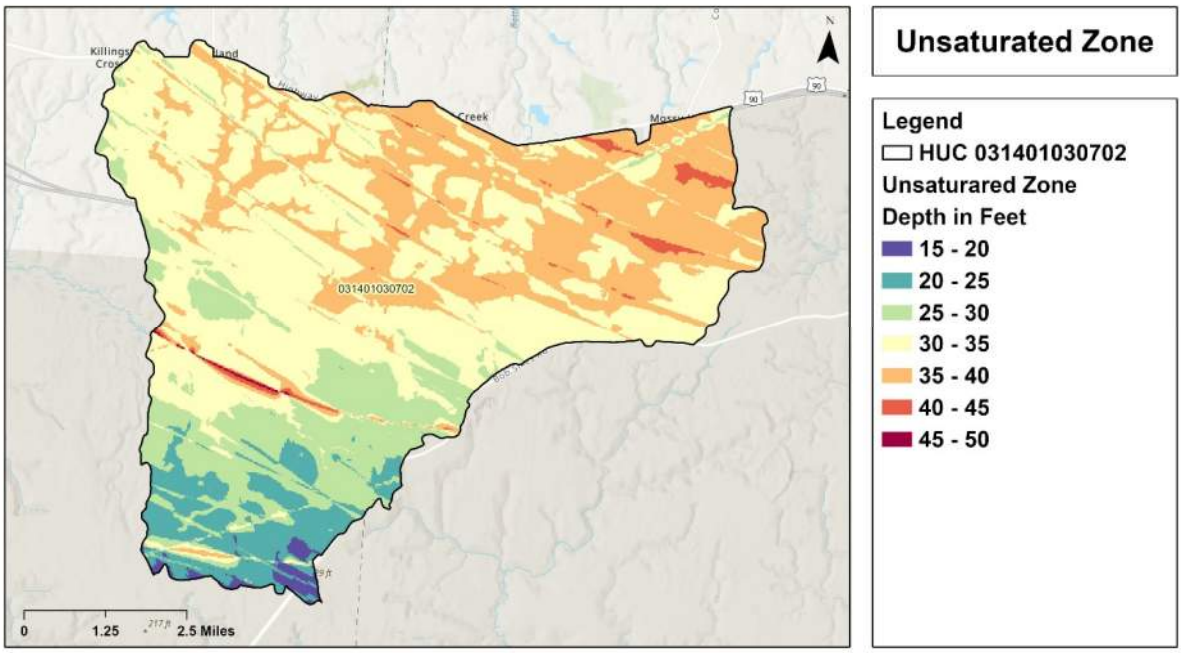

Figure 15. Unsaturated zone map for HUC 031401030702, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. Much of the basin has limited soil storage capacity, ranging between 20 to 40 inches of capacity left.

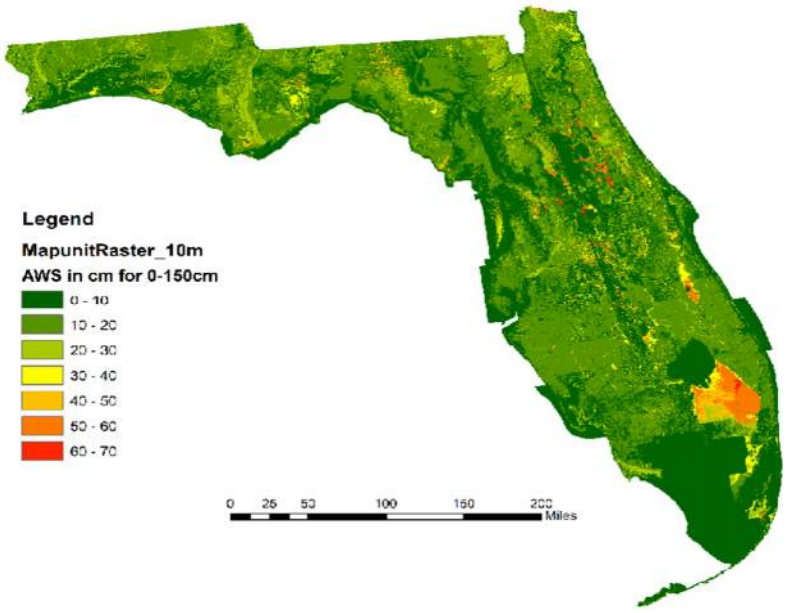

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

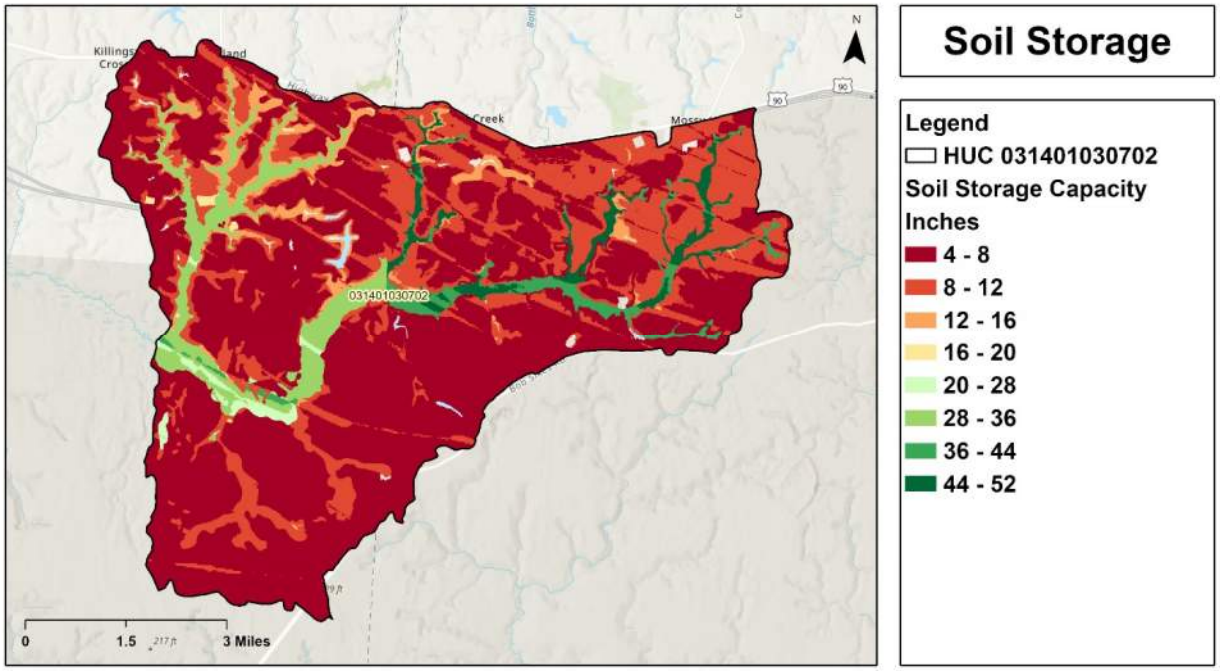

Figure 17. Water storage capacity of soil for the HUC 031401030702 (inches), processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

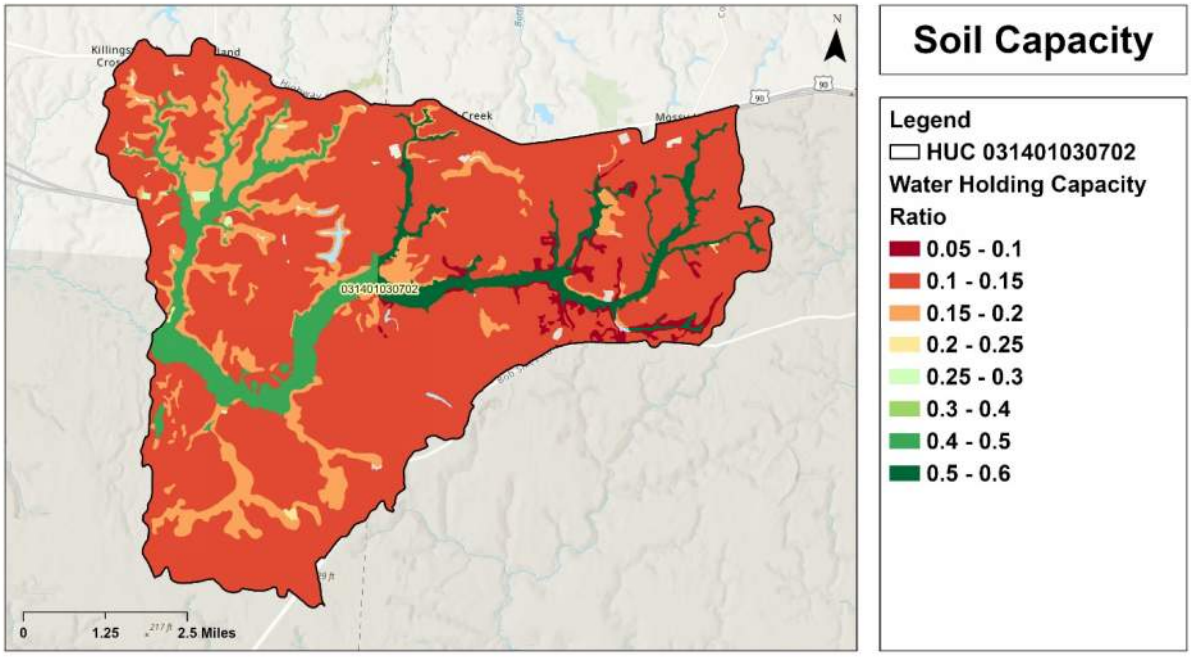

Figure 18: Water Holding Capacity (ratio) for the HUC 031401030702, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

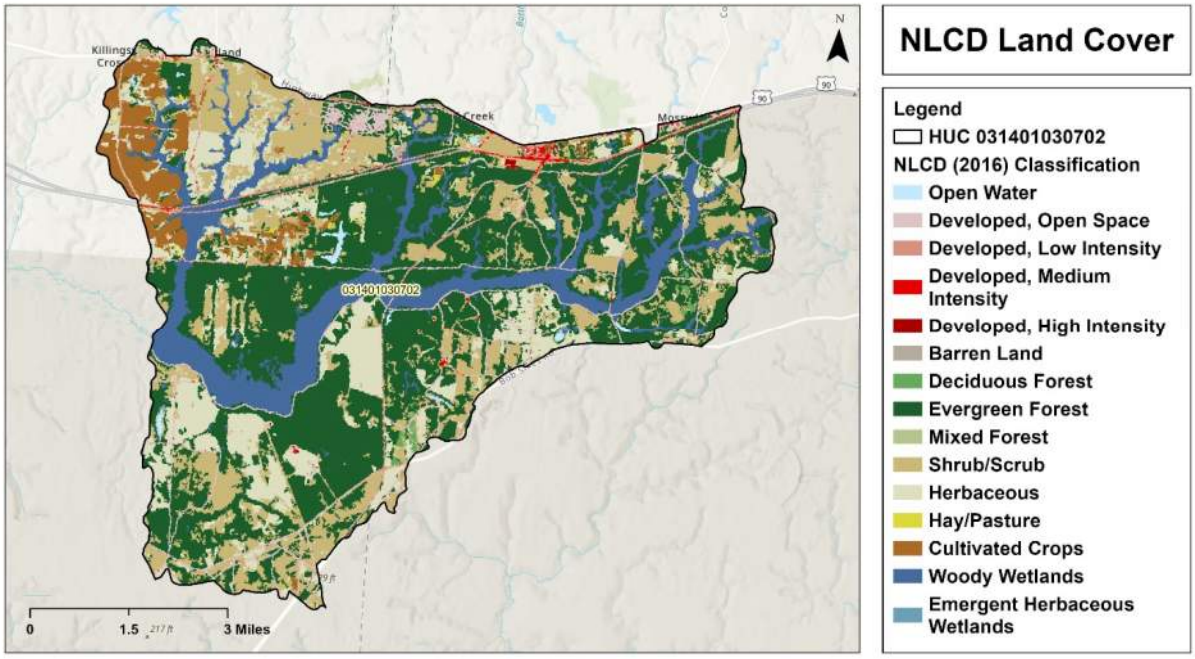

Figure 19. Land use in the HUC 031401030702 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps were used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

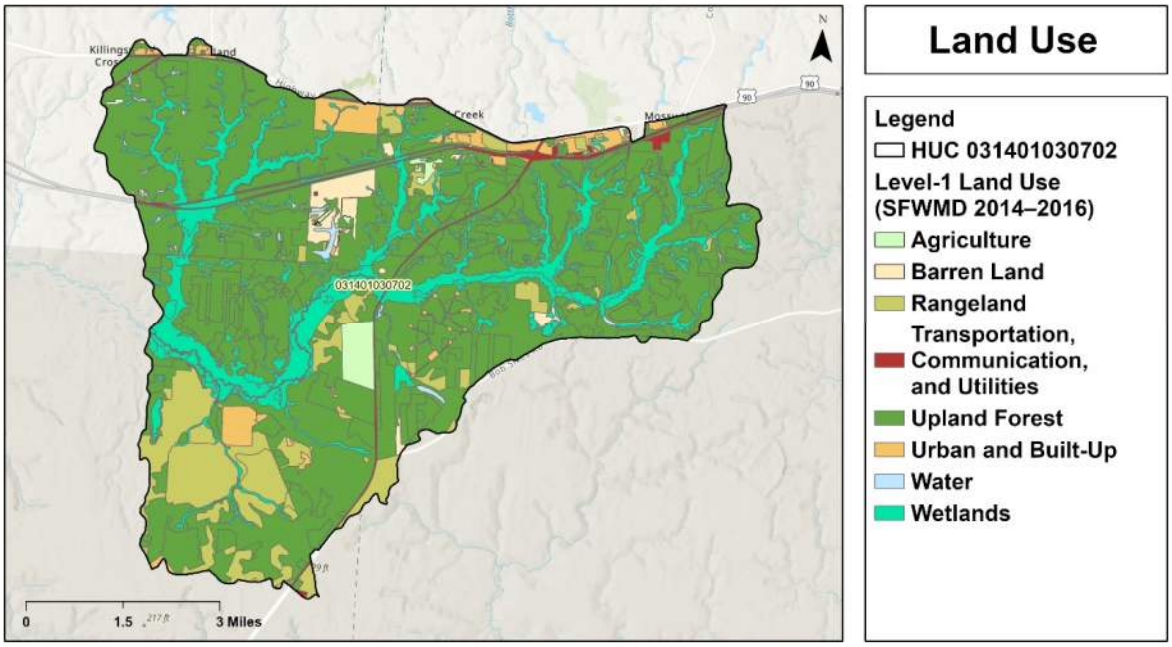

Figure 20. Land use in the HUC 031401030702 processed by FAU (from the 2023 Florida Geographic Data Library (FGDL) database), processed by FAU.

In the HUC 031401030702 sub-watershed, the predominant land cover is upland forest, accounting for 59.51% of the area. Rangeland comes in second at 14.56%, followed by wetlands at 11.50%, and Transportation, Communication, and Utilities at 7.85%. Developed land constitutes a minor portion, with only 3.15% categorized as urban and built-up, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031401030702 subwatershed.

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	384.80	0.95%
Barren Land	528.28	1.31%
Rangeland	5892.16	14.56%
Transportation, Communication, and Utilities	3174.66	7.85%
Upland Forest	24077.91	59.51%
Urban and Built-Up	1275.42	3.15%
Water	476.71	1.18%
Wetlands	4653.09	11.50%
Grand Total:	**40463.03**	**100.00%**

(Source Data: 2023 Florida Geographic Data Library (FGDL) database))

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

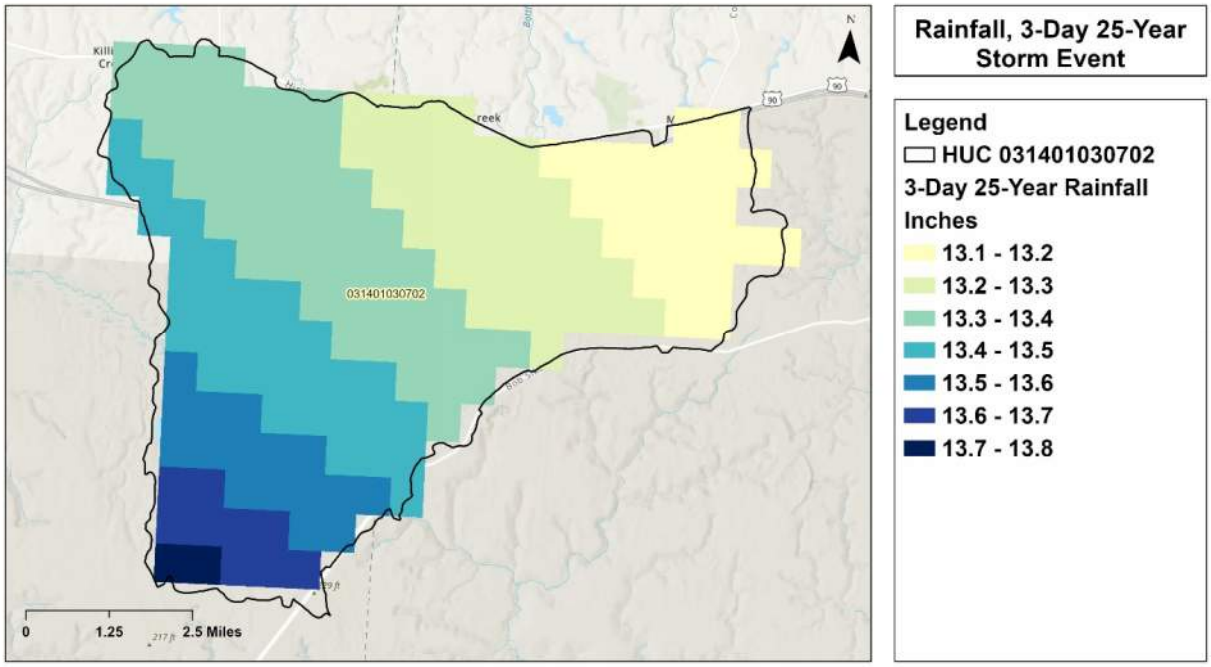

Figure 21. Rainfall distribution map across HUC 031401030702 sub-watershed, for 3-day 25-year storm event, processed by FAU.

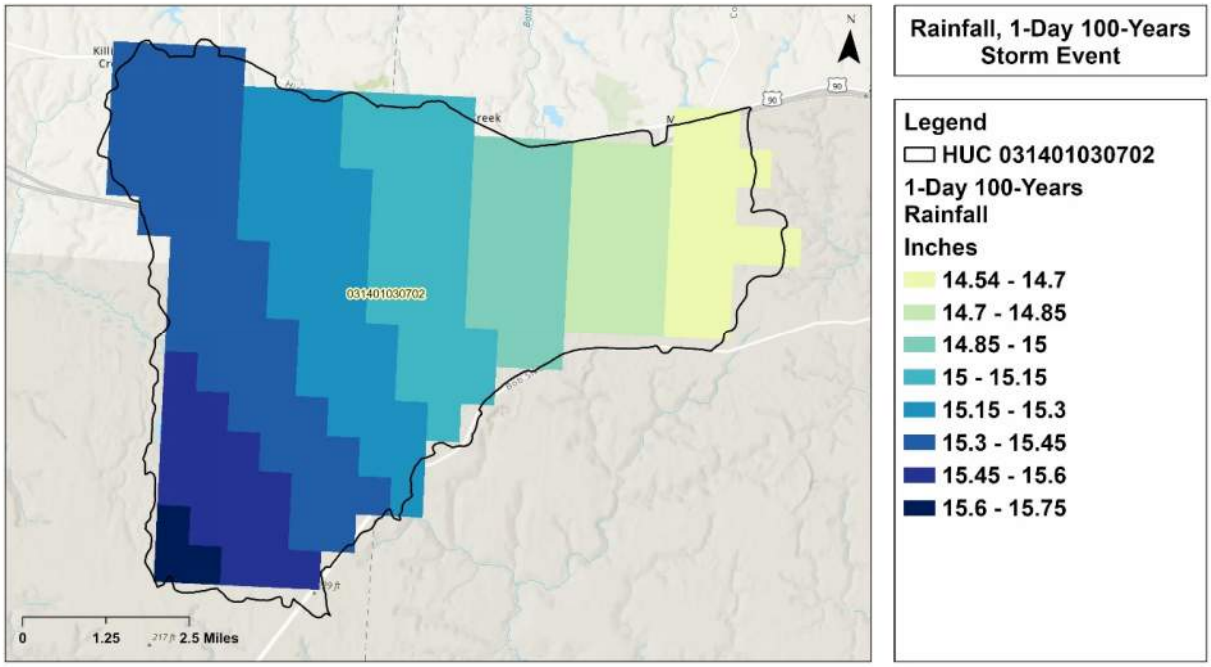

Figure 22. Rainfall distribution map across HUC 031401030702 sub-watershed, for 1-day 100-year storm event, processed by FAU.

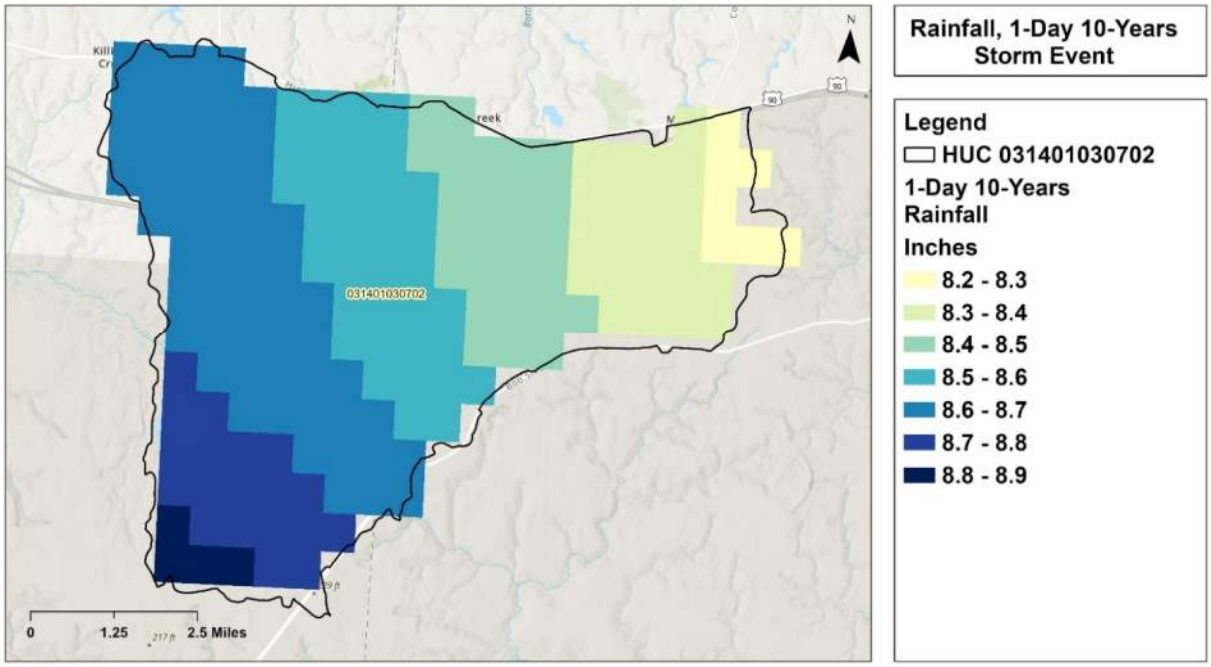

Figure 23. Rainfall distribution map across HUC 031401030702 sub-watershed, for 1-day 10-year storm event, processed by FAU.

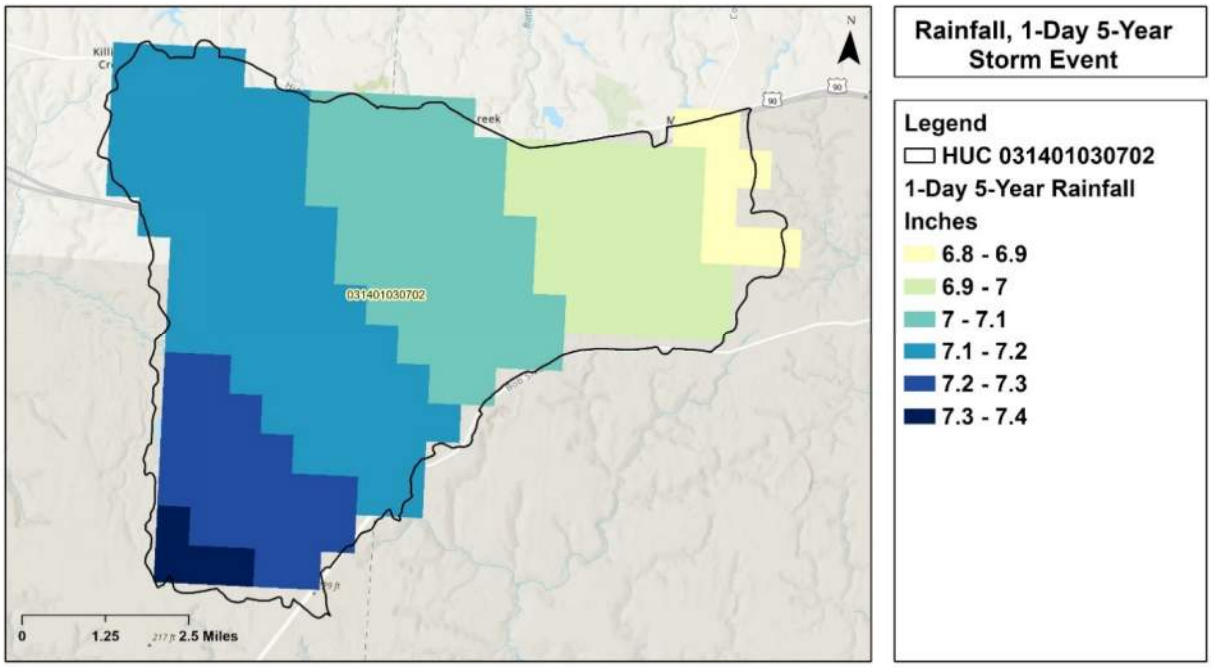

Figure 24. Rainfall distribution map across HUC 031401030702 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

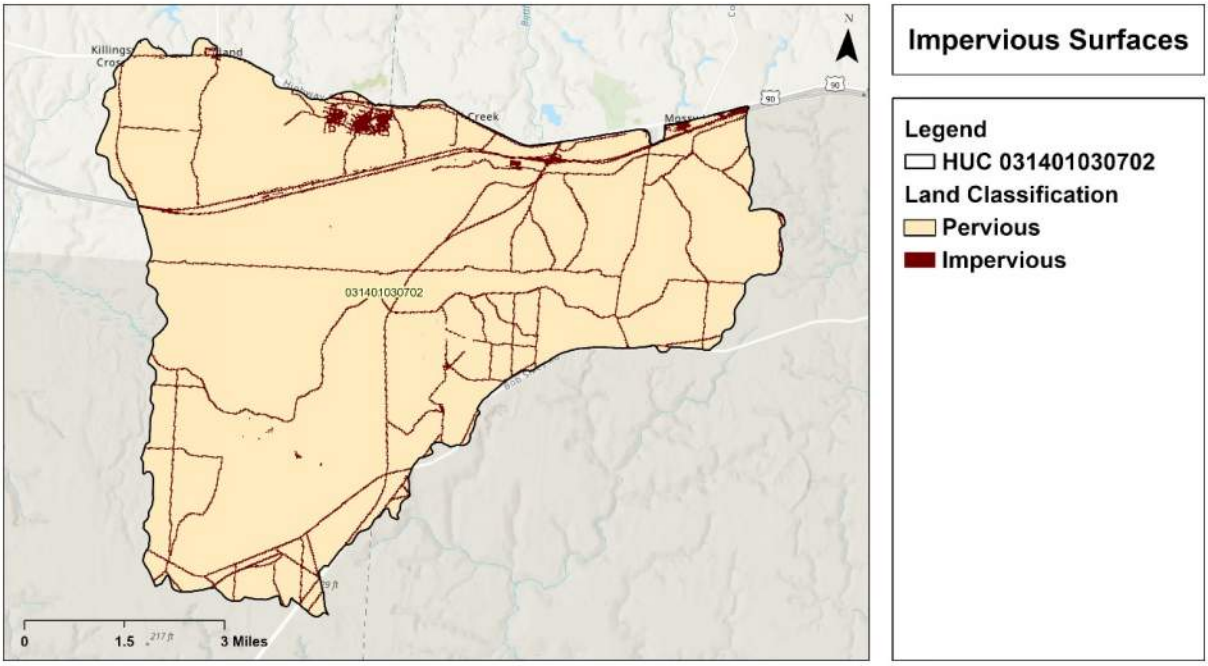

Figure 25. Impervious area map for the HUC 031401030702 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

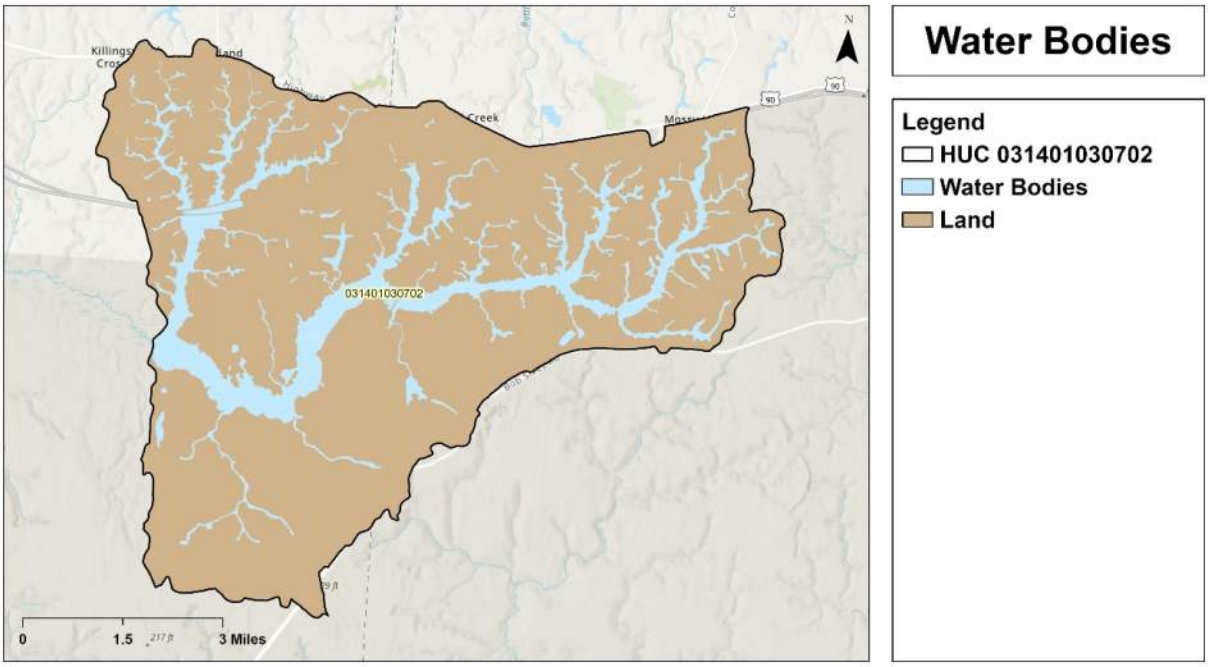

Figure 26. Water bodies map for the HUC 031401030702 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

(Source: US Census Bureau 2020, and Zip-codes.com)

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.

- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

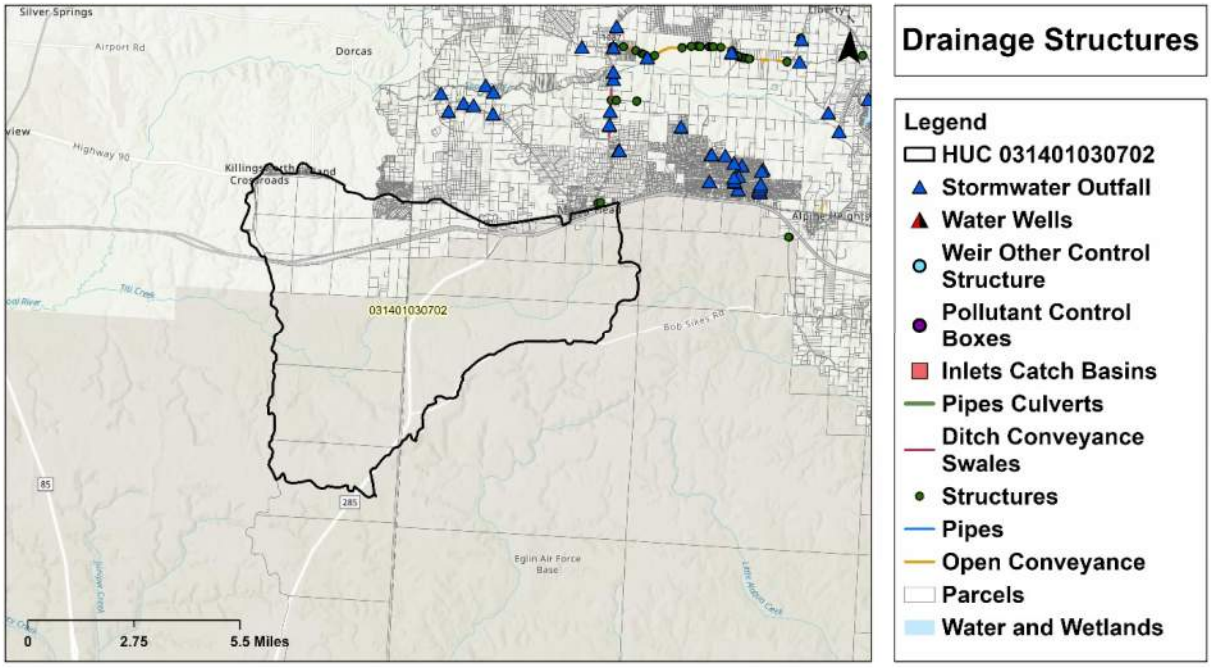

Figure 27. Stormwater Infrastructure for the HUC 031401030702. Processed by FAU.

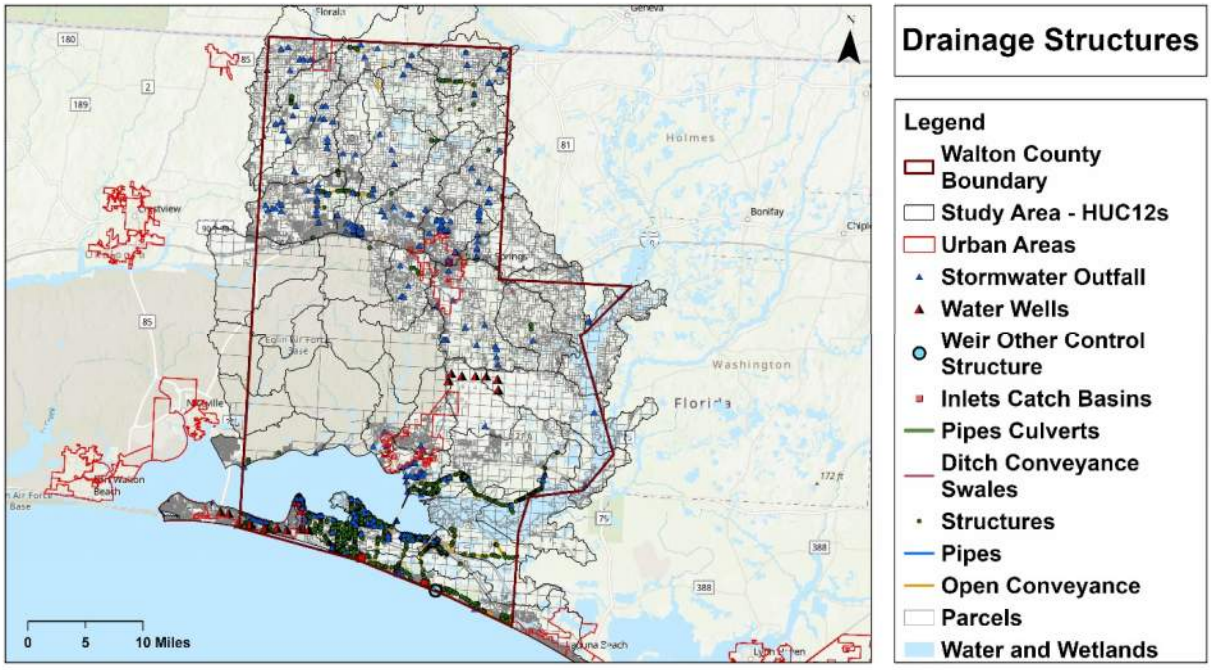

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1, analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401030702 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.3.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD DBHYDRO website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

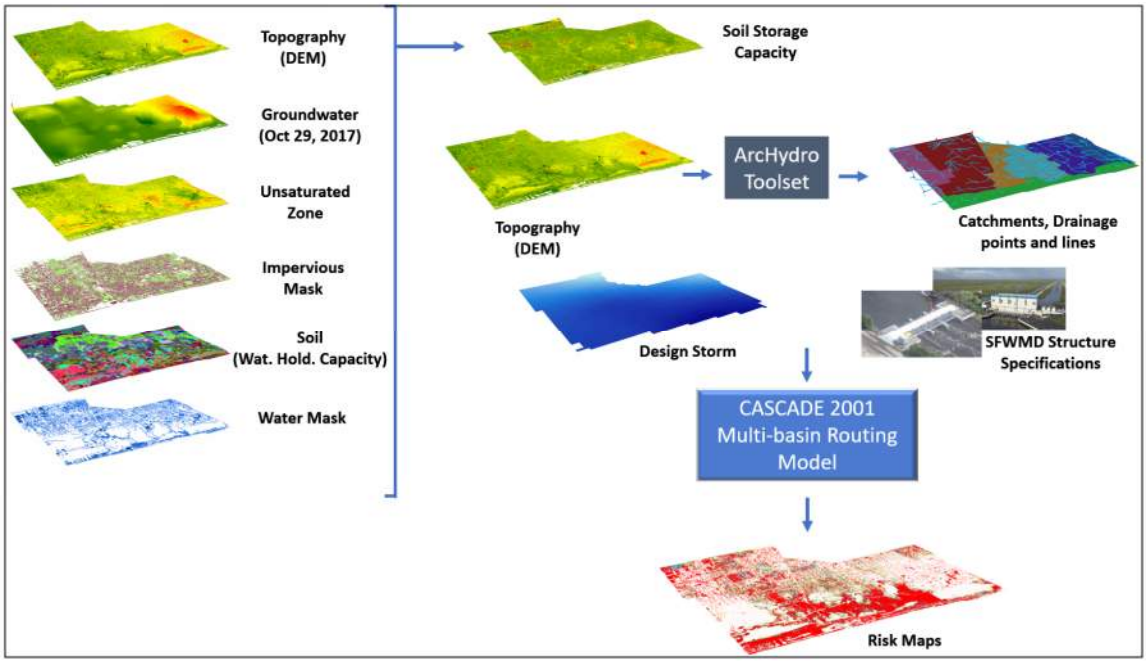

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
= 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

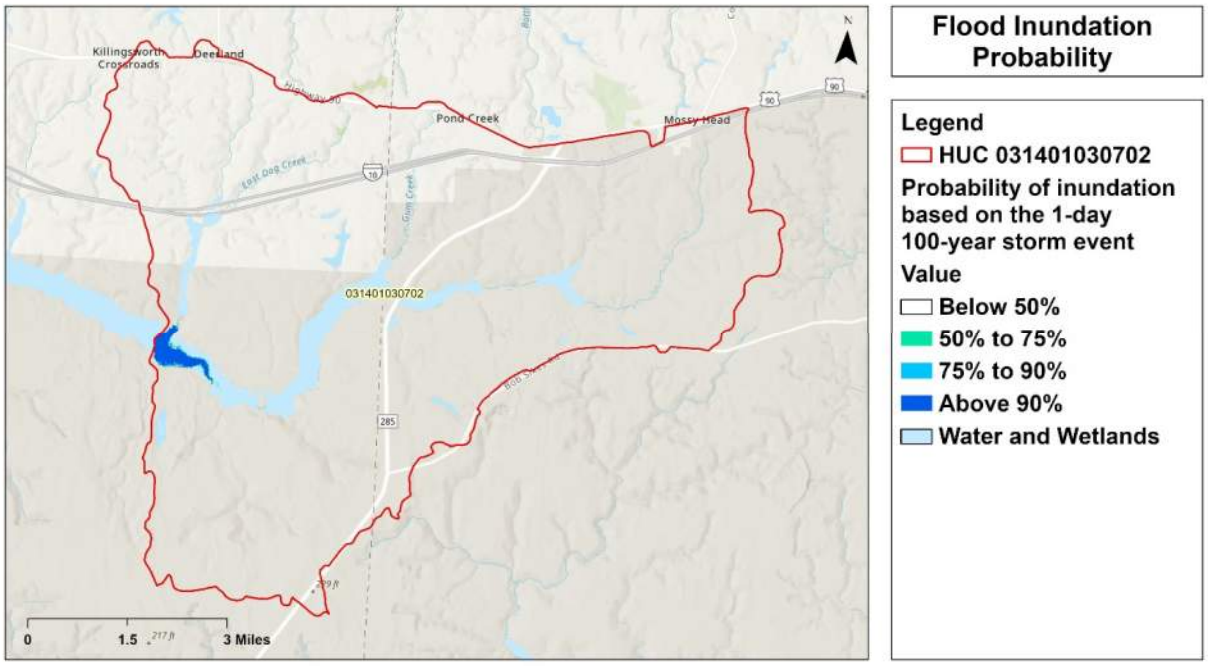

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031401030702, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital

elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 2.4 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a small portion of flooding is noted at the creek entrance to the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, the HUC is expected to remain unaffected by sea level rise, therefore SLR scenarios were not computed.

The design storm simulation determined that approximately 0.5% of the HUC total area or 0.25 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 0.52% of the HUC's total area, or 0.26 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.44% of the HUC's total area, or 0.22 mi^2,

would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0.42% of the HUC's total area, or 0.21 mi², would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031401030702 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	49.01	0.25	99.50%	0.50%
1-day 100-year	49.00	0.26	99.48%	0.52%
1-day 10-year	49.04	0.22	99.56%	0.44%
1-day 5-year	49.05	0.21	99.58%	0.42%

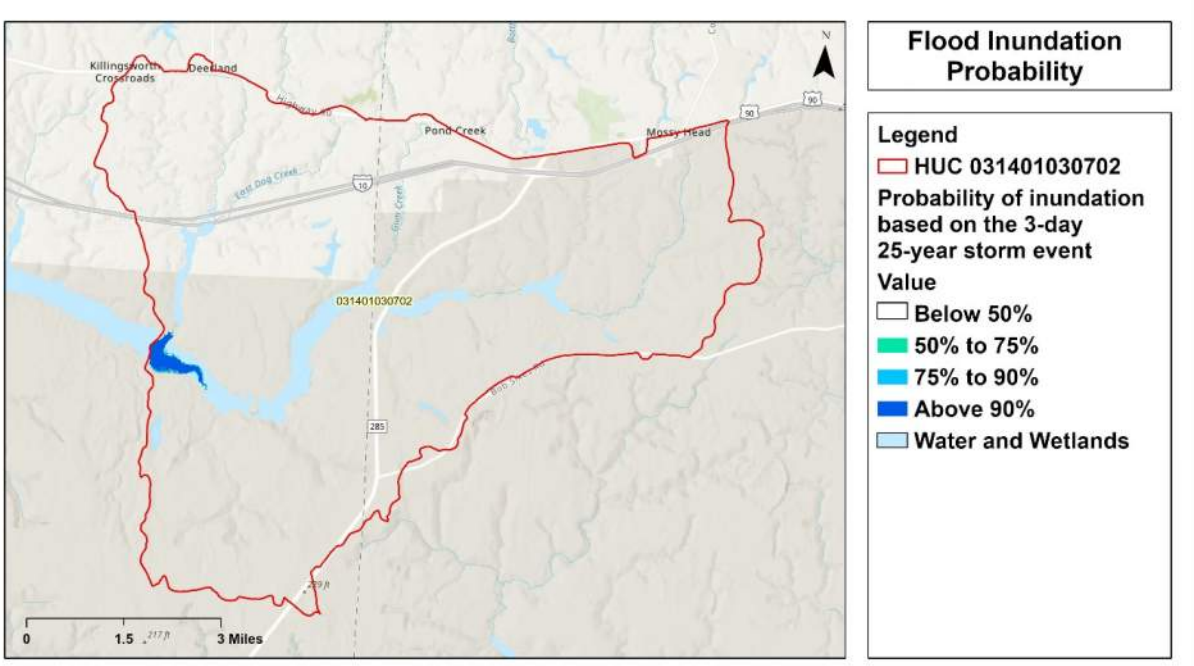

Figure 31. 3-day 25-year storm event for HUC 031401030702 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

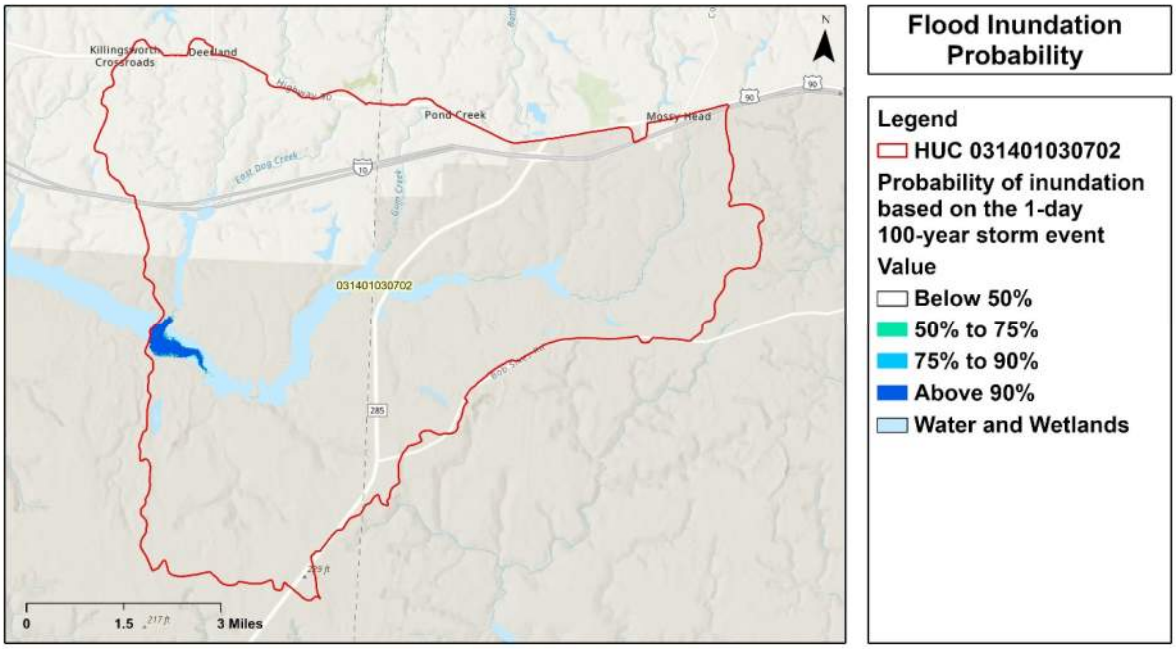

Figure 32. 1-day 100-year storm event for HUC 031401030702 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

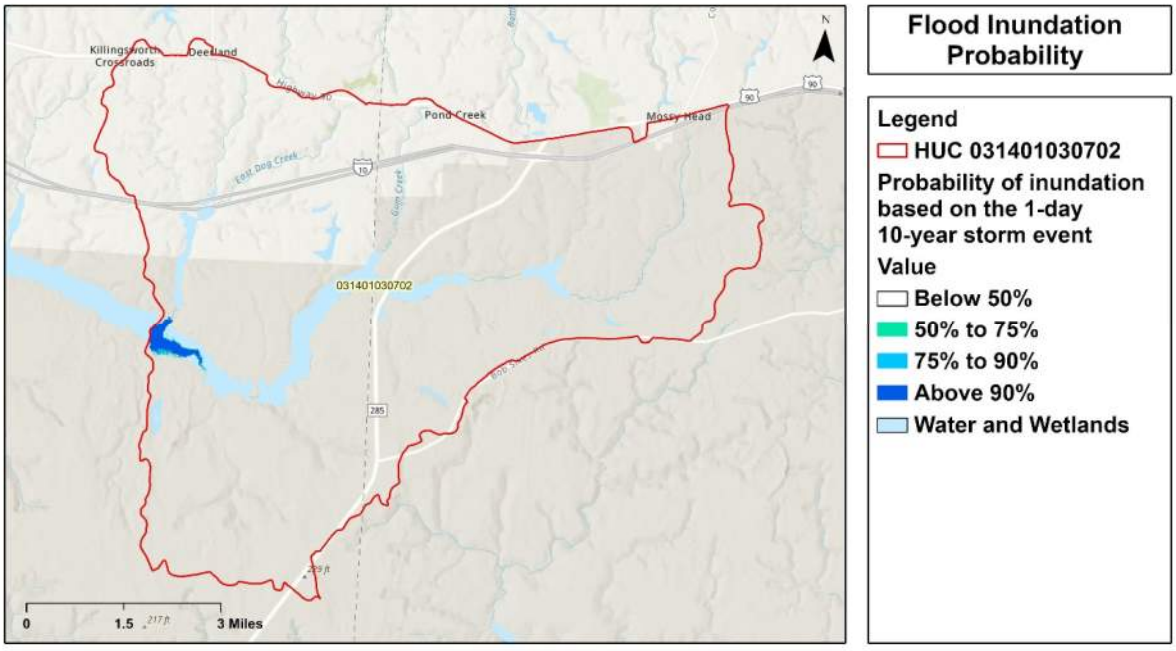

Figure 33. 1-day 10-year storm event for HUC 031401030702 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

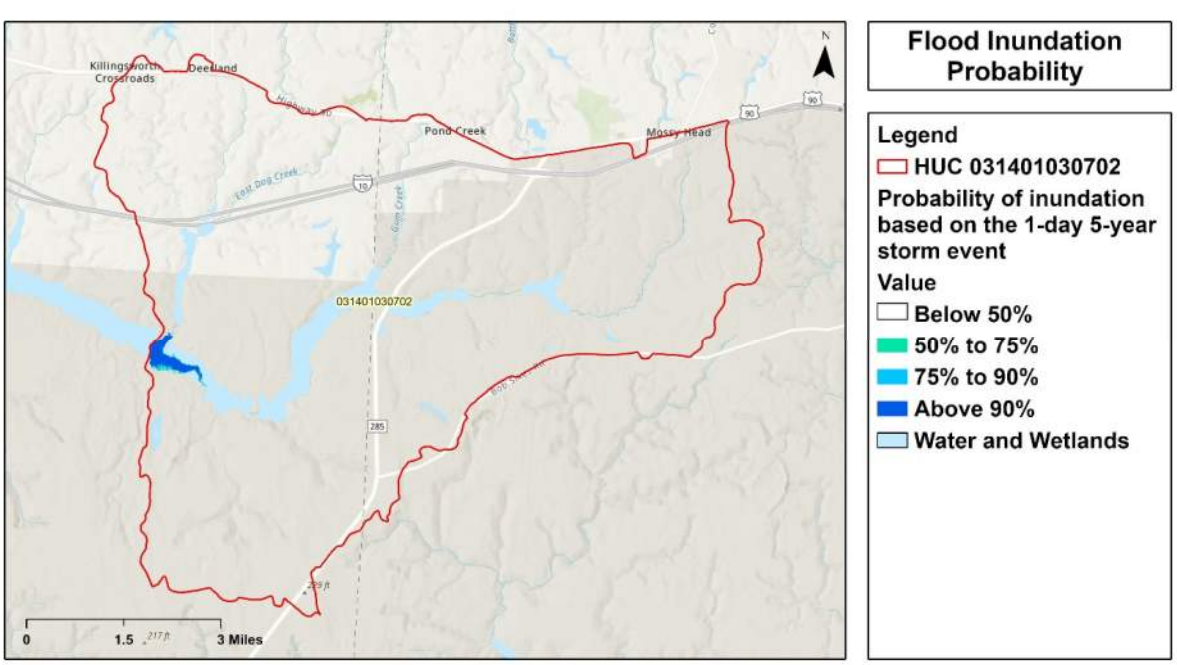

Figure 34. 1-day 5-year storm event for HUC 031401030702 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older,

poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3

28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6

60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6

97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031401030702 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

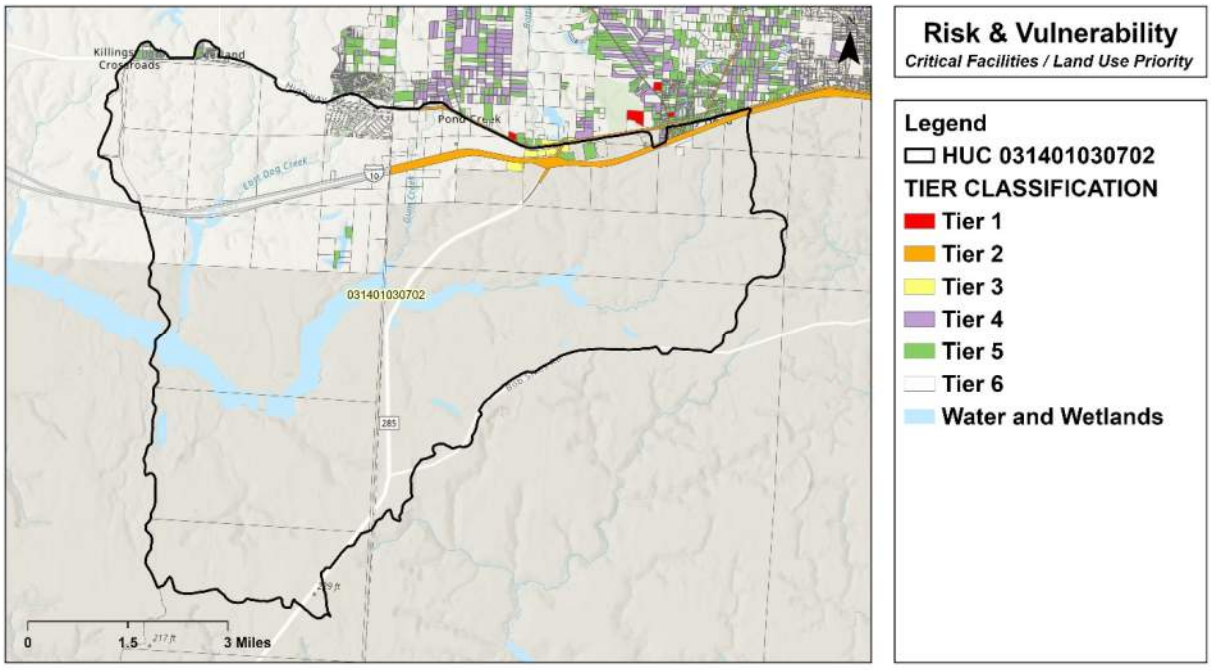

Figure 35. HUC 031401030702 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

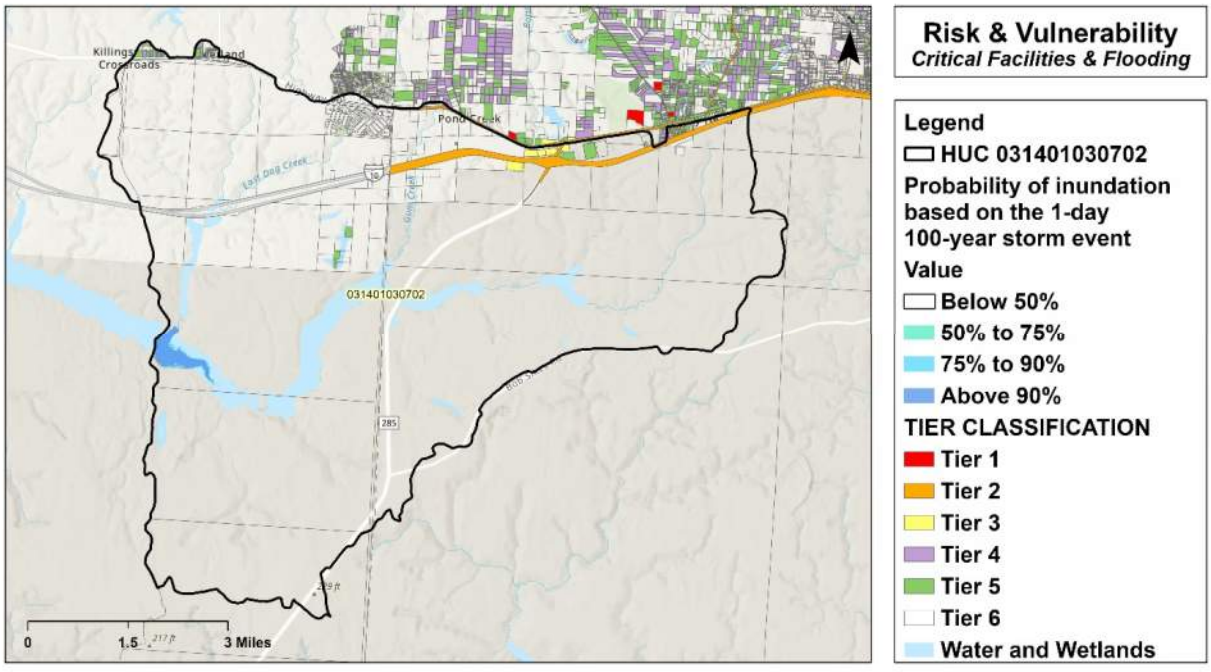

Figure 36. HUC 031401030702 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

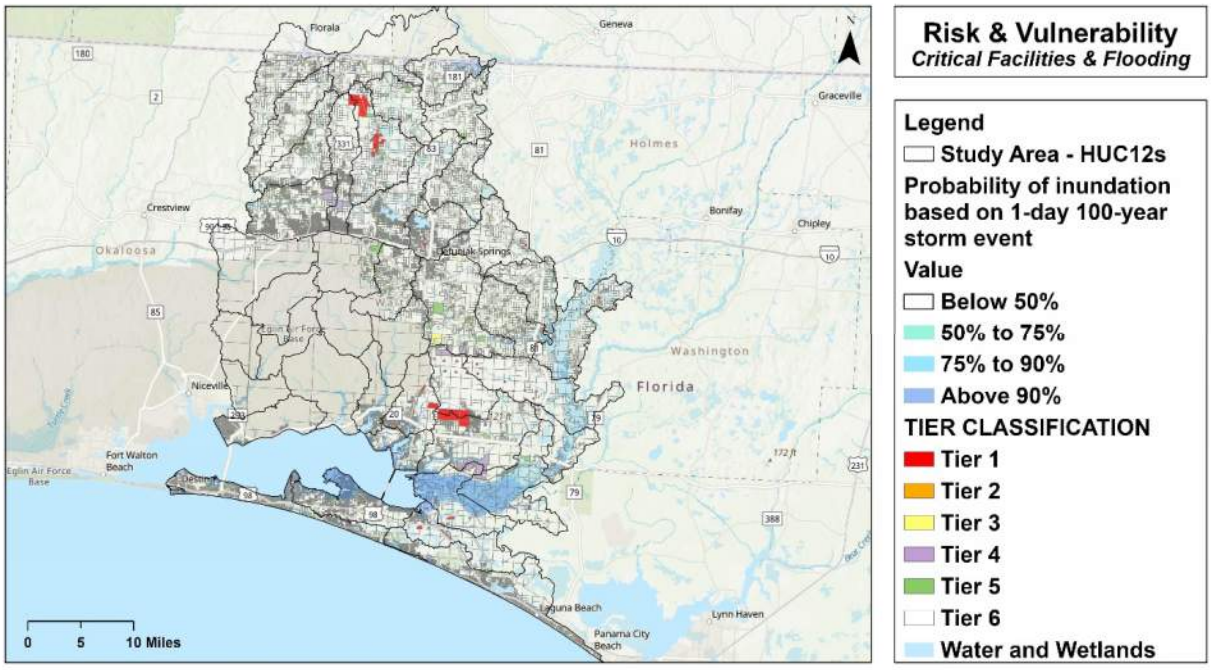

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

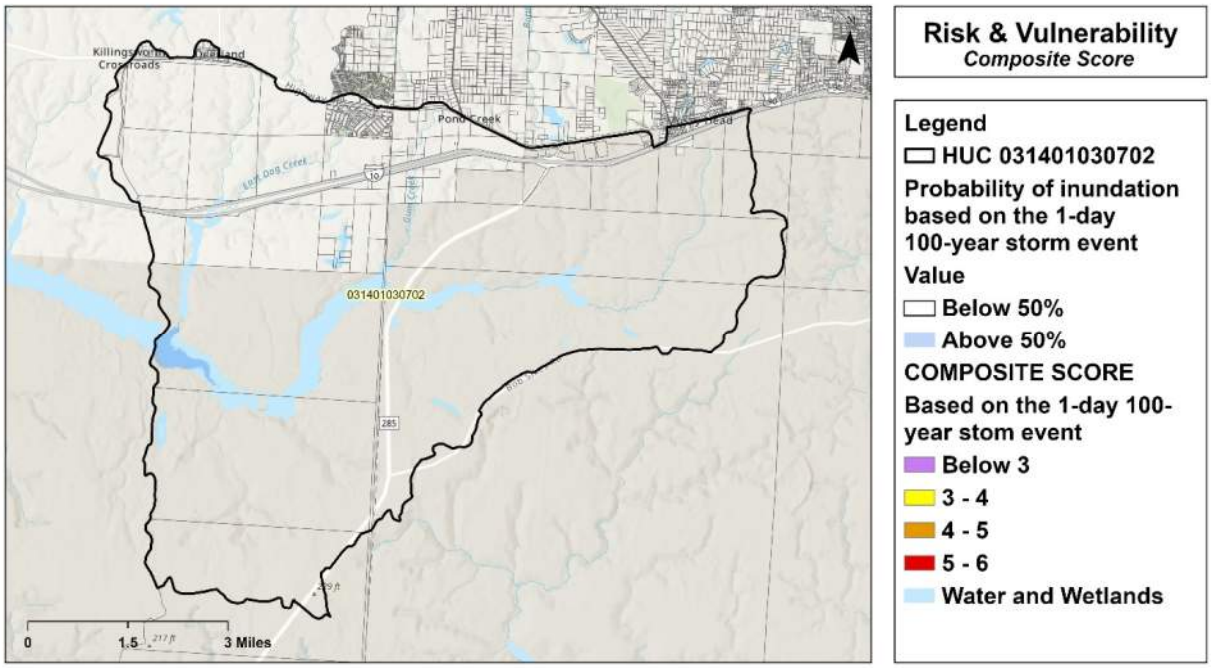

Figure 38. HUC 031401030702 sub-watershed Composite Score Risk map, with calculation based on 1-day 100-year storm event. Processed by FAU.

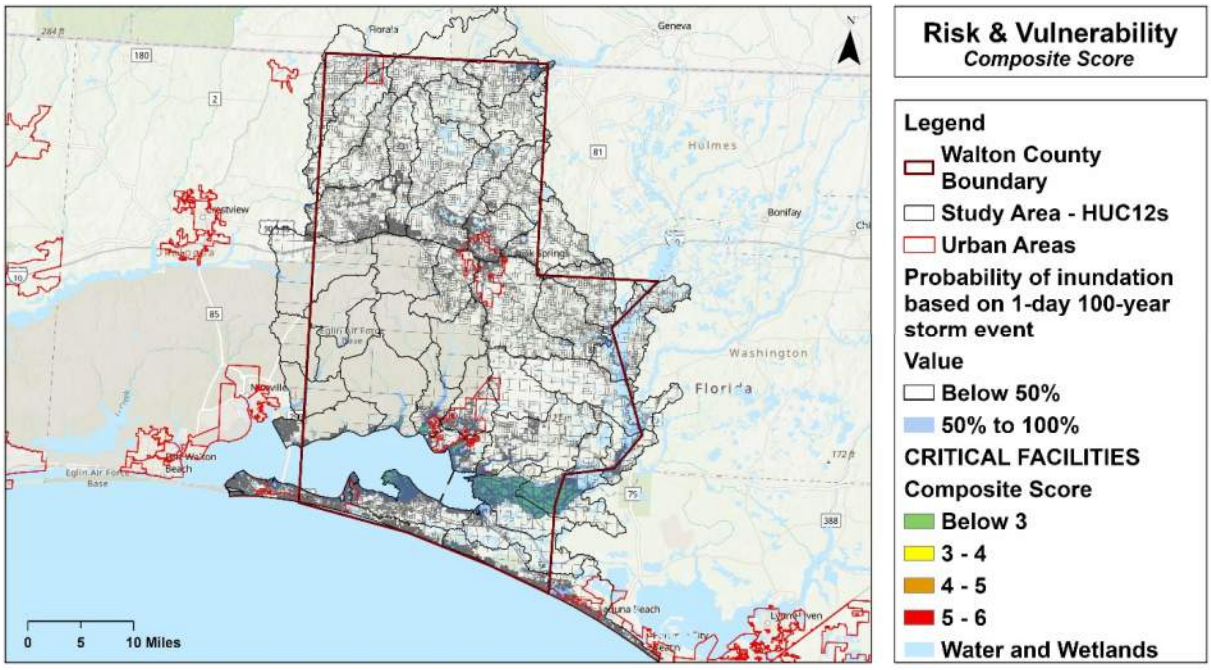

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031401030702. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It is important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031401030702. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031401030702	31522.36
All of the 1-day 100-year storm event inundation	**164.64**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	18.47
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	146.18
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	146.18

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that

have a higher concentration of properties prone to repetitive losses. . **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

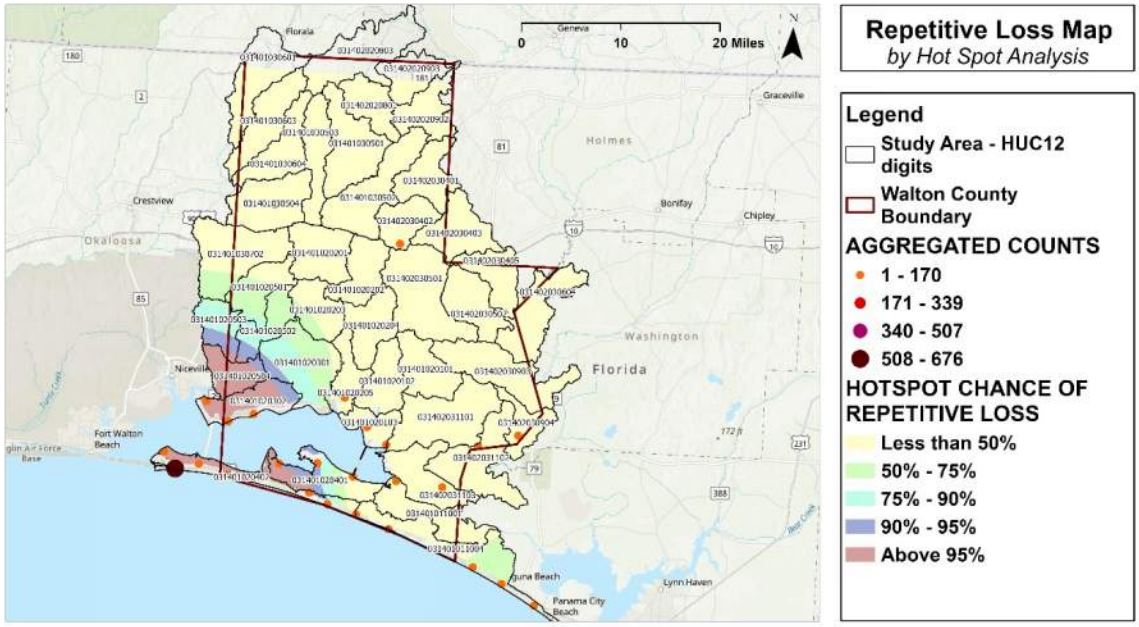

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5 Priority Projects

Although there are some parcels falling within tiers 2 (roads), 3, 4 and 5 of priority of land uses, none of them are within the flooding zone, once flooding in the area is minor and not alarming. Consequently, when considering the composite score, it is notable that the results are null, indicating no priority for intervention within the basin.

APPENDIX AB

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031402020801

UPPER EIGHTMILE CREEK

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This resource was funded in part, through a grant agreement from the Florida Division of Emergency Management's (FDEM) Bureau of Mitigation, by a grant provided by through the Hazard Mitigation Grant Program (HMGP) DR-4337-004-P, as approved by FDEM and the Federal Emergency Management Agency (FEMA) to create and update Watershed Master Plans (WMP) throughout the state of Florida. The views, statements, findings, conclusions, and recommendations expressed herein are those of the authors and do not necessarily reflect the views of the State of Florida, FEMA, or any of their sub-agencies.

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 (031402020801) is highlighted among all the HUCs to help identify its location. (Figure 3).

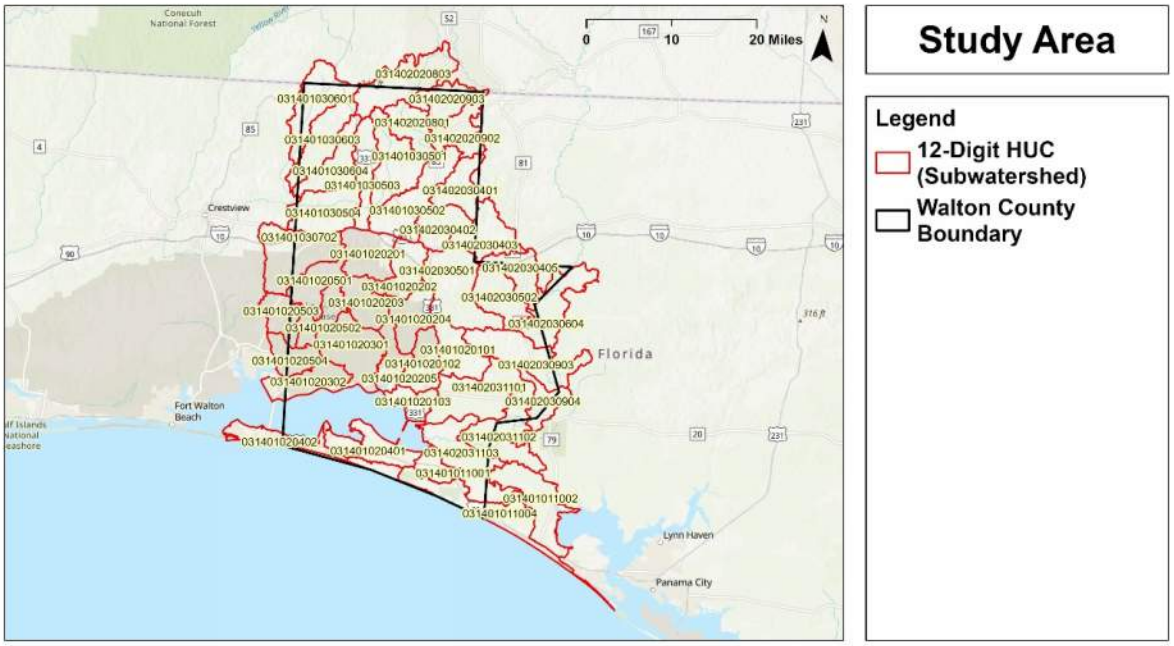

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

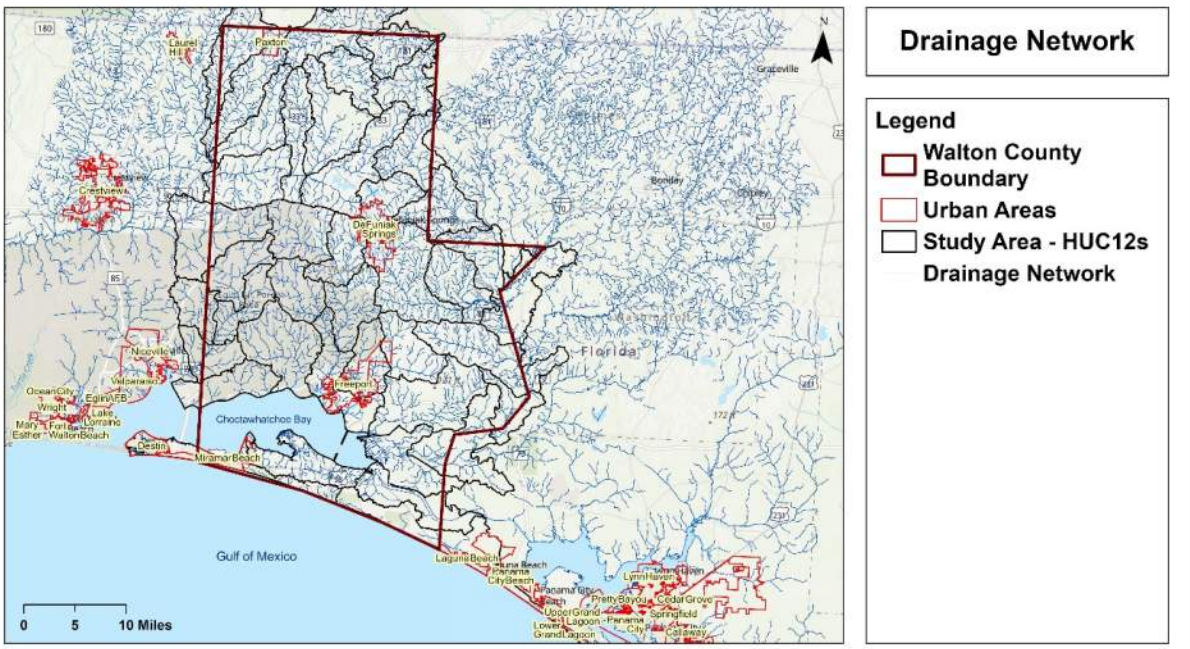

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

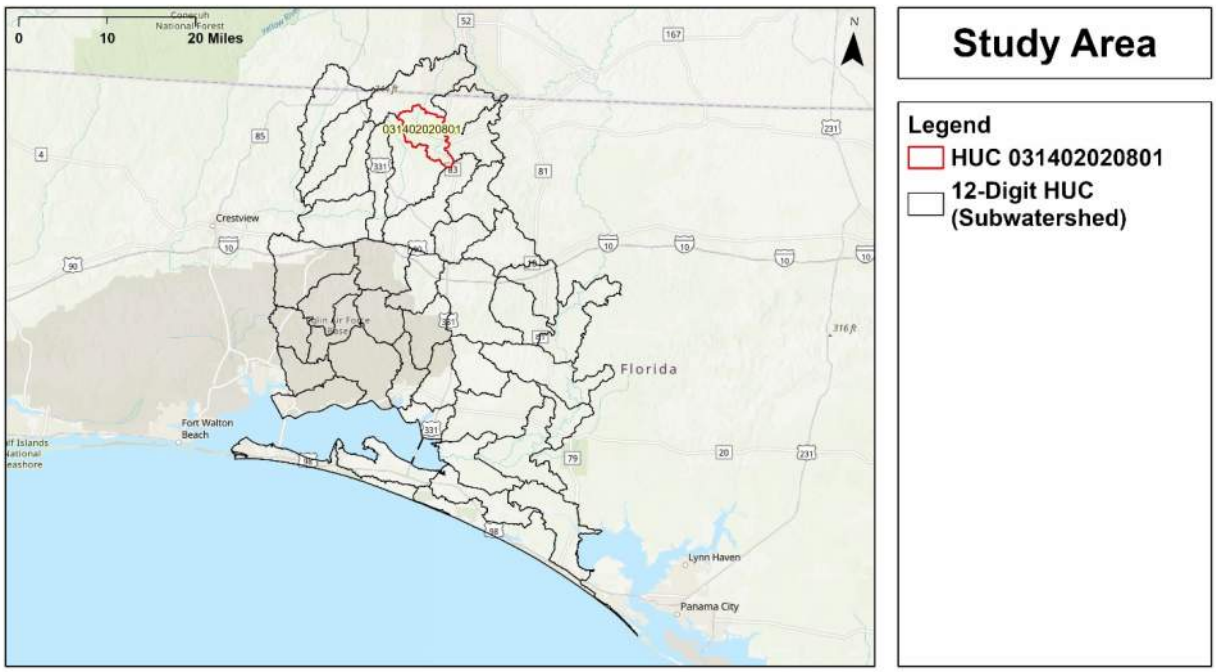

Figure 3. HUC 031402020801 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

(Source Data: FEMA)

Figures 12 and 13 is the county-wide report show the current and projected land use for the County. Based on the 2017 future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land Use in Walton County (Prepared by FAU from future land use map) versus land use in the entire watershed

Level 1 Land Use-Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

(Source Data: NWFWMD, 2017)

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 1.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

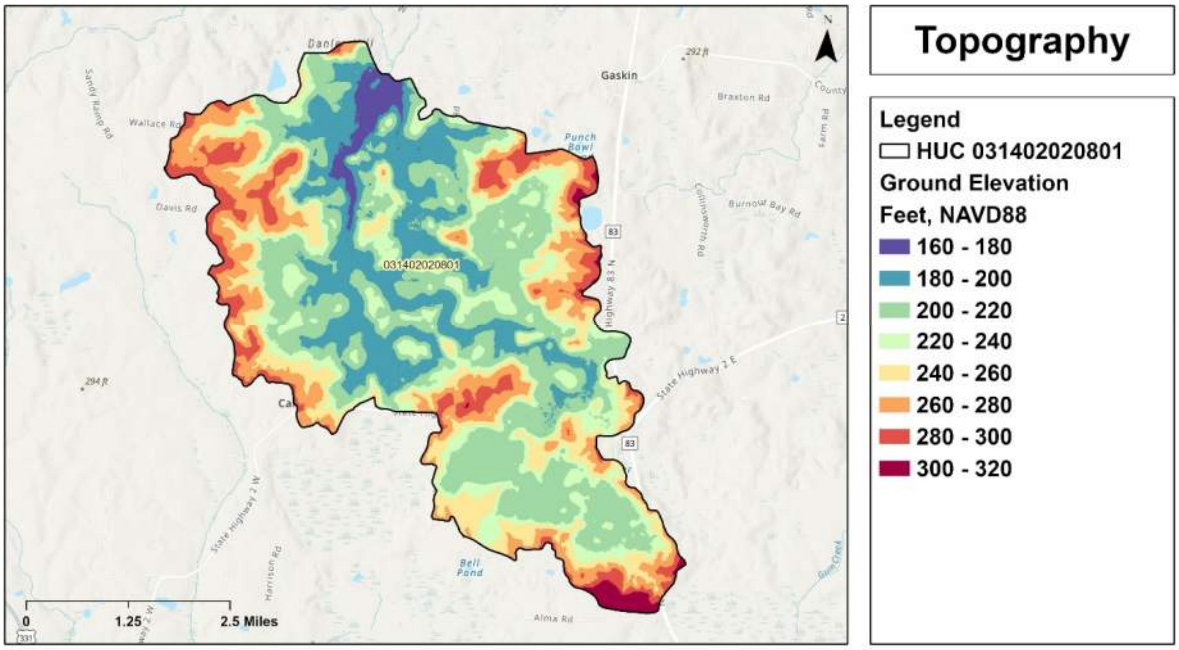

Figure 4. Topographic map of the HUC 031402020801 sub-watershed, processed by FAU

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology.
Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.
Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031402020801 sub-watershed is shown in **Error! Reference source not found.**..

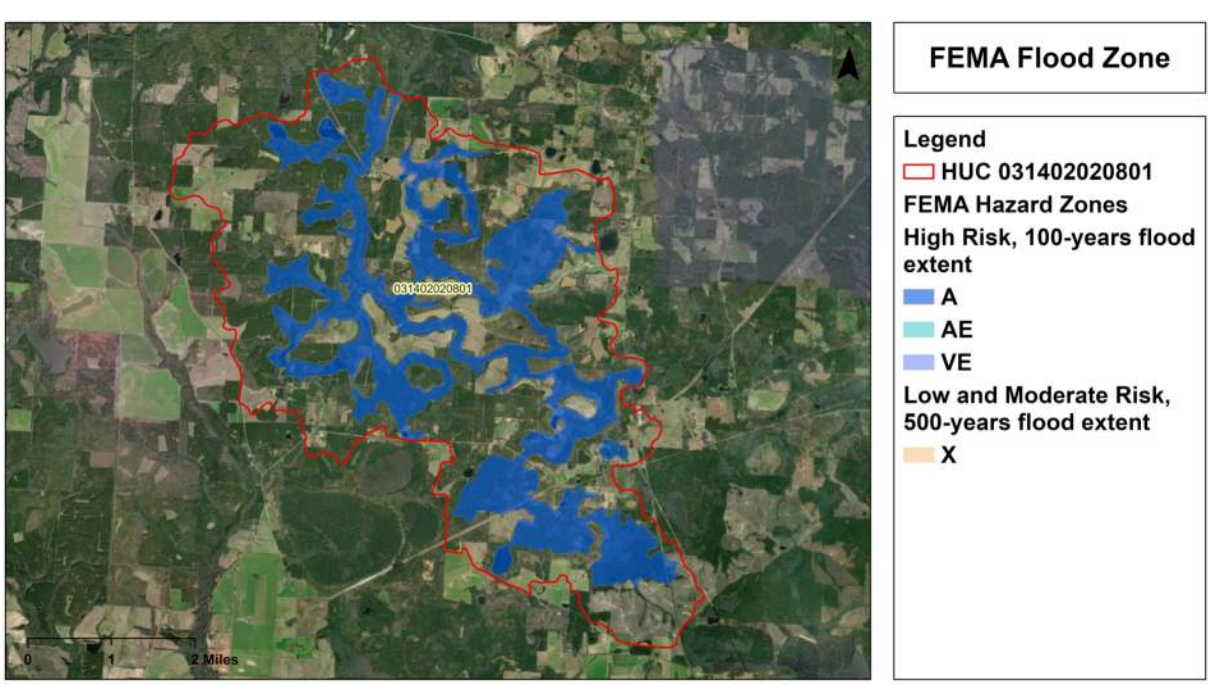

Figure 5. FEMA Flood Zone map (2020) for HUC 031402020801 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031402020801 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

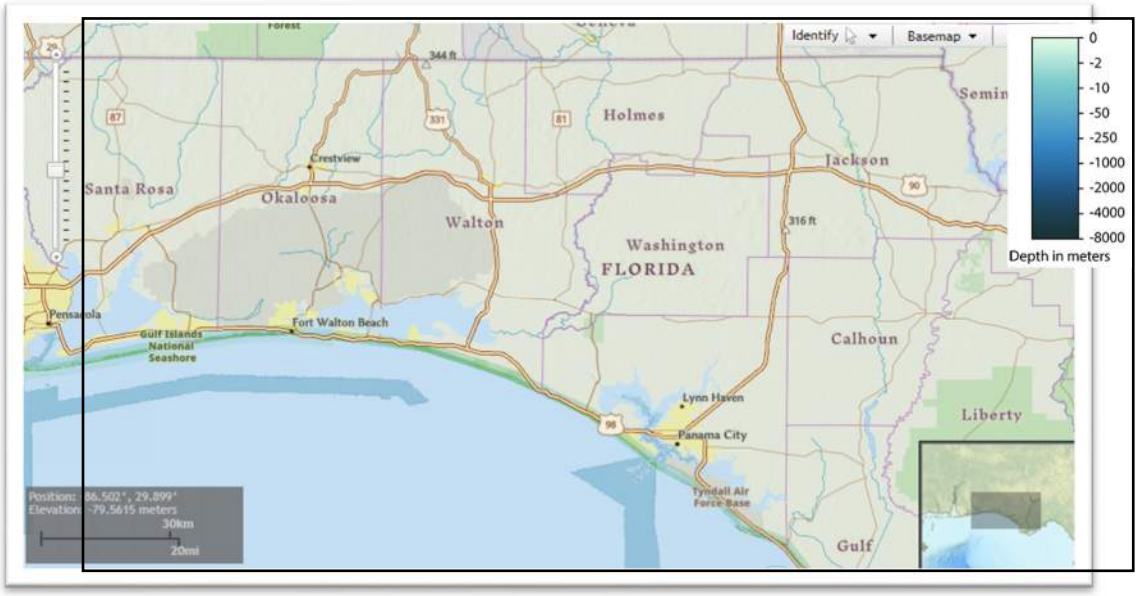

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle. Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

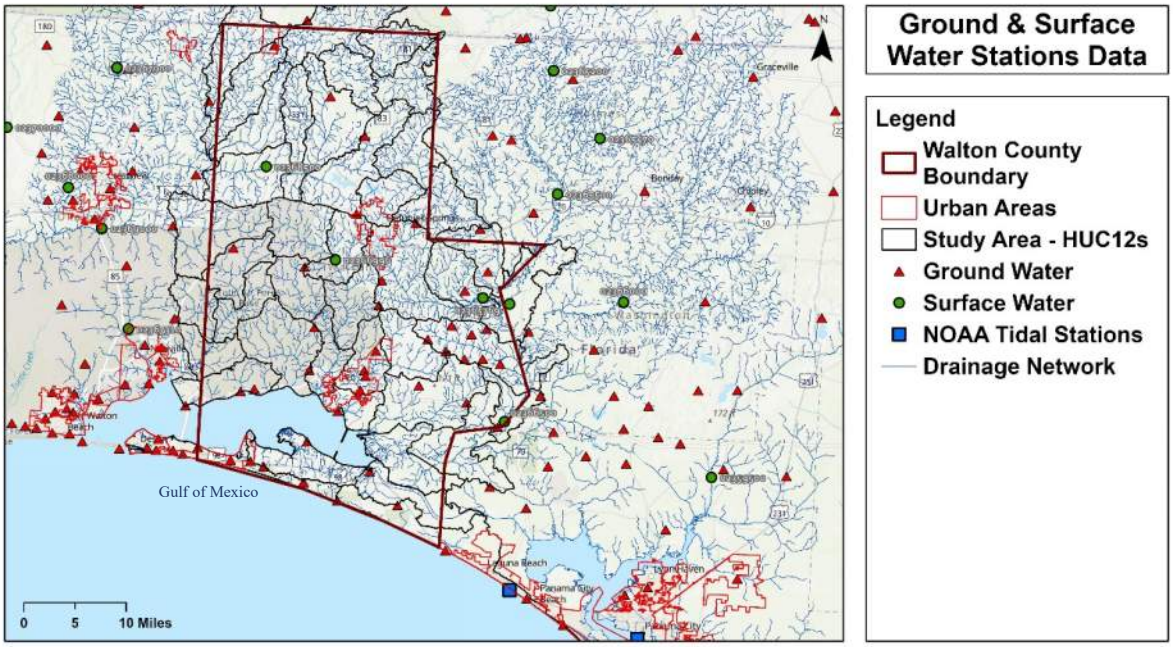

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031402020801 has no major rivers and canals, but well-branched creeks, which have no names.

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02368500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031402020801, which is USGS 02368500 Shoal River.

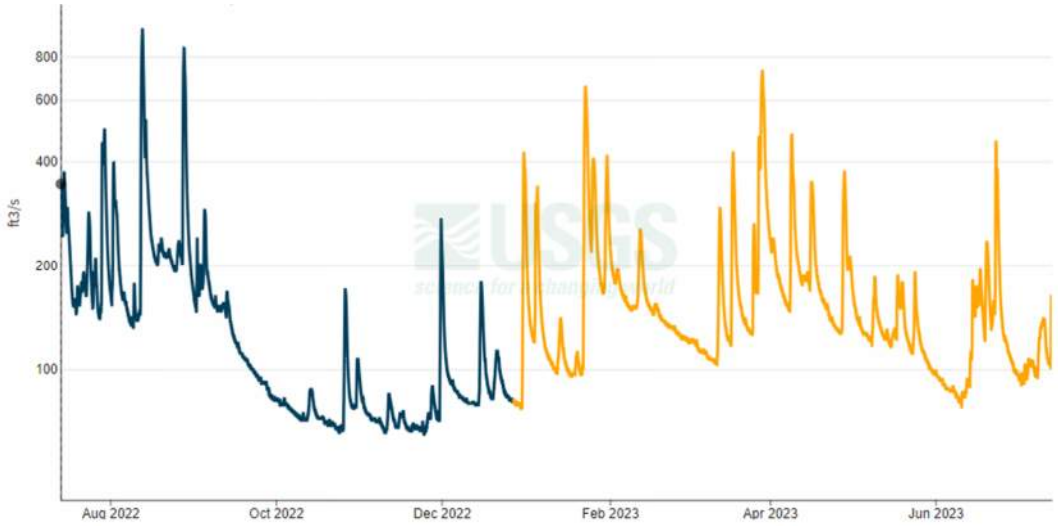

Figure 8. Average streamflow for Shoal River NR Mossy Head, Fla (USGS 02368500 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02368500/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031402020801 and points out the location of the ground water station in the surroundings. A groundwater-surface layer for the HUC 031402020801 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

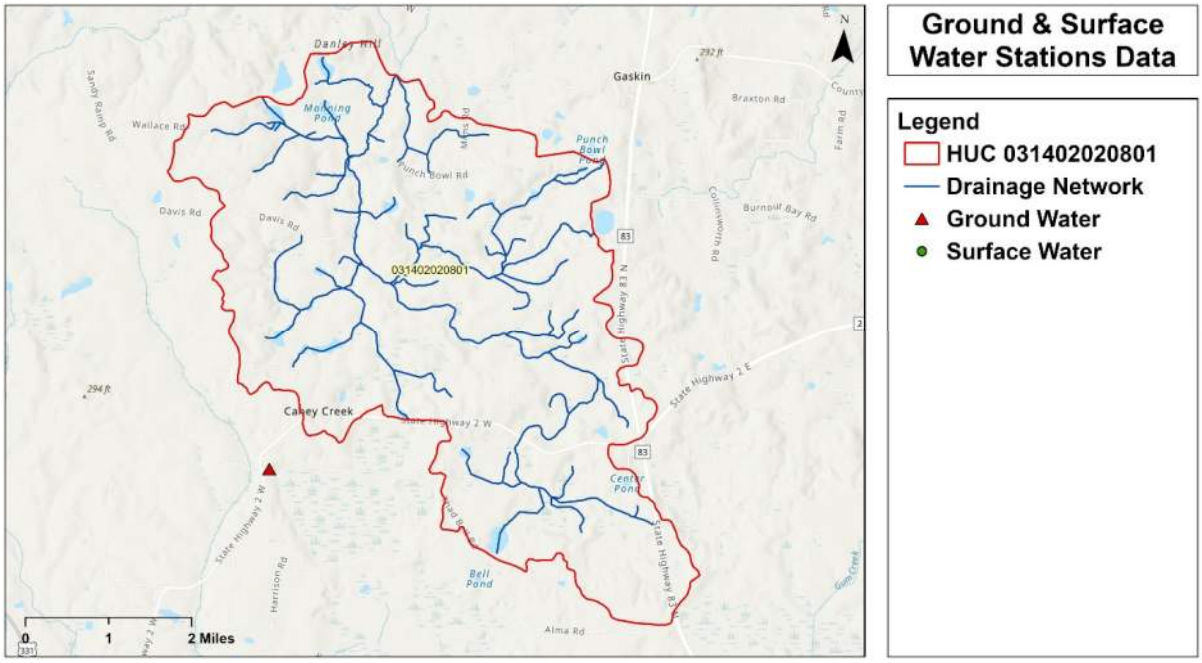

Figure 9. Ground and Surface Water Stations in the HUC 031402020801 sub-watershed, processed by FAU.

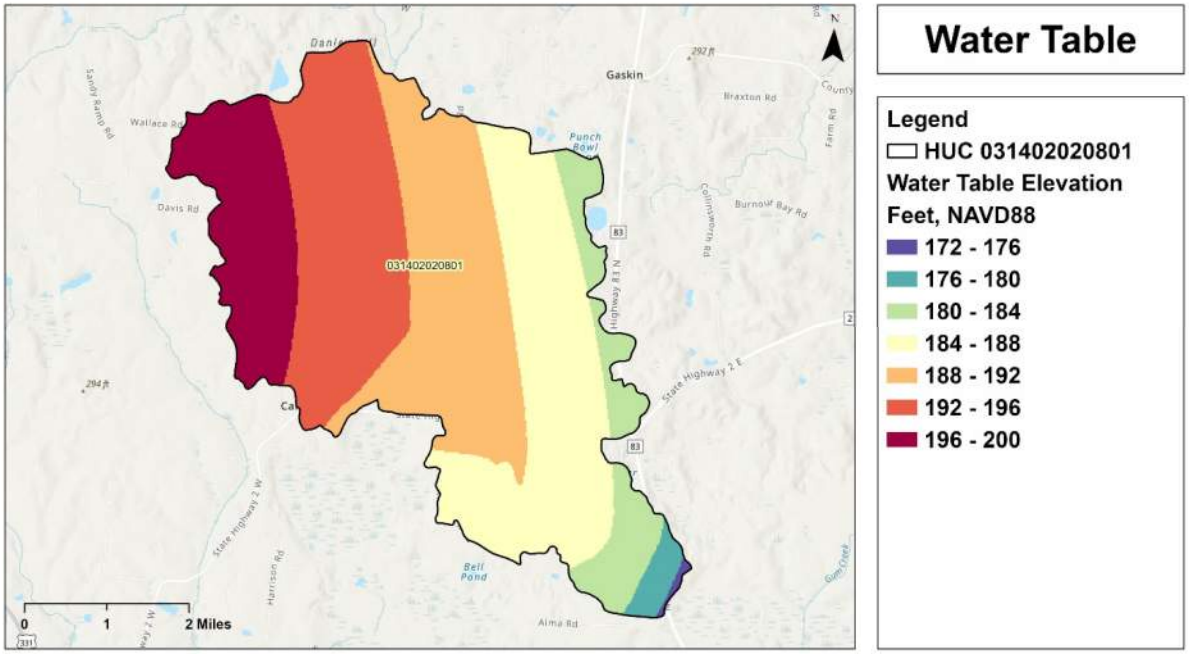

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031402020801 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the average precipitation over Walton County for every month of the year between 2011 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches for the entire county.

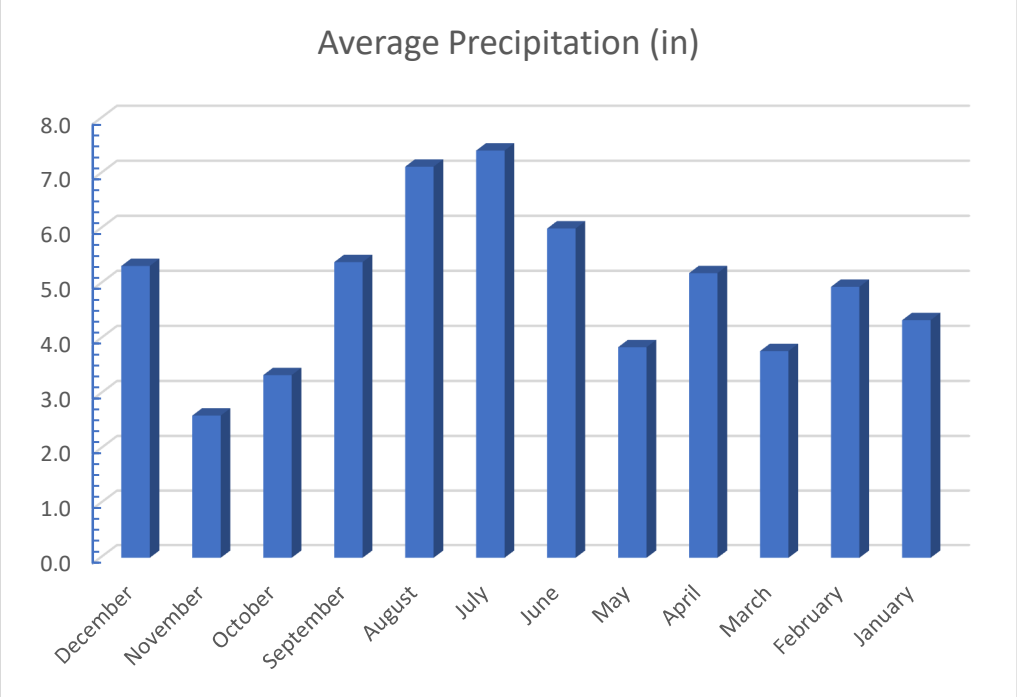

Figure 11. Monthly precipitation in Walton County, FL (2011-2023).
(Data Source: Florida Weather Data, available at https://data.usatoday.com/weather-data/walton-county/12131/1975-04-01/Table/)

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as

opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. Figure 12 shows the two closest tide stations to Walton County. Since there is none NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

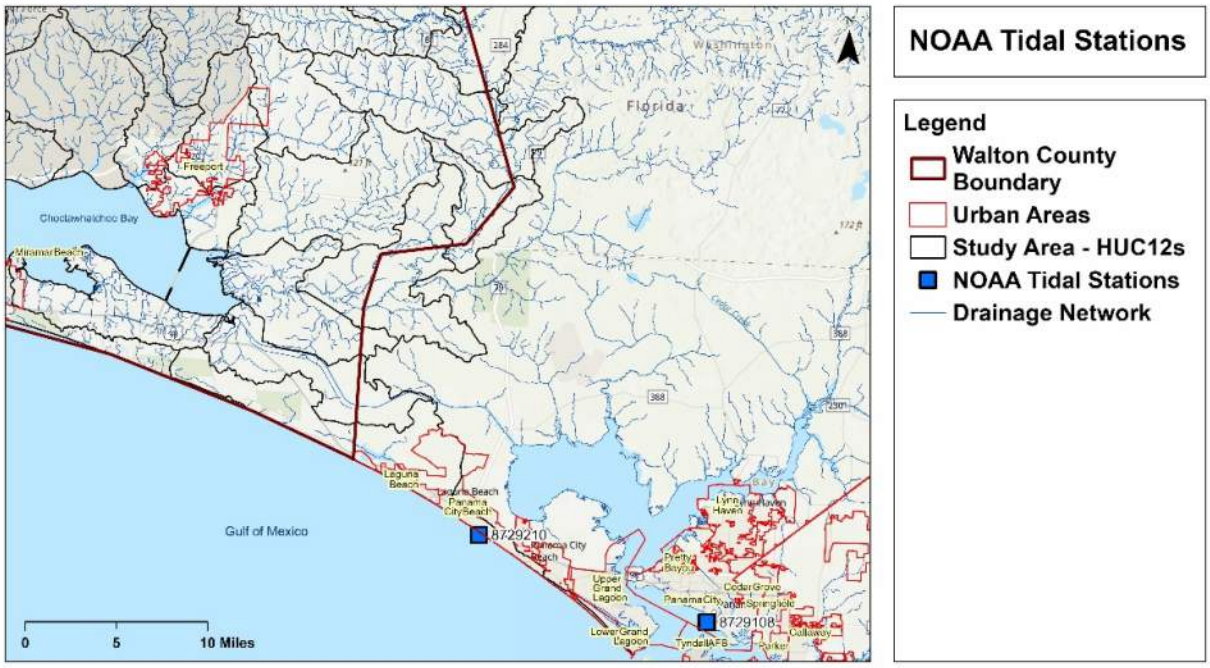

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

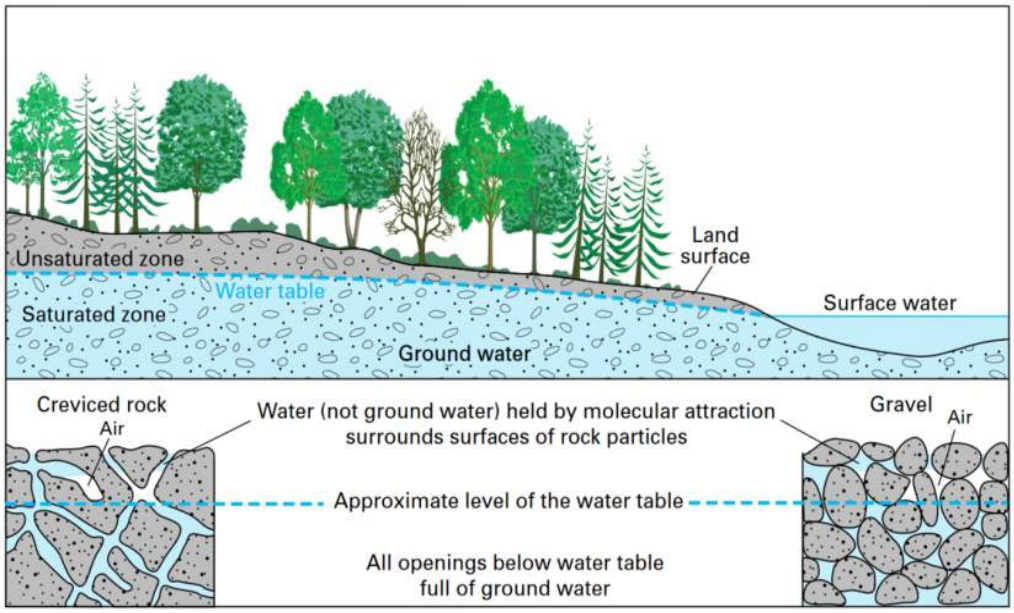

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

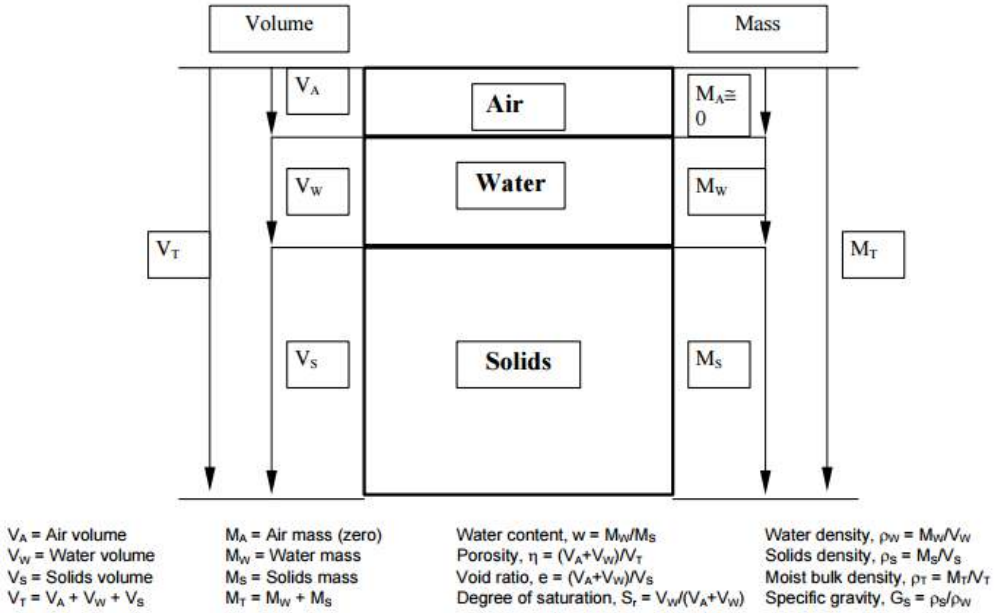

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

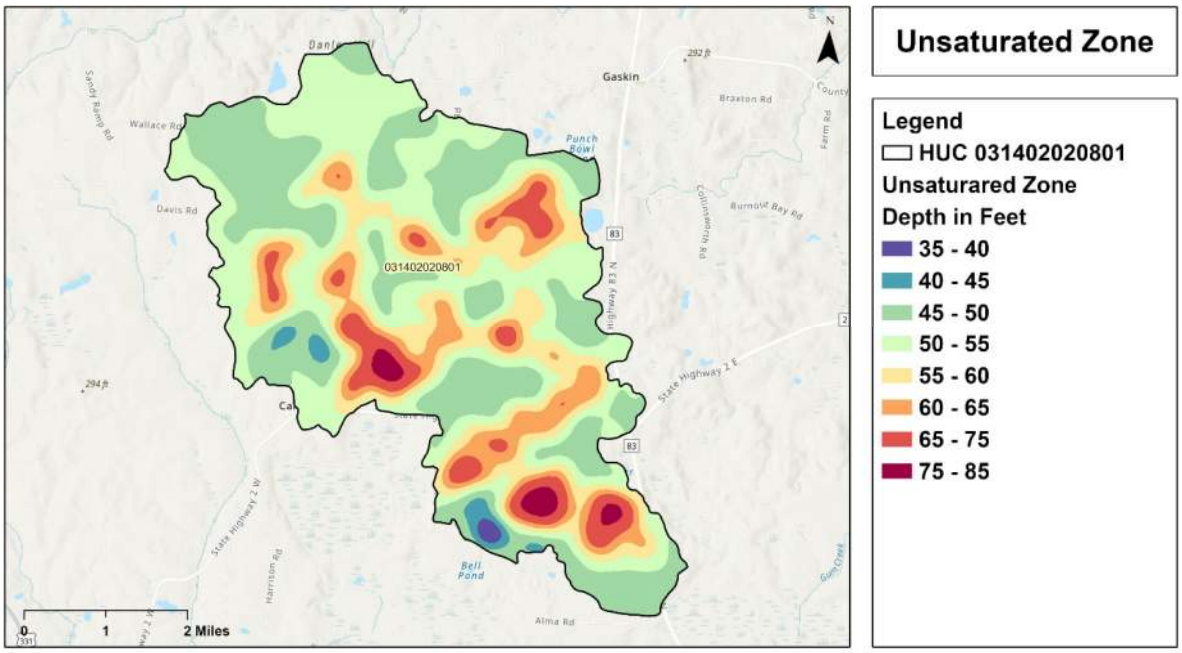

Figure 15. Unsaturated zone map for HUC 031402020801, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin exhibits a favorable soil storage capacity, ranging between 45 to 75 inches of remaining capacity.

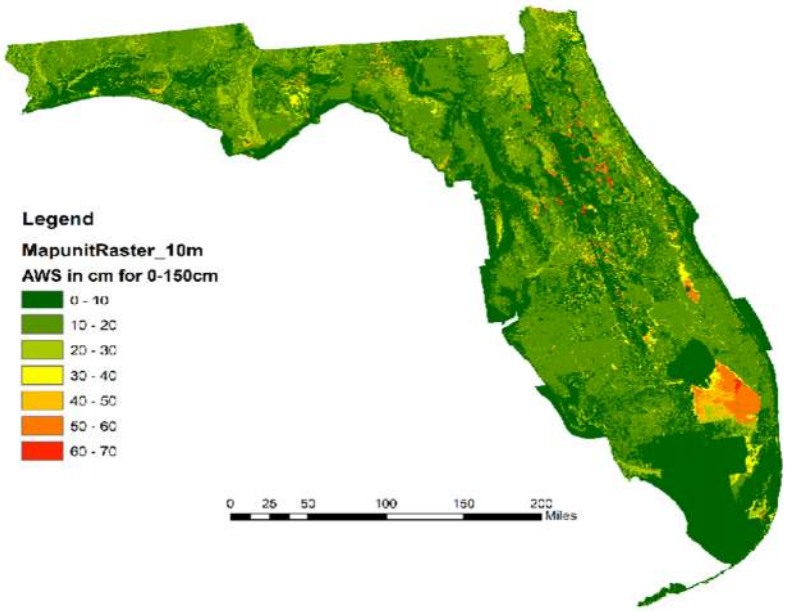

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

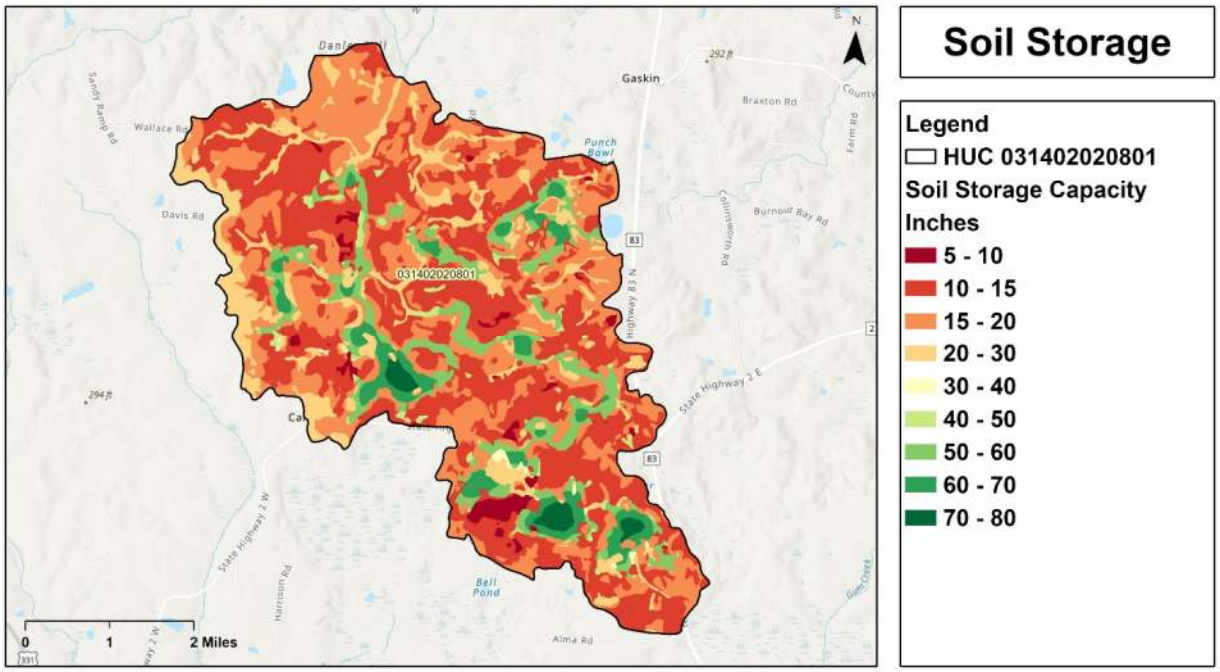

Figure 17. Water storage capacity of soil for the HUC 031402020801 (inches), processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

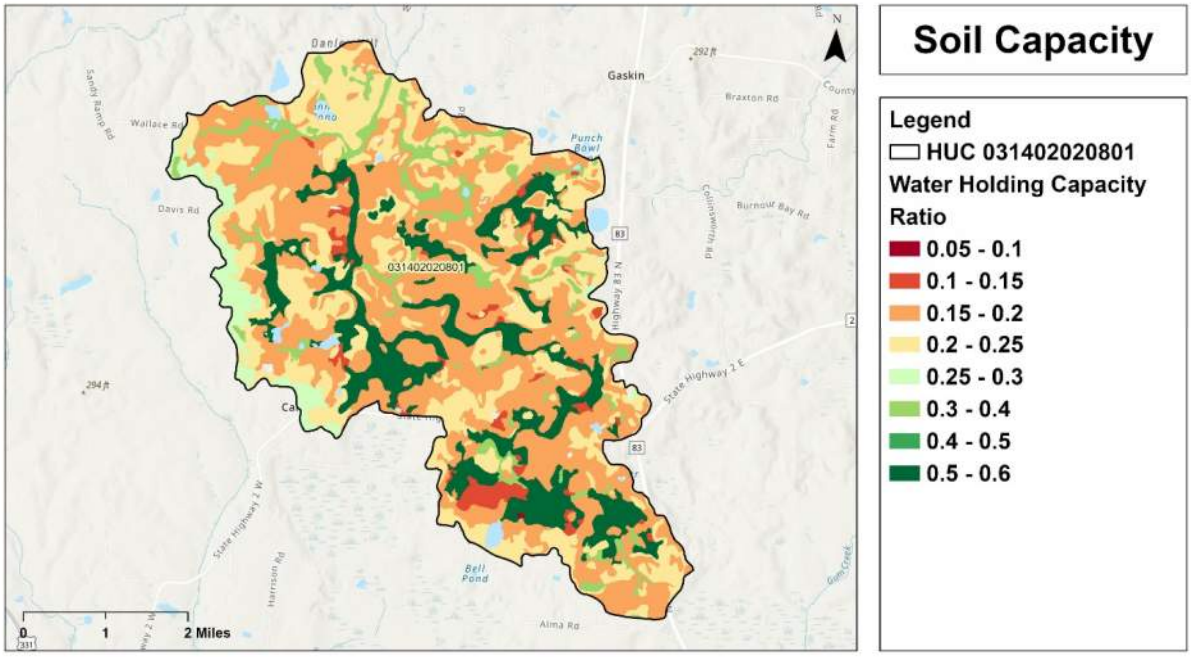

Figure 18. Water Holding Capacity (ratio) for the HUC 031402020801, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

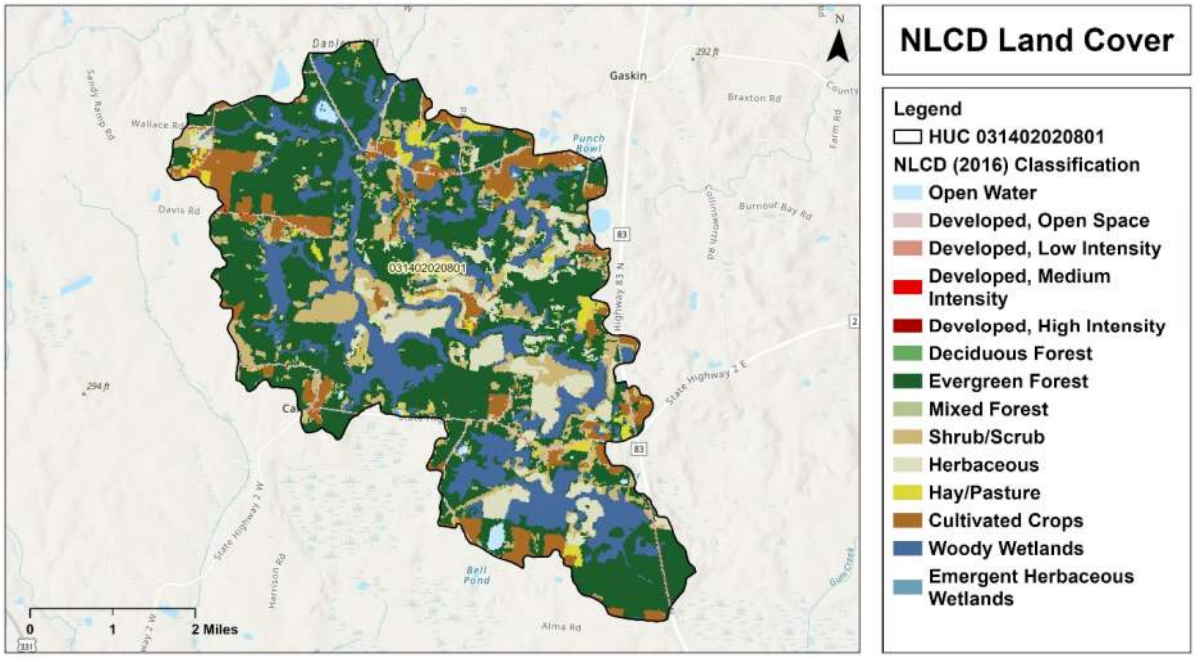

Figure 19. Land use in the HUC 031402020801 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD 2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

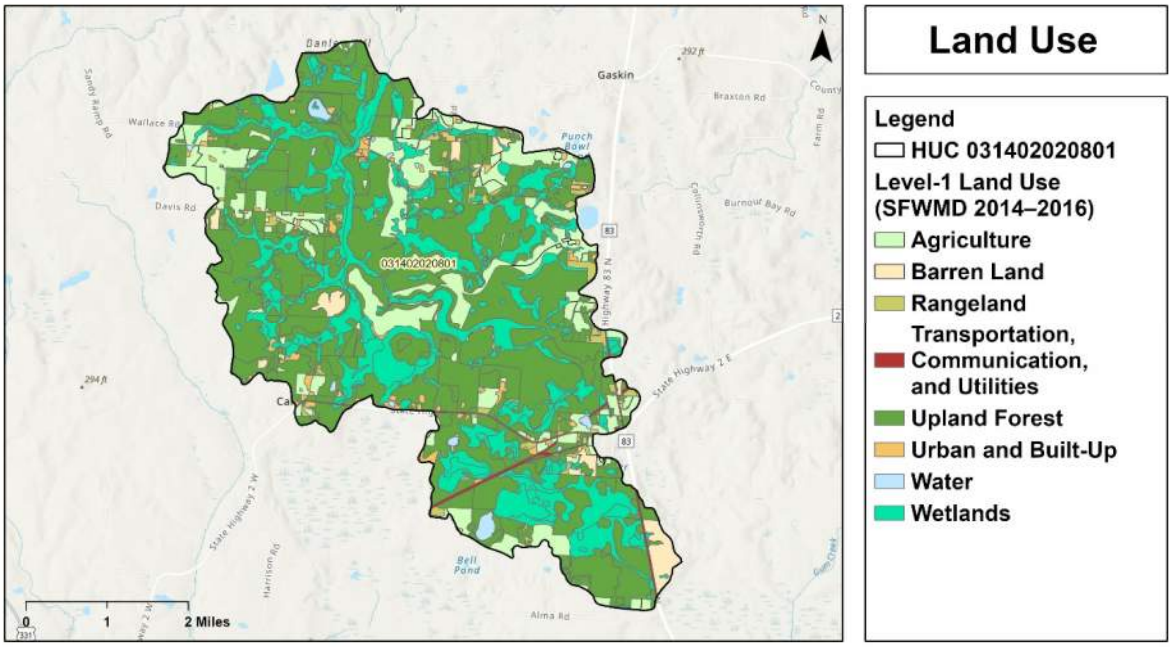

Figure 20. Land use in the HUC 031402020801 031401011001 (from the 2023 Florida Geographic Data Library (FGDL) database), processed by FAU.

In the HUC 031402020801 sub-watershed, the predominant land cover is upland forest, accounting for 60.11% of the area. Transportation, Communication, and Utilities comes in second at 16.24%, followed by wetlands at 10.64%. Developed land constitutes a minor portion, with only 2.16% categorized as urban and built-up, as indicated in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031402020801 subwatershed

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	121.92	0.42%
Barren Land	75.01	0.26%
Rangeland	2849.14	9.93%
Transportation, Communication, and Utilities	4662.31	16.24%
Upland Forest	17254.18	60.11%
Urban and Built-Up	620.10	2.16%
Water	66.22	0.23%
Wetlands	3055.21	10.64%
Grand Total:	**28704.07**	**100.00%**

(Source Data: 2023 Florida Geographic Data Library (FGDL) database))

Table 4. Roughness and CN Values for Each Land Use Code

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

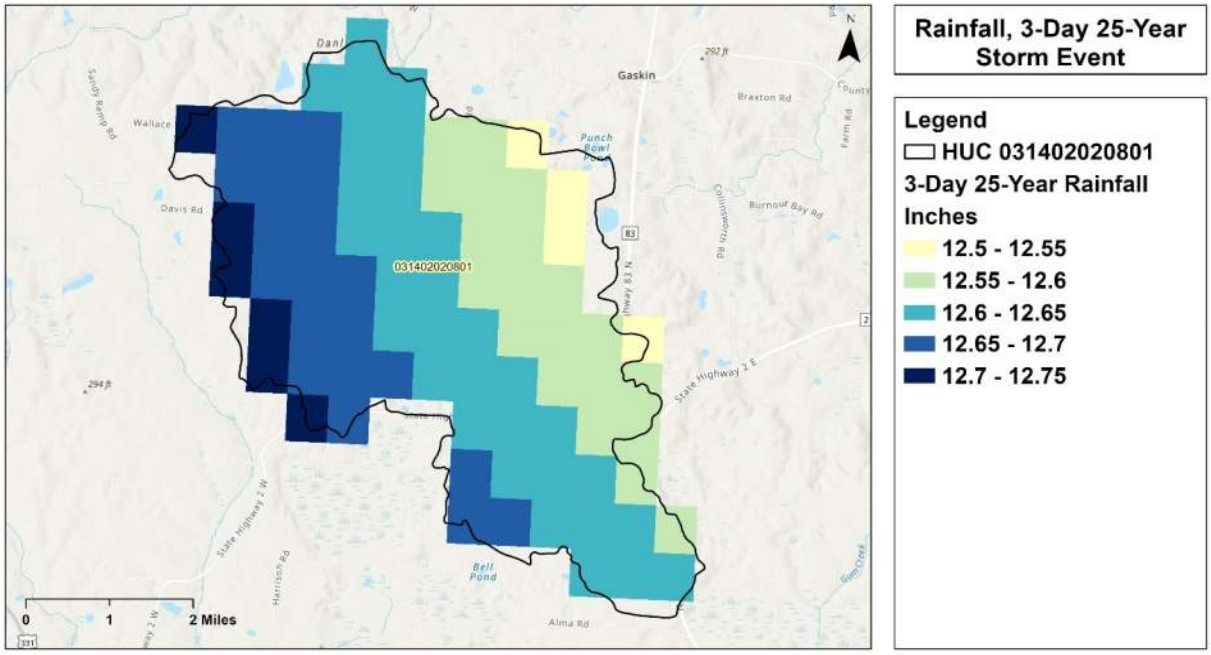

Figure 21. Rainfall distribution map across HUC 031402020801 sub-watershed, for 3-day 25-year storm event, processed by FAU.

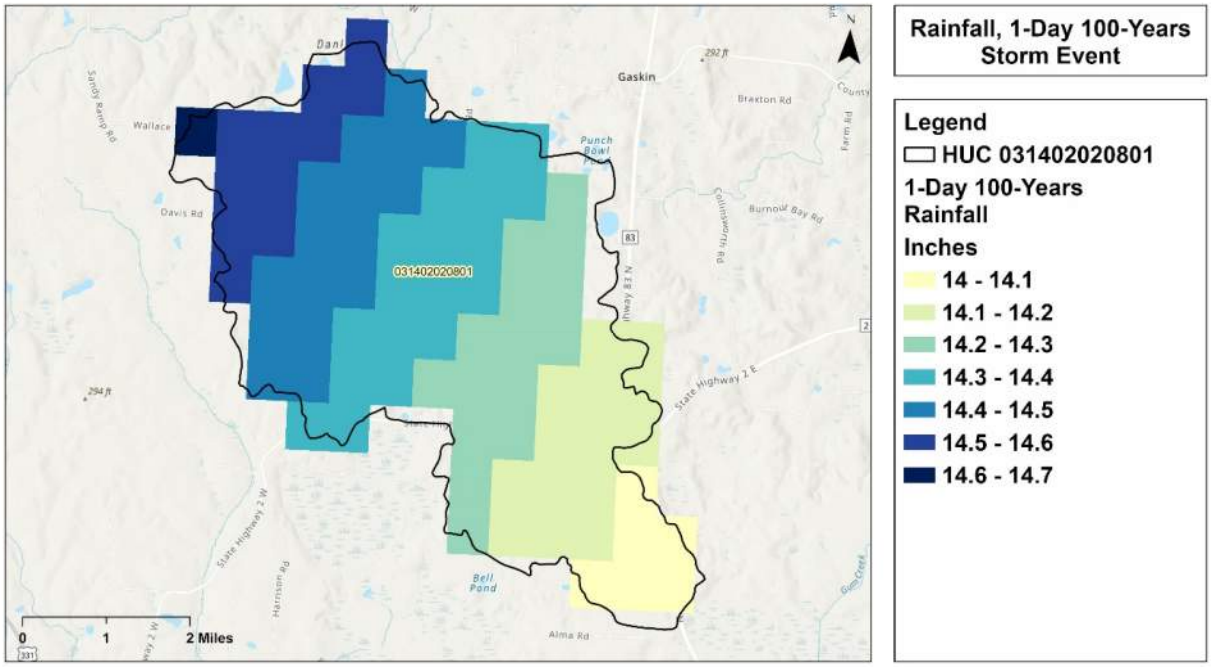

Figure 22. Rainfall distribution map across HUC 031402020801 sub-watershed, for 1-day 100-year storm event, processed by FAU.

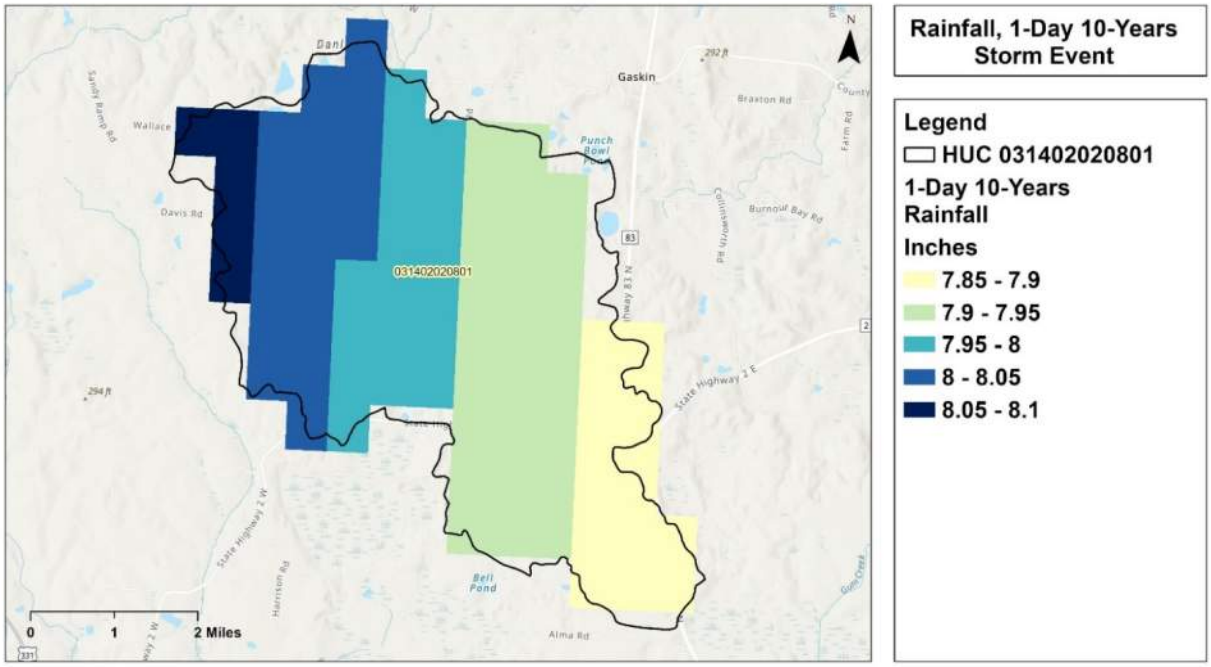

Figure 23. Rainfall distribution map across HUC 031402020801 sub-watershed, for 1-day 10-year storm event, processed by FAU.

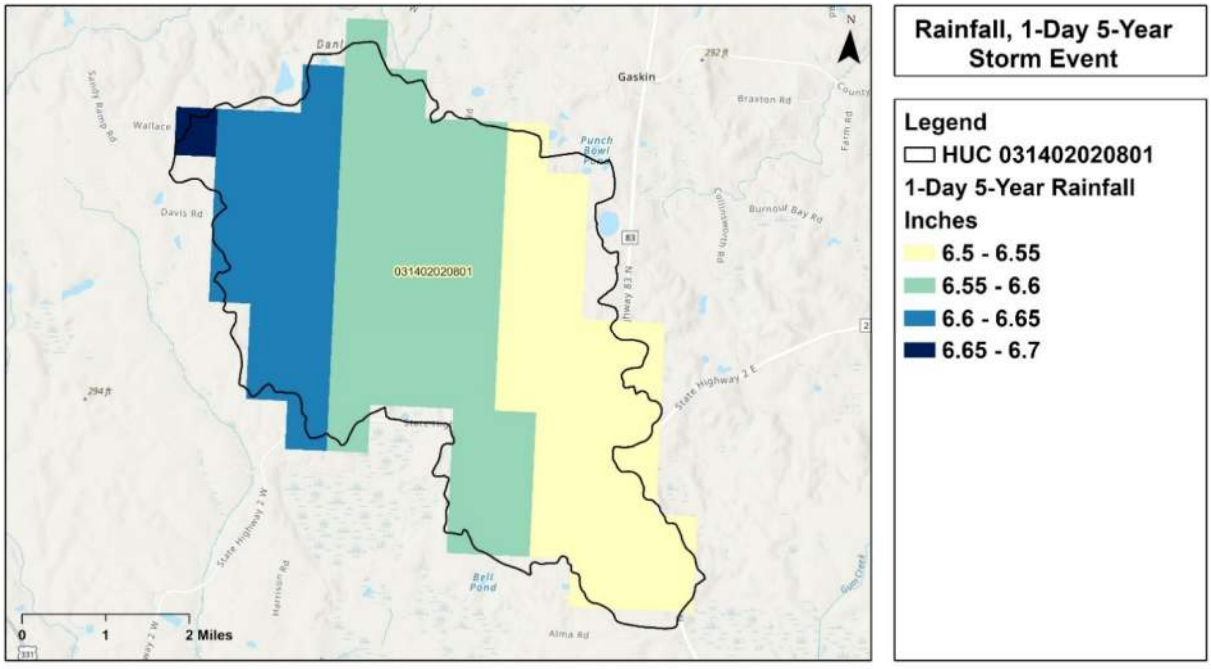

Figure 24. Rainfall distribution map across HUC 031402020801 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

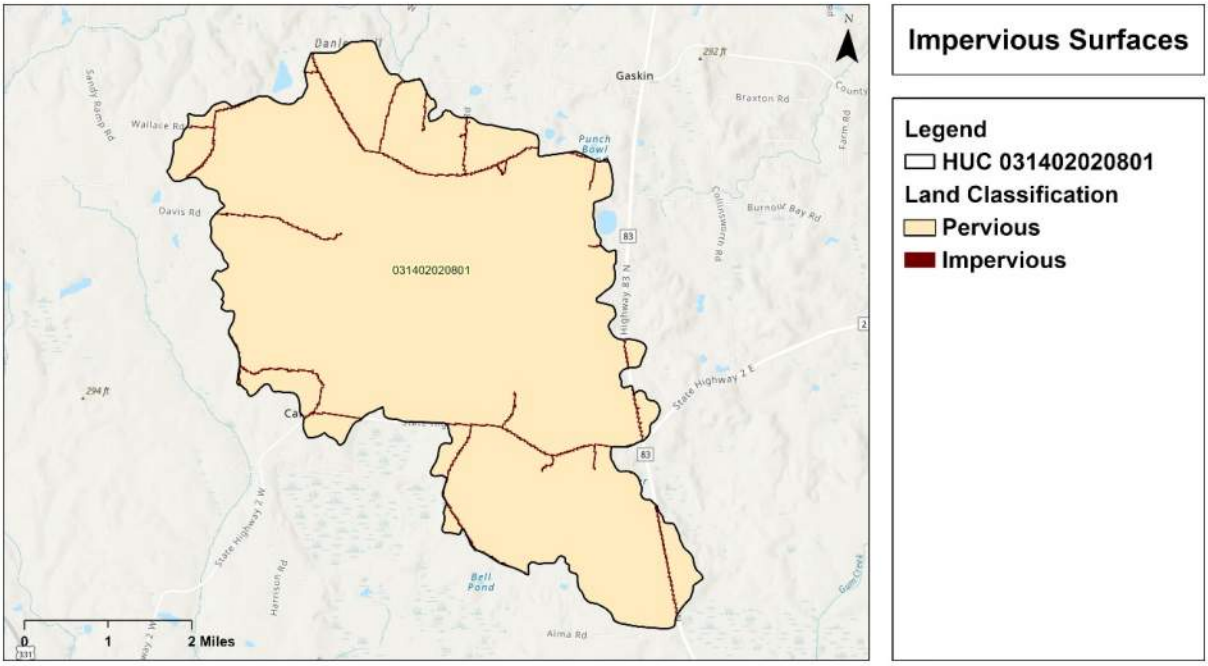

Figure 25. Impervious area map for the HUC 031402020801 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

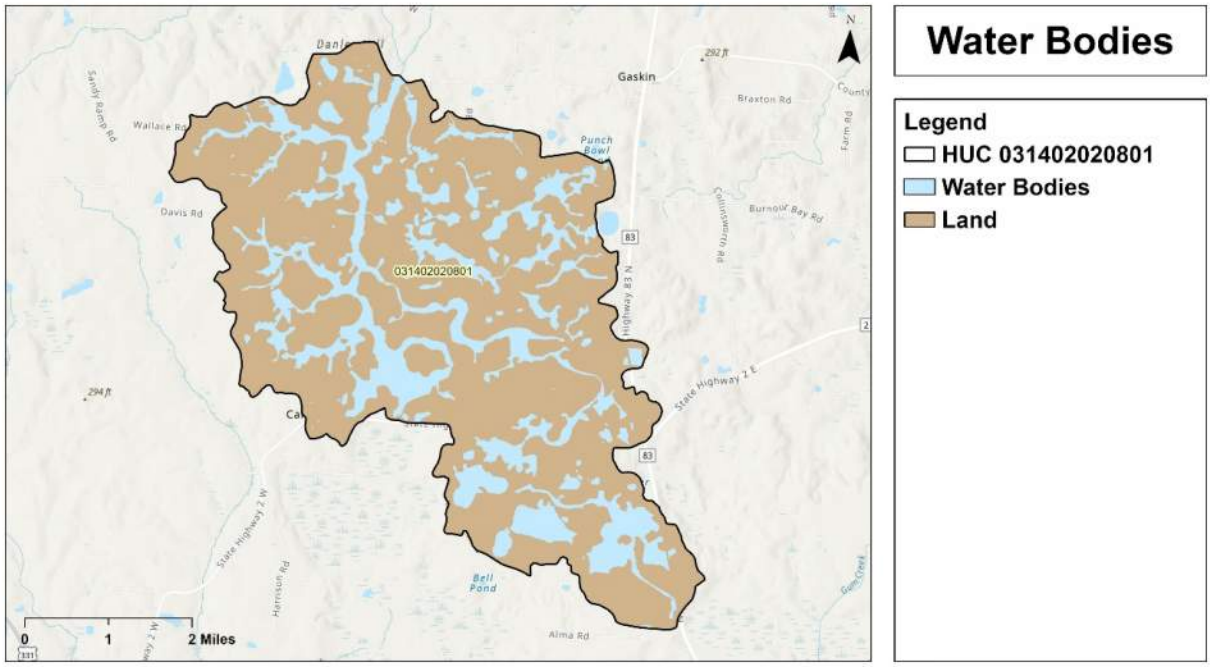

Figure 26. Water bodies map for the HUC 031402020801 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

(Source: US Census Bureau 2020, and Zip-codes.com)

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

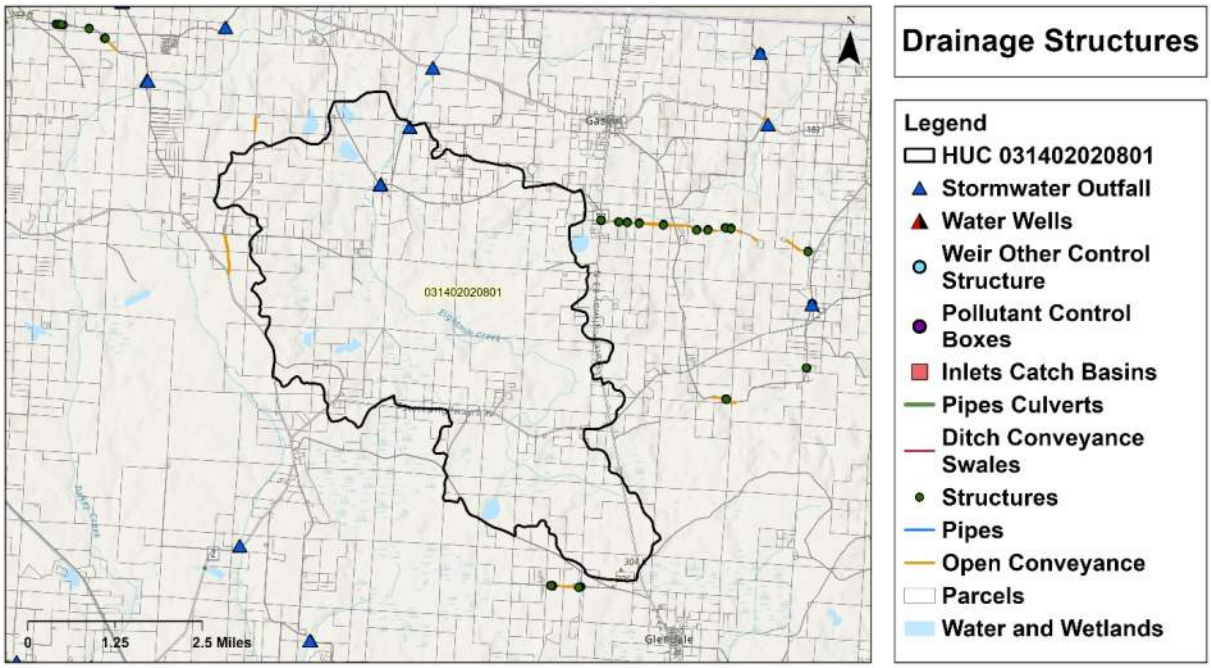

Figure 27. Stormwater Infrastructure for the HUC 031402020801. Processed by FAU.

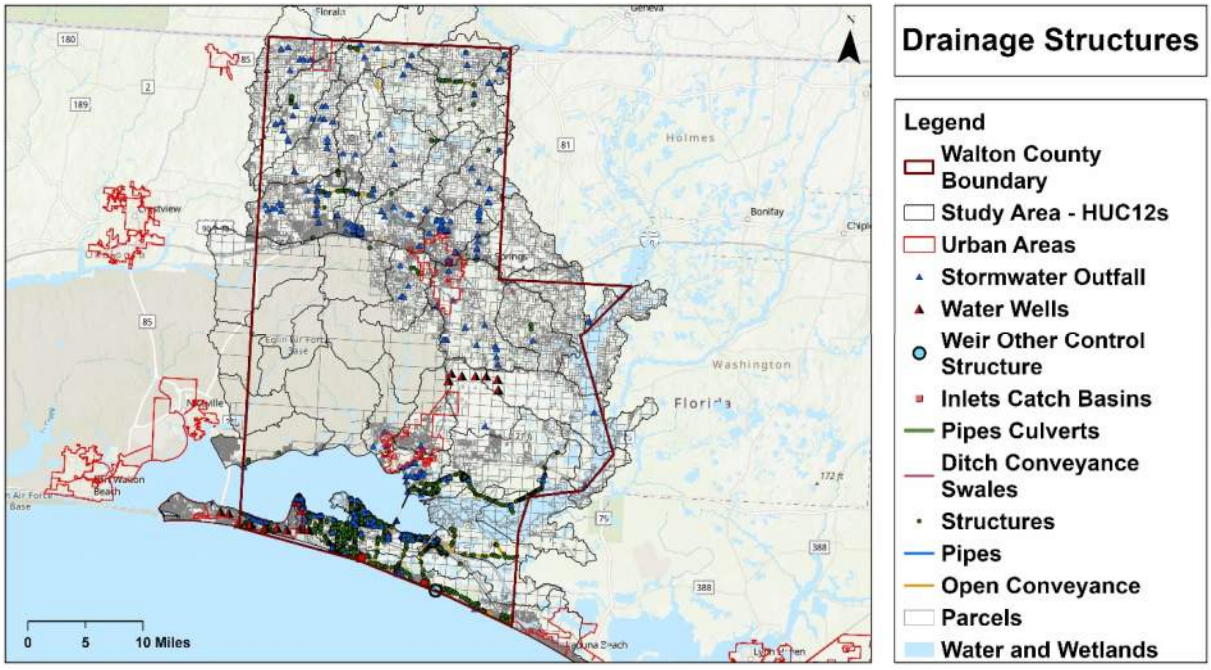

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020)

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1, an analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031402020801 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.3.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD DBHYDRO website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

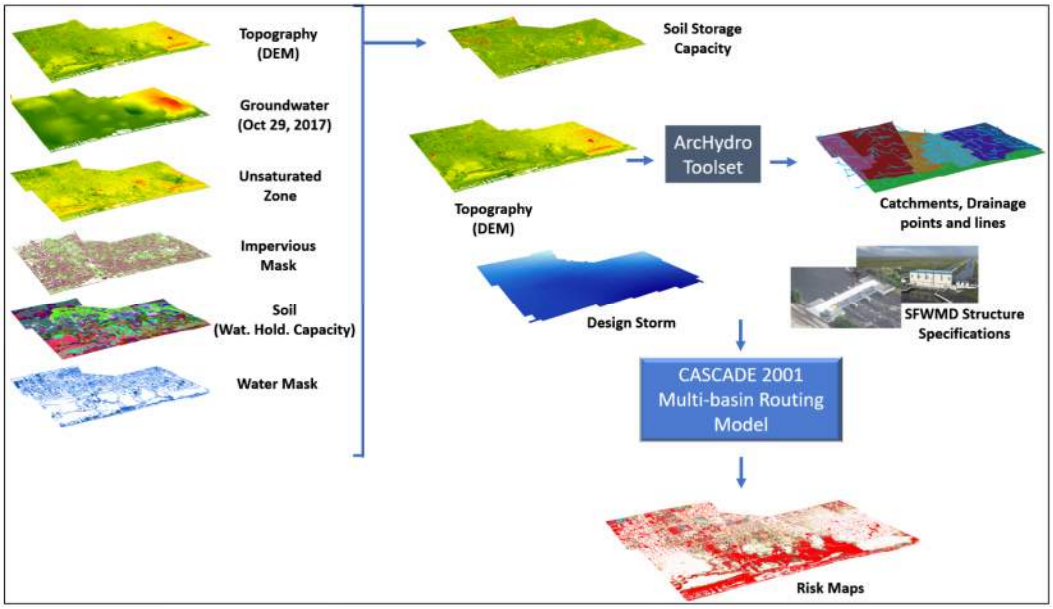

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)

= 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (Figure 30), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

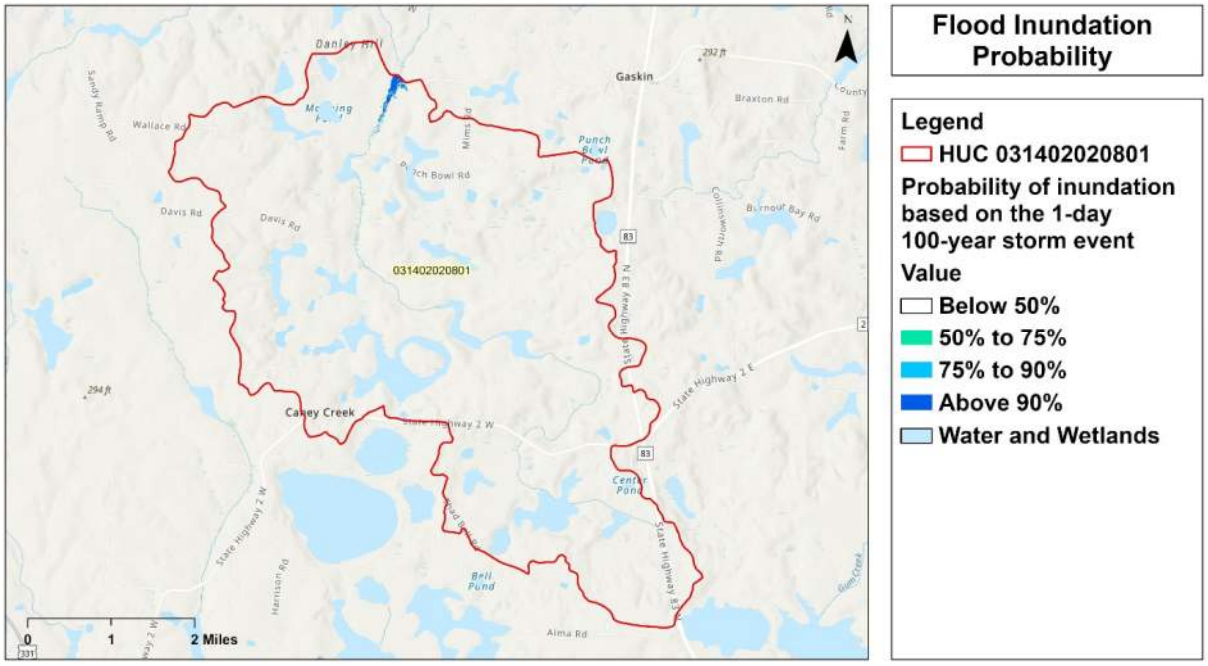

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031402020801, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation

and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 2.4 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations,

Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a small portion of flooding is noted at the creek entrance to the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, the HUC is expected to remain unaffected by sea level rise, therefore SLR scenarios were not computed.

The design storm simulation determined that approximately 0.34% of the HUC total area or 0.078 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 0.18% of the HUC's total area, or 0.041 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.05% of the HUC's total area, or 0.013 mi^2, would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0.04% of the HUC's total area, or 0.01 mi^2, would be expected to be inundated

during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 03140102020801 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	22.737	0.078	99.66%	0.34%
1-day 100-year	22.774	0.041	99.82%	0.18%
1-day 10-year	22.802	0.013	99.95%	0.05%
1-day 5-year	22.805	0.010	99.96%	0.04%

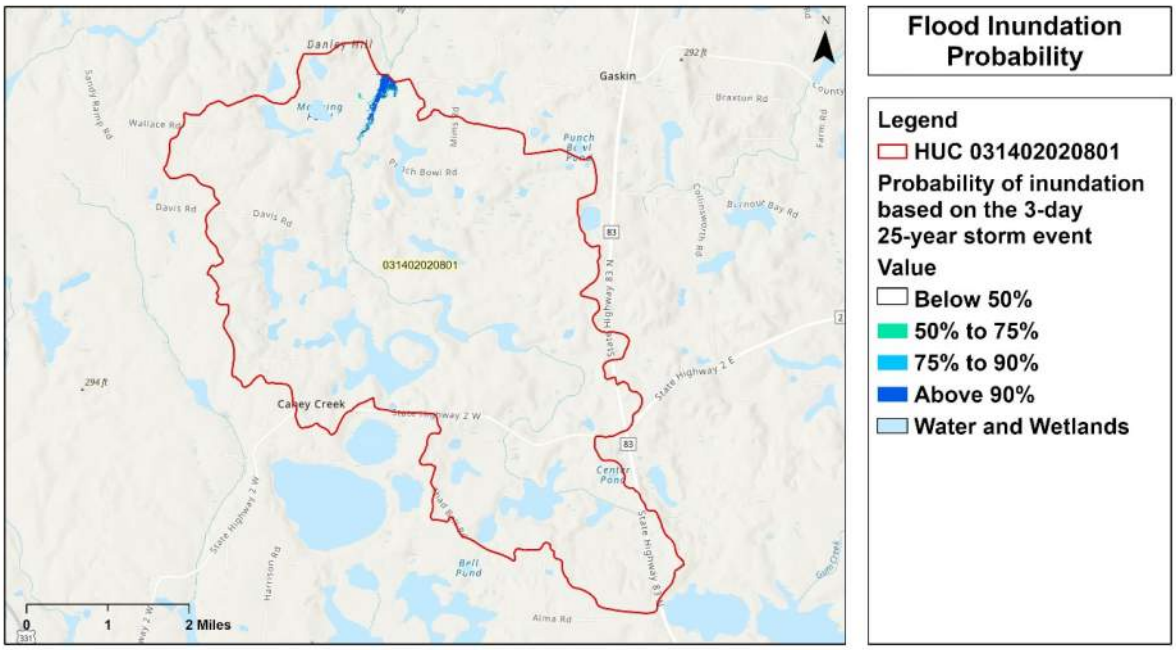

Figure 31. 3-day 25-year storm event for HUC 031402020801 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

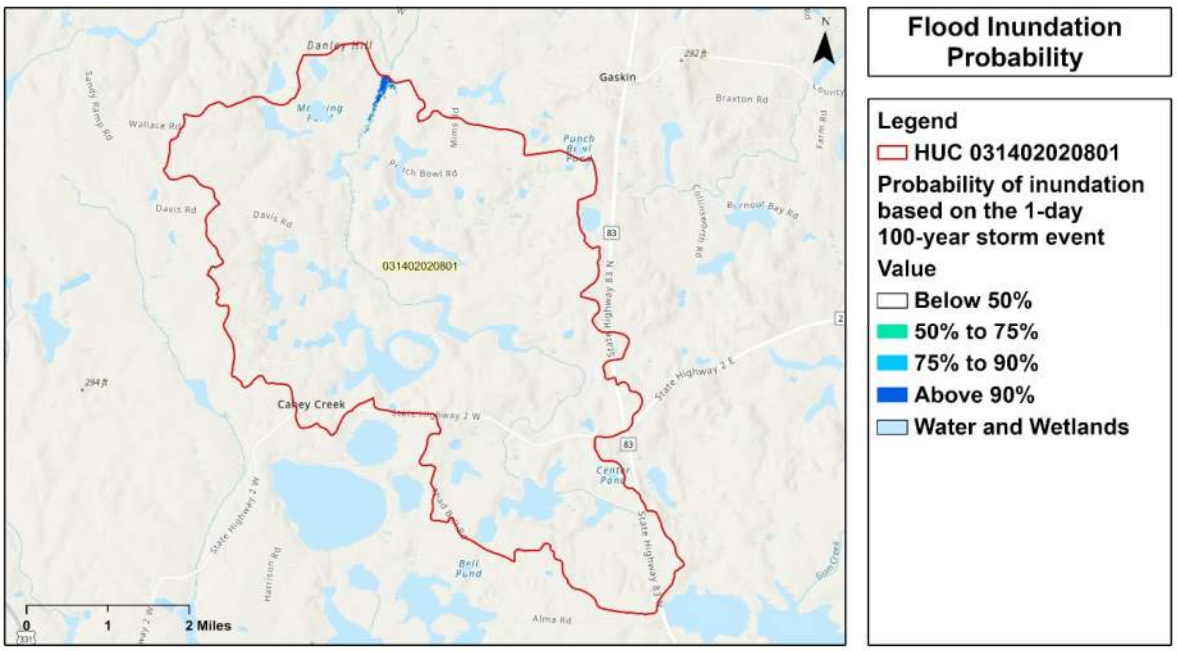

Figure 32. 1-day 100-year storm event for HUC 031402020801 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

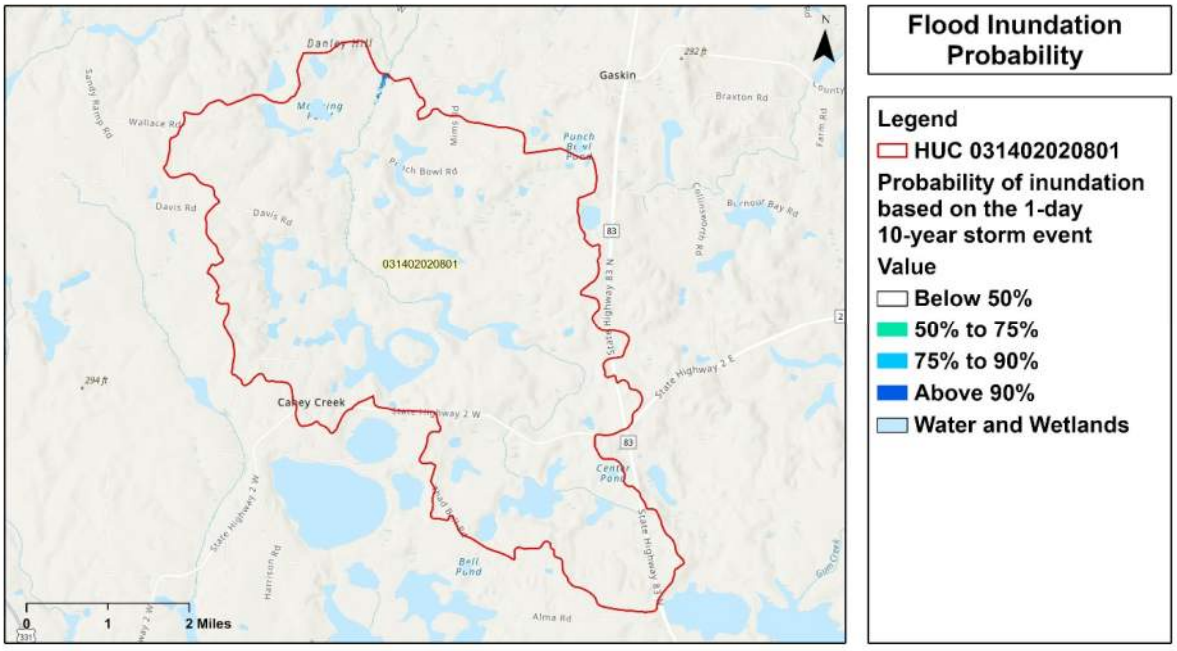

Figure 33. 1-day 10-year storm event for HUC 031402020801 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

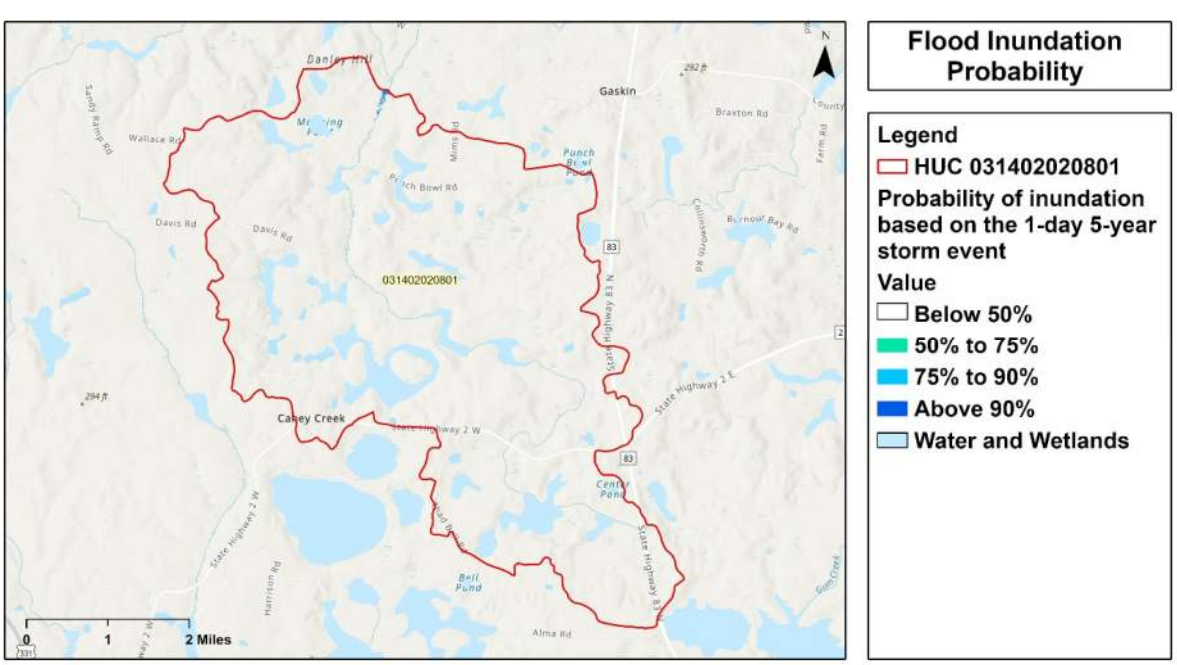

Figure 34. 1-day 5-year storm event for HUC 031402020801 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older,

poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3

28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
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60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6

97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031402020801 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (Figure 35) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 36) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

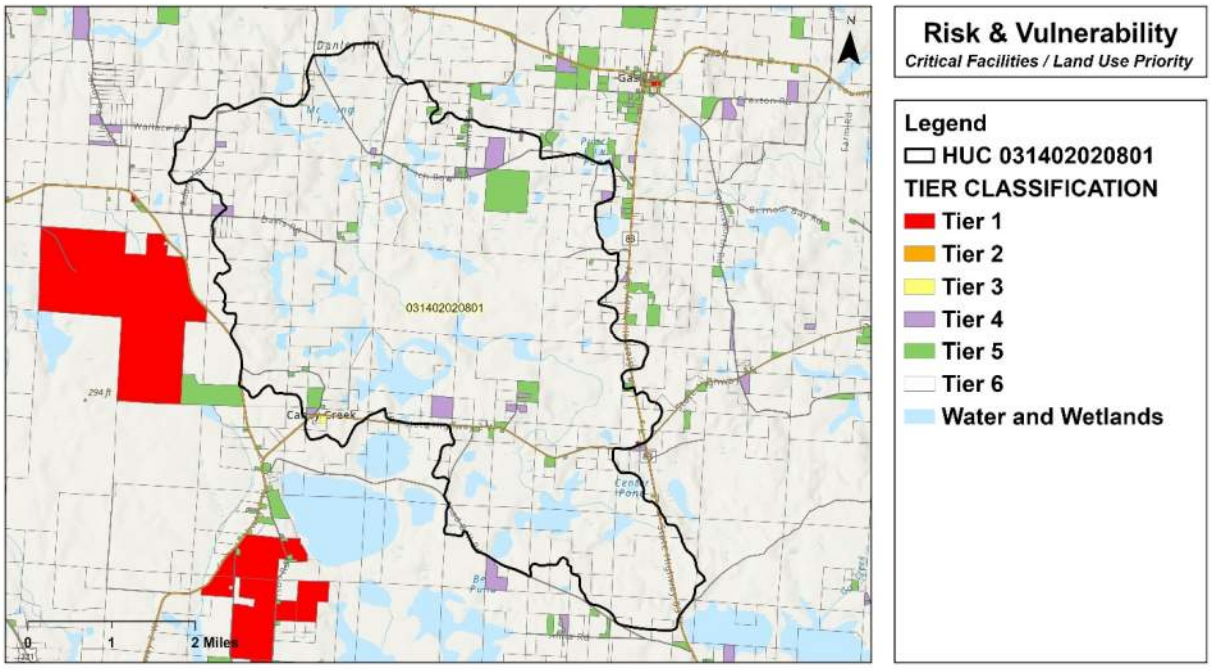

Figure 35. HUC 031402020801 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

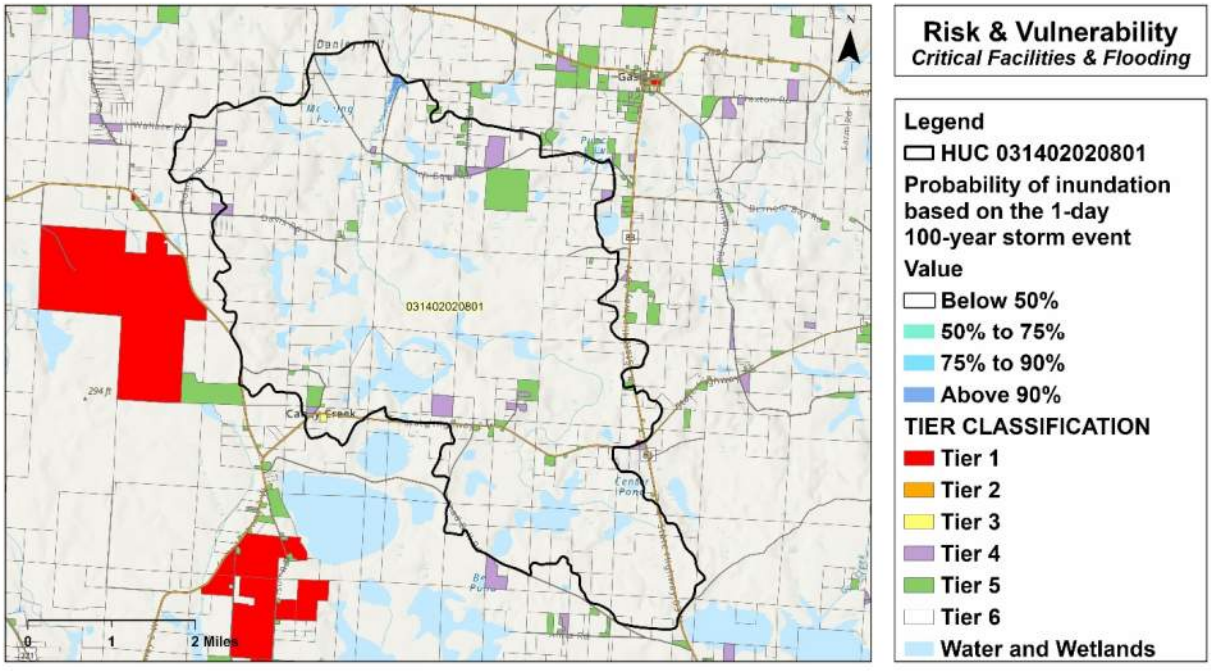

Figure 36. HUC 031402020801 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

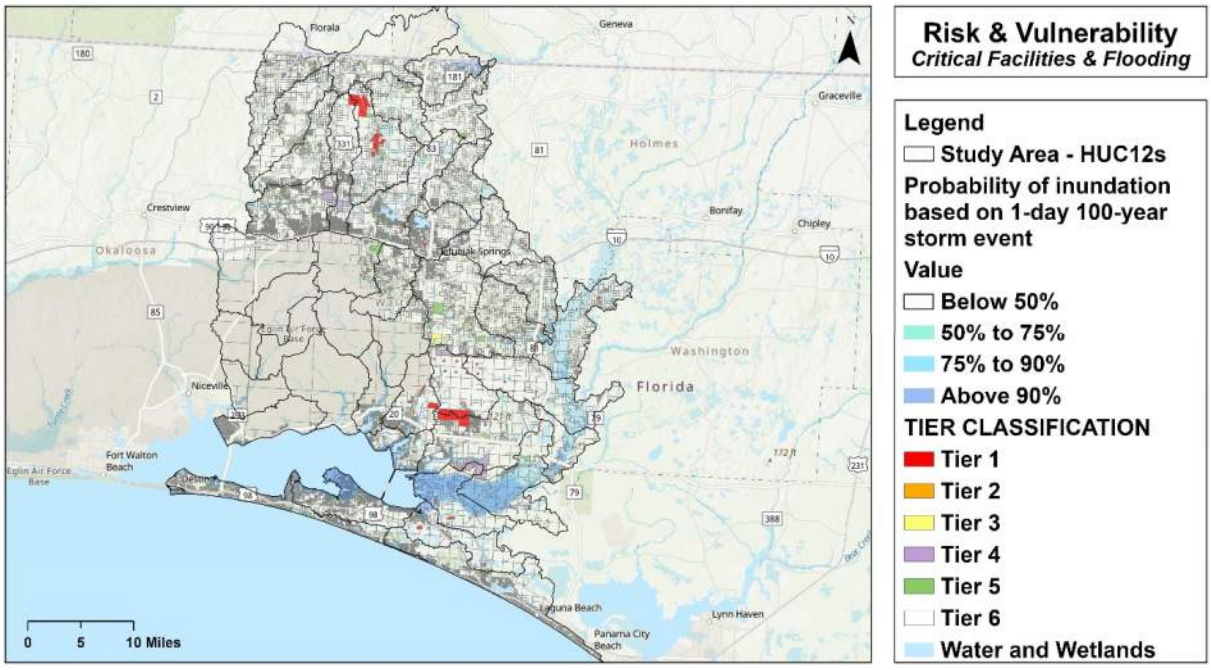

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

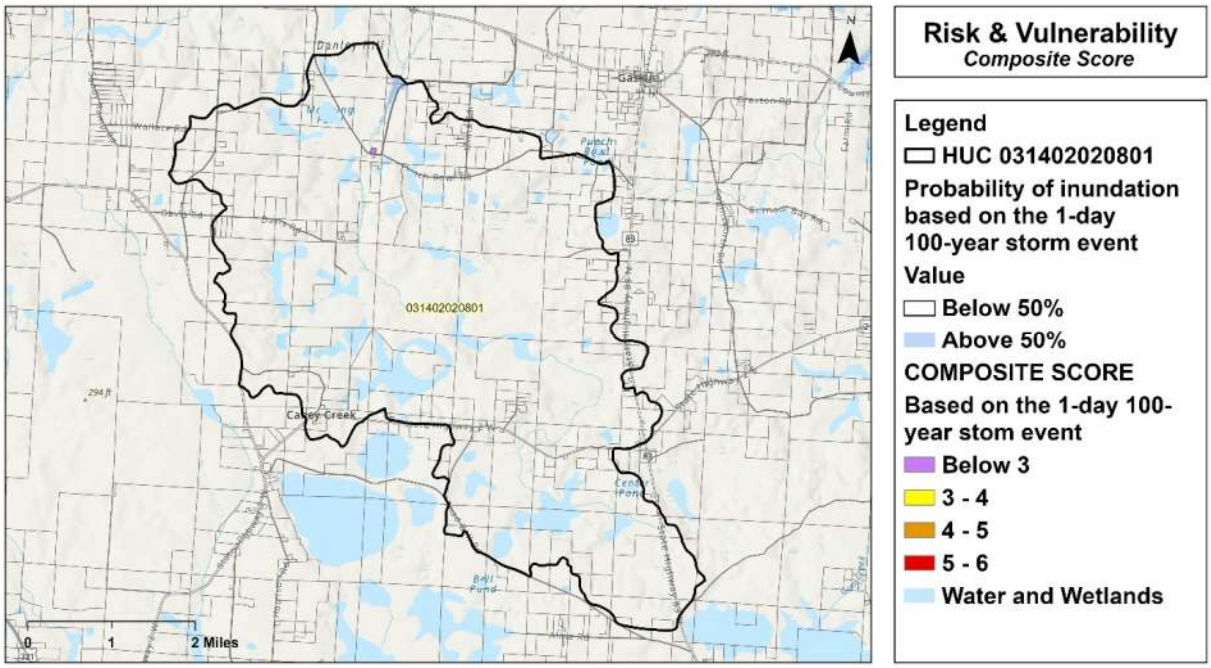

Figure 38. HUC 031402020801 sub-watershed Composite Score Risk map, with calculation based on 1-day 100-year storm event. Processed by FAU.

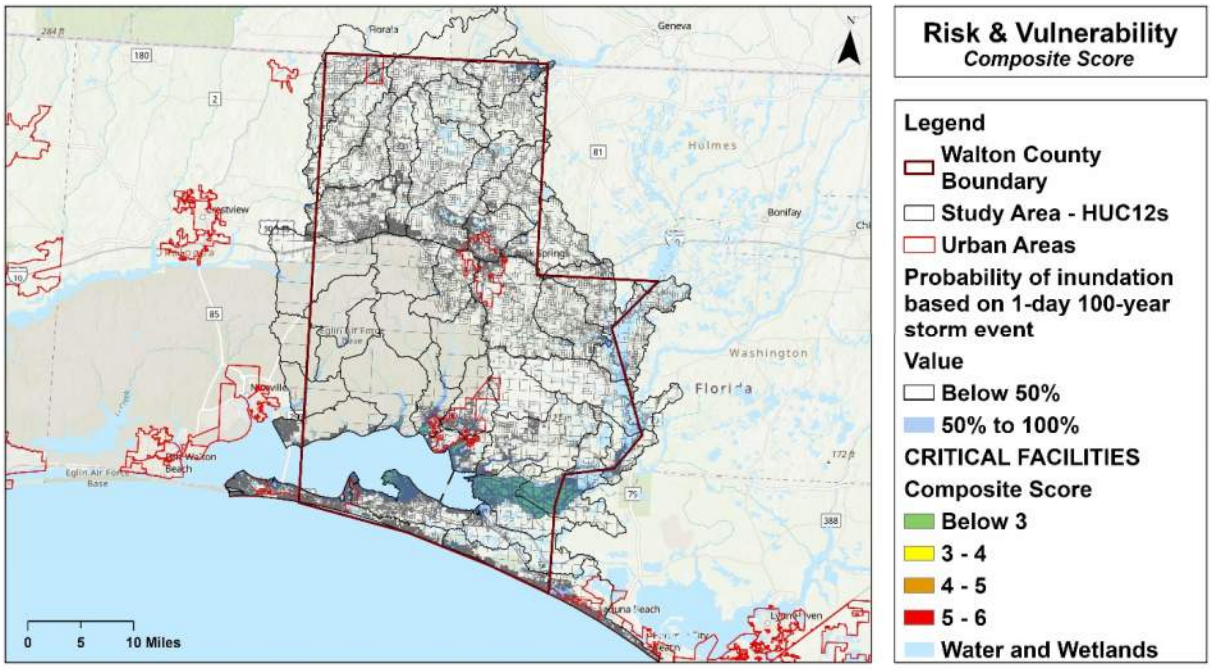

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031402020801. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It is important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031402020801. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031402020801	14601.58
All of the 1-day 100-year storm event inundation	**26.34**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	26.34
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	26.34

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

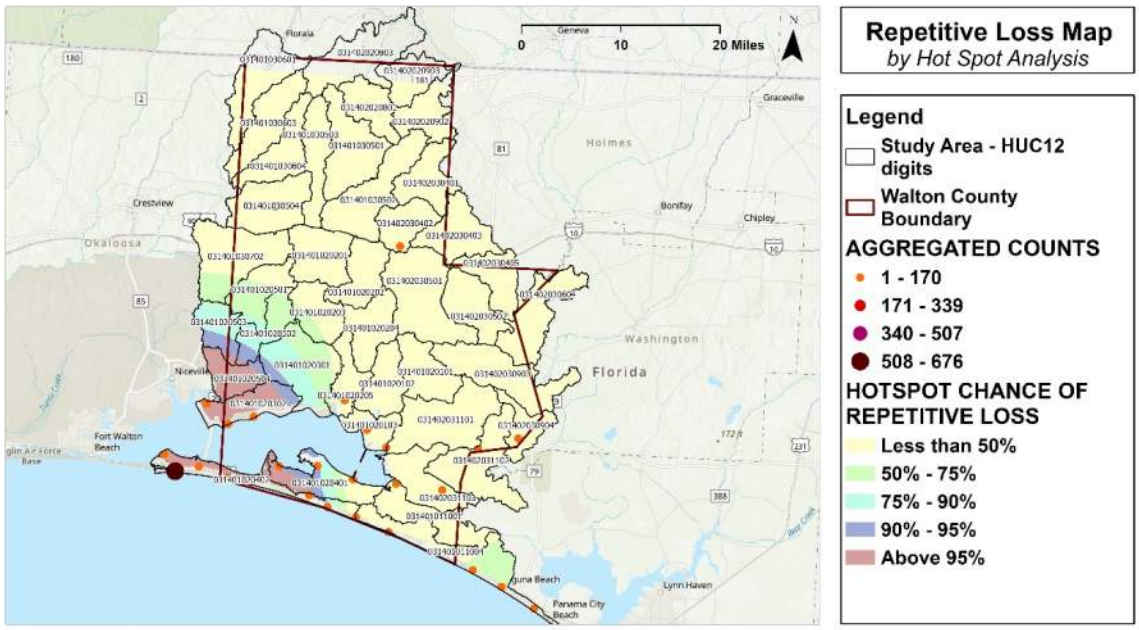

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5 Priority Projects

Although there are some parcels falling within tiers 2 (roads), 3, 4, and 5 of priority land uses, none of them are within the flooding zone, as the flooding in the area is minor and not alarming. Consequently, when considering the composite score, it is notable that most of the results are null, indicating no priority for intervention within the basin. There is only one exception within the basin, which is a mobile home parcel with a score below 3.

APPENDIX AV

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031402020803

LOWER EIGHTMILE CREEK

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Research Assistant: Leticia Sabio

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**,, the HUC-12 (031402020803) is highlighted among all the HUCs to help identifying its location (Figure 3). While a significant portion of this HUC's area lies within Walton County, Florida, the remaining portion, comprising slightly more than half, extends into the state of Alabama.

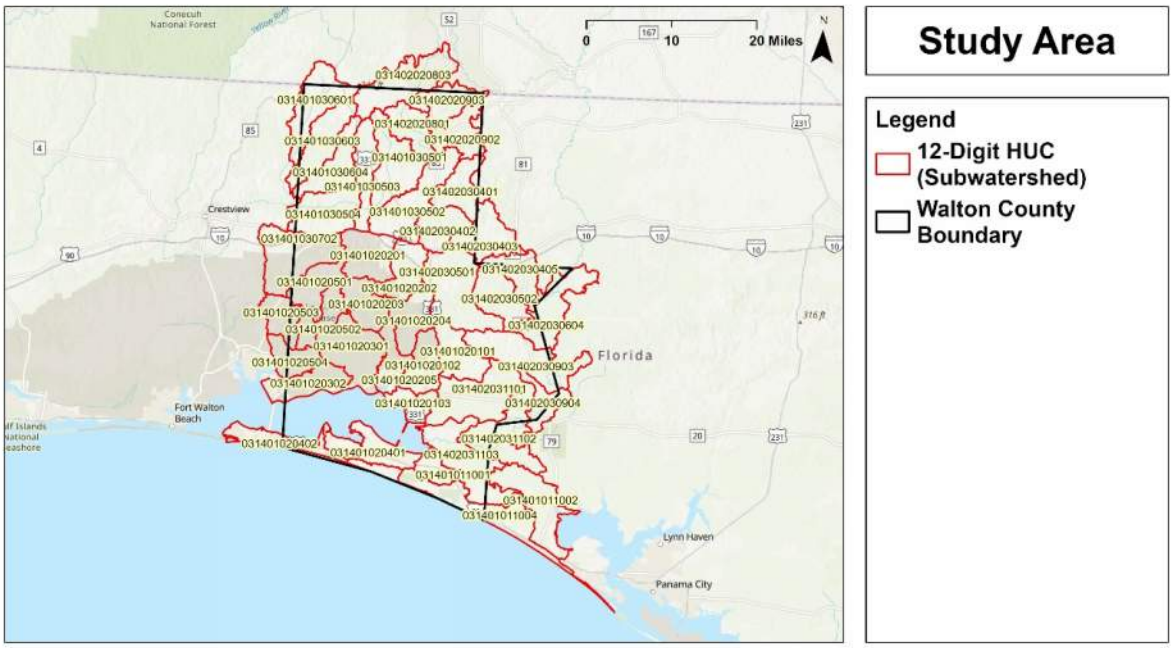

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

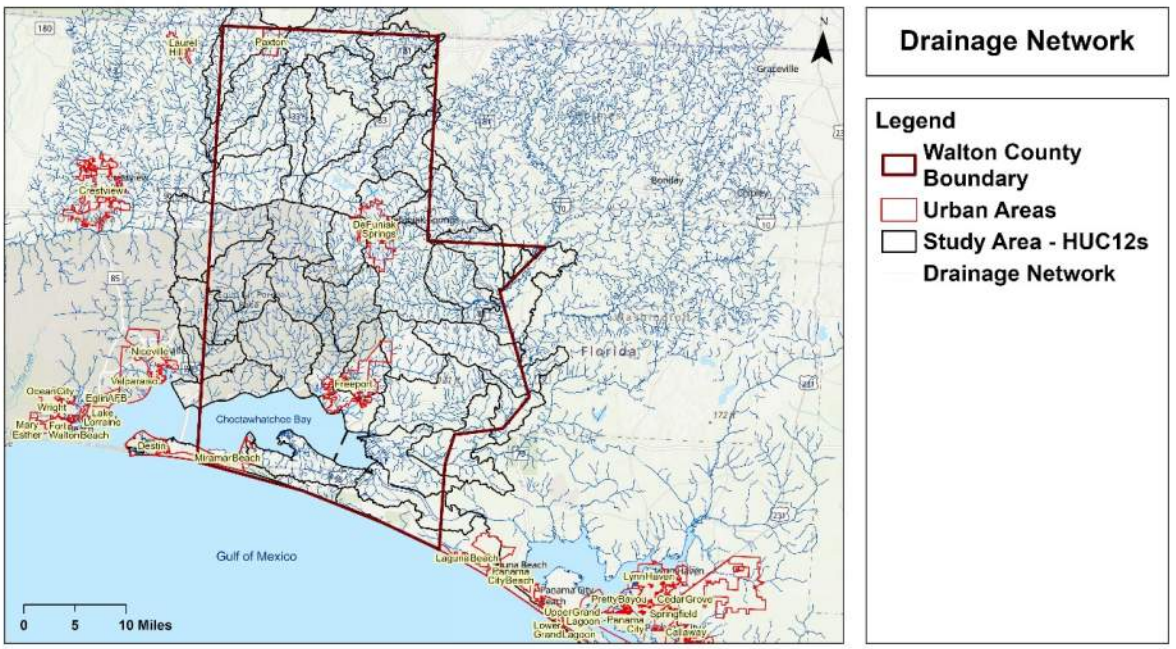

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

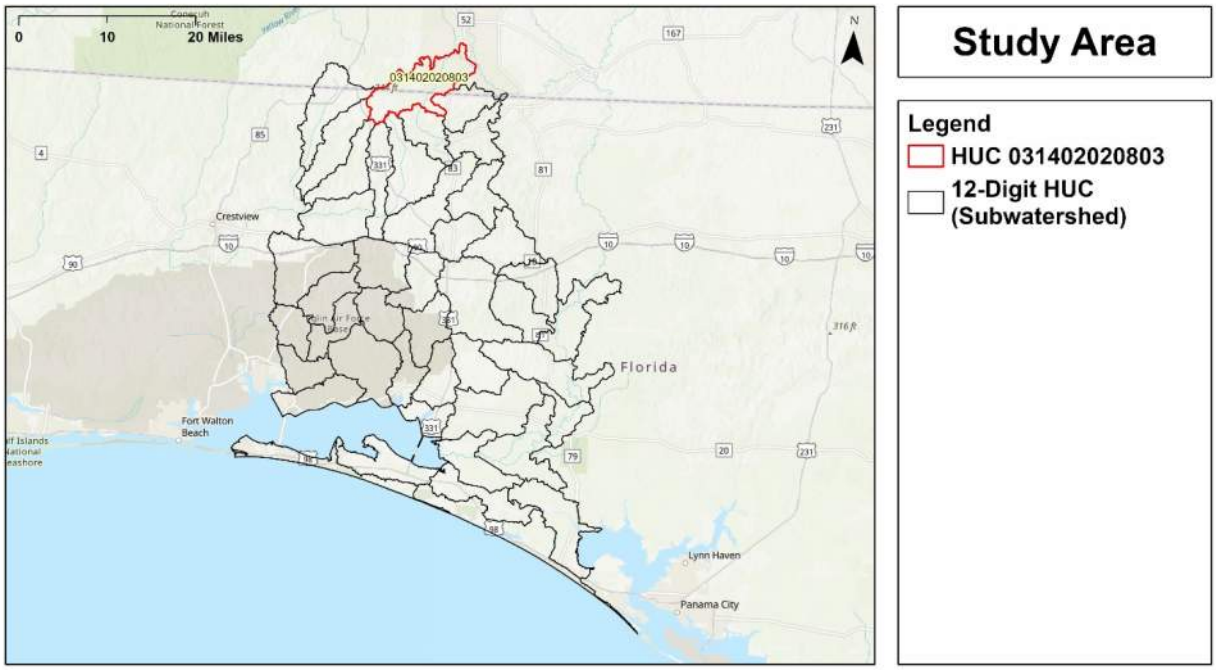

Figure 3. HUC 031402020803 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

(Source Data: FEMA)

Figures 12 and 13 is the county-wide report show the current and projected land use for the County. Based on the 2017 future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land Use in Walton County (Prepared by FAU from future land use map) versus land use in the entire watershed

Level 1 Land Use-Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

(Source Data: NWFWMD, 2017)

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 1.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.

- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

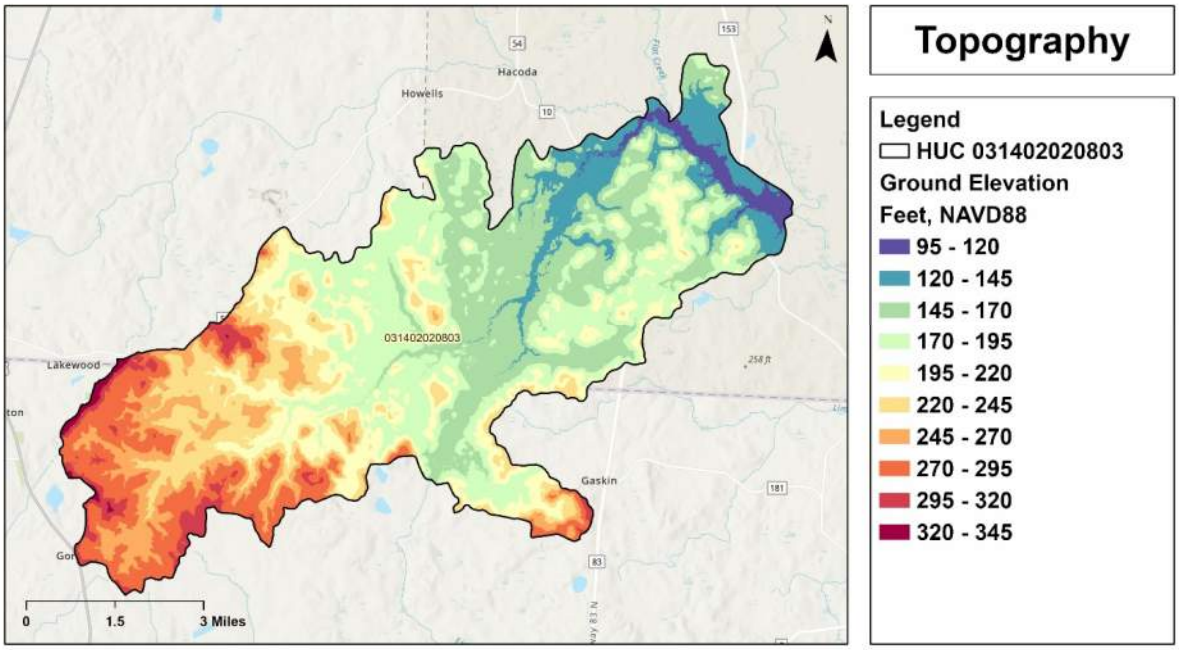

Figure 4. Topographic map of the HUC 031402020803 sub-watershed, processed by FAU

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031402020803 sub-watershed is shown in **Error! Reference source not found.**.

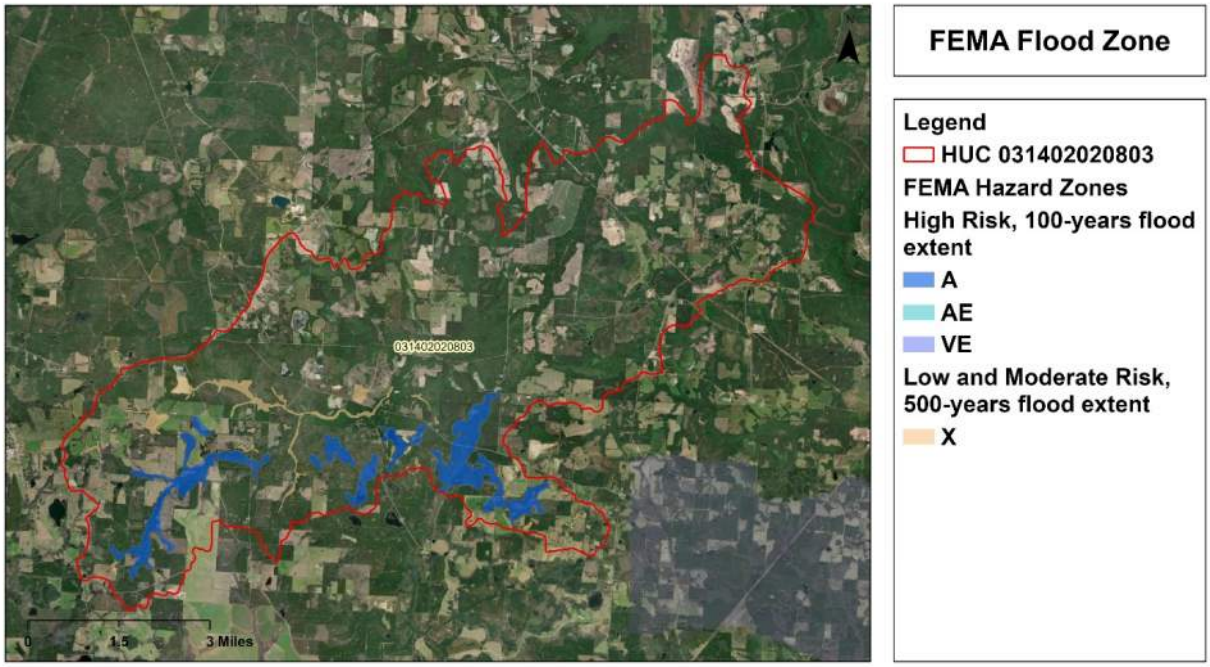

Figure 5. FEMA Flood Zone map (2020) for HUC 031402020803 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031402020803 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including

various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

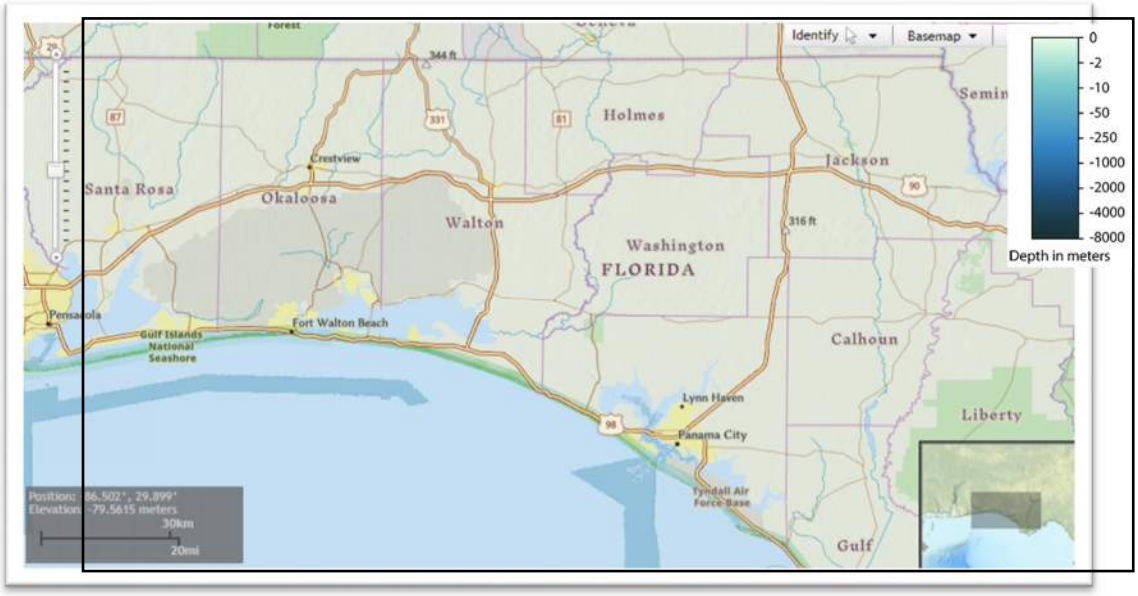

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle. Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

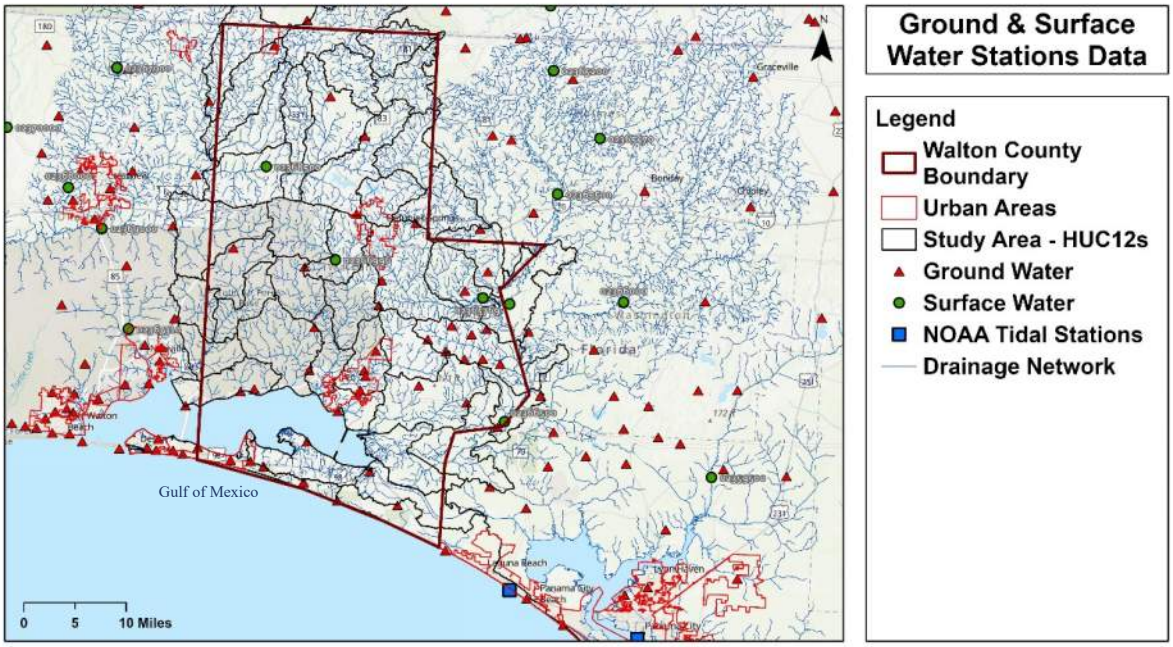

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031402020803 lacks major rivers and canals, instead featuring a network of well-branched creeks without specific names. These creeks originate from various directions and flow in different directions as well.

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02368500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031402020803, which is USGS 02368500 Shoal River.

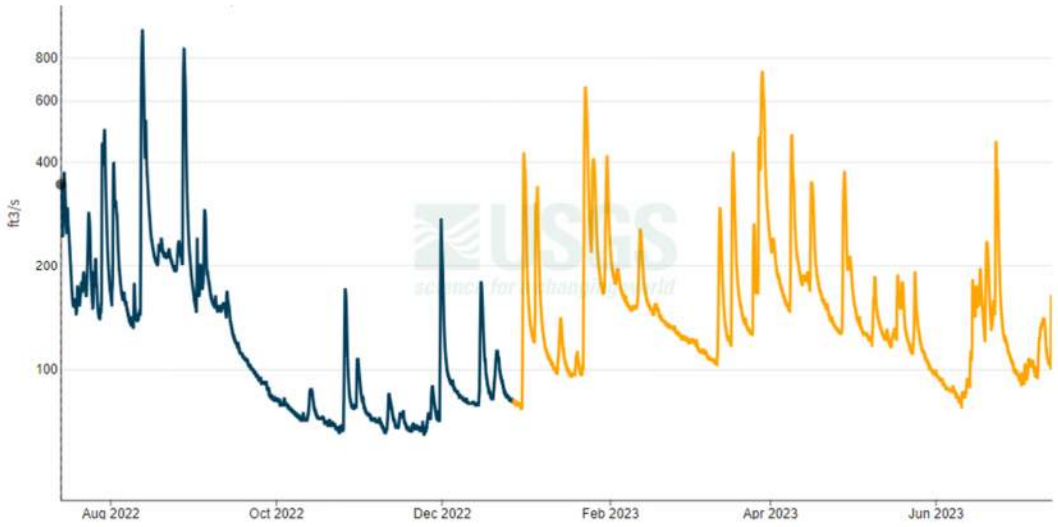

Figure 8. Average streamflow for Shoal River NR Mossy Head, Fla (USGS 02368500 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02368500/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station

(or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu.. Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031402020803 and points out the location of the ground water station in the surroundings. A groundwater-surface layer for the HUC 031402020803 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

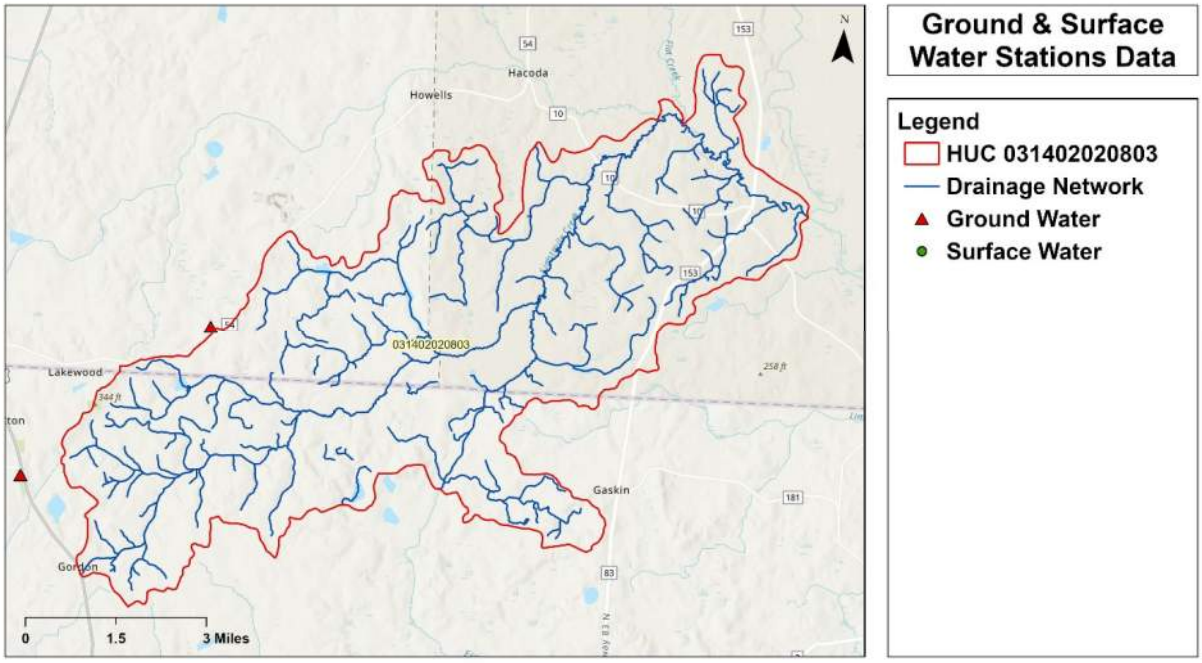

Figure 9. Ground and Surface Water Stations in the HUC 031402020803 sub-watershed, processed by FAU.

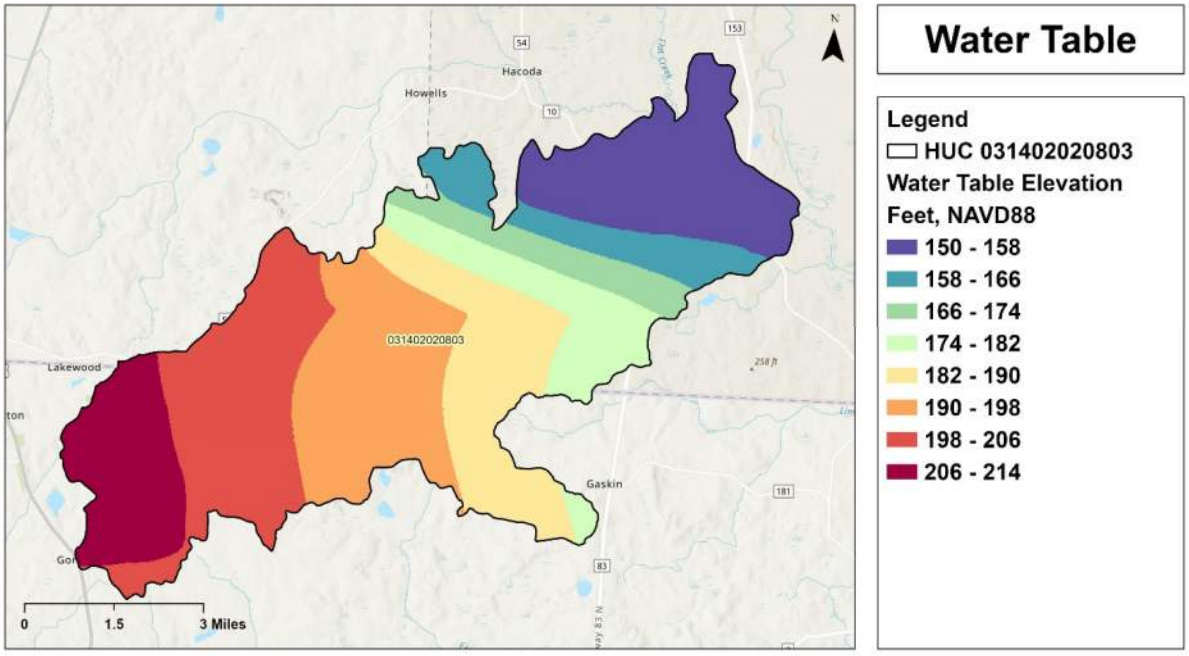

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031402020803 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows average precipitation over Walton County for every month of the year between 2011 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches for the entire county.

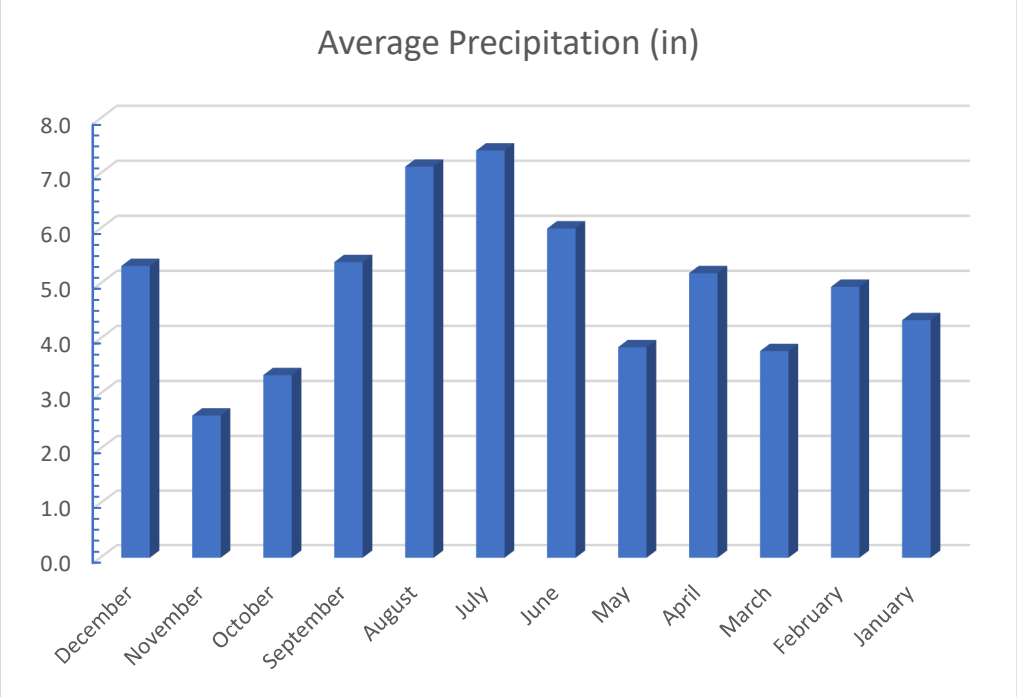

Figure 11. Monthly precipitation in Walton County, FL (2011-2023).
(Data Source: Florida Weather Data, available at https://data.usatoday.com/weather-data/walton-county/12131/1975-04-01/Table/)

While the topography (Section 1.1) and native soil (Section 1.4)create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as

opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. Figure 12 shows the two closest tide stations to Walton County. Since there is none NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

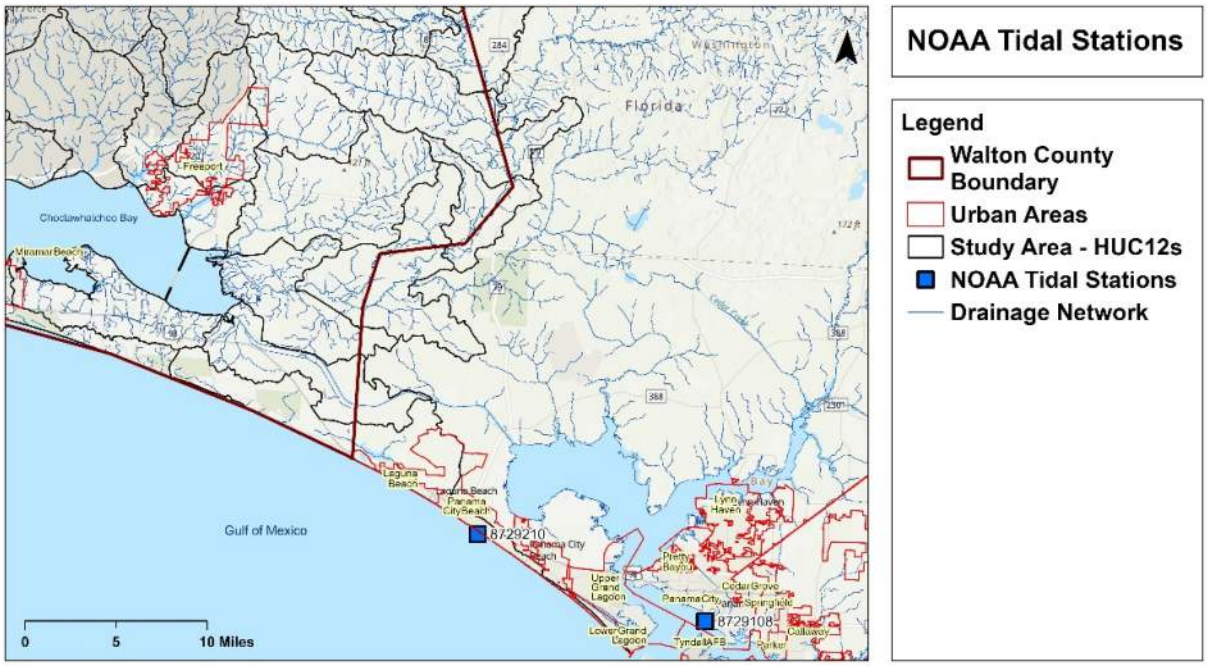

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

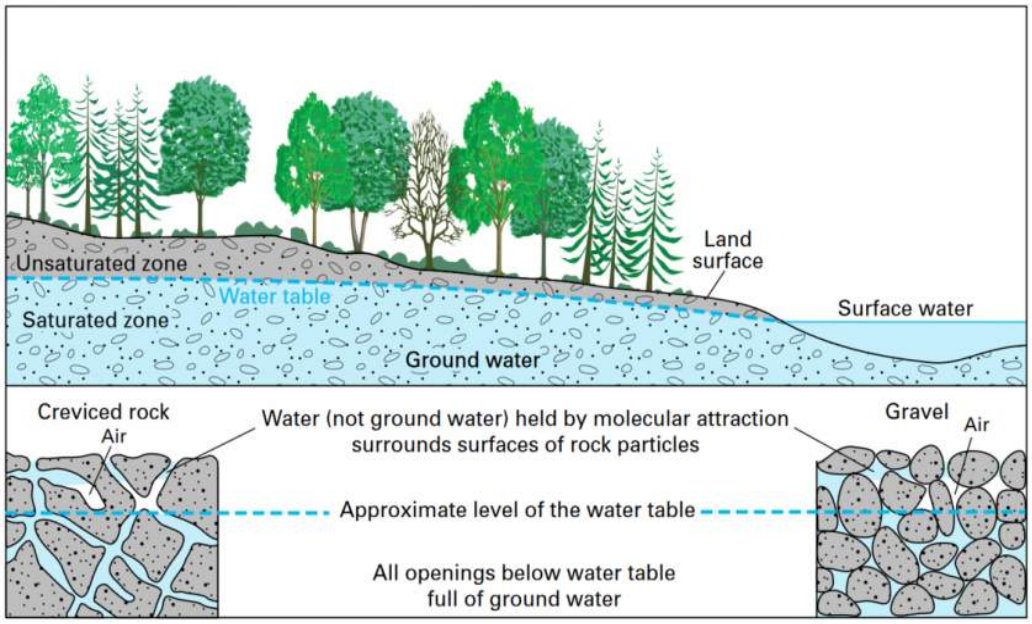

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

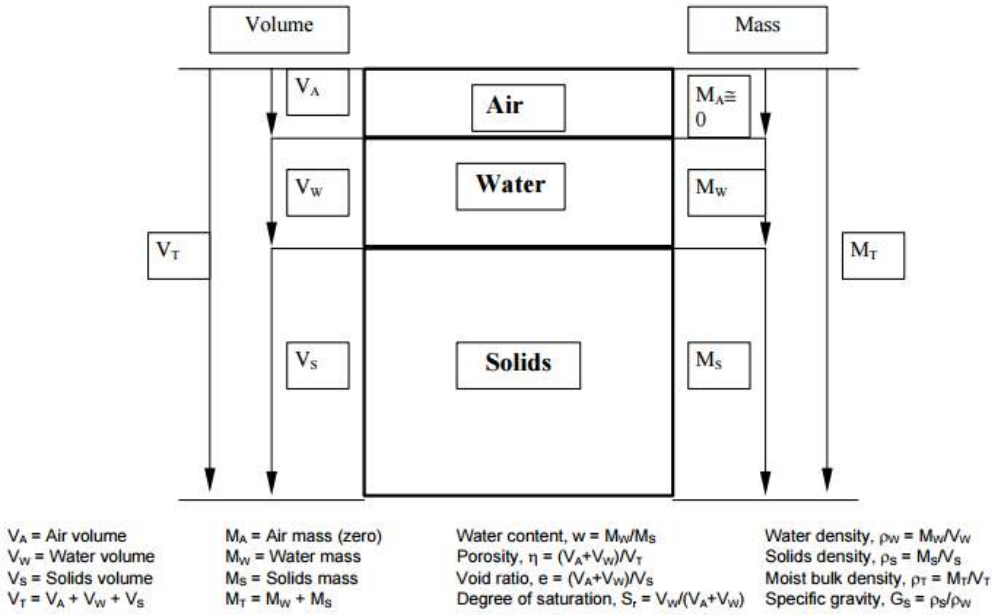

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

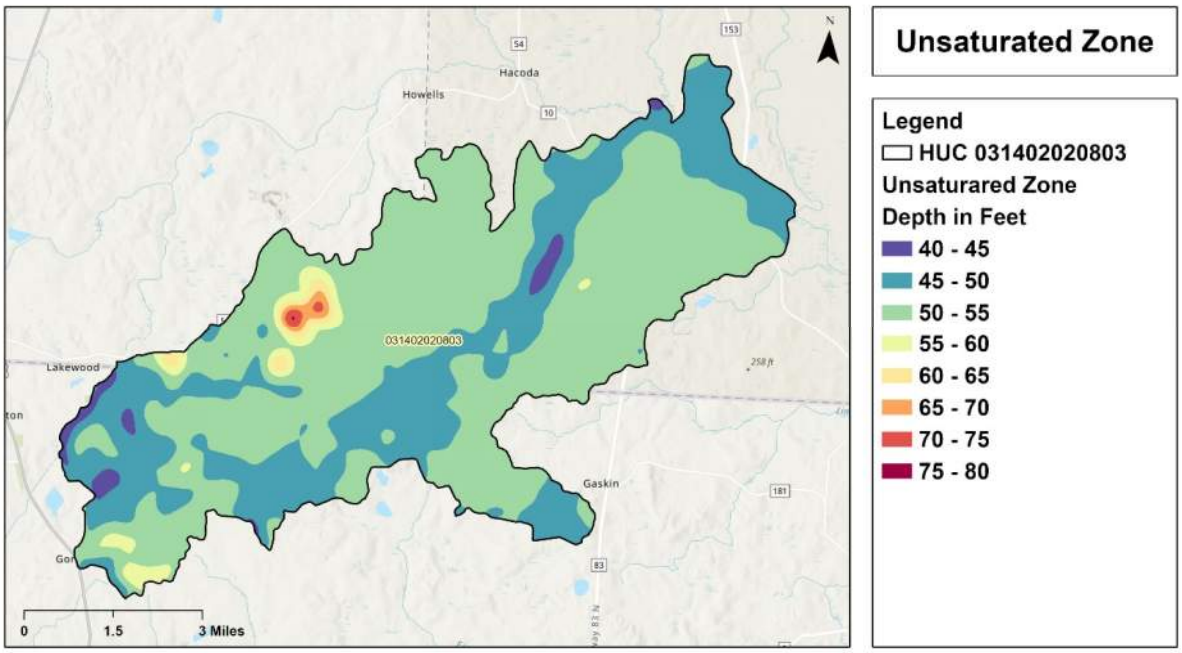

Figure 15. Unsaturated zone map for HUC 031402020803, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin exhibits a favorable soil storage capacity, ranging between 45 to 60 inches of remaining capacity.

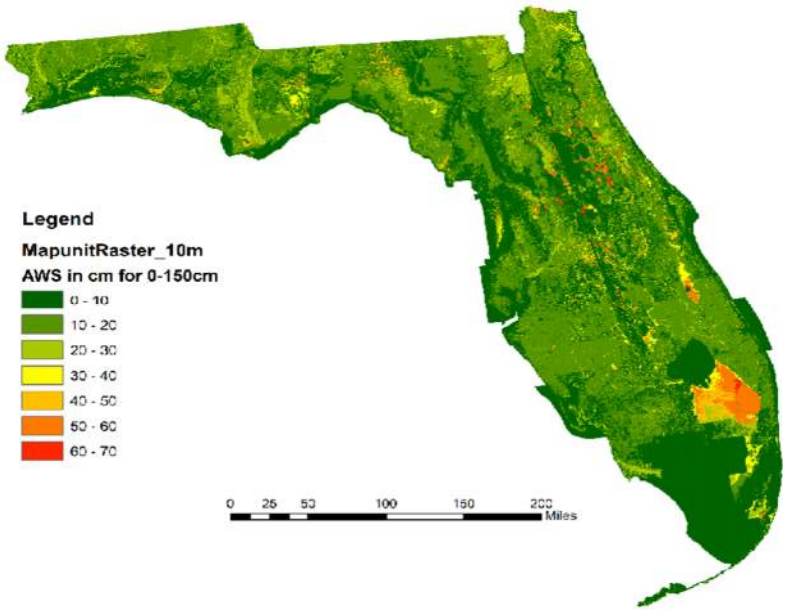

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

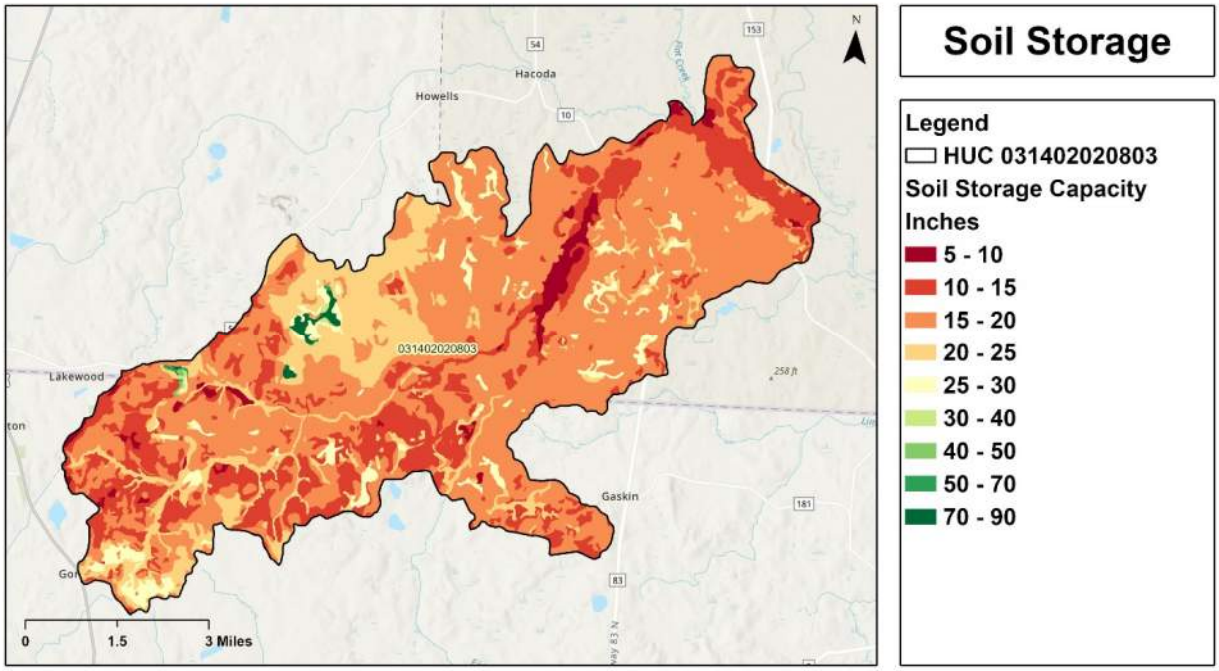

Figure 17. Water storage capacity of soil for the HUC 031402020803, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

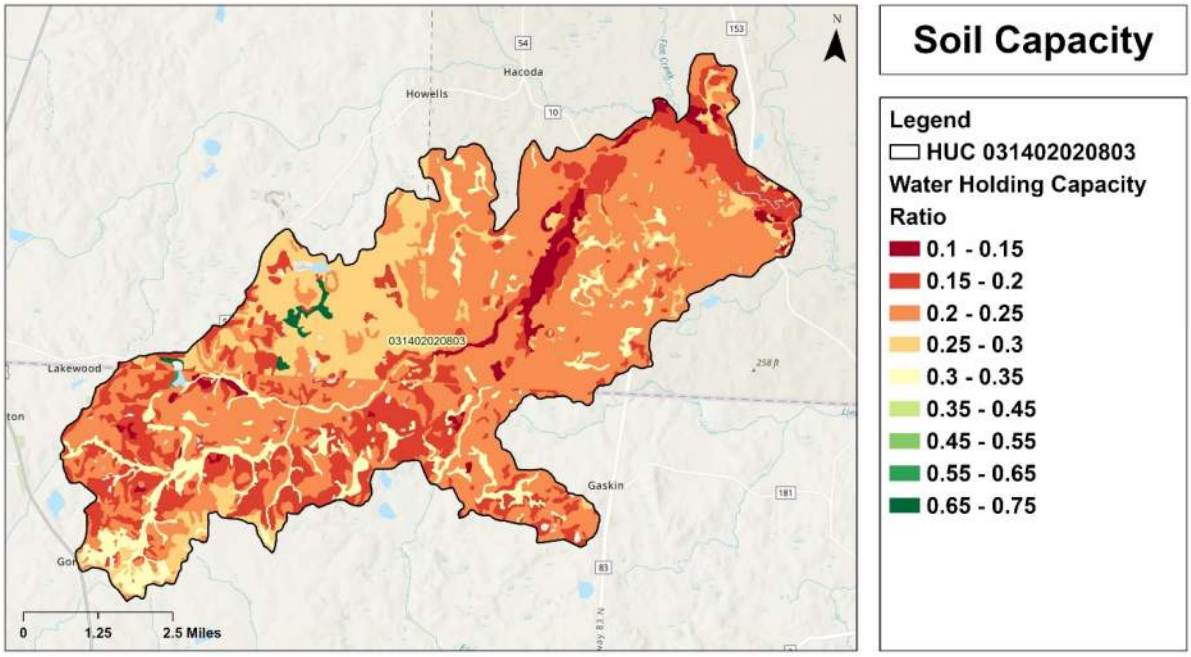

Figure 18. Water Holding Capacity (ratio) for the HUC 031402020803, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

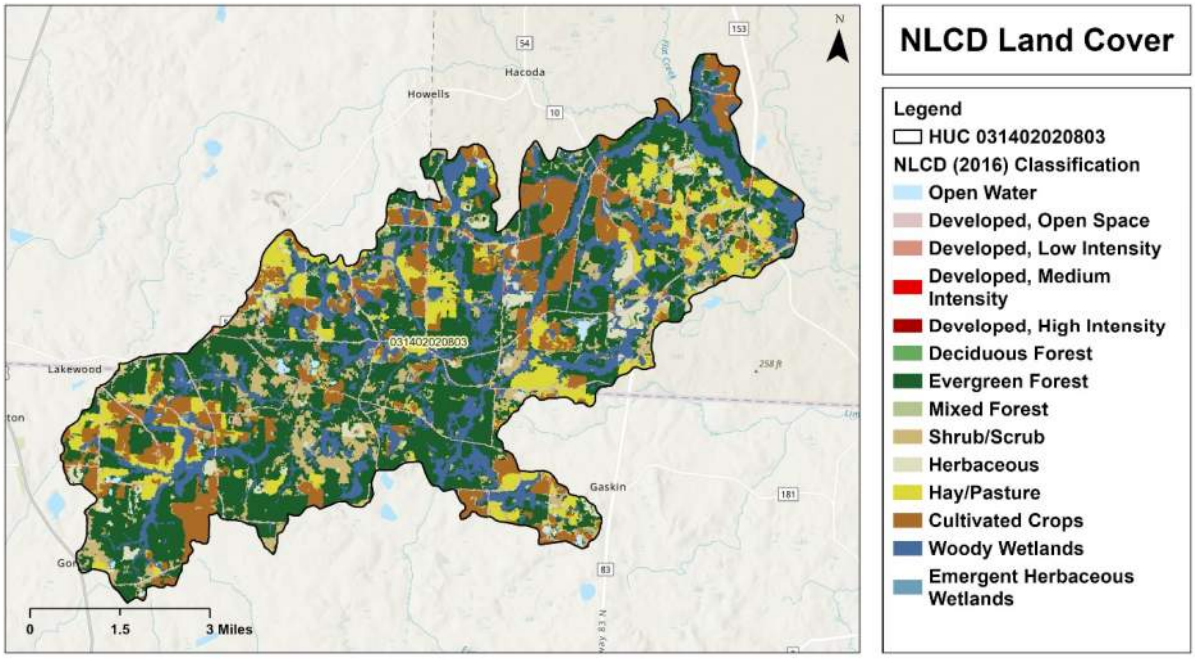

Figure 19. Land use in the HUC 031402020803 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD 2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

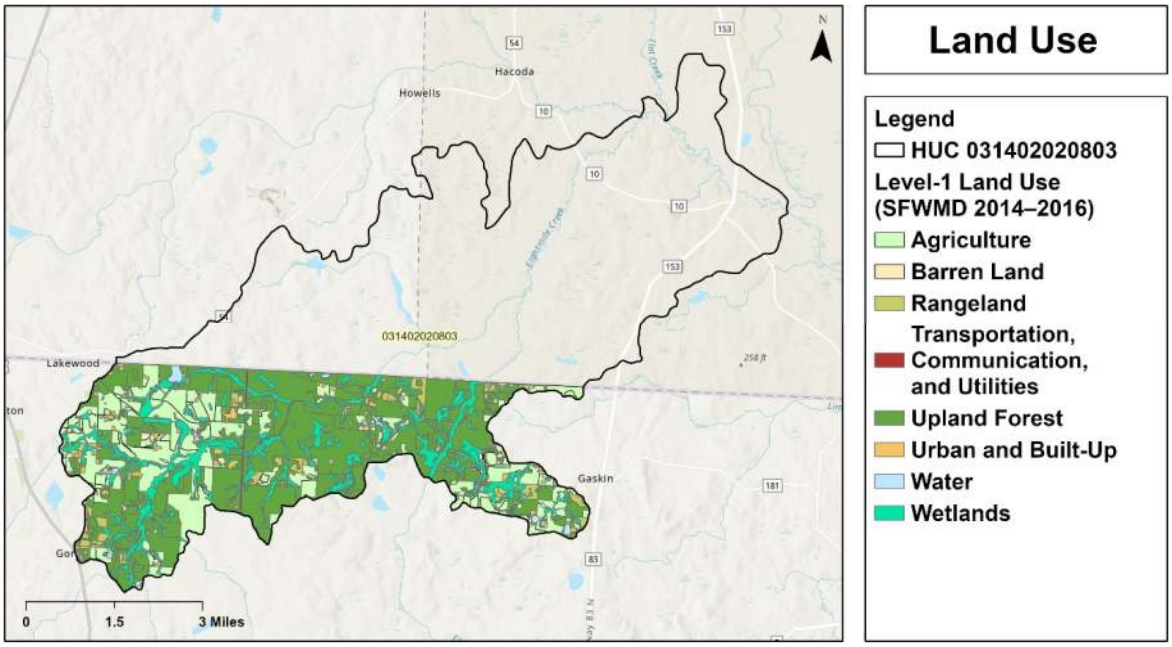

Figure 20. Land use in the HUC 031402020803 (from the 2023 Florida Geographic Data Library (FGDL) database), processed by FAU.

Please be aware that the Alabama portion of the HUC was not considered in this land use study. Consequently, the following analysis pertains solely to the Florida portion of the HUC 031402020803 sub-watershed. In this area, the predominant land cover is upland forest, accounting for 47.18% of the region. Agriculture comes in second at 30.39%, followed by wetlands at 13.98%. Developed land is limited, with only 2.12% categorized as urban and built-up, as illustrated in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface

Table 3. Land use for HUC 031402020803 subwatershed

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	4666.67	30.39%
Barren Land	25.13	0.16%
Rangeland	495.12	3.22%
Transportation, Communication, and Utilities	258.44	1.68%
Upland Forest	7244.48	47.18%
Urban and Built-Up	325.91	2.12%
Water	193.16	1.26%
Wetlands	2146.50	13.98%
Grand Total:	**15355.42**	**100.00%**

(Source Data: 2023 Florida Geographic Data Library (FGDL) database))

Table 4. Roughness and CN Values for Each Land Use Code

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

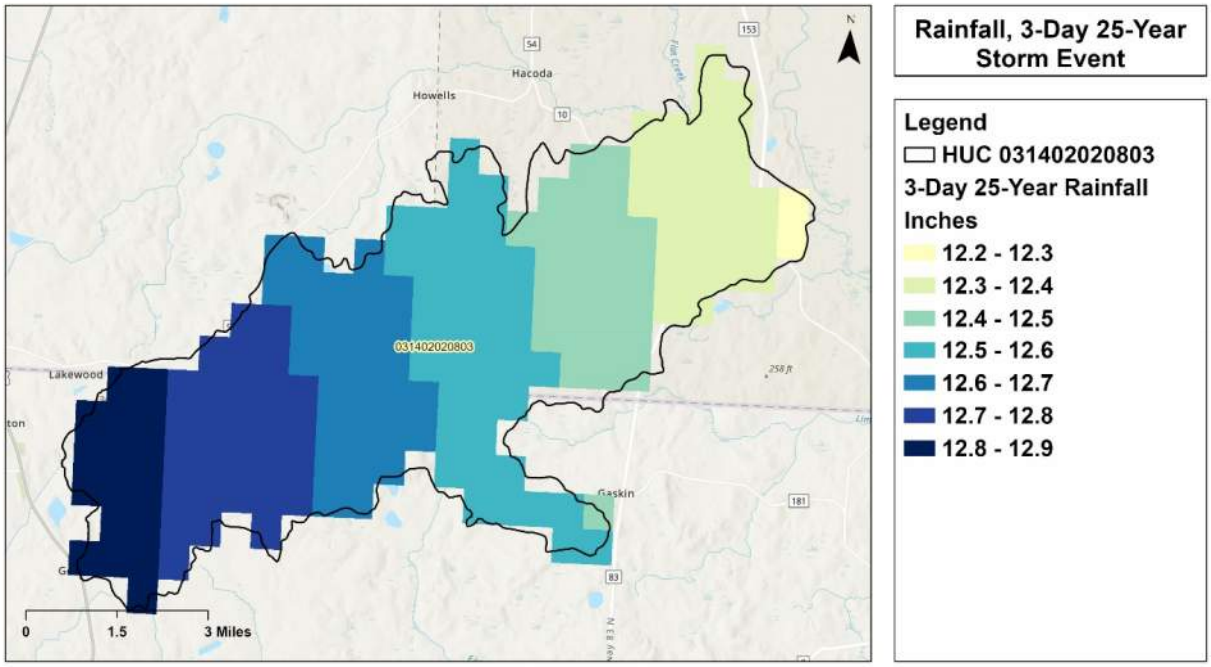

Figure 21. Rainfall distribution map across HUC 031402020803 sub-watershed, for 3-day 25-year storm event, processed by FAU.

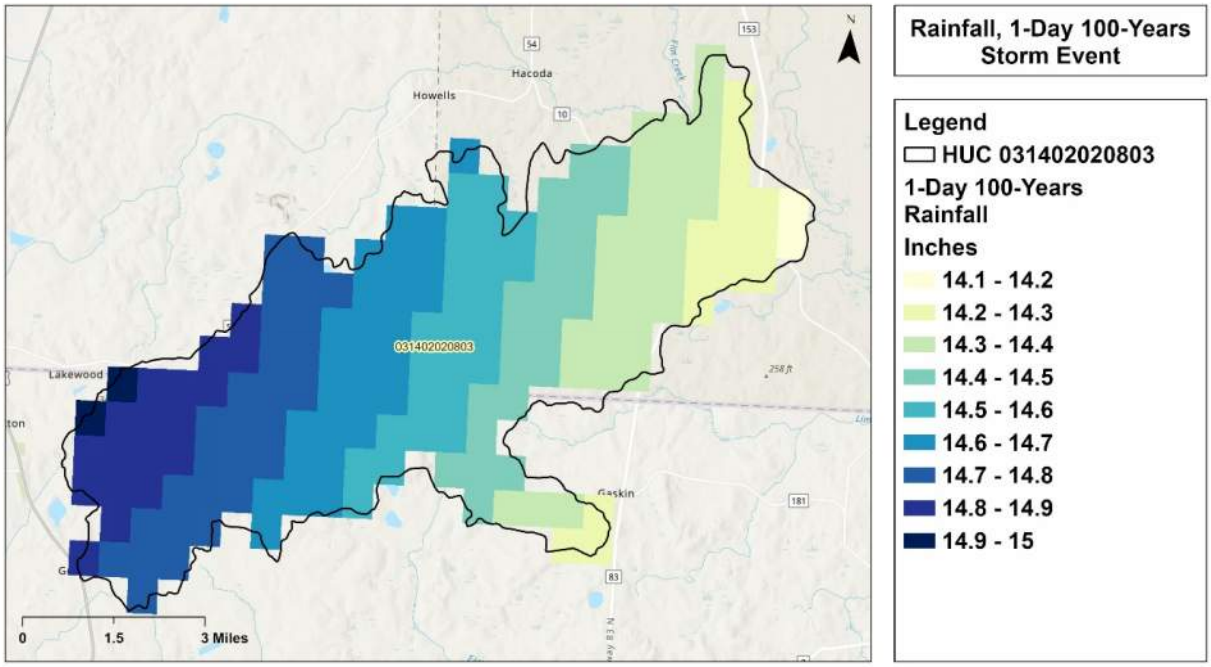

Figure 22. Rainfall distribution map across HUC 031402020803 sub-watershed, for 1-day 100-year storm event, processed by FAU.

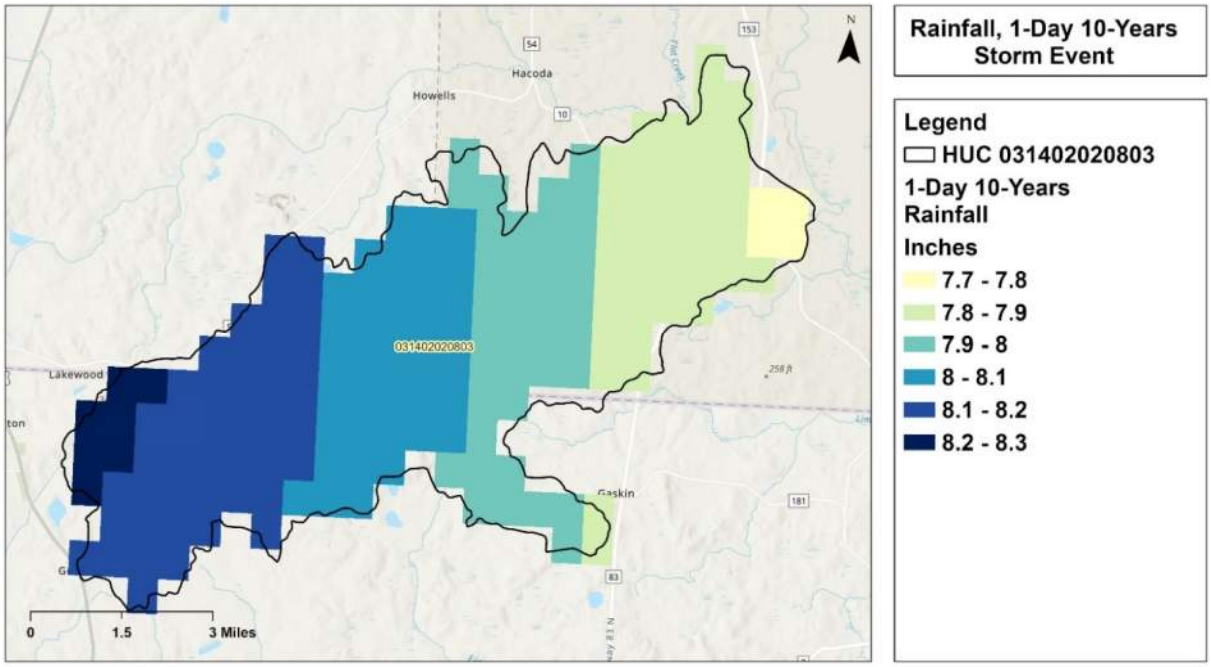

Figure 23. Rainfall distribution map across HUC 031402020803 sub-watershed, for 1-day 10-year storm event, processed by FAU.

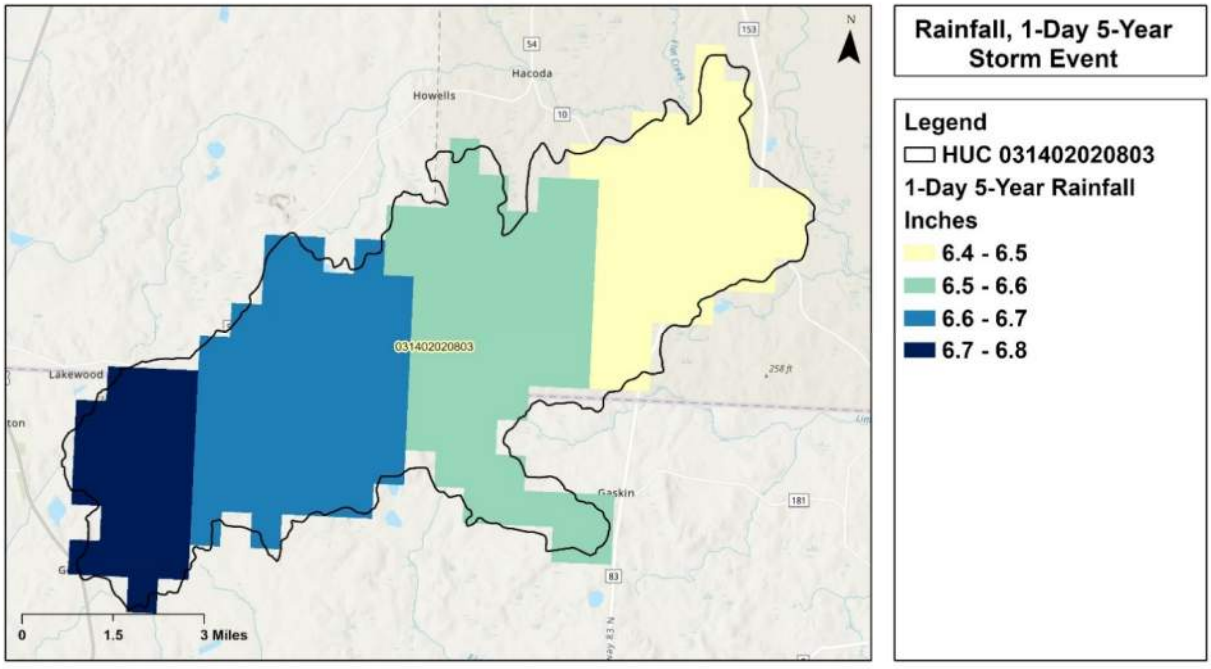

Figure 24. Rainfall distribution map across HUC 031402020803 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

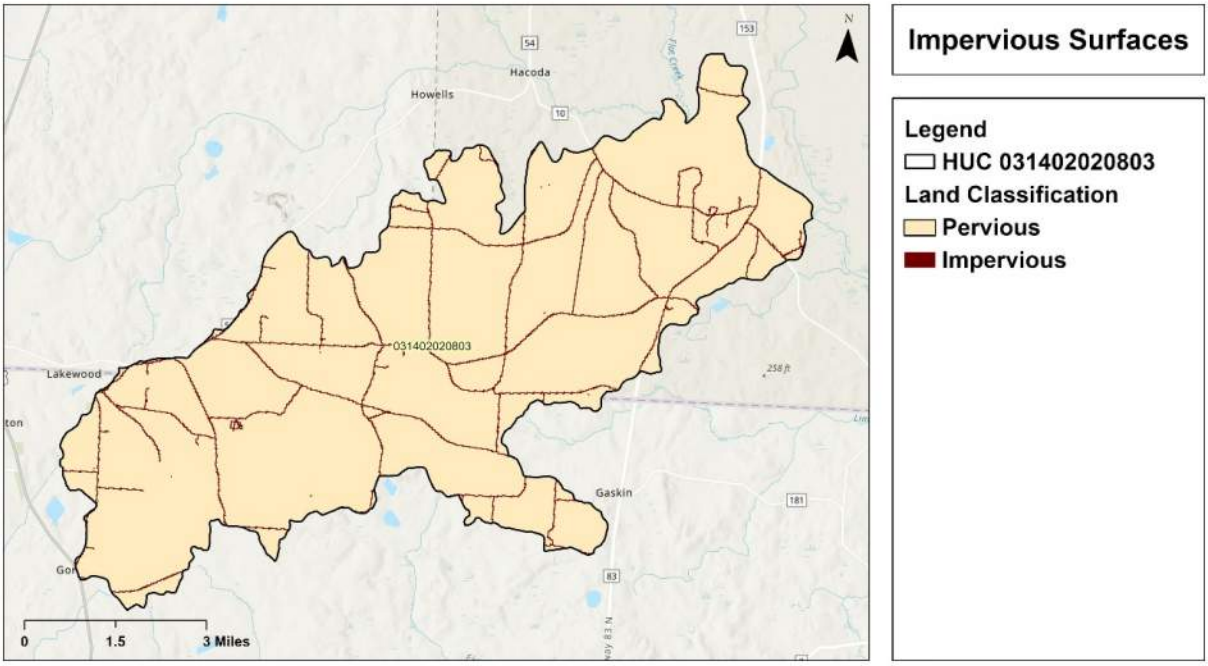

Figure 25. Impervious area map for the HUC 031402020803 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

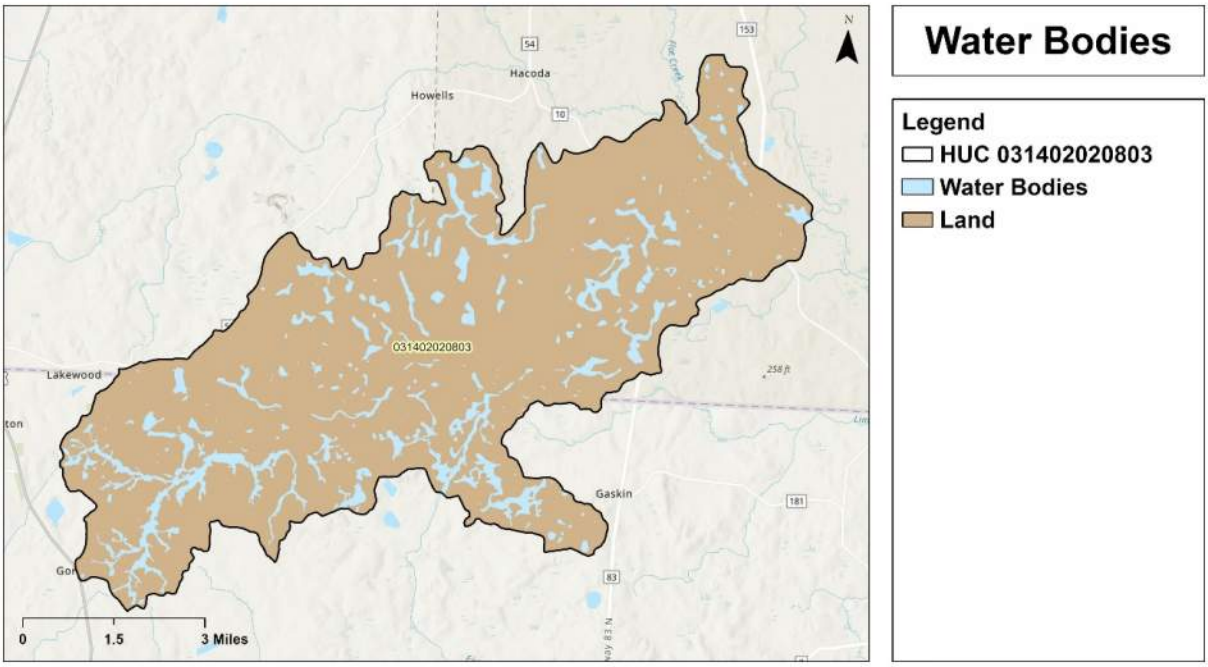

Figure 26. Water bodies map for the HUC 031402020803 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

(Source: US Census Bureau 2020, and Zip-codes.com)

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.

- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

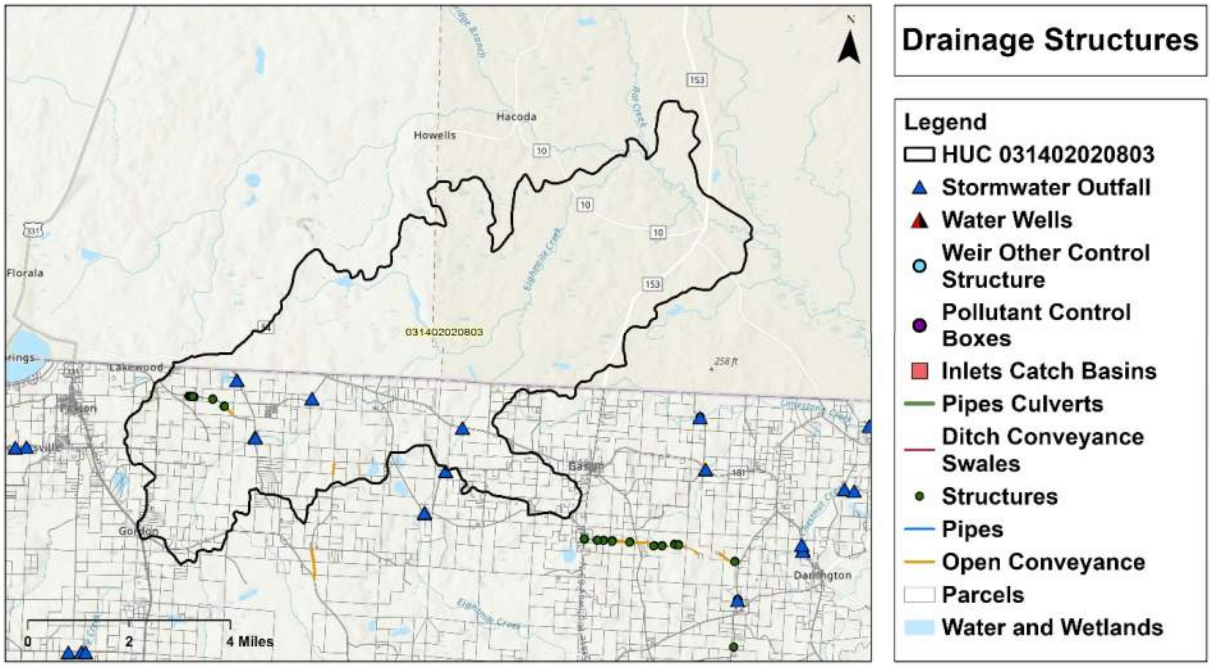

Figure 27. Stormwater Infrastructure for the HUC 031402020803. Processed by FAU.

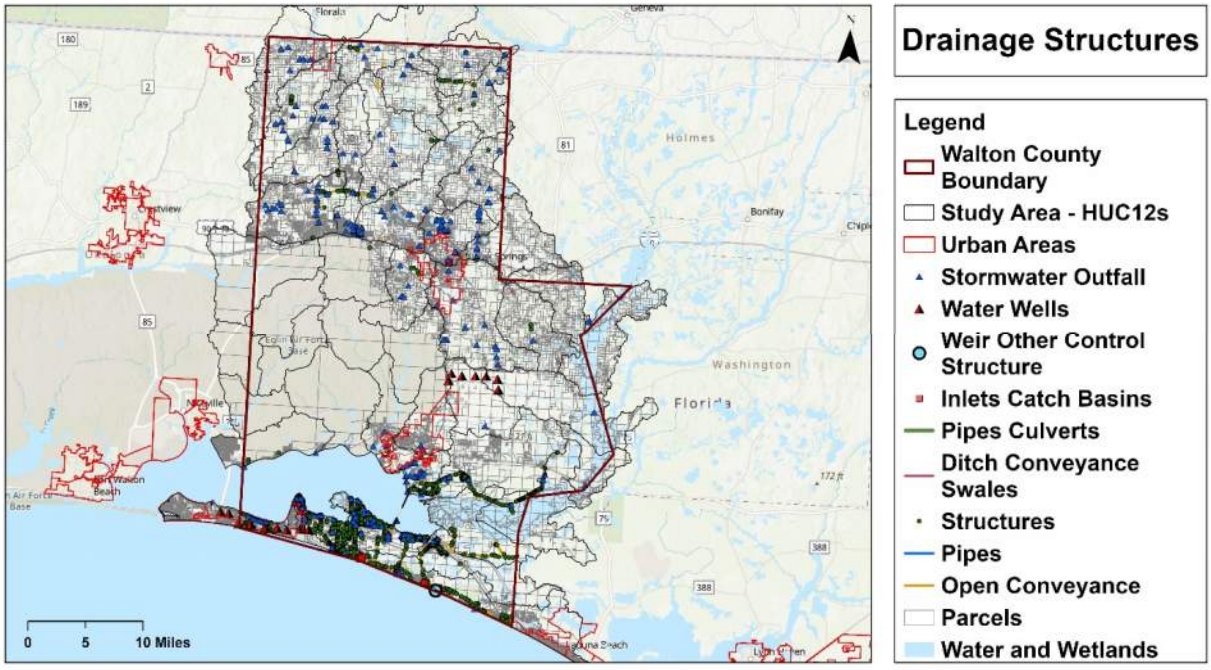

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020)

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapter 1, an analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031402020803 sub-watershed flood response to a series of rainfall events (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.3.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD DBHYDRO website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

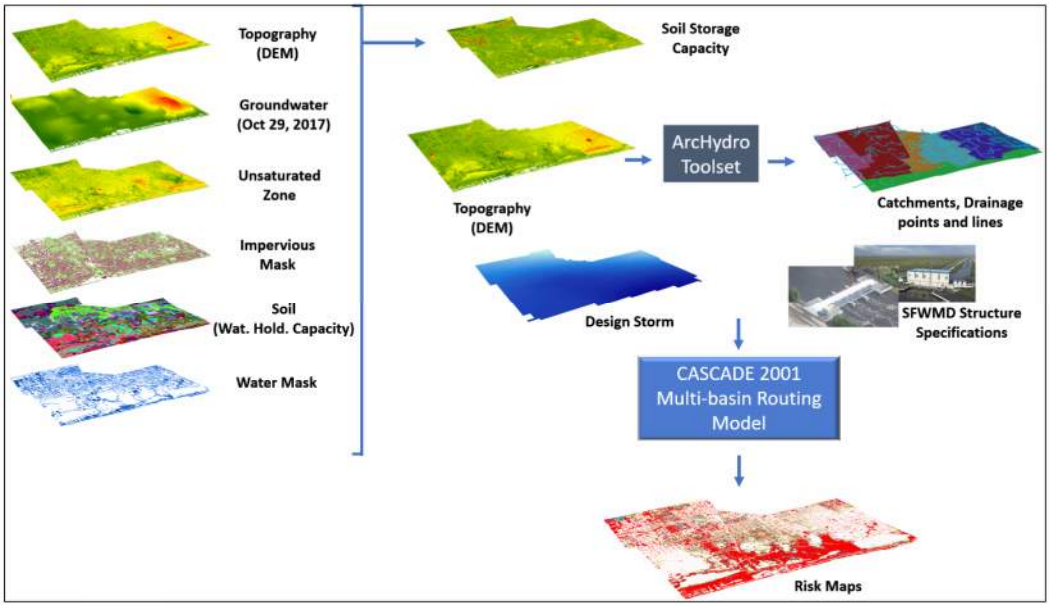

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)

= 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

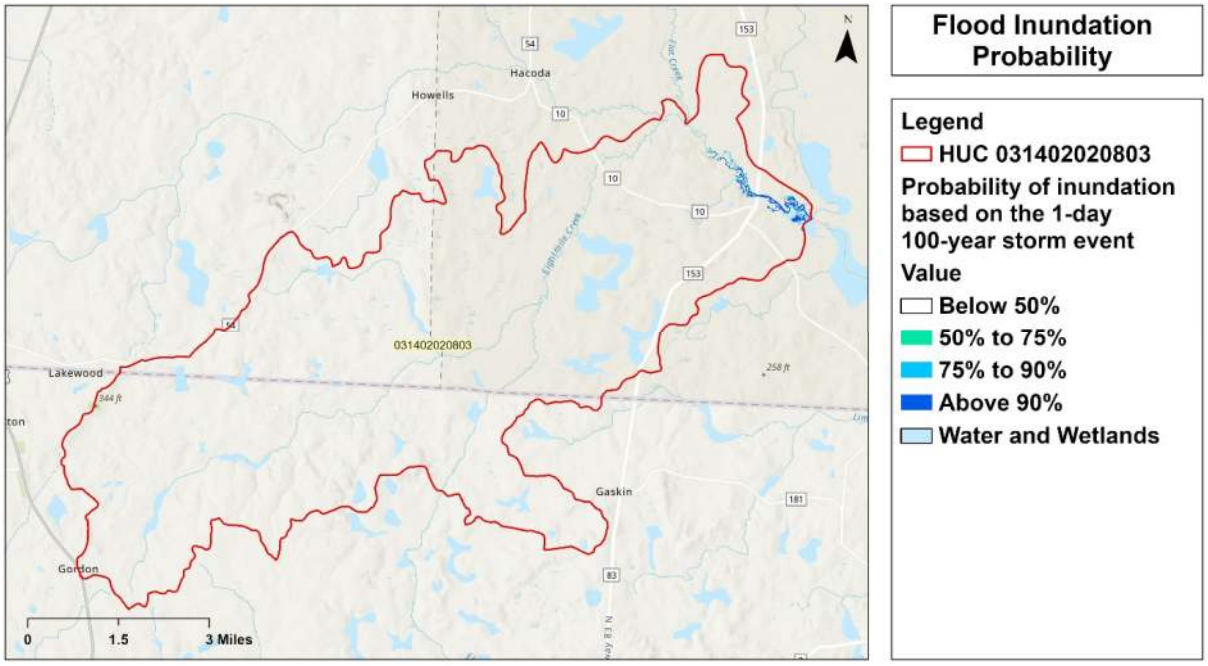

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031402020803, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation

and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 2.4 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations,

Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a small portion of flooding is noted at the creek entrance to the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, the HUC is expected to remain unaffected by sea level rise, therefore SLR scenarios were not computed.

The design storm simulation determined that approximately 0.38% of the HUC total area or 0.183 mi² has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 0.32% of the HUC's total area, or 0.153 mi² would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.23% of the HUC's total area, or 0.111 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0.22% of the HUC's total area, or 0.104 mi², would be expected to be inundated

during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 03140102020803 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	48.050	0.183	99.62%	0.38%
1-day 100-year	48.081	0.153	99.68%	0.32%
1-day 10-year	48.123	0.111	99.77%	0.23%
1-day 5-year	48.130	0.104	99.78%	0.22%

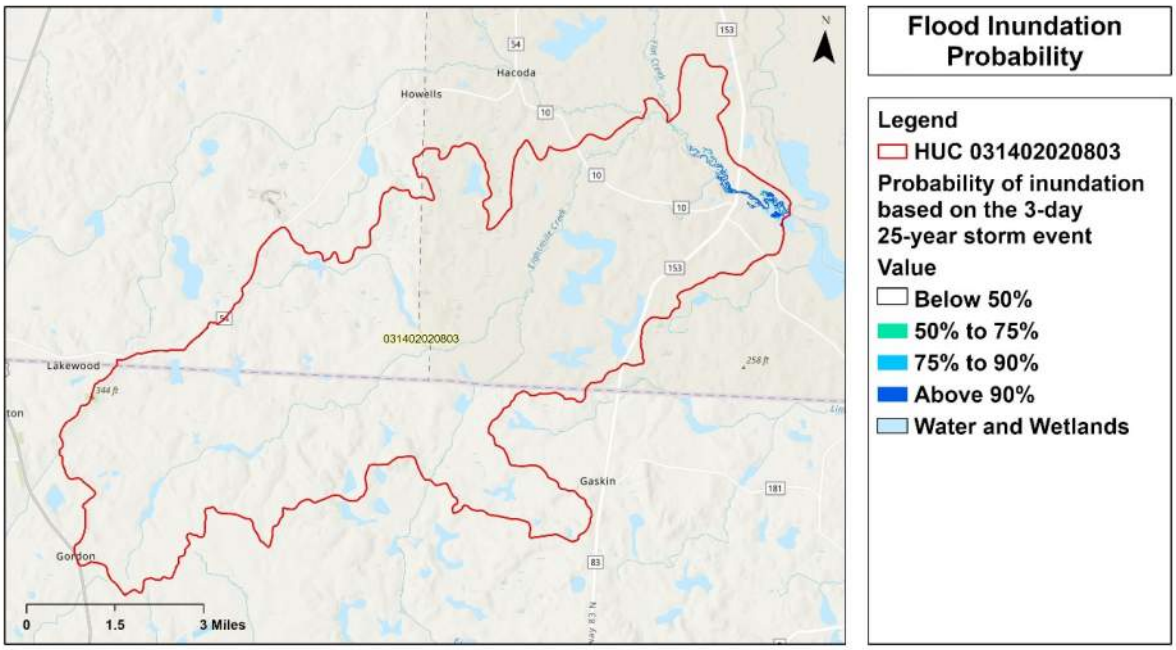

Figure 31. 3-day 25-year storm event for HUC 031402020803 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

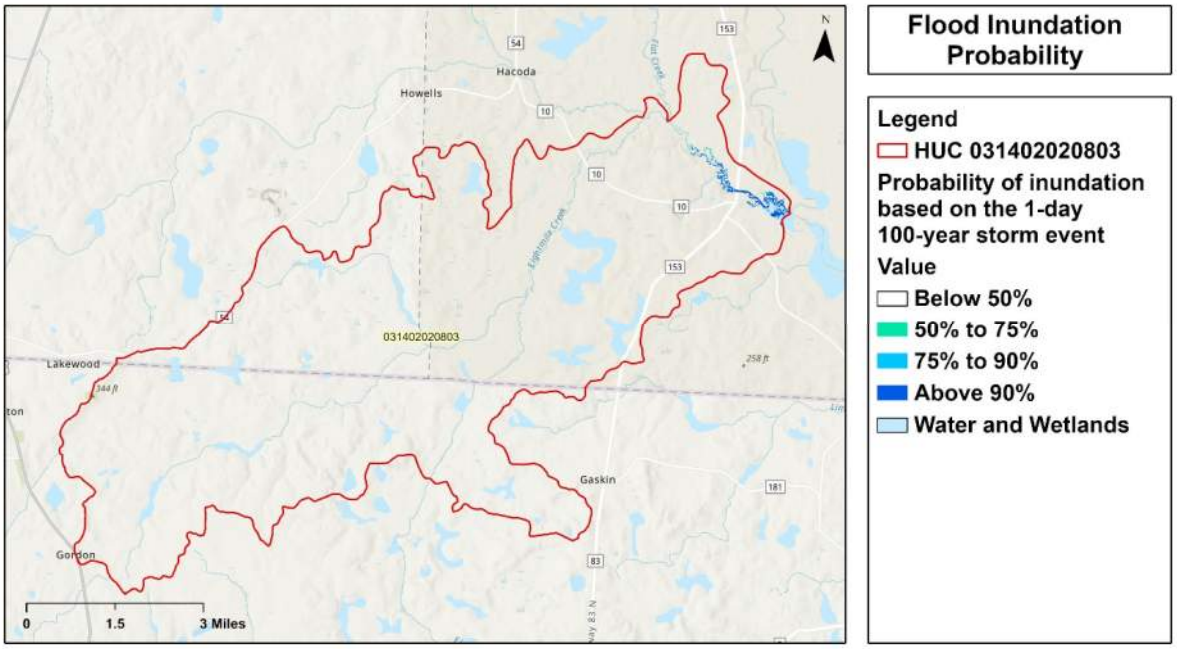

Figure 32. 1-day 100-year storm event for HUC 031402020803 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

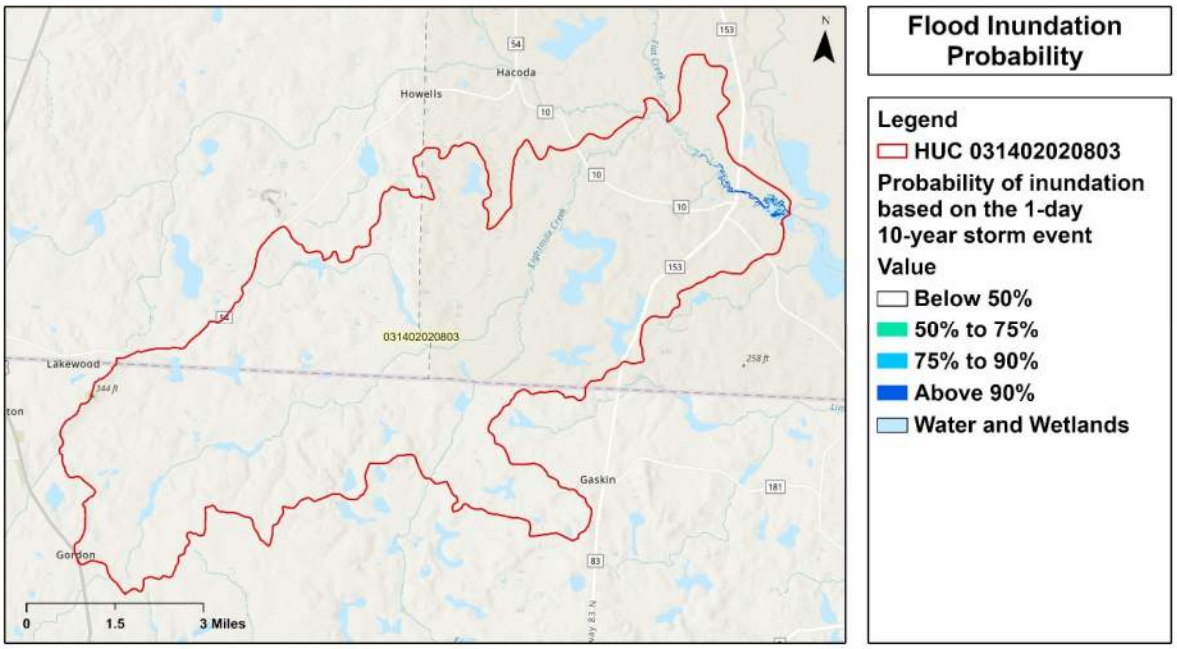

Figure 33. 1-day 10-year storm event for HUC 031402020803 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

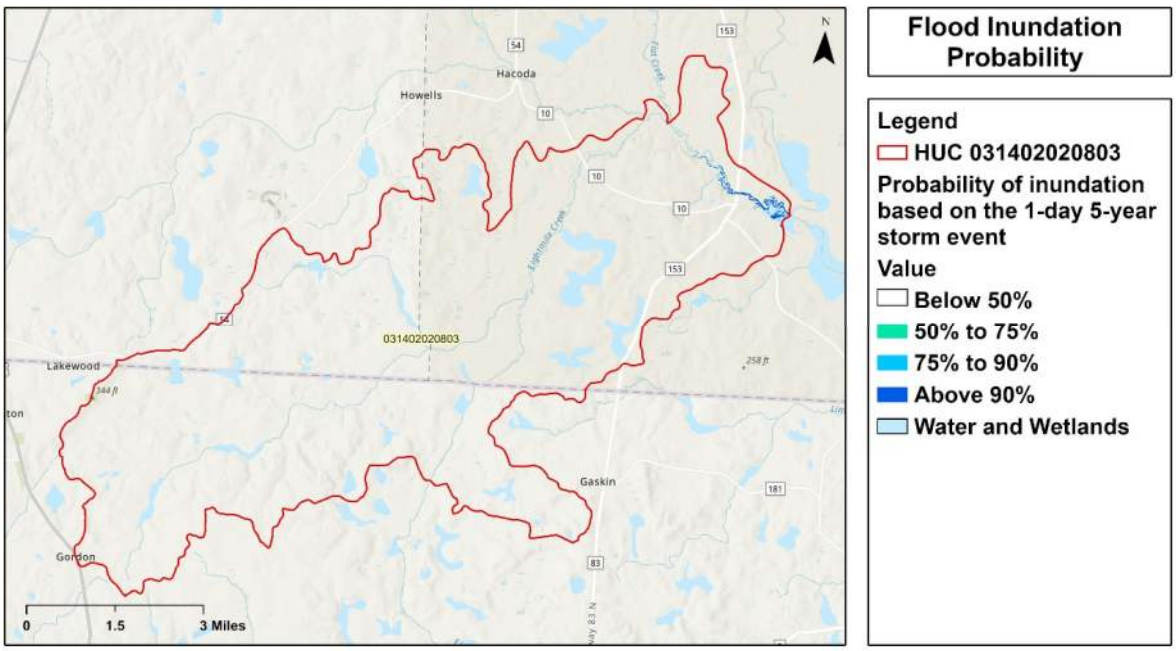

Figure 34. 1-day 5-year storm event for HUC 031402020803 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older,

poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service,	3

	Electric Repair, Laundries, Laundromats	
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6

48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4

79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031402020803 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (Figure 35) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 36) overlays critical facilities onto the 1-day

100-year storm event scenario. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

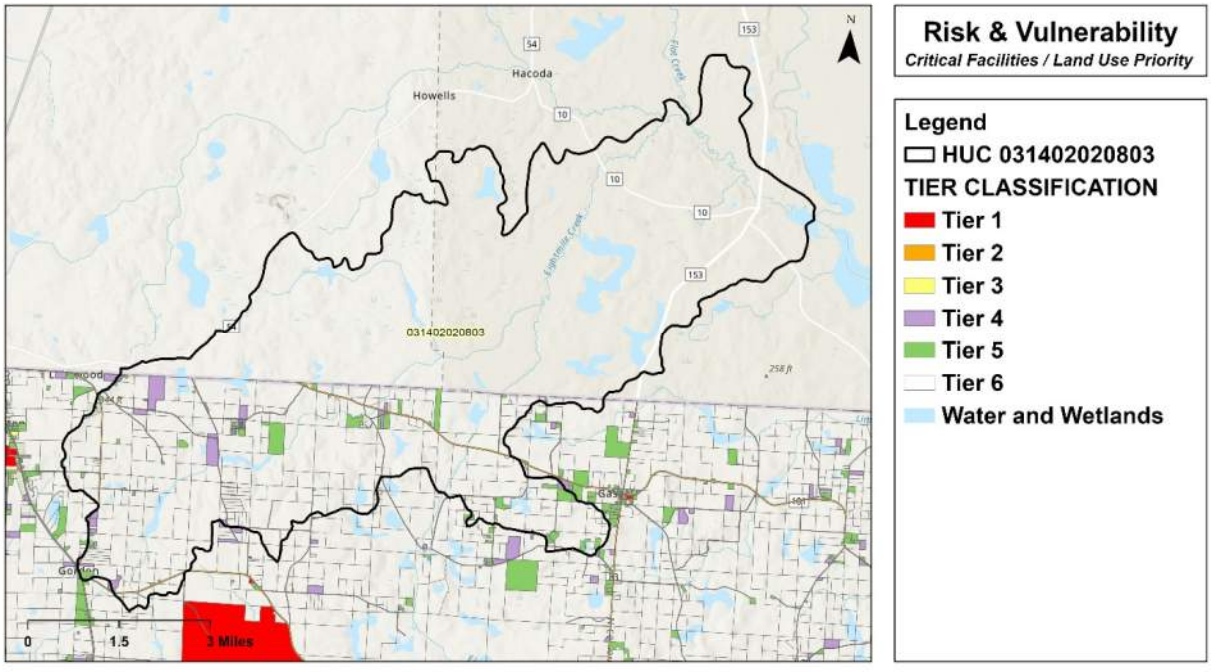

Figure 35. HUC 031402020803 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

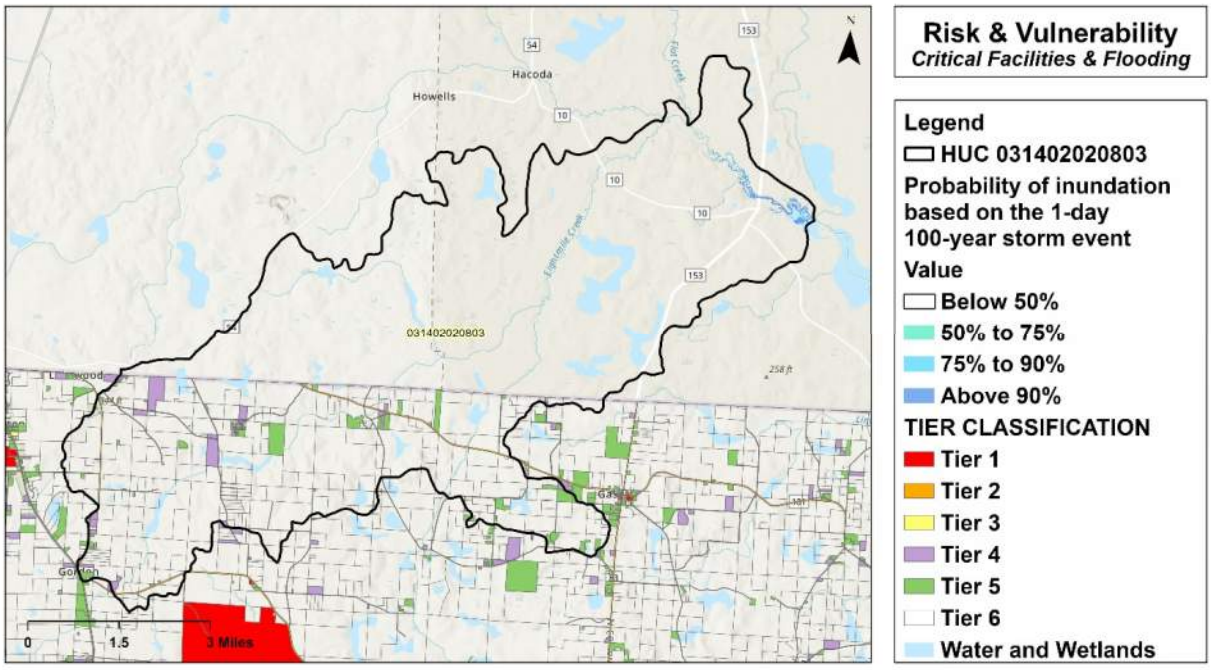

Figure 36. HUC 031402020803 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

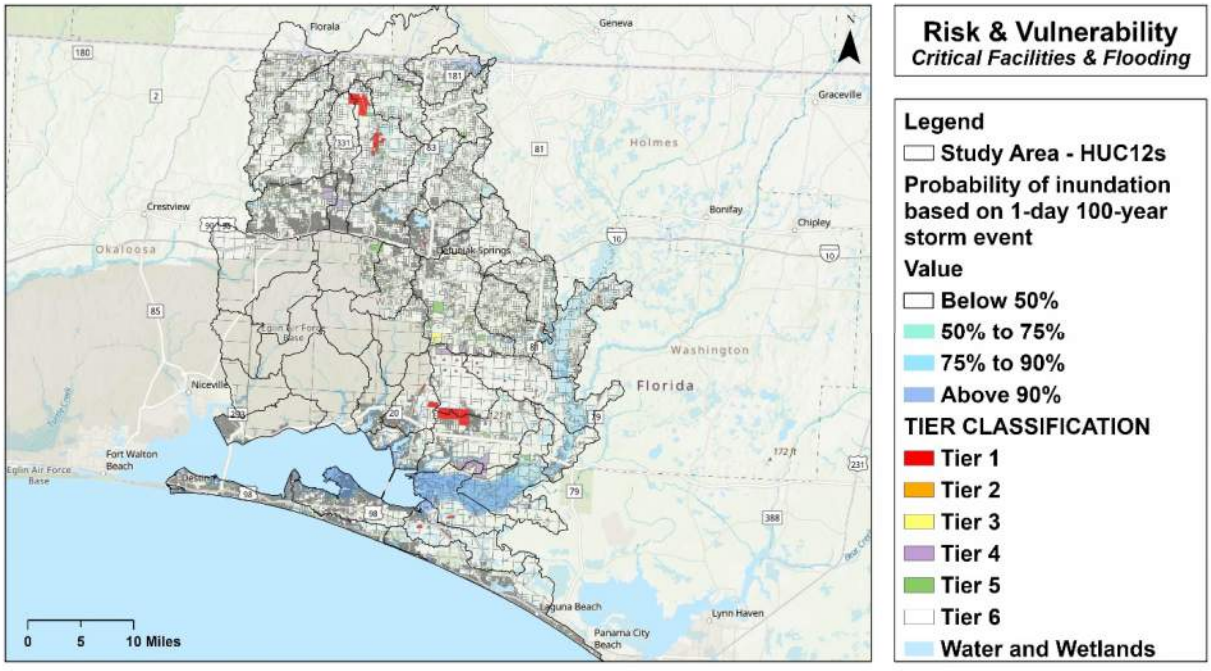

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

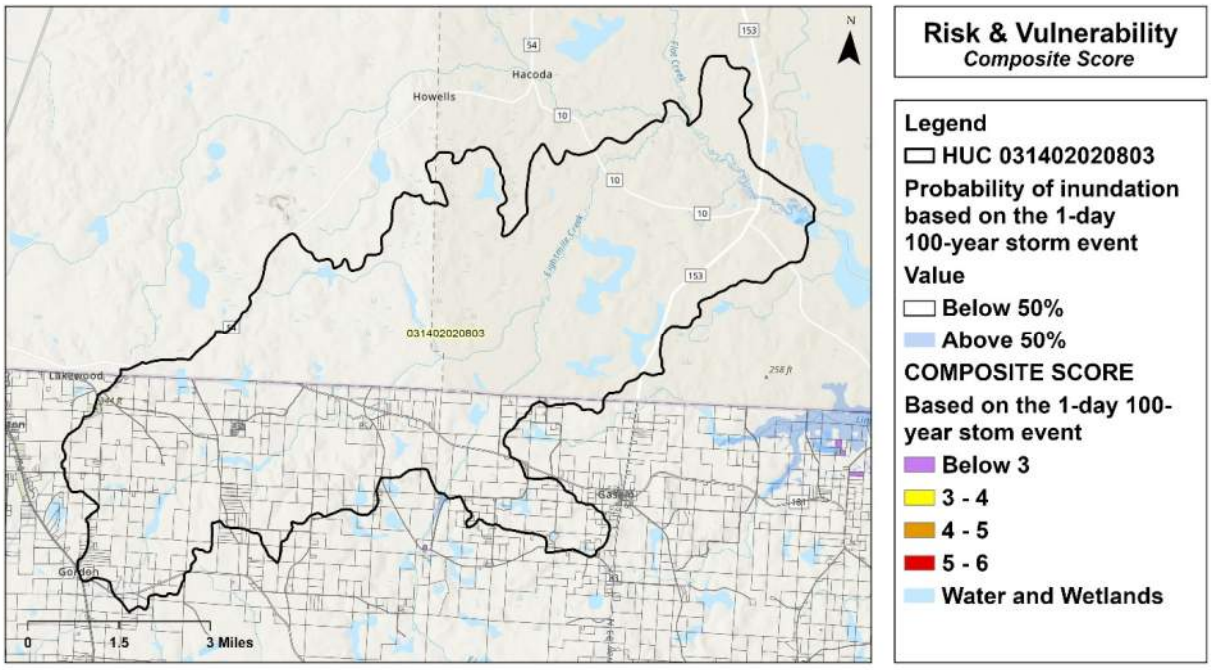

Figure 38. HUC 031402020803 sub-watershed Composite Score Risk map, with calculation based on 1-day 100-year storm event. Processed by FAU.

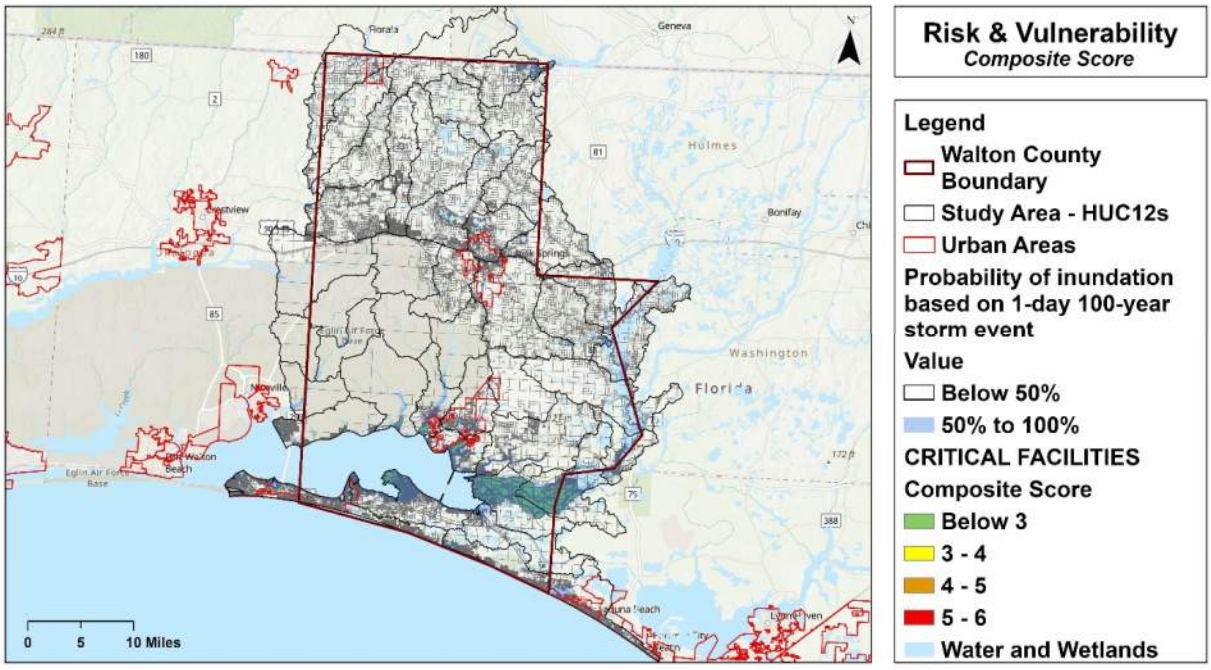

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031402020803. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It is important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031402020803. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031402020803	30870.63
All of the 1-day 100-year storm event inundation	**97.63**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	97.63
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	97.63

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

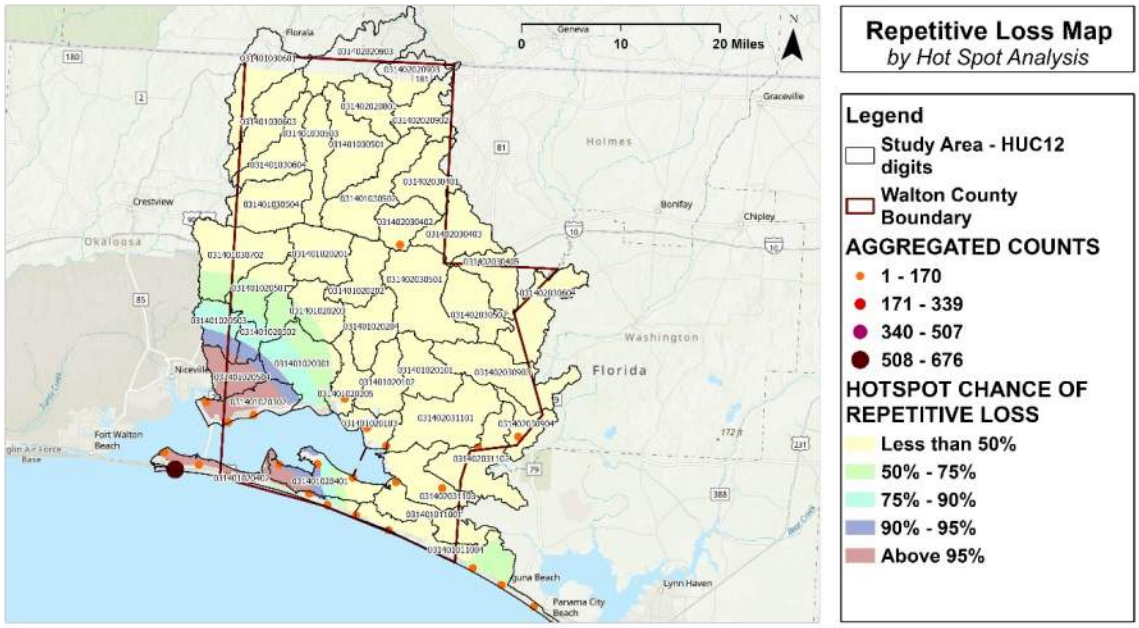

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5 Priority Projects

Although there are a few parcels falling within classification tier 4 and 5 of priority of land uses, none of them are within the flooding zone, which is outside Florida's boundary. Consequently, when considering the composite score, it is notable that the results are null, indicating no priority for intervention within the Florida's side of the basin.

It is also important to mention that a good portion of the basin has not been included in the priority land use analysis and, consequently, in the composite score calculation. This omission is due to the project's reliance on land use data solely from Florida, and the basin has a portion on Alabama as well. The categories of land use maps in Alabama would be different, making it impossible to match the data from two different databases in different states. As a result, there is a slight

possibility that there may be priority projects on the Alabama side of the basin of which we are not aware.

APPENDIX AD

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031402020902

CHESTNUT CREEK

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 (031402020902) is highlighted among all the HUCs to help identifying its location. (Figure 3).

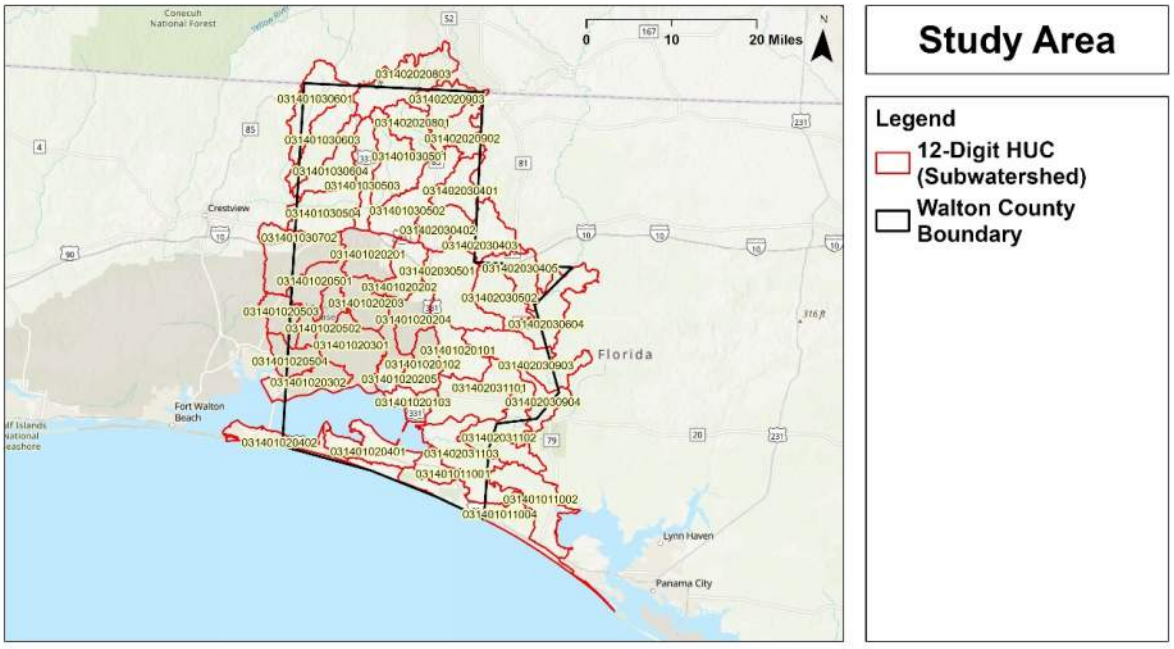

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

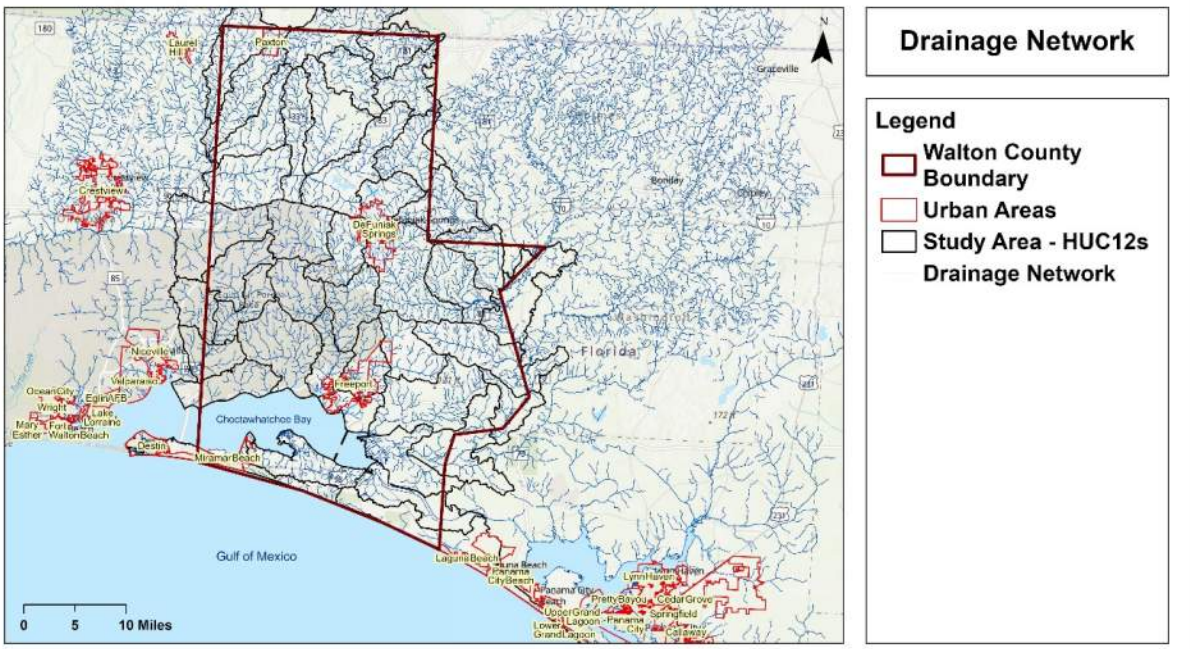

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

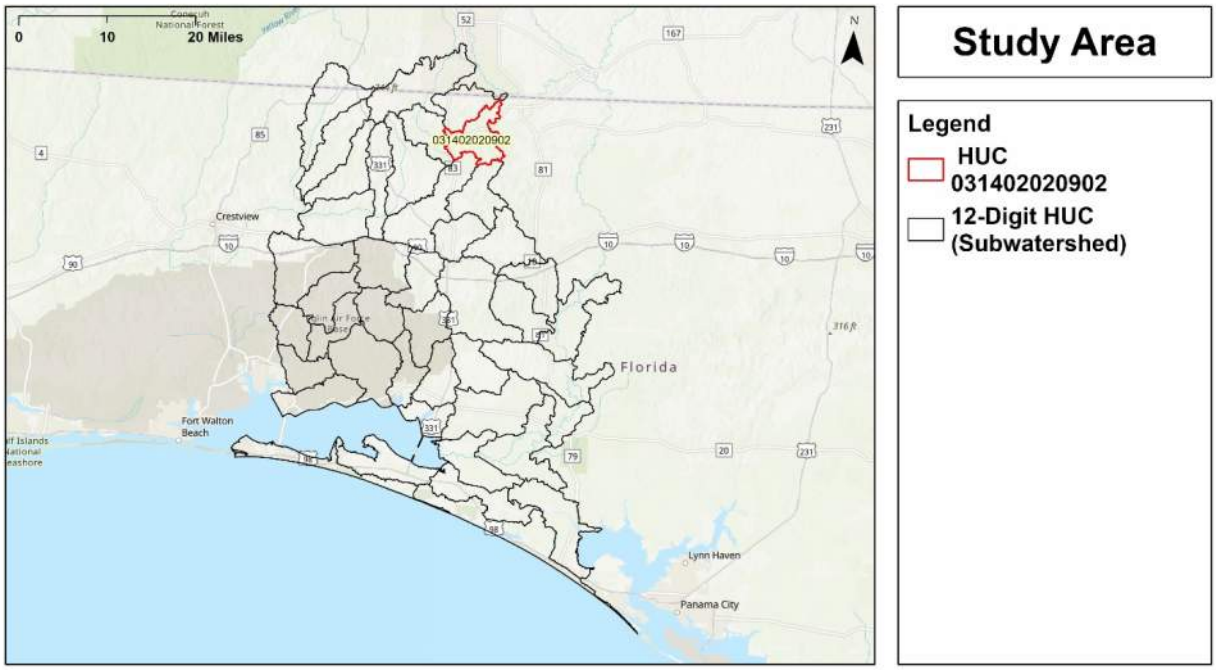

Figure 3. HUC 031402020902 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed i in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

(Source Data: FEMA)

Figures 12 and 13 is the county-wide report show the current and projected land use for the County. Based on the 2017 future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land Use in Walton County (Prepared by FAU from future land use map) versus land use in the entire watershed

Level 1 Land Use-Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

(Source Data: NWFWMD, 2017)

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 1.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.

April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads. Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

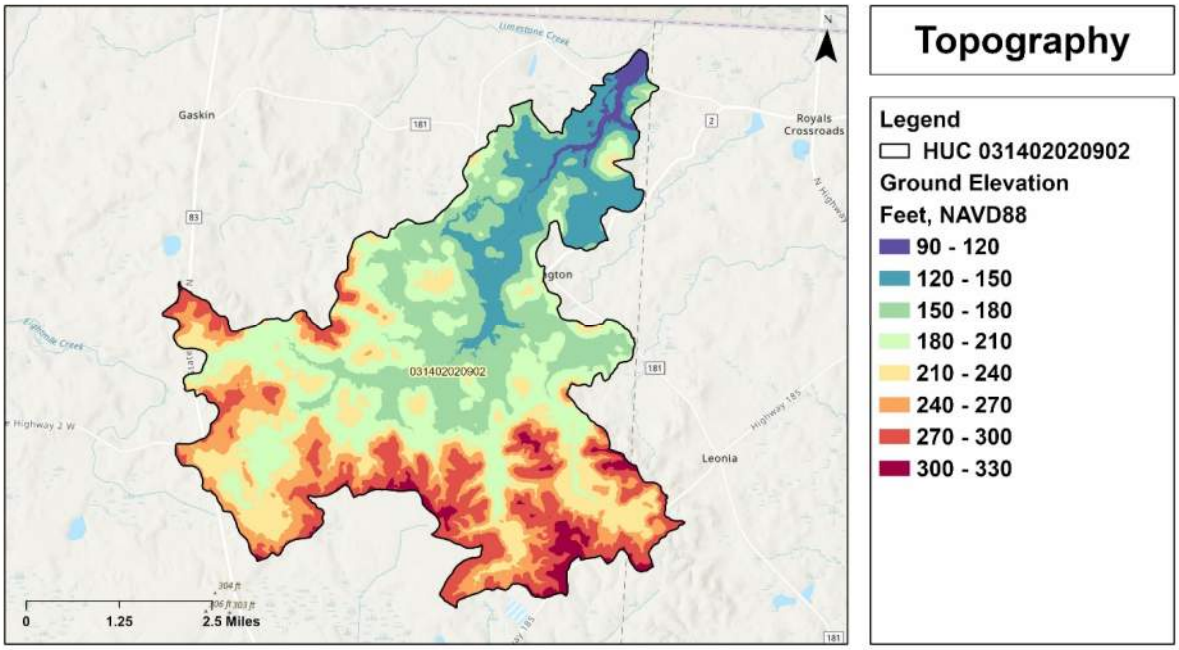

Figure 4. Topographic map of the HUC 031402020902 sub-watershed, processed by FAU

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031402020902 sub-watershed is shown in Figure 5.

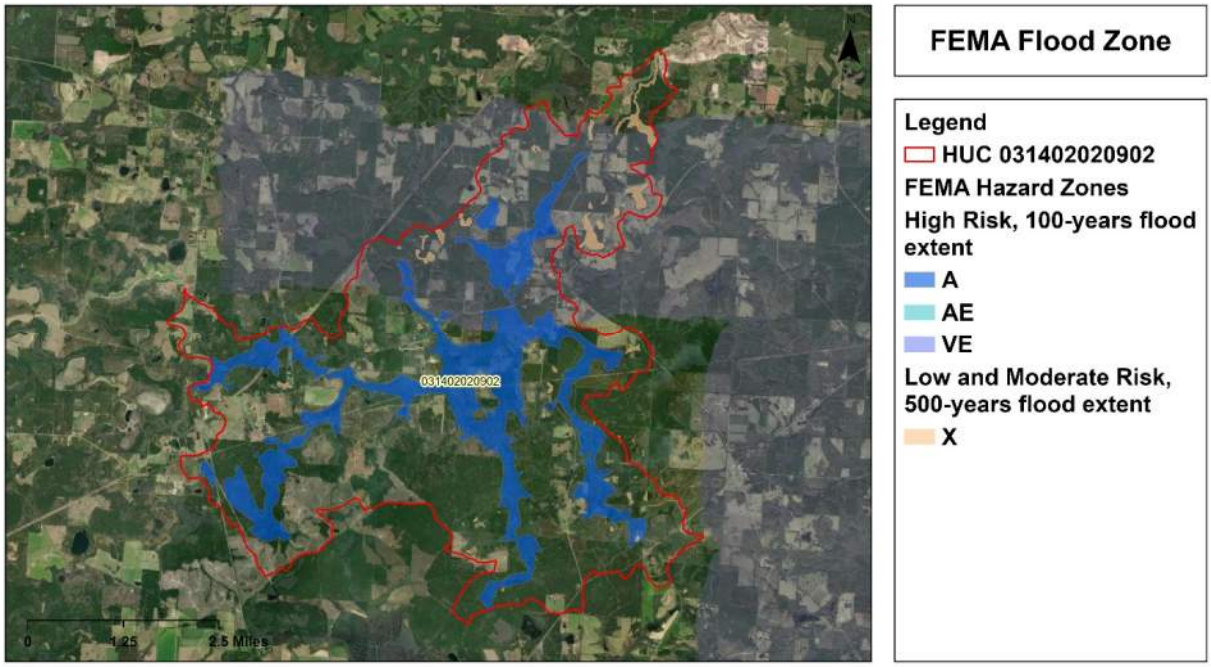

Figure 5. FEMA Flood Zone map (2020) for HUC 031402020902 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031402020902 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including

various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

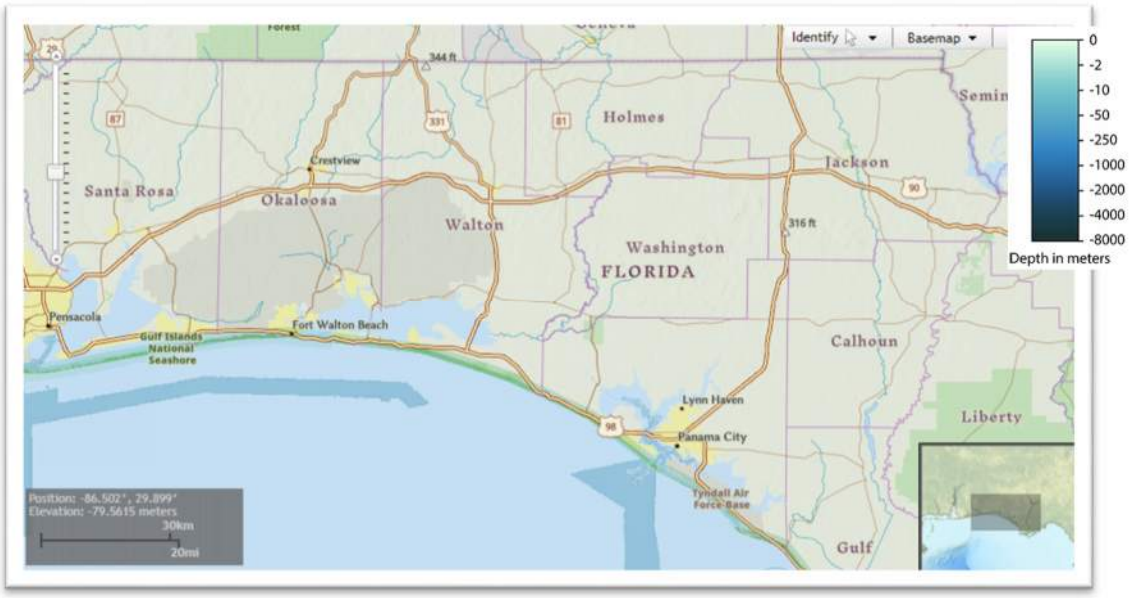

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle. Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

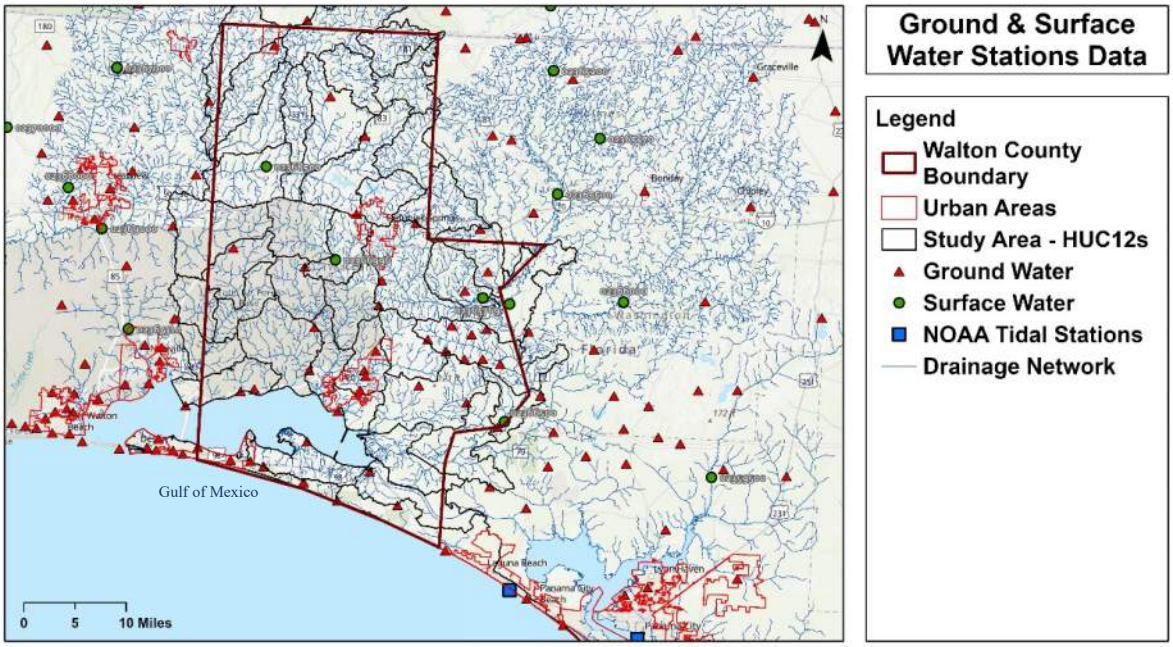

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031402020902 lacks major rivers and canals, instead featuring a network of well-branched creeks without specific names. These creeks originate in Alabama and flow in different directions though the basin.

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02368500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031402020902, which is USGS 02368500 Shoal River.

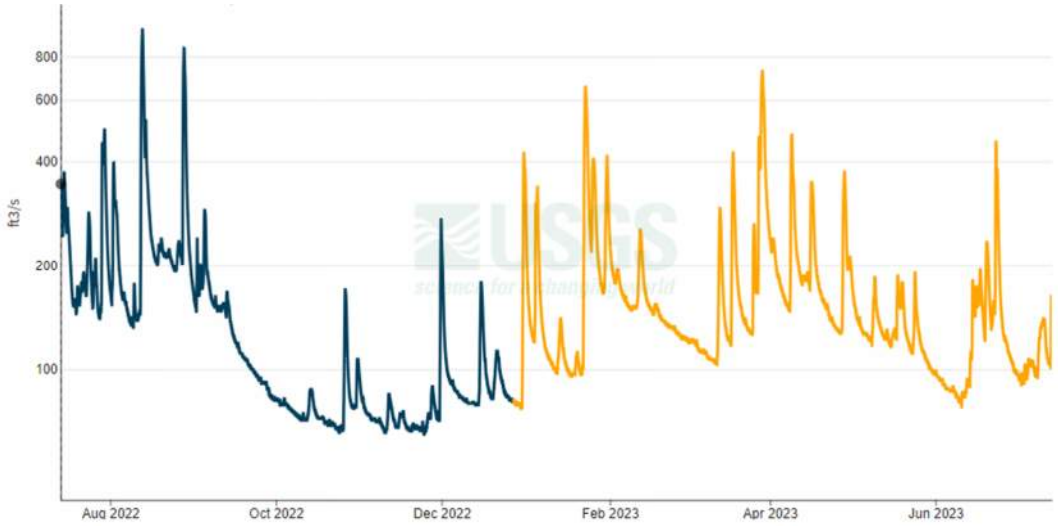

Figure 8. Average streamflow for Shoal River NR Mossy Head, Fla (USGS 02368500 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02368500/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data is obtained from the SFWMD DBHYDRO site for surface waters (https://www.sfwmd.gov/science-data/dbhydro) and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031402020902 and points out the location of the ground water station in the surroundings. A groundwater-surface layer for the HUC 031402020902 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

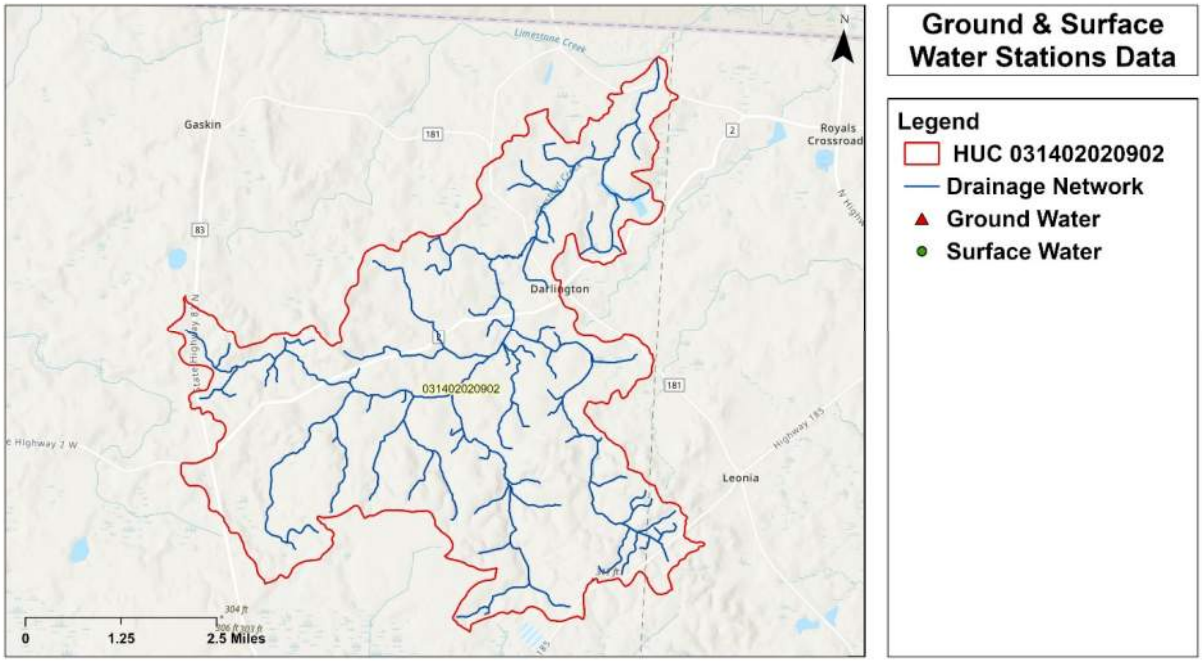

Figure 9. Ground and Surface Water Stations in the HUC 031402020902 sub-watershed, processed by FAU.

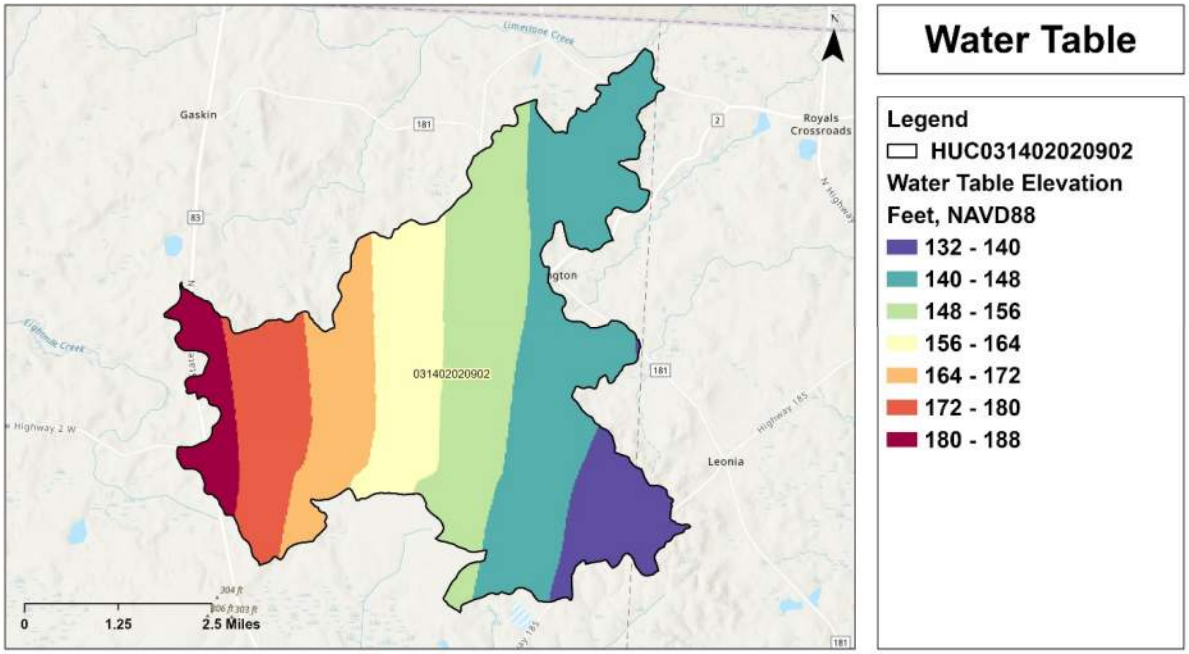

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031402020902 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the average precipitation over Walton County for every month of the year between 2011 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches for the entire county.

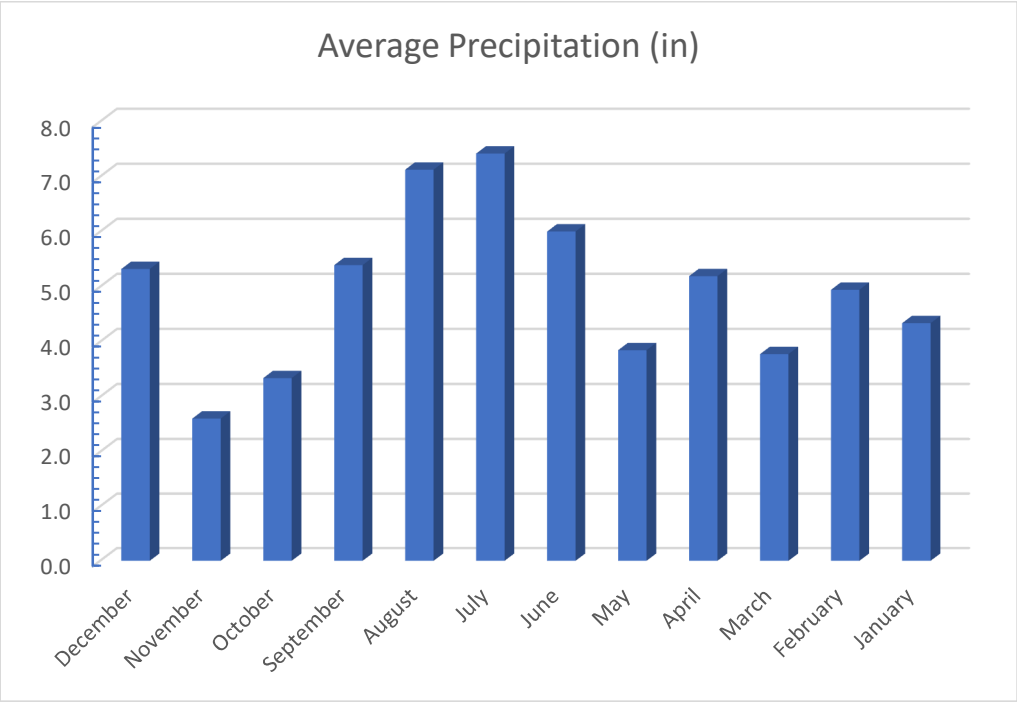

Figure 11. Monthly precipitation in Walton County, FL (2011-2023).
(Data Source: Florida Weather Data, available at https://data.usatoday.com/weather-data/walton-county/12131/1975-04-01/Table/)

While the topography (Section 1.1) and native soil (Section 1.4)create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as

opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. Figure 12 shows the two closest tide stations to Walton County. Since there is none NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

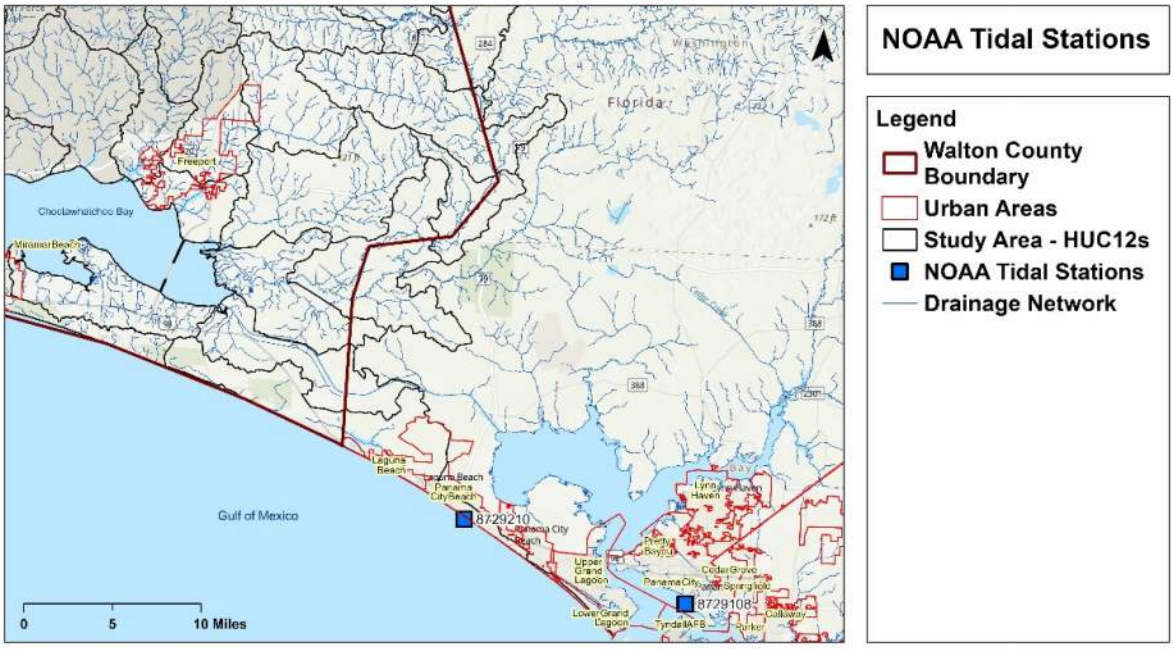

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

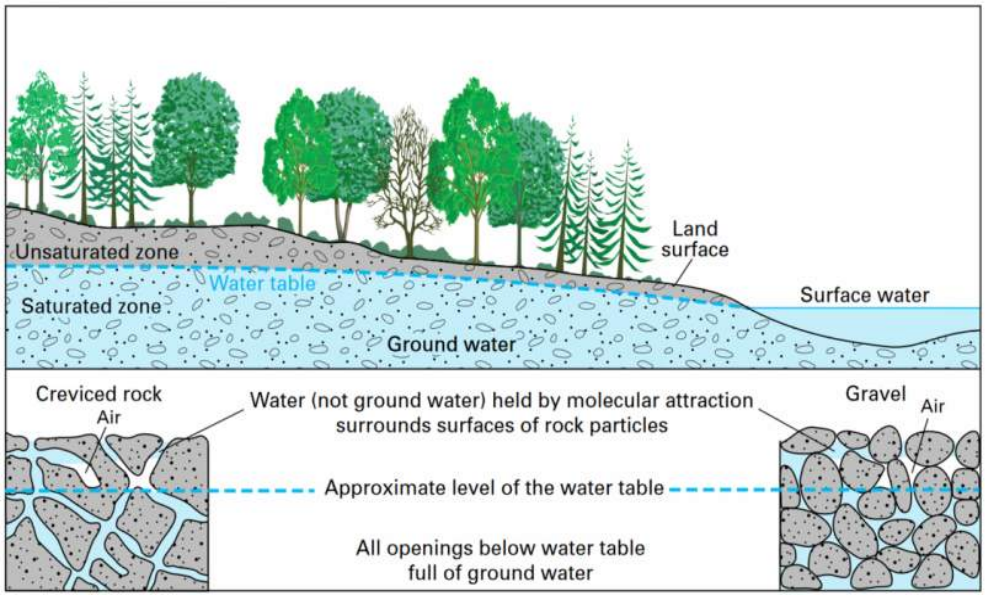

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in Figure 14. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

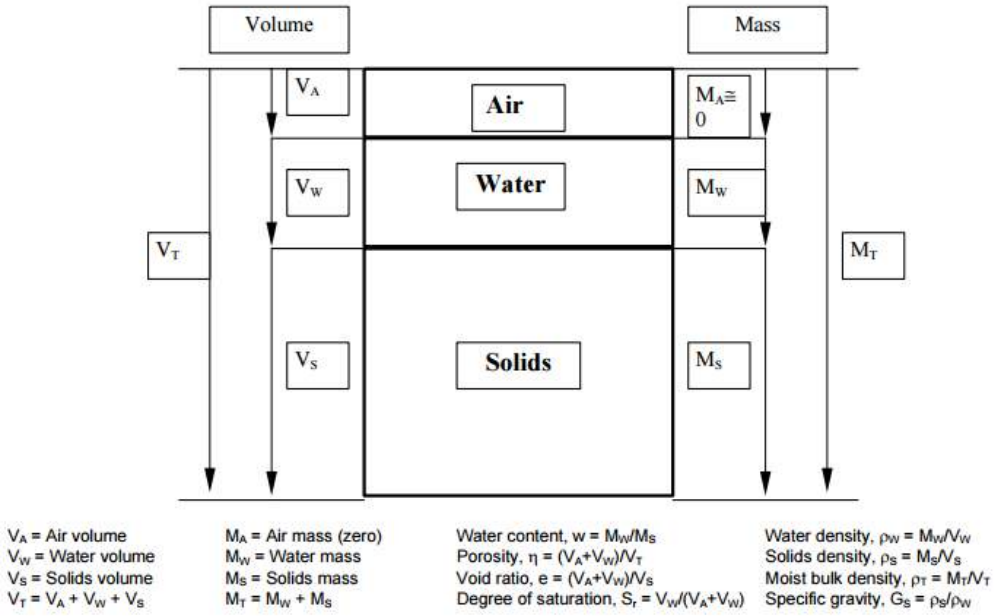

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

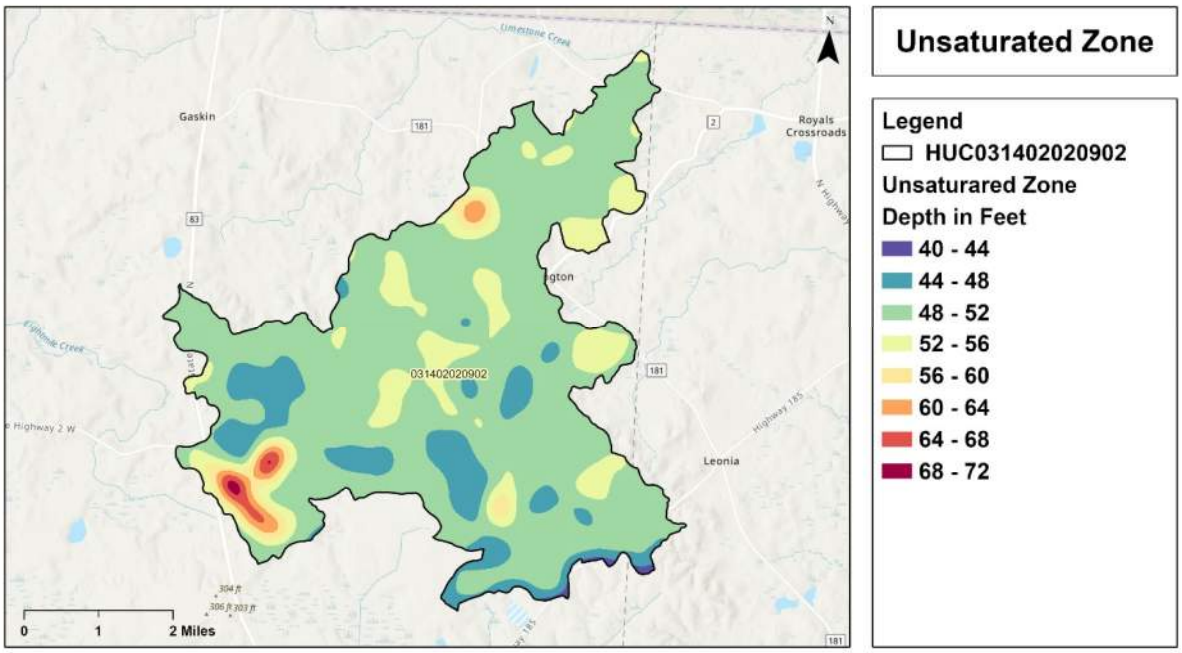

Figure 15. Unsaturated zone map for HUC 031402020902, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. The entire basin exhibits a favorable soil storage capacity, ranging between 40 to 72 inches of remaining capacity.

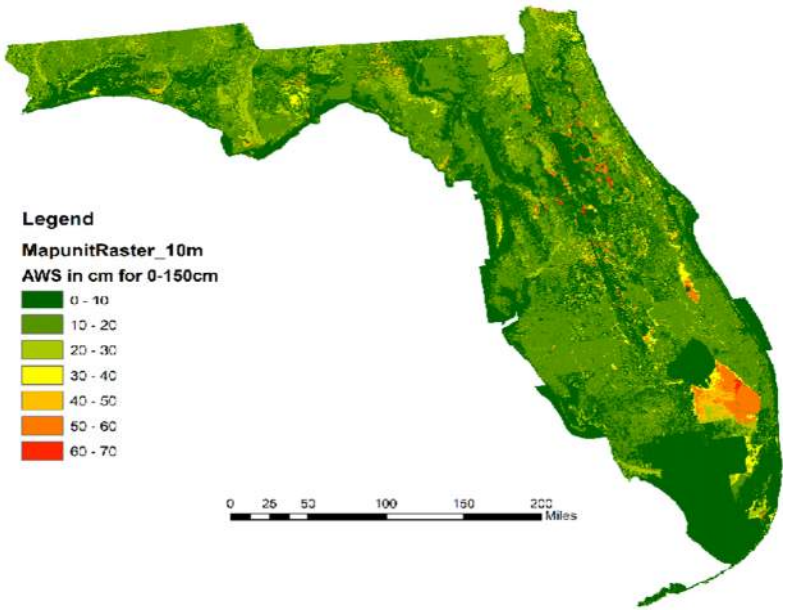

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

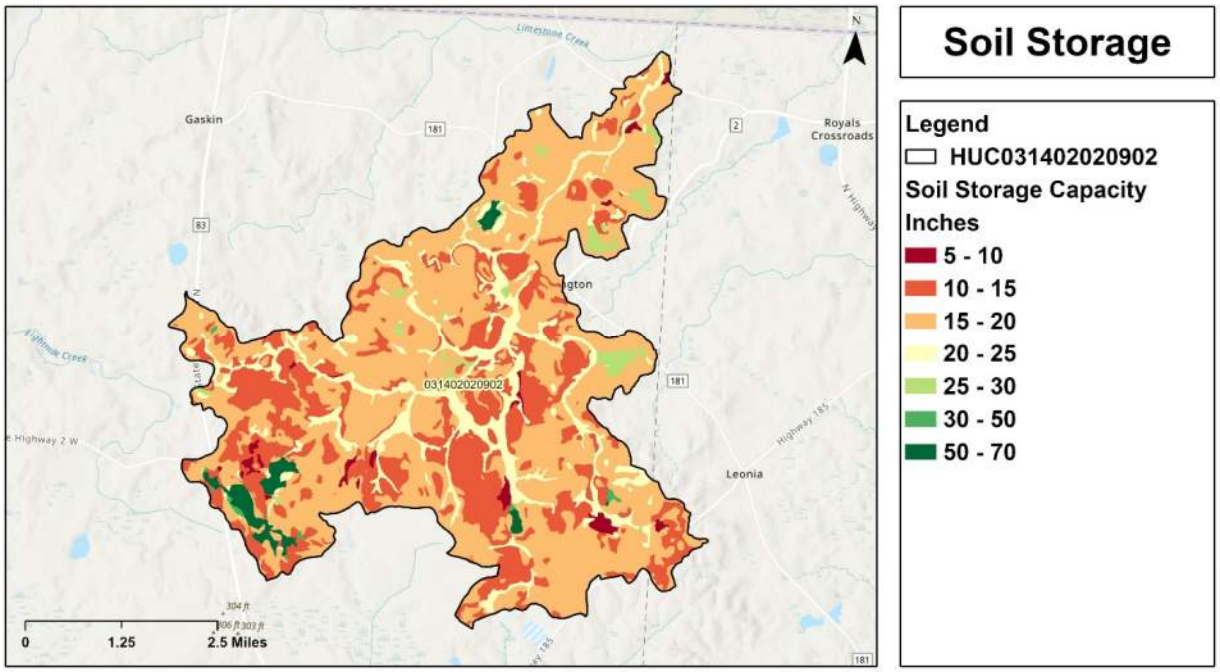

Figure 17. Water storage capacity of soil for the HUC 031402020902, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

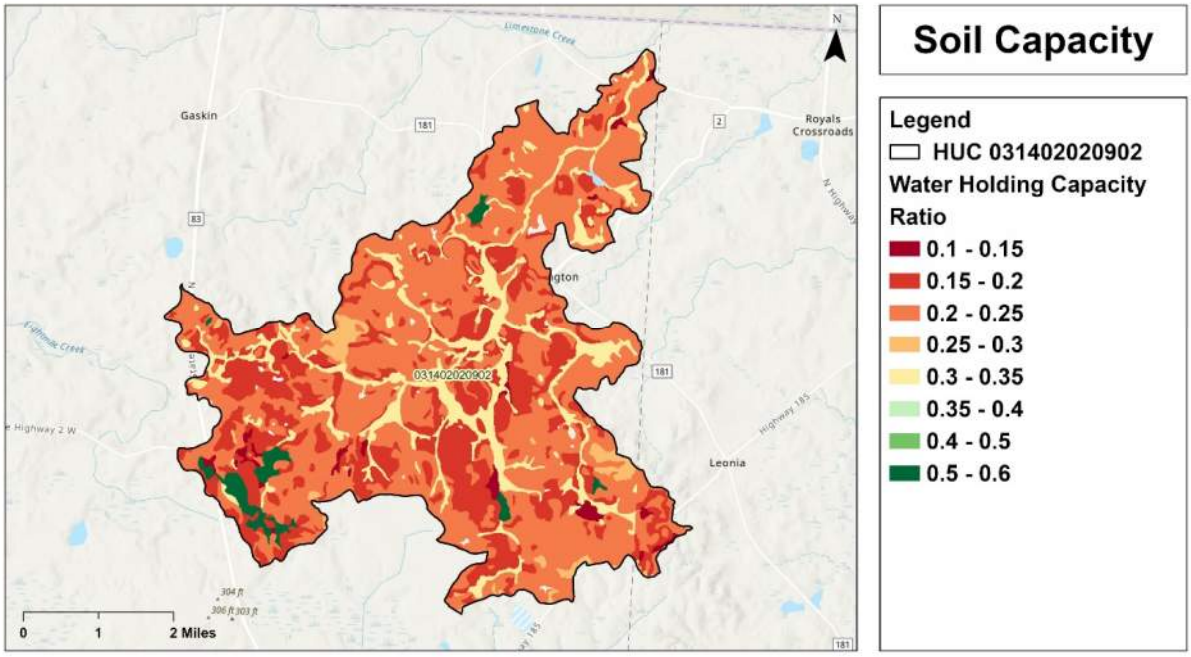

Figure 18.Water Holding Capacity (ratio) for the HUC 031402020902, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

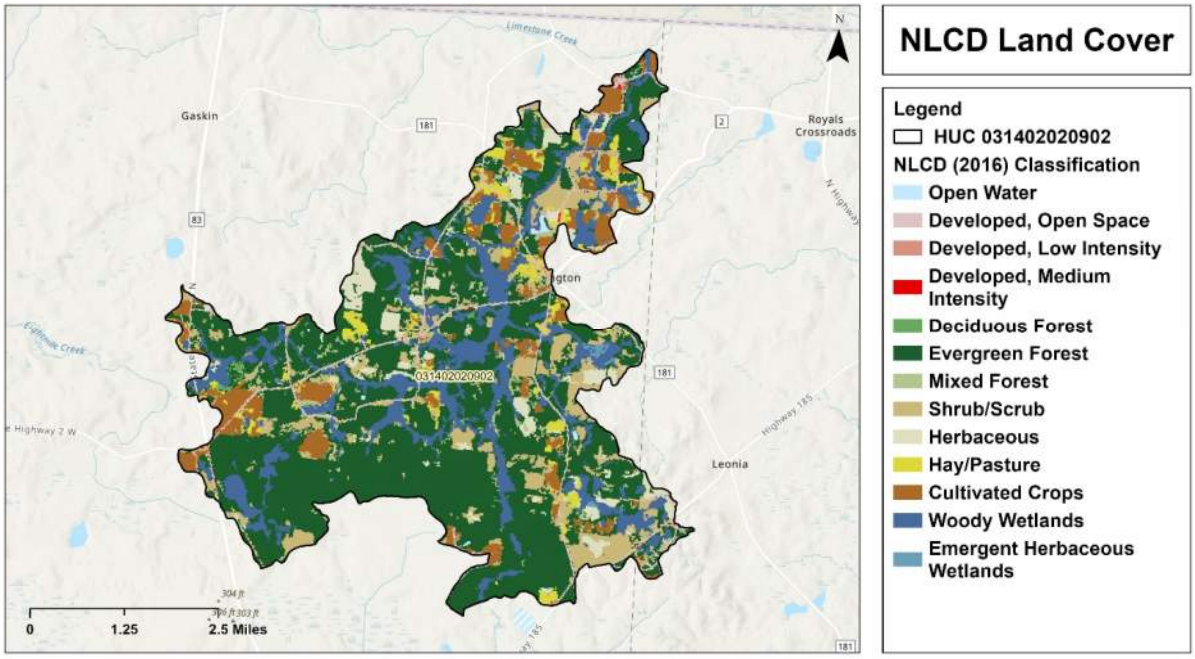

Figure 19. Land use in the HUC 031402020902 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD 2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

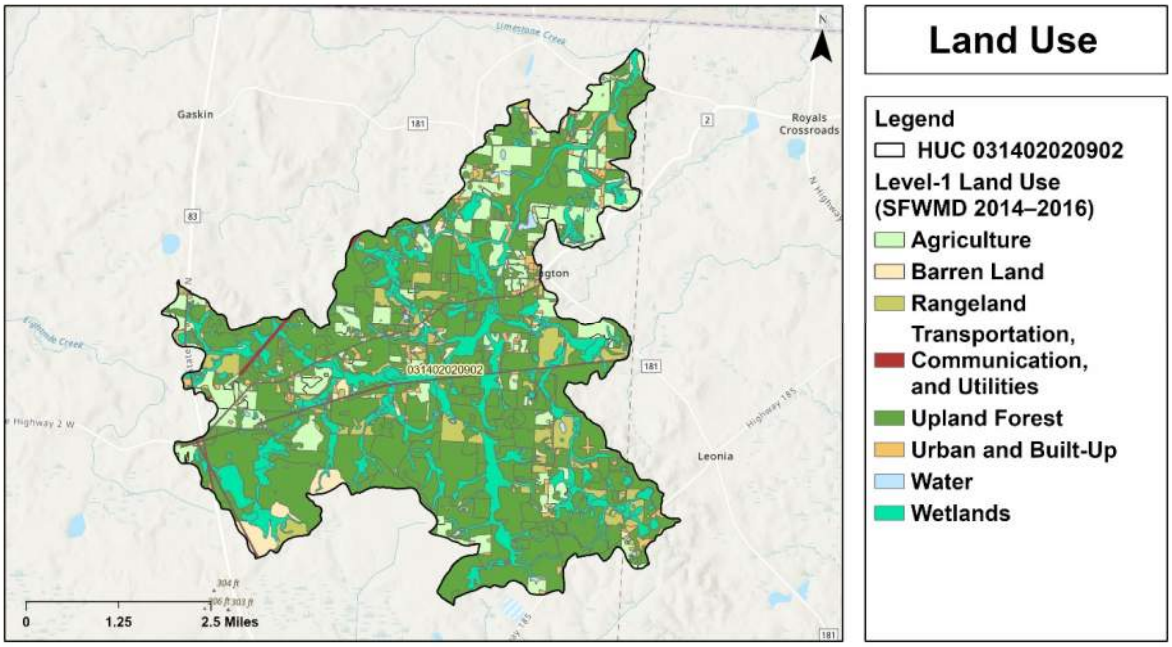

Figure 20. Land use in the HUC 031402020902 (from the 2023 Florida Geographic Data Library (FGDL) database), processed by FAU.

In the HUC 031402020902 sub-watershed, the predominant land cover is upland forest, accounting for 52.93% of the area. Wetlands comes in second at 13.70%, followed by Transportation, Communication, and Utilities at 12.87%, and agriculture at 11.11%. Developed land constitutes a minor portion, with only 1.99% categorized as urban and built-up, as indicated in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031402020902 subwatershed

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	2566.45	11.11%
Barren Land	532.15	2.30%
Rangeland	1081.55	4.68%
Transportation, Communication, and Utilities	2972.31	12.87%
Upland Forest	12227.29	52.93%
Urban and Built-Up	460.71	1.99%
Water	96.64	0.42%
Wetlands	3164.76	13.70%
Grand Total:	**23101.87**	**100.00%**

(Source Data: 2023 Florida Geographic Data Library (FGDL) database))

Table 4. Roughness and CN Values for Each Land Use Code

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

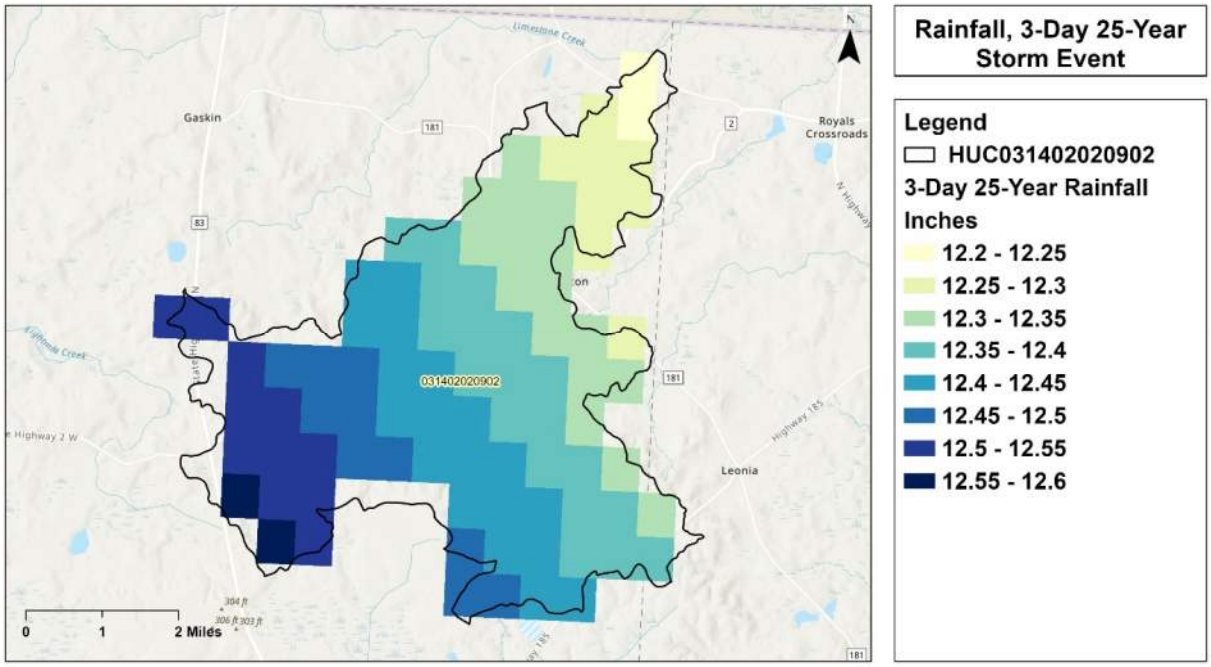

Figure 21. Rainfall distribution map across HUC 031402020902 sub-watershed, for 3-day 25-year storm event, processed by FAU.

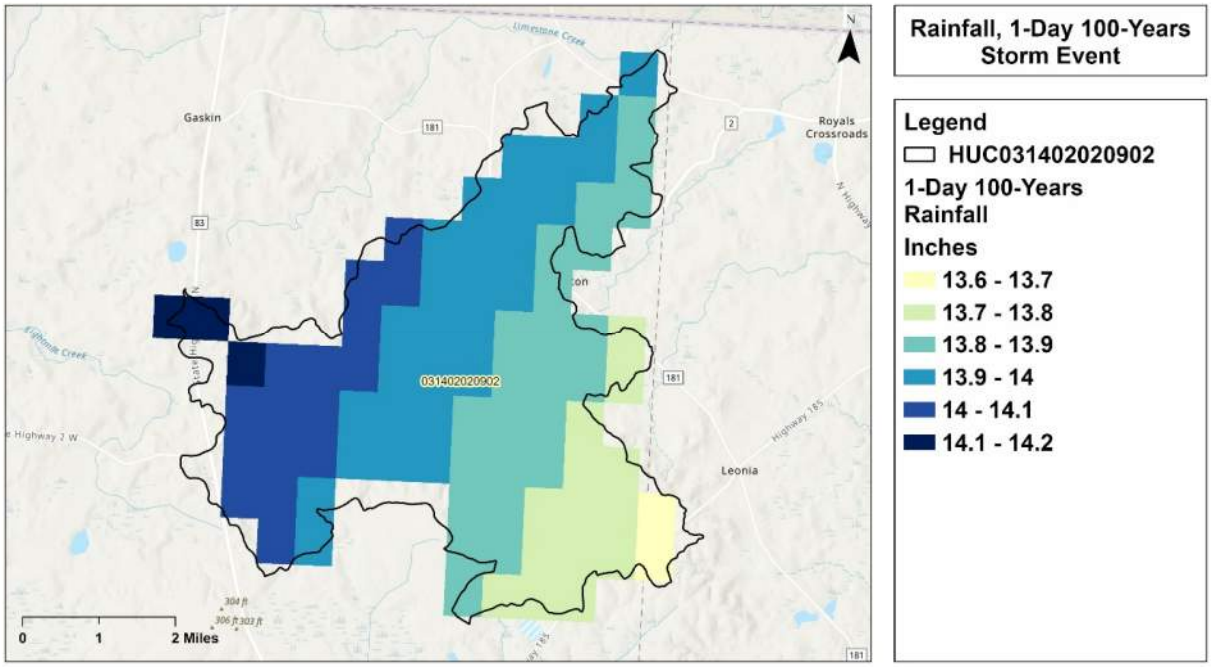

Figure 22. Rainfall distribution map across HUC 031402020902 sub-watershed, for 1-day 100-year storm event, processed by FAU.

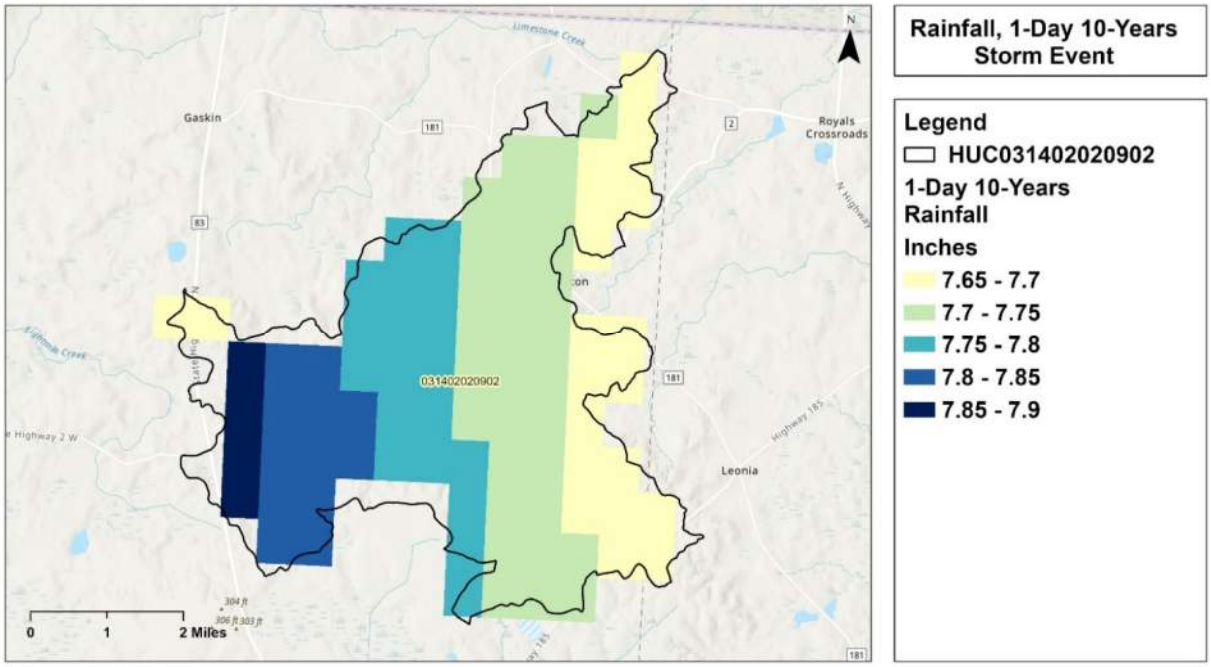

Figure 23. Rainfall distribution map across HUC 031402020902 sub-watershed, for 1-day 10-year storm event, processed by FAU.

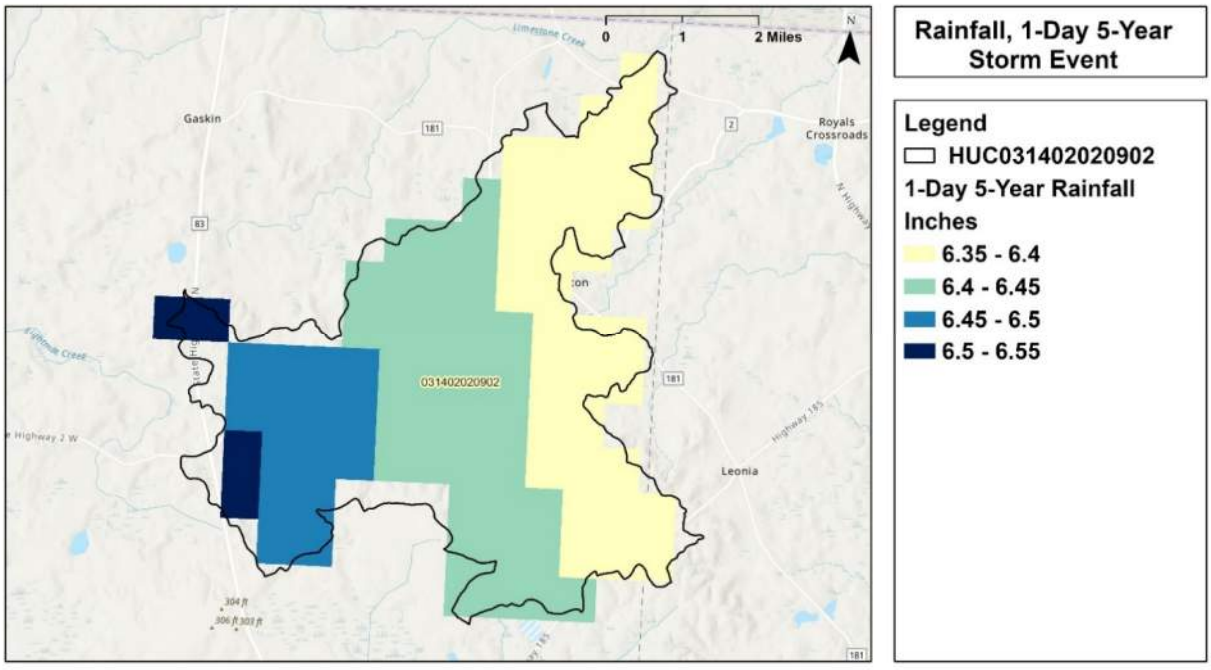

Figure 24. Rainfall distribution map across HUC 031402020902 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

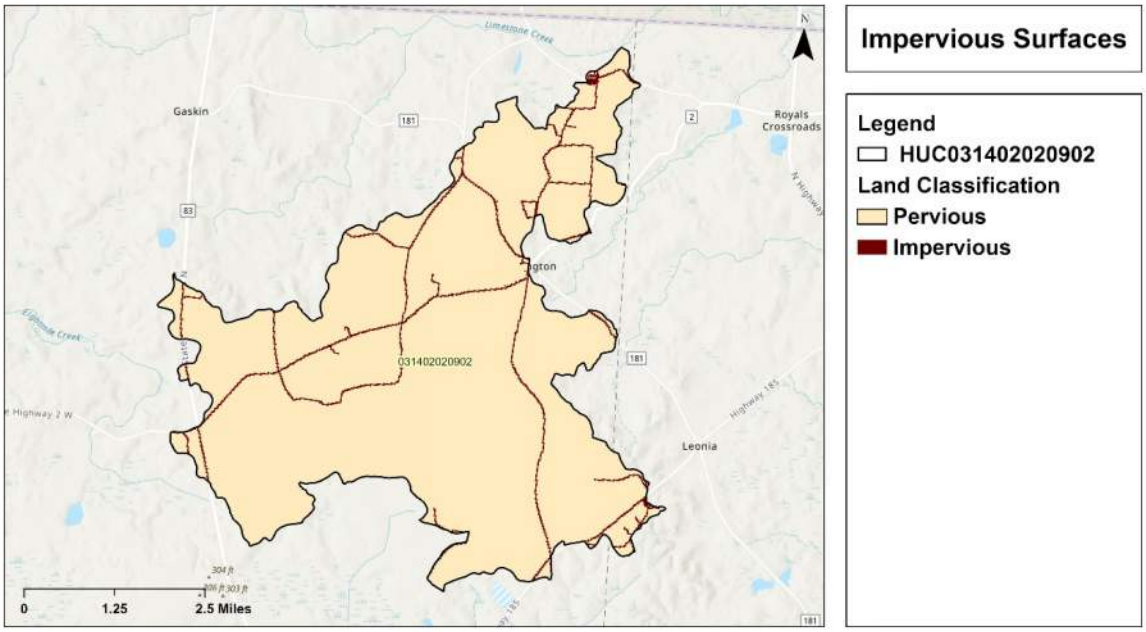

Figure 25. Impervious area map for the HUC 031402020902 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

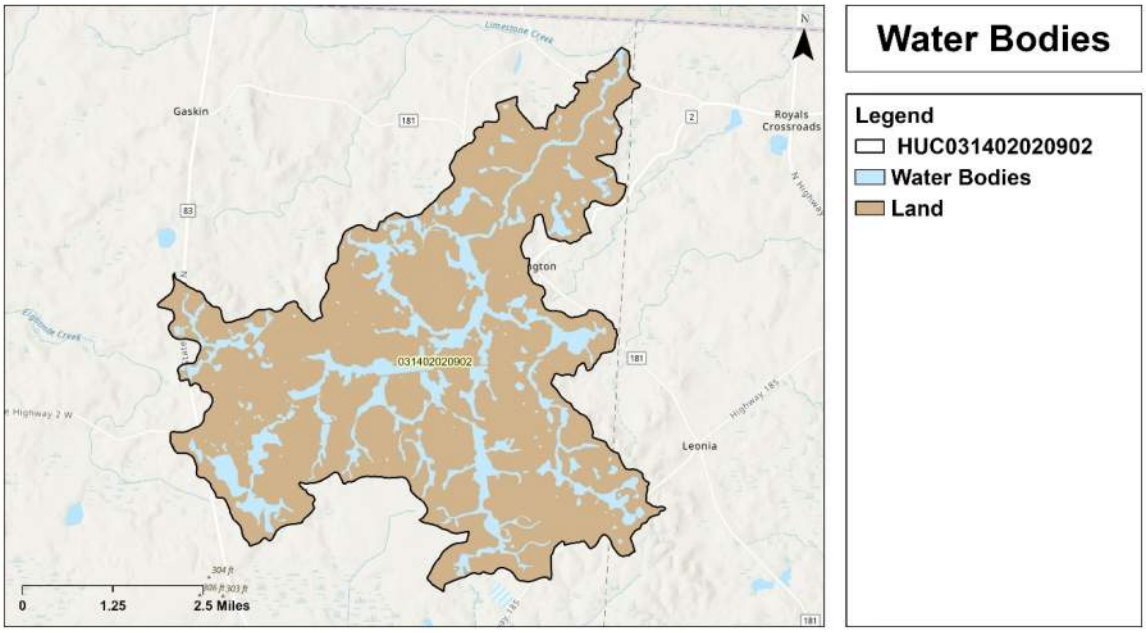

Figure 26. Water bodies map for the HUC 031402020902 sub-watershed, processed by FAU.

1.10. Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

(Source: US Census Bureau 2020, and Zip-codes.com)

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.

- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

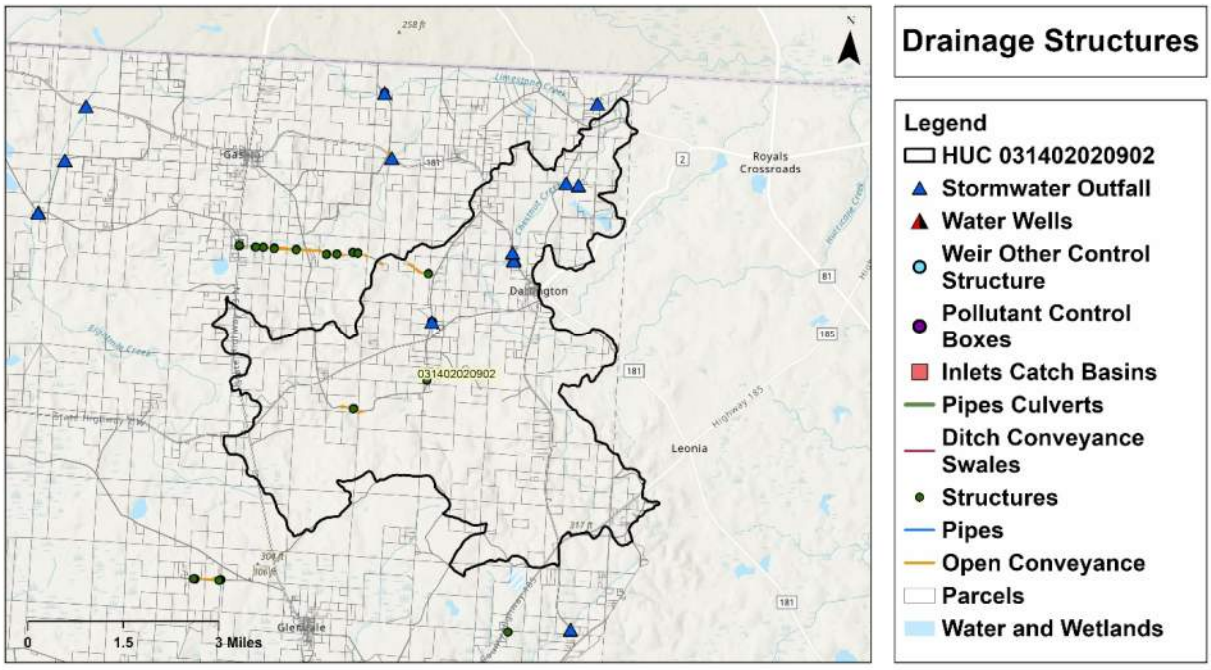

Figure 27. Stormwater Infrastructure for the HUC 031402020902. Processed by FAU.

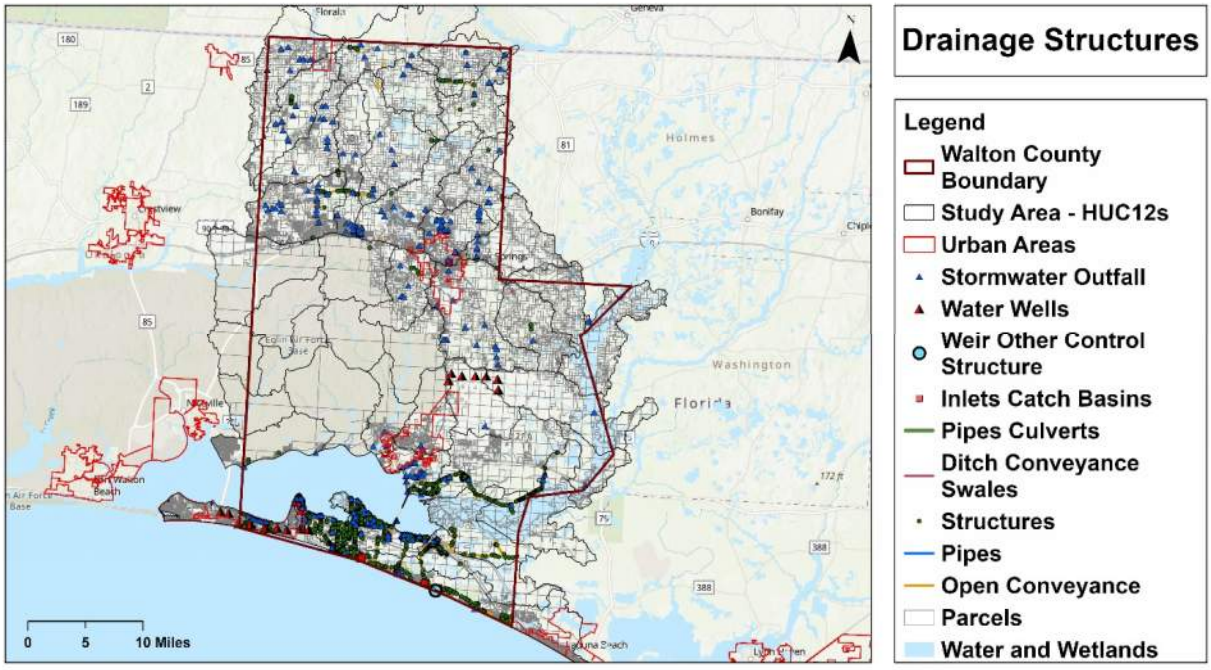

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020)

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapter 1, an analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031402020902 sub-watershed flood response to a series of rainfall events (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.3.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species

while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD DBHYDRO website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

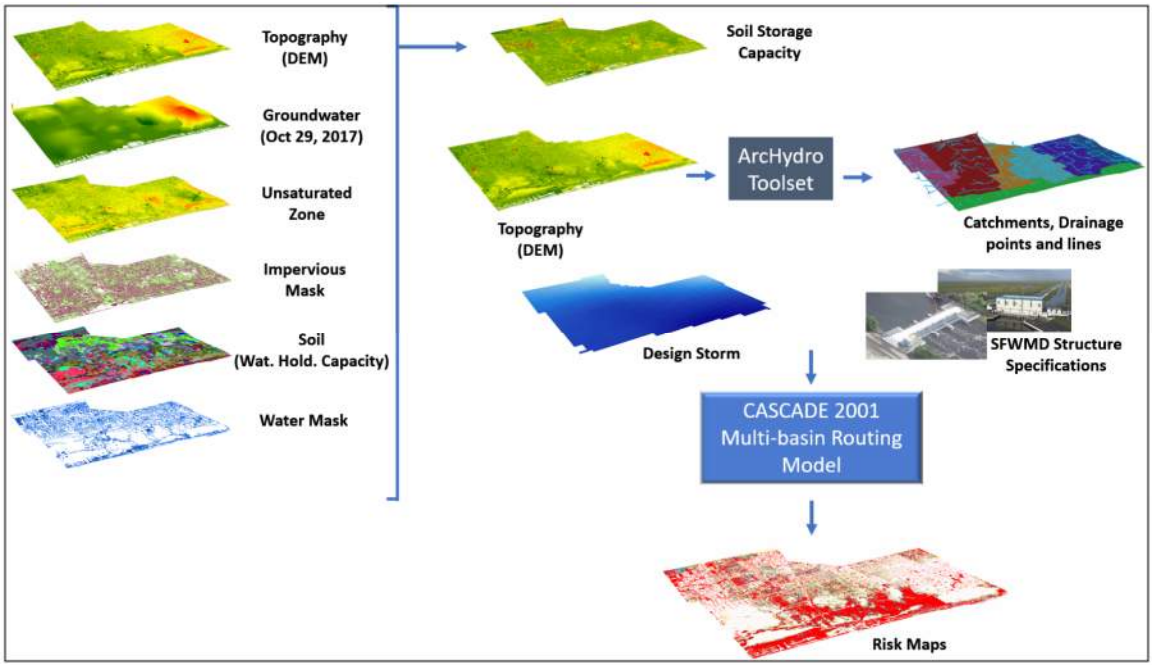

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are

critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

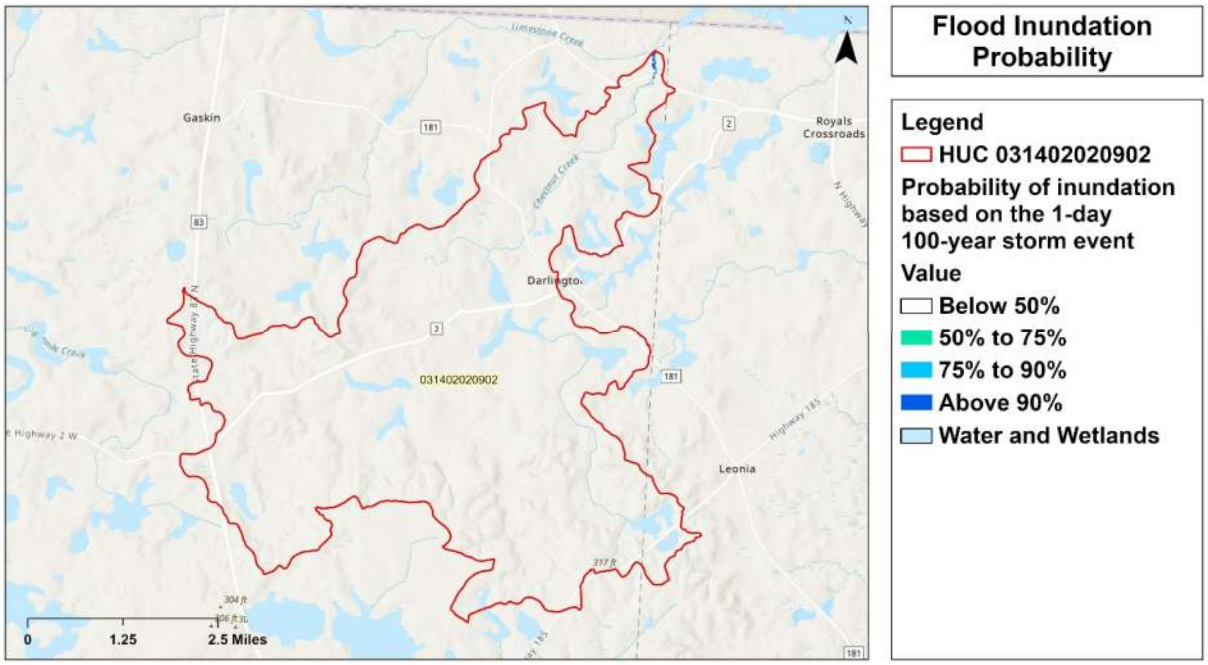

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031402020902, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate

the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 2.4 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not

eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a small portion of flooding, almost imperceptible, is noted at the creek entrance to the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, the HUC is expected to remain unaffected by sea level rise, therefore SLR scenarios were not computed.

The design storm simulation determined that approximately 0.07% of the HUC total area or 0.02 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 0.05% of the HUC's total area, or 0.01 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.03% of the HUC's total area, or 0.01 mi^2, would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0.03% of the HUC's total area, or 0.01 mi^2, would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031402020902 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	24.595	0.016	99.93%	0.07%
1-day 100-year	24.598	0.013	99.94%	0.05%
1-day 10-year	24.602	0.009	99.96%	0.03%
1-day 5-year	24.603	0.008	99.96%	0.03%

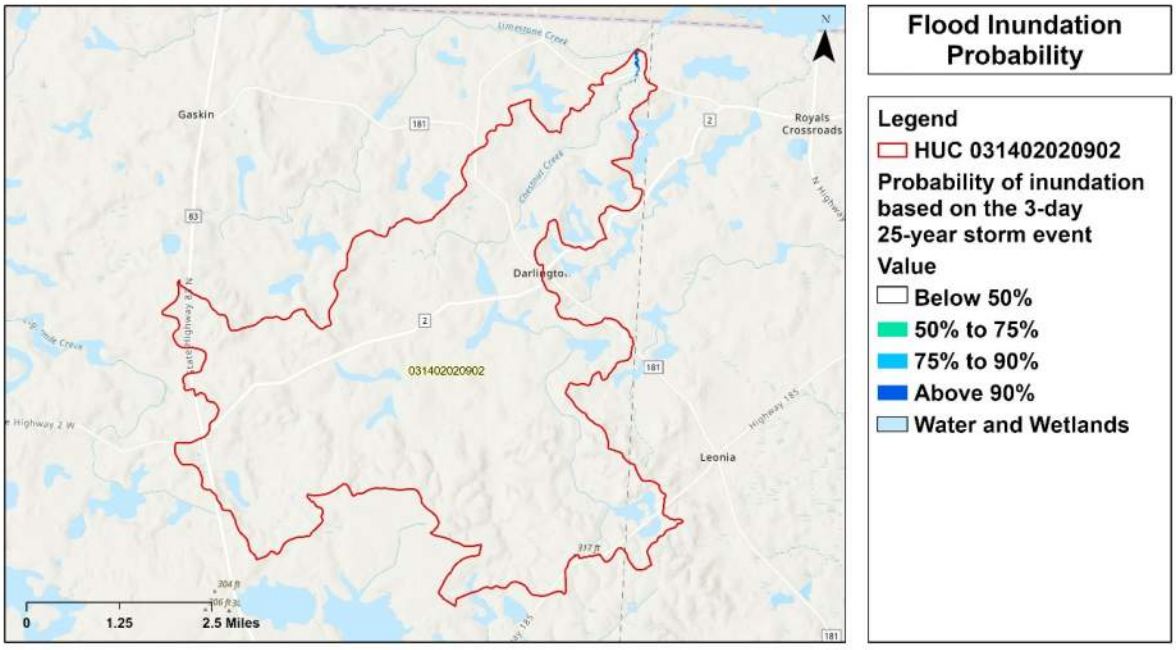

Figure 31. 3-day 25-year storm event for HUC 031402020902 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

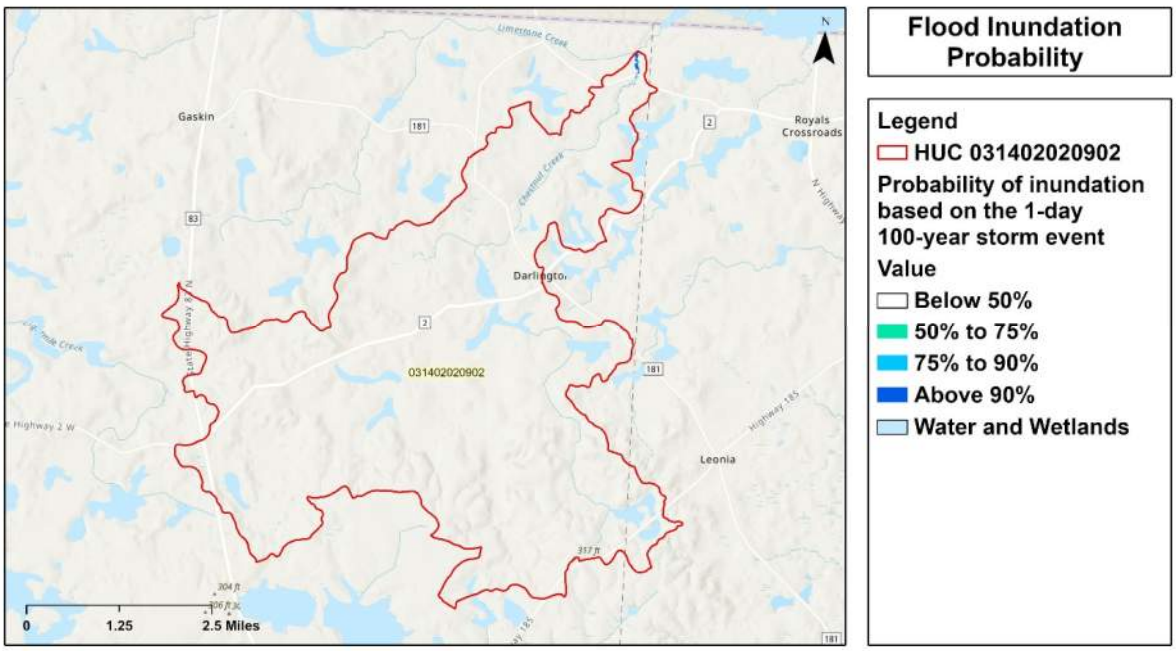

Figure 32. 1-day 100-year storm event for HUC 031402020902 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

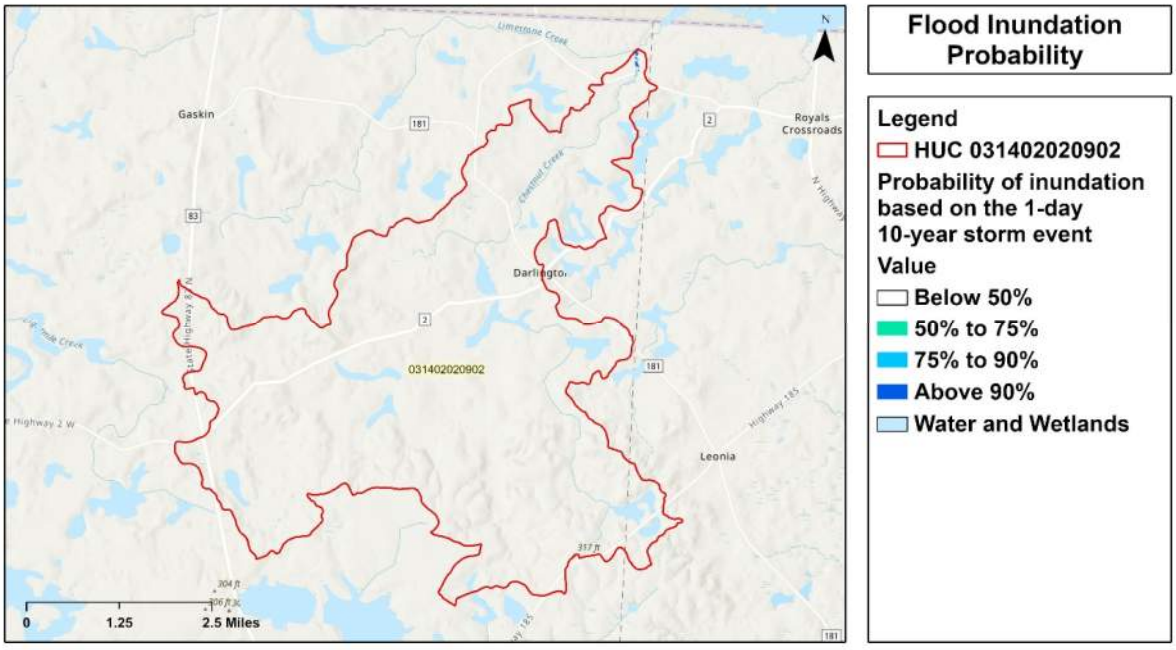

Figure 33. 1-day 10-year storm event for HUC 031402020902 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

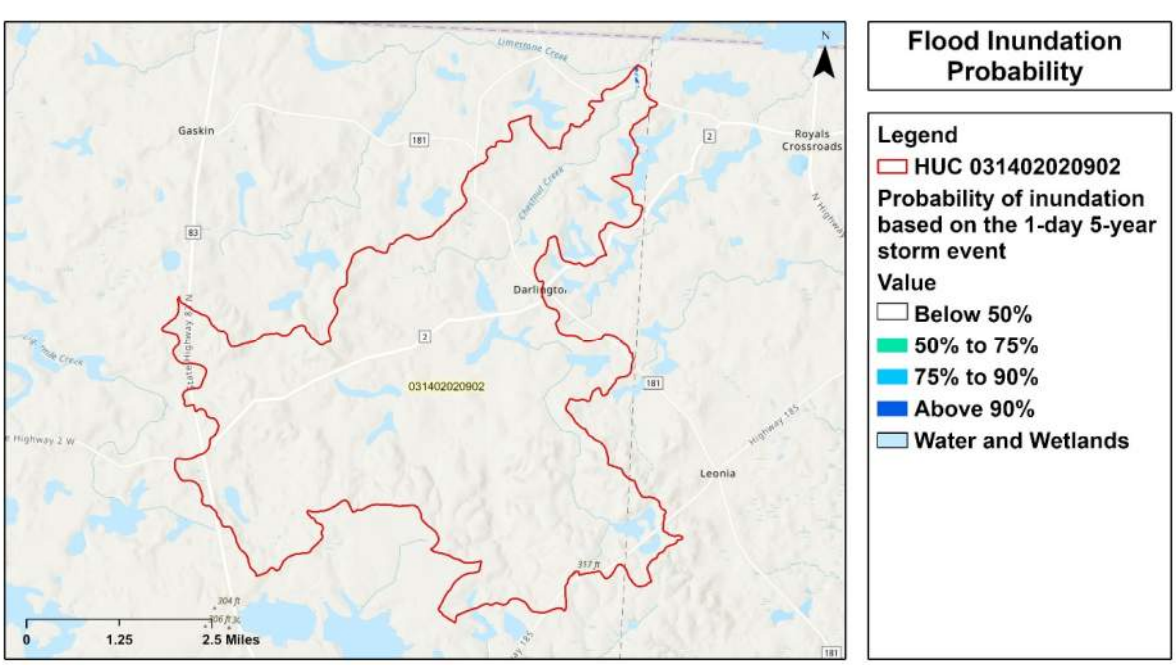

Figure 34. 1-day 5-year storm event for HUC 031402020902 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older,

poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service,	3

	Electric Repair, Laundries, Laundromats	
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6

48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4

79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031402020902 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (Figure 35) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 36) overlays critical facilities onto the 1-day

100-year storm event scenario. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

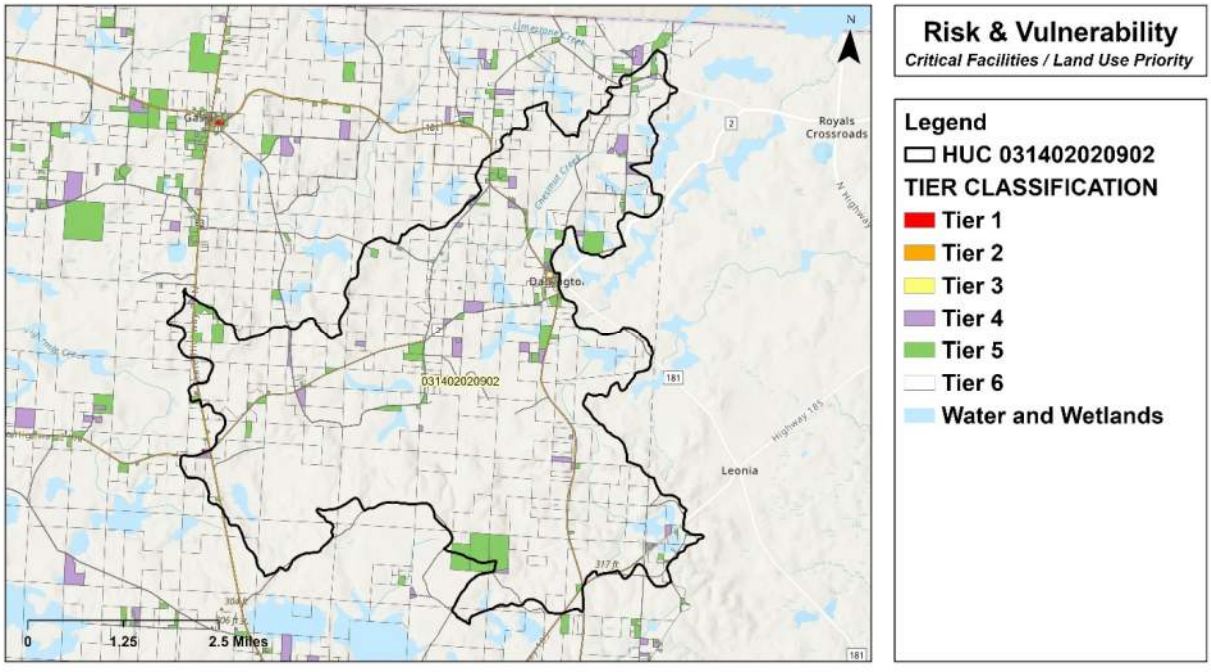

Figure 35. HUC 031402020902 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

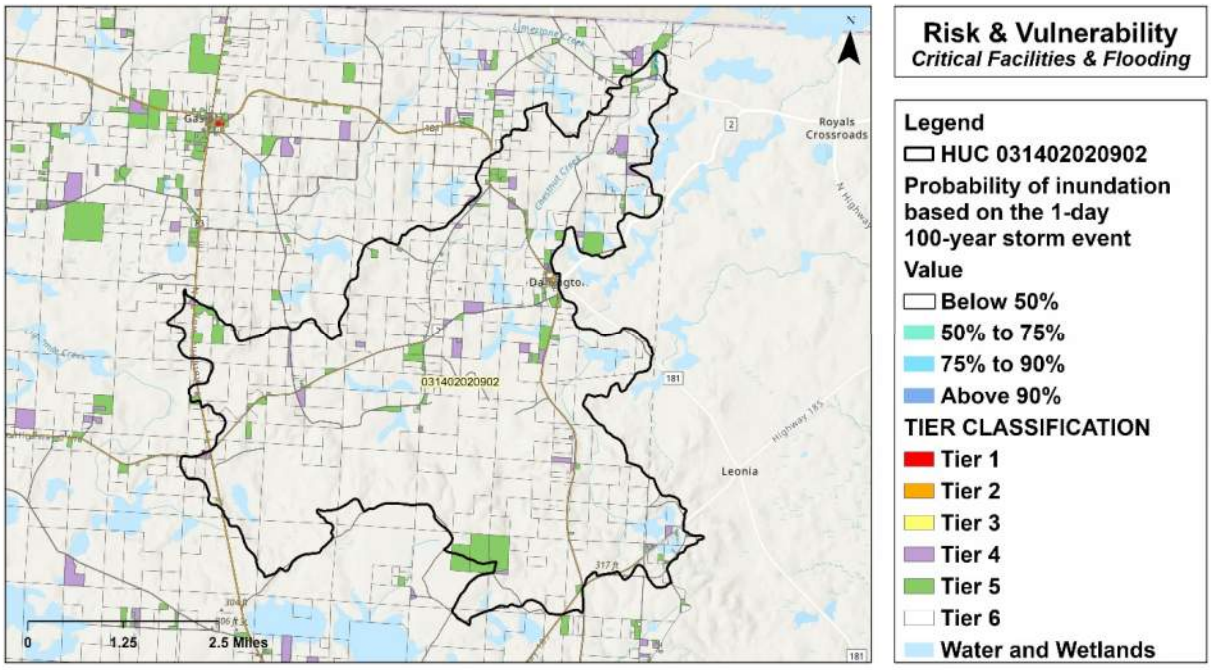

Figure 36. HUC 031402020902 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

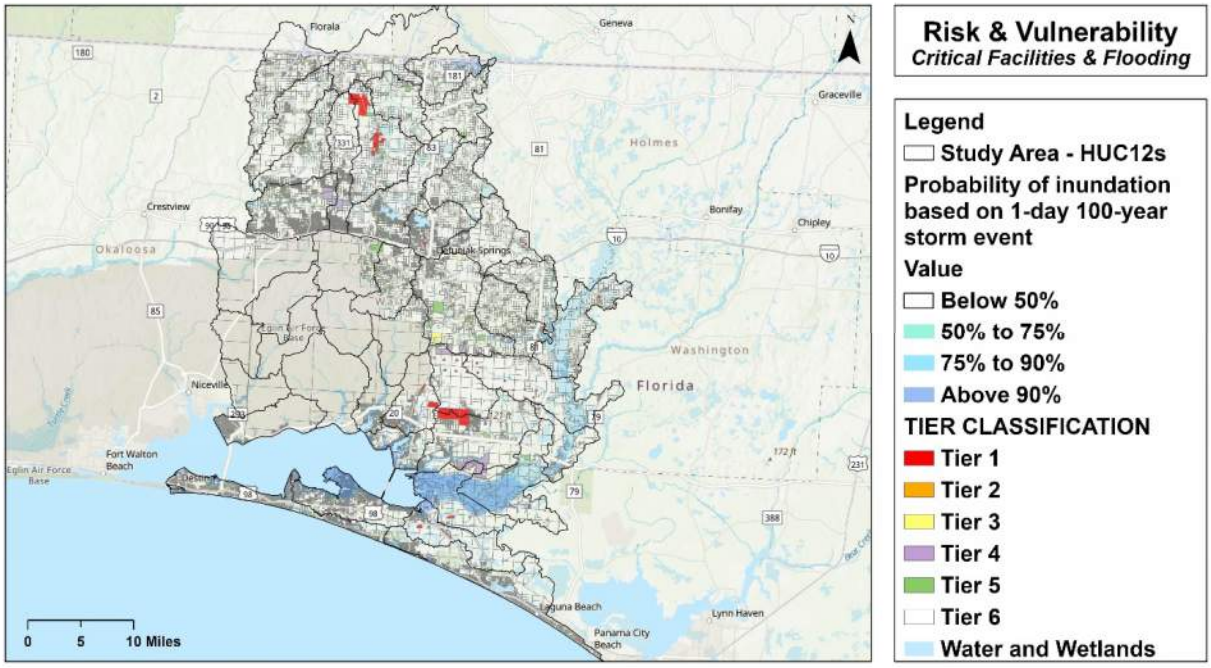

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

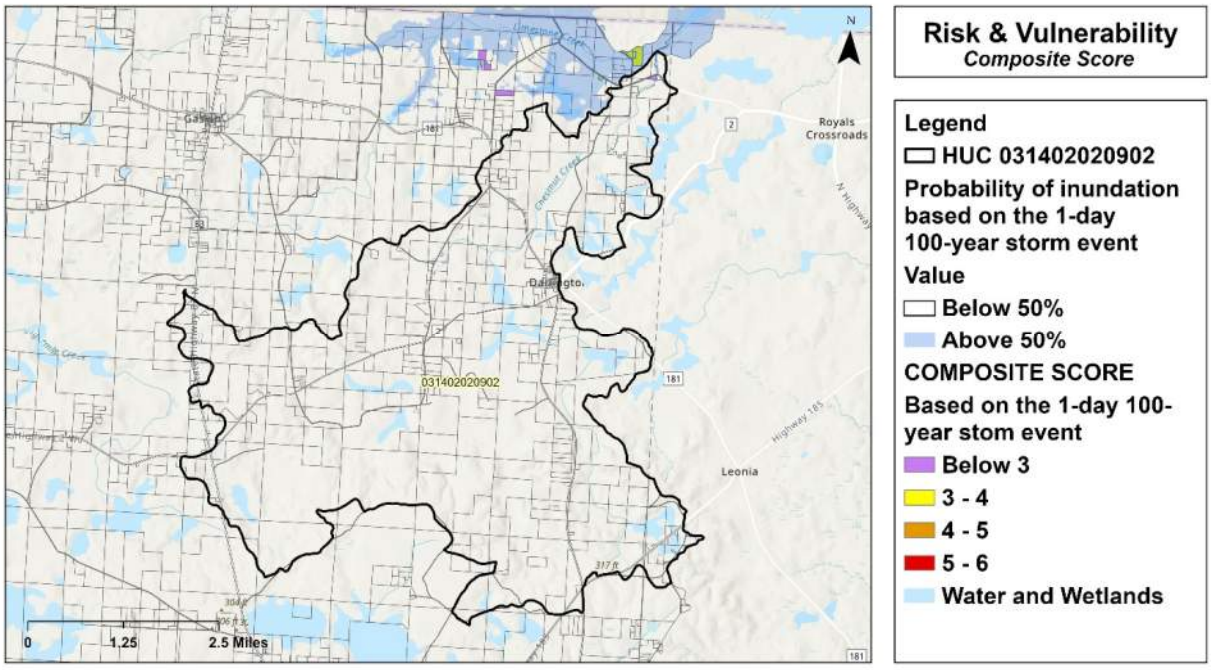

Figure 38. HUC 031402020902 sub-watershed Composite Score Risk map, with calculation based on 1-day 100-year storm event. Processed by FAU.

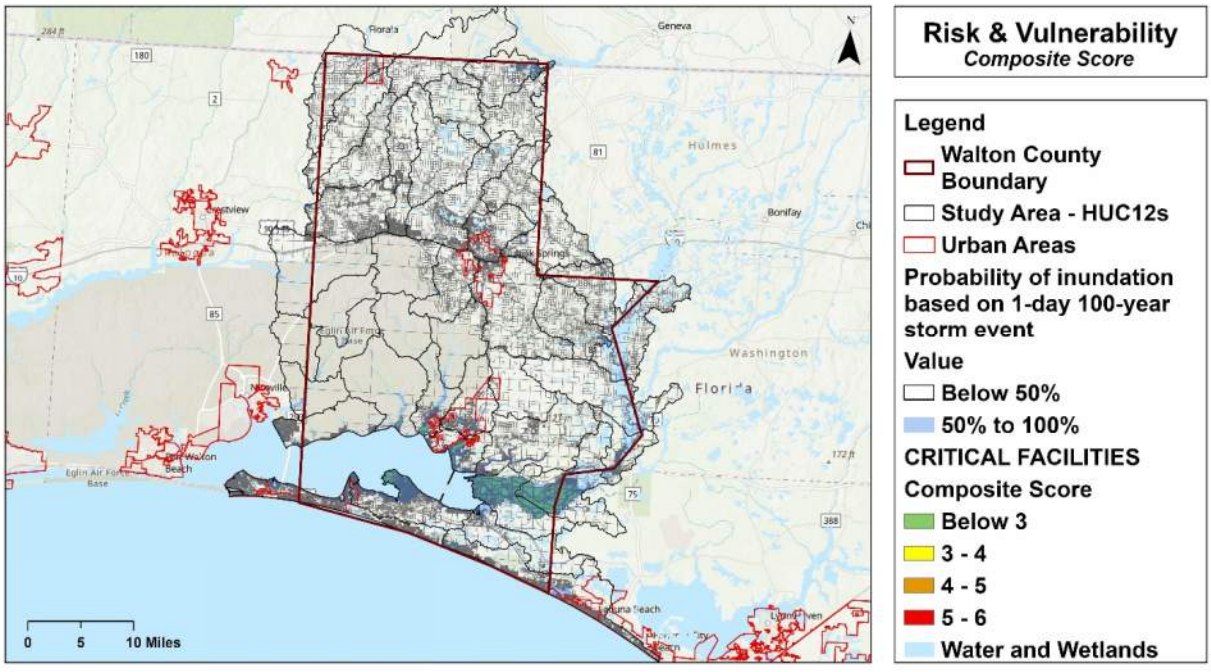

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.
Please note that due to the scale of the map, the composite score layer is not properly visible in this map.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031402020902. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located

within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031402020902. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031402020902	15751.67
All of the 1-day 100-year storm event inundation	**8.38**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	8.38
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	8.38

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

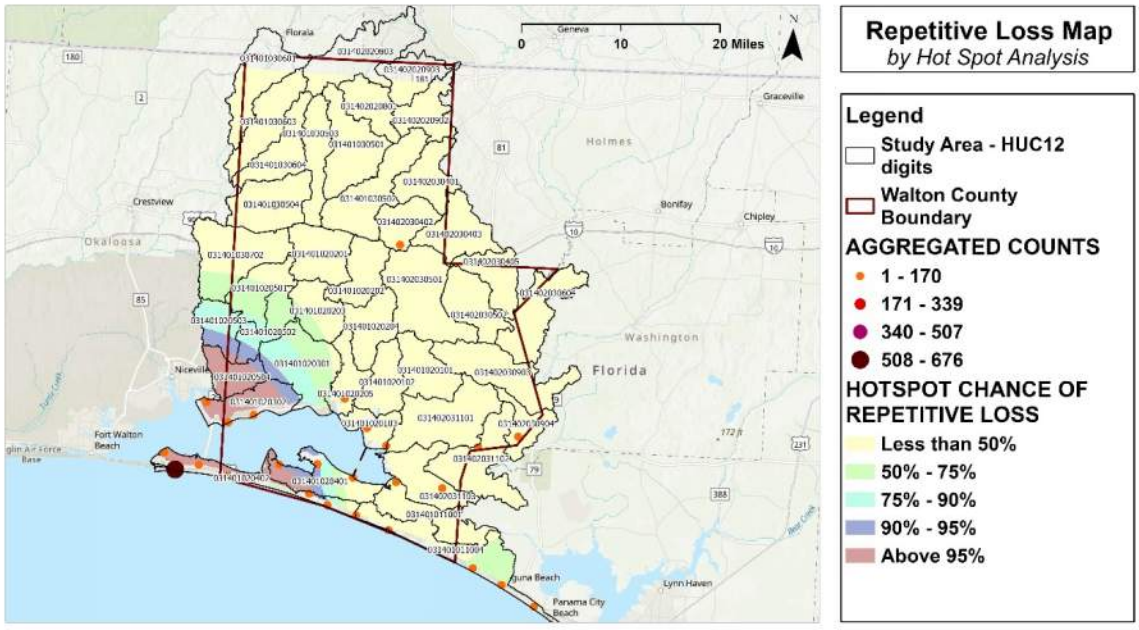

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5 Priority Projects

Although there are some parcels falling within tiers 2 (roads), 3, 4 and 5 of priority of land uses, none of them are within the flooding zone, once flooding in the area is minor and not alarming. Consequently, when considering the composite score, it is notable that most of the results are null,

indicating no priority for intervention within the basin. There are only three exceptions within the basin: a mobile home parcel with a score below 3, and two roads—Oak Grove Road, with a score of 4-5, and Cook Road, with a score of 5-6, indicating the highest priority for intervention.

APPENDIX AE

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031402020903

LIMESTONE CREEK

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Research Assistant: Leticia Sabio

This resource was funded in part, through a grant agreement from the Florida Division of Emergency Management's (FDEM) Bureau of Mitigation, by a grant provided by through the Hazard Mitigation Grant Program (HMGP) DR-4337-004-P, as approved by FDEM and the Federal Emergency Management Agency (FEMA) to create and update Watershed Master Plans (WMP) throughout the state of Florida. The views, statements, findings, conclusions, and recommendations expressed herein are those of the authors and do not necessarily reflect the views of the State of Florida, FEMA, or any of their sub-agencies.

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**,, the HUC-12 (031402020903) is highlighted among all the HUCs to help identifying its location. (Figure 3).

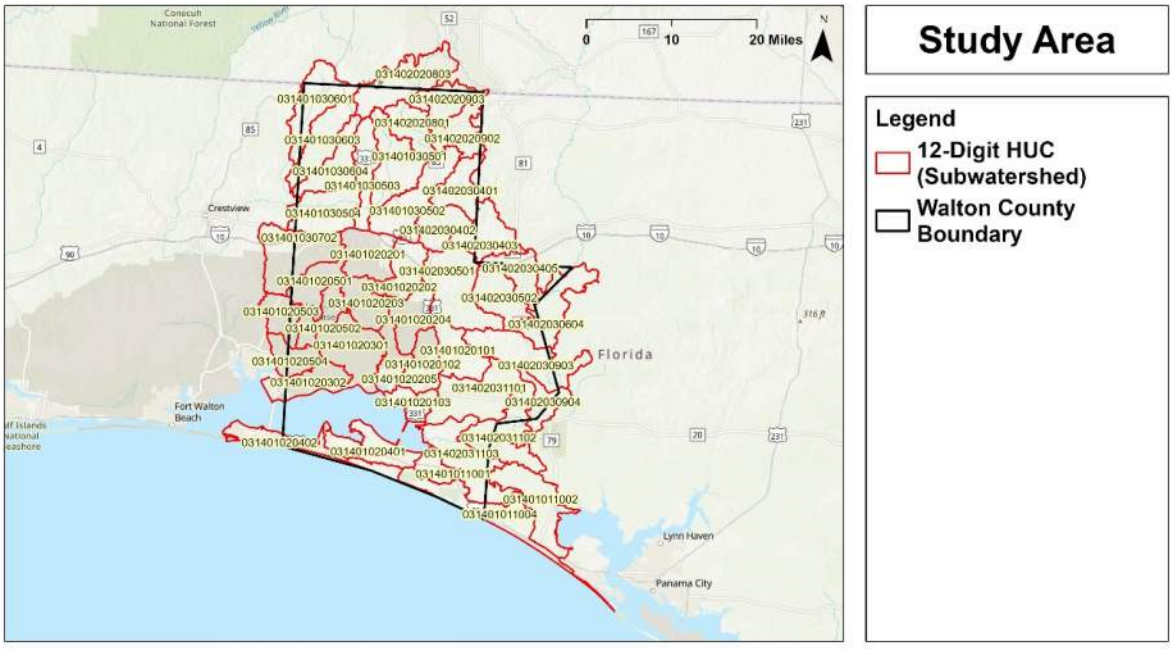

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

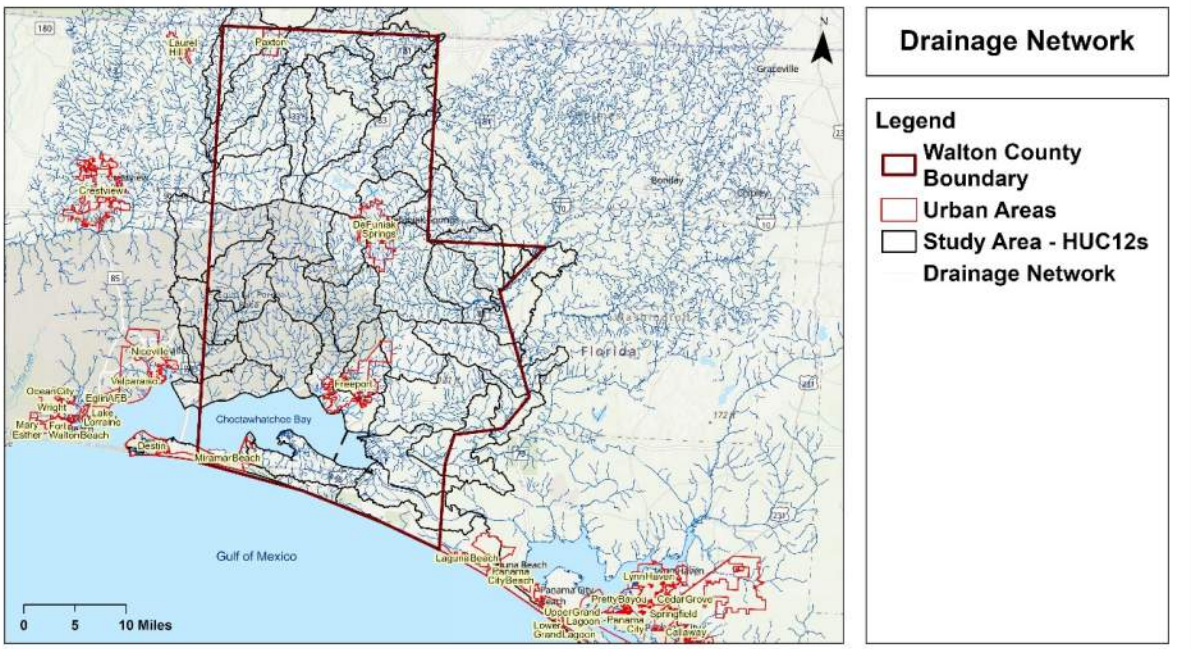

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

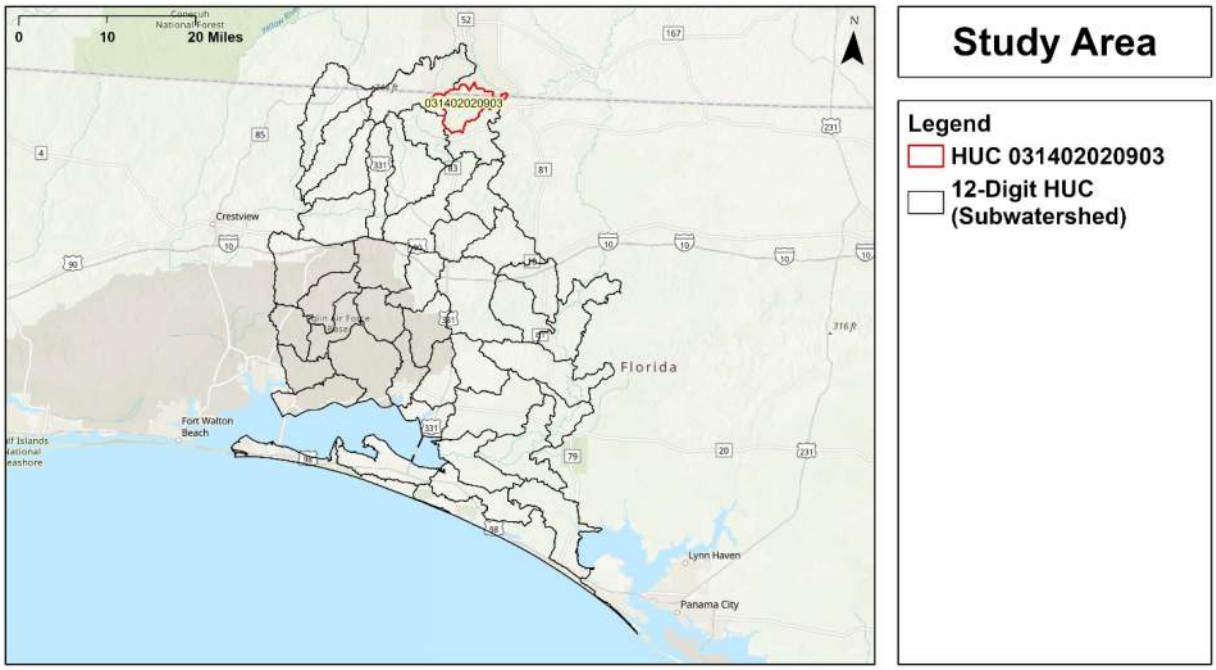

Figure 3. HUC 031402020903 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in Table 1. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

(Source Data: FEMA)

Figures 12 and 13 is the county-wide report show the current and projected land use for the County. Based on the 2017 future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land Use in Walton County (Prepared by FAU from future land use map) versus land use in the entire watershed

Level 1 Land Use-Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

(Source Data: NWFWMD, 2017)

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 1.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.

April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

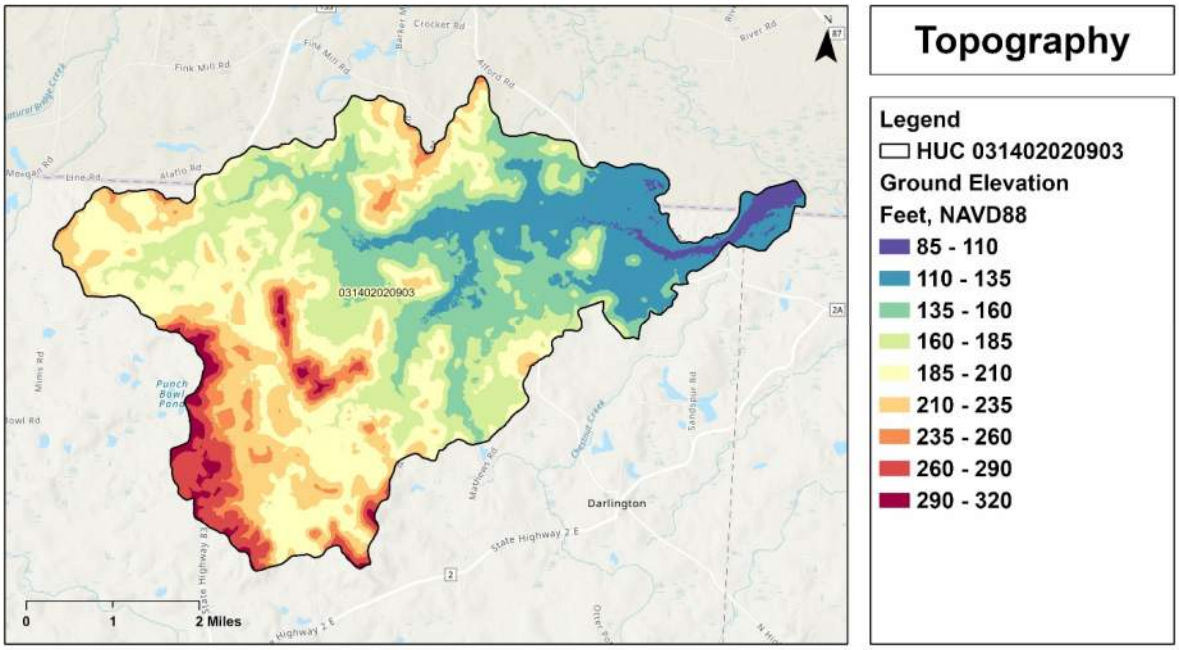

Figure 4. Topographic map of the HUC 031402020903 sub-watershed, processed by FAU

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031402020903 sub-watershed is shown in **Error! Reference source not found.**..

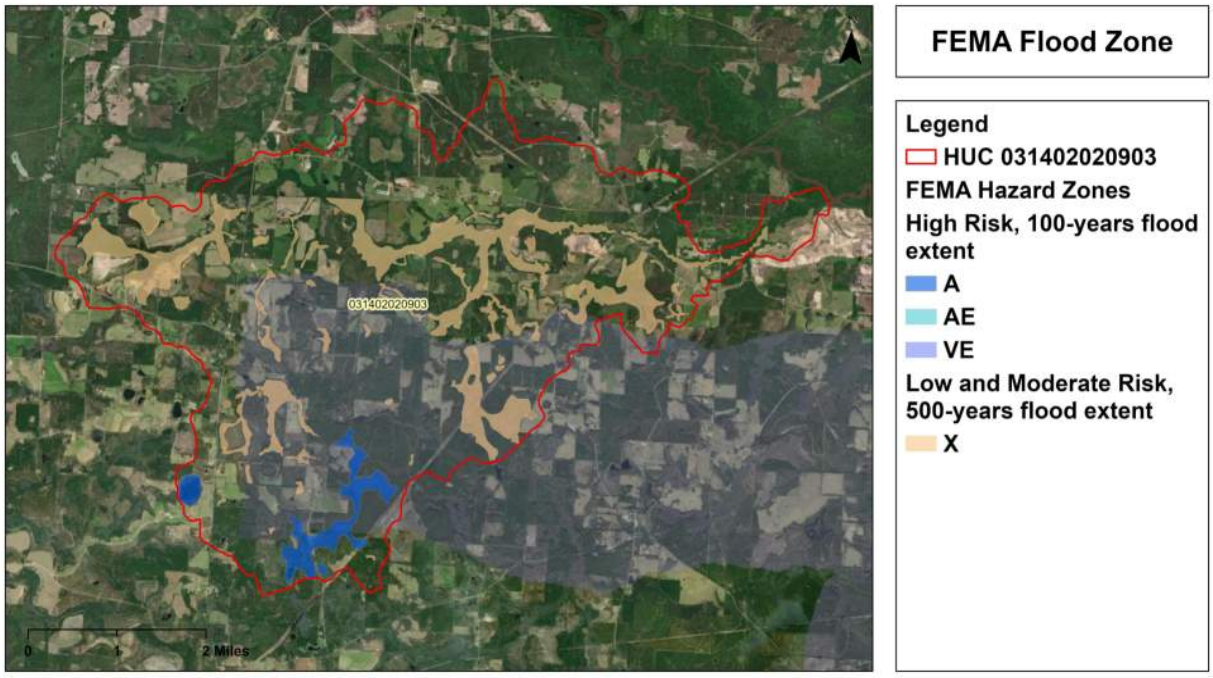

Figure 5. FEMA Flood Zone map (2020) for HUC 031402020903 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031402020903 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem.

This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

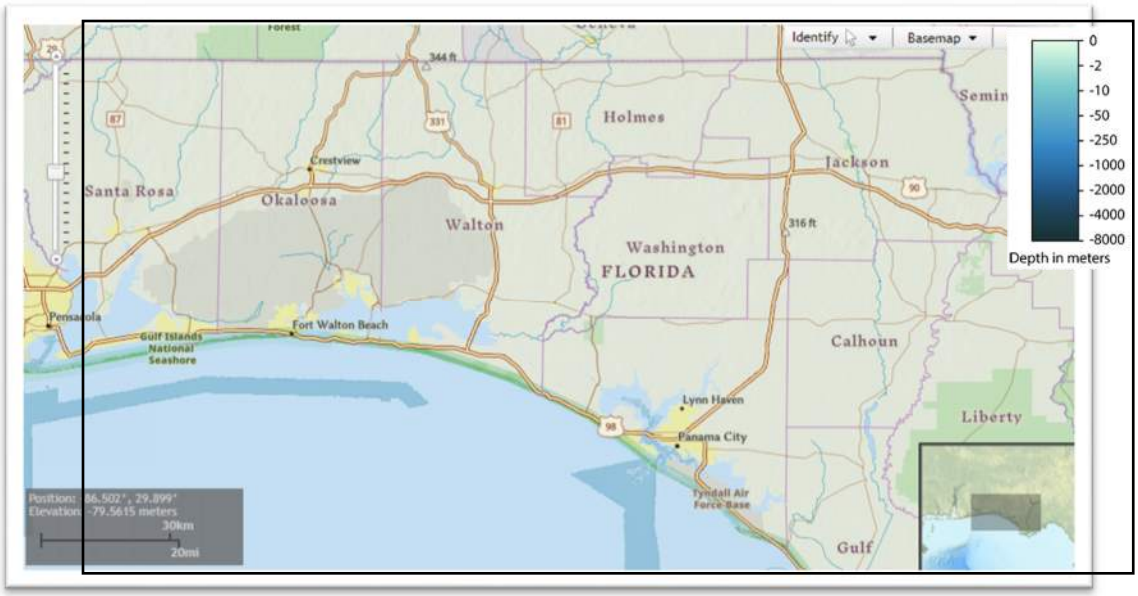

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

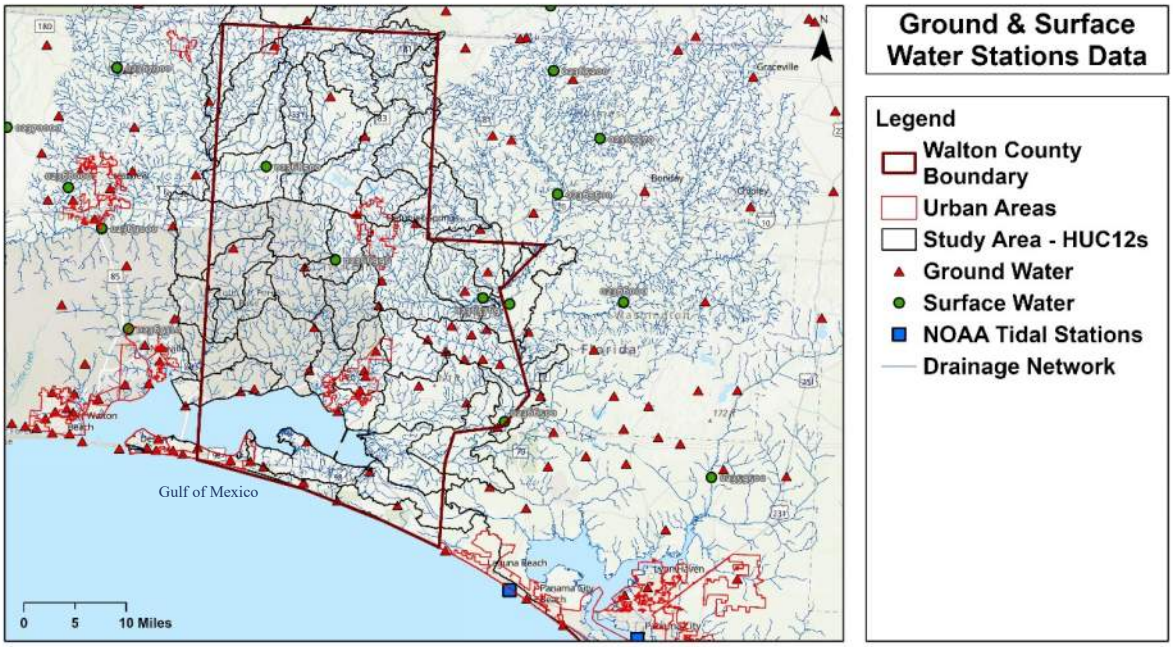

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031402020903 lacks major rivers and canals, instead featuring a network of well-branched creeks without specific names. These creeks originate in Alabama and flow in different directions though the basin.

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02368500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031402020903, which is USGS 02368500 Shoal River.

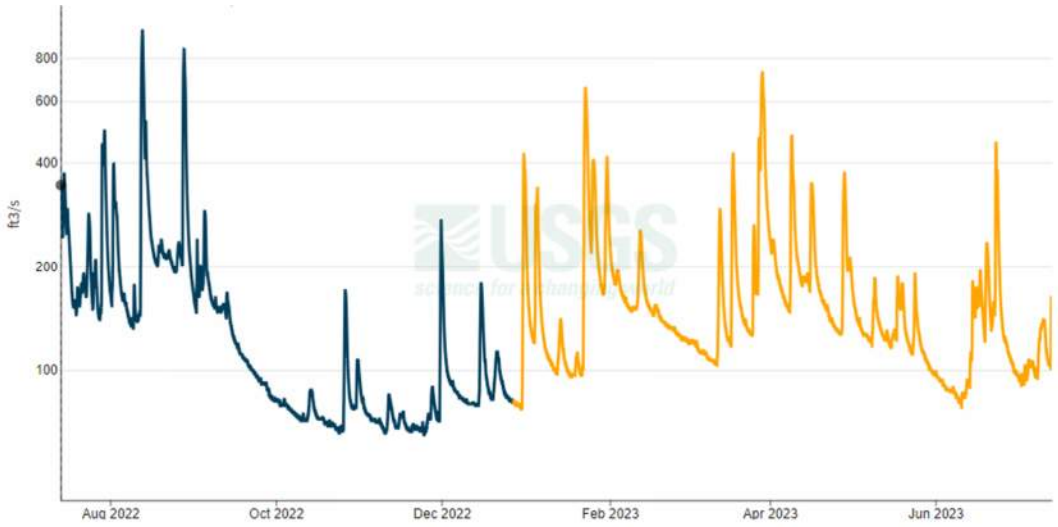

Figure 8. Average streamflow for Shoal River NR Mossy Head, Fla (USGS 02368500 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02368500/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station

(or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031402020903 and points out the location of the ground water station in the surroundings. A groundwater-surface layer for the HUC 031402020903 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

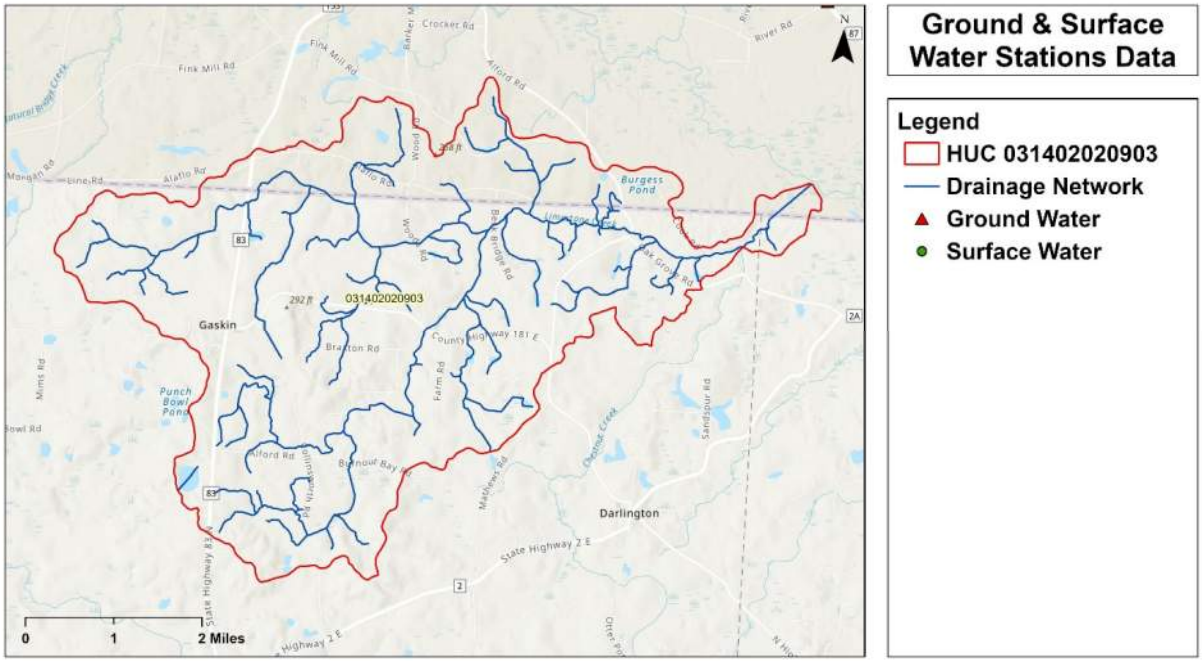

Figure 9. Ground and Surface Water Stations in the HUC 031402020903 sub-watershed, processed by FAU.

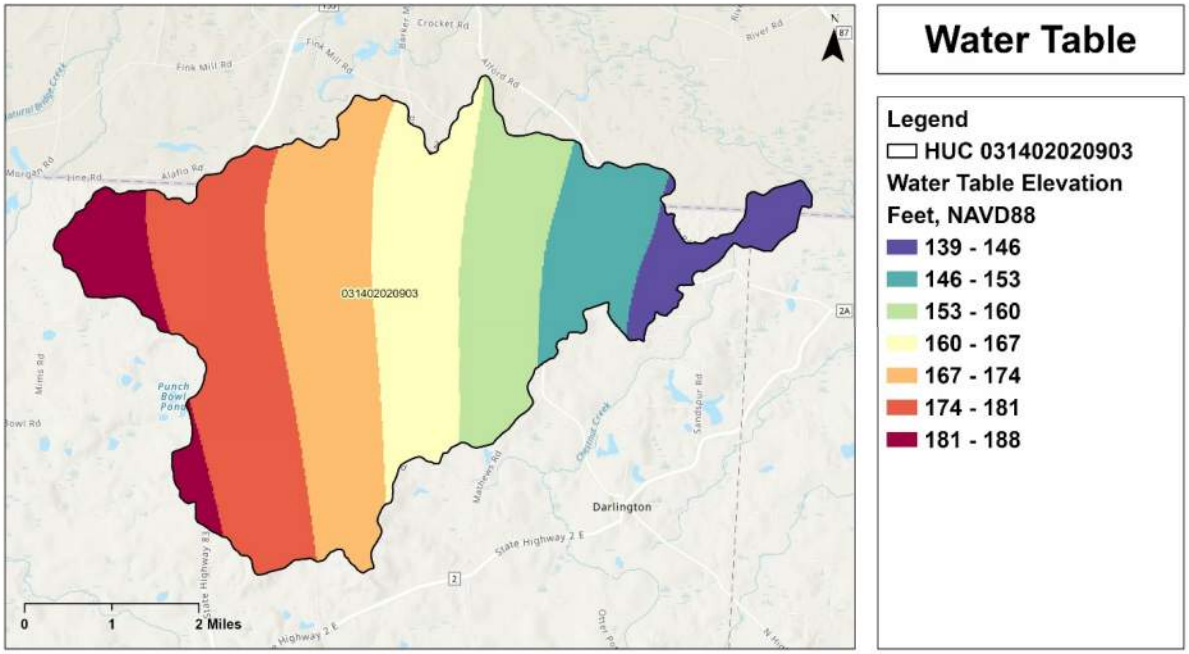

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031402020903 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the average precipitation over Walton County for every month of the year between 2011 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches for the entire county.

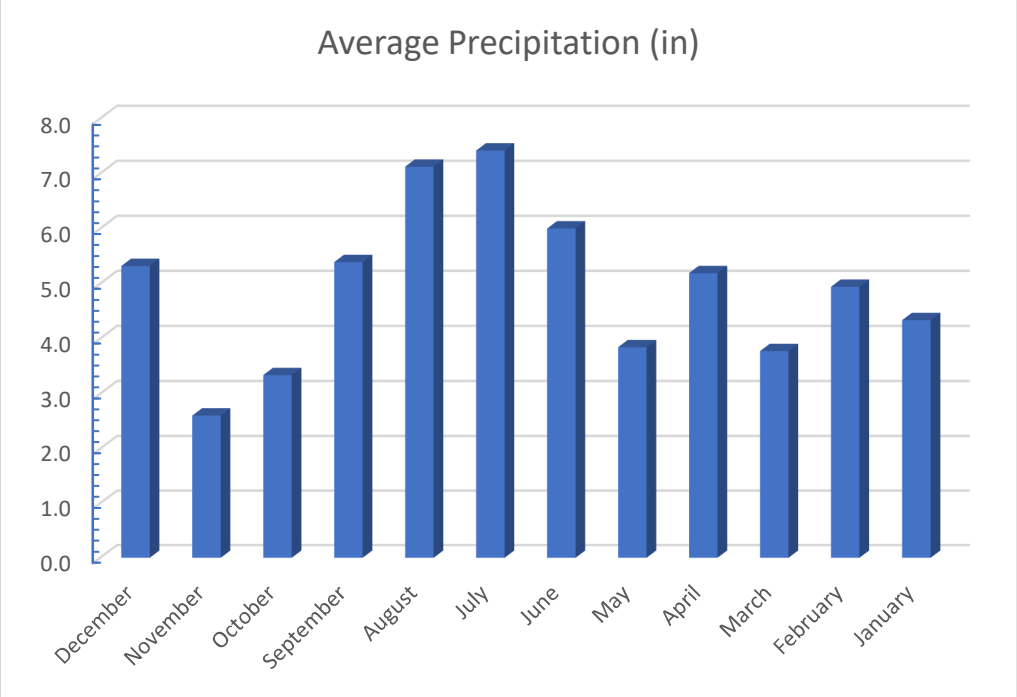

Figure 11. Monthly precipitation in Walton County, FL (2011-2023).
(Data Source: Florida Weather Data, available at https://data.usatoday.com/weather-data/walton-county/12131/1975-04-01/Table/)

While the topography (Section 1.1) and native soil (Section 1.4)create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as

opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. Figure 12 shows the two closest tide stations to Walton County. Since there is none NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

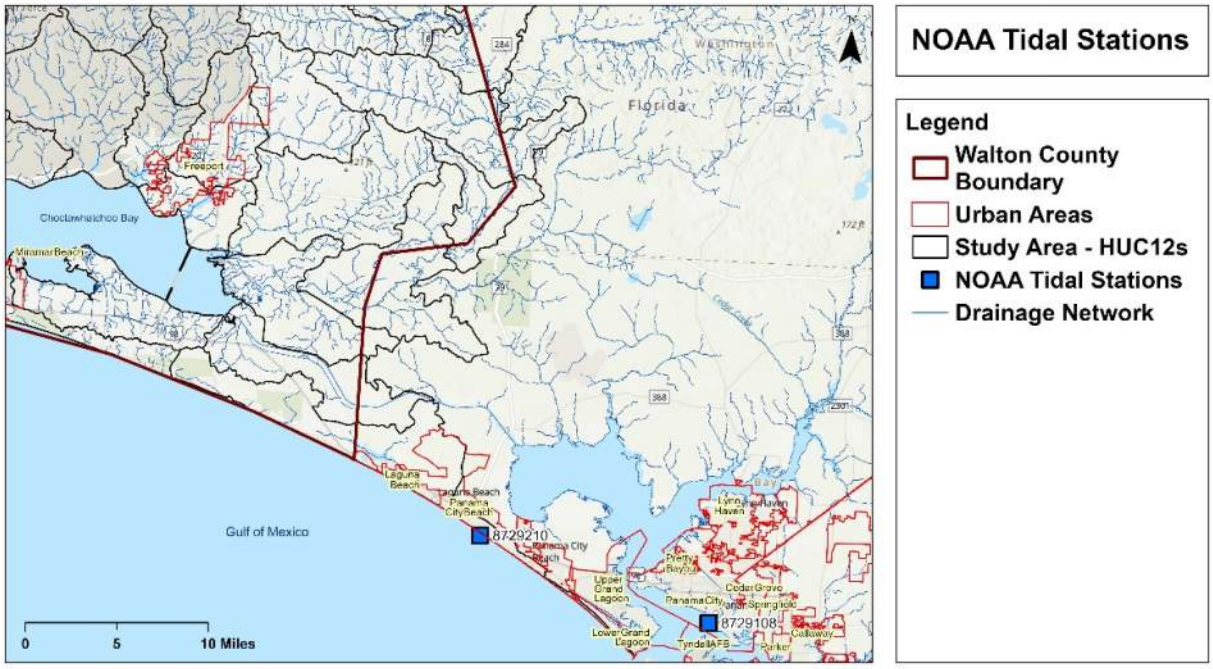

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

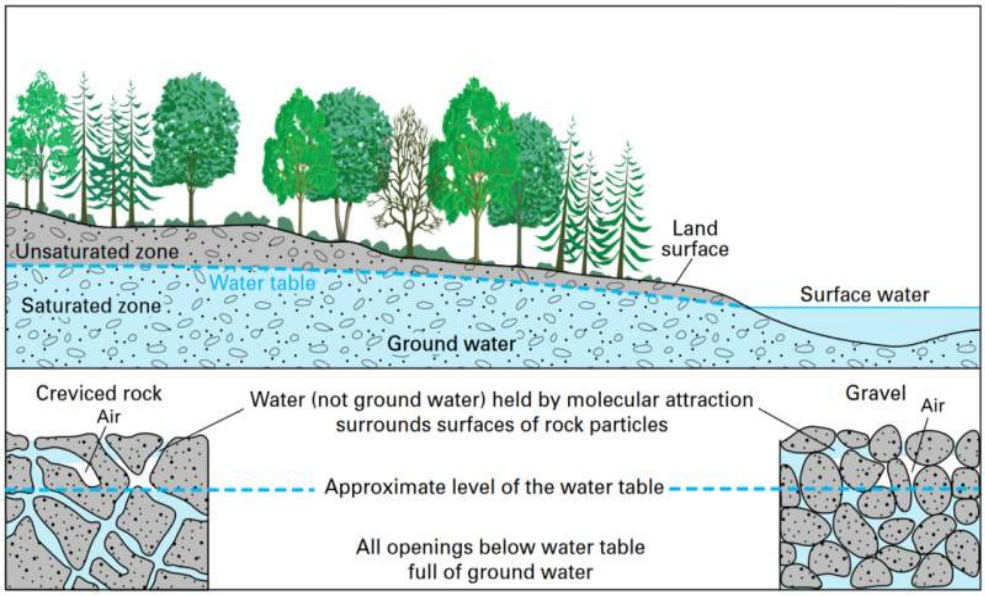

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in Figure 14. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

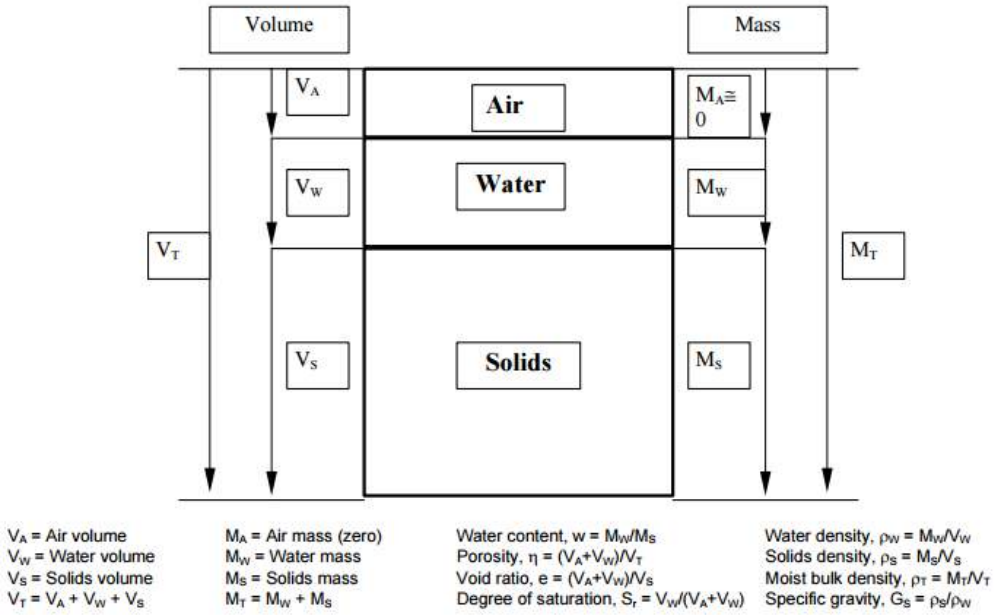

Figure 14. Saturated zone soil phase diagram and definitions .
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

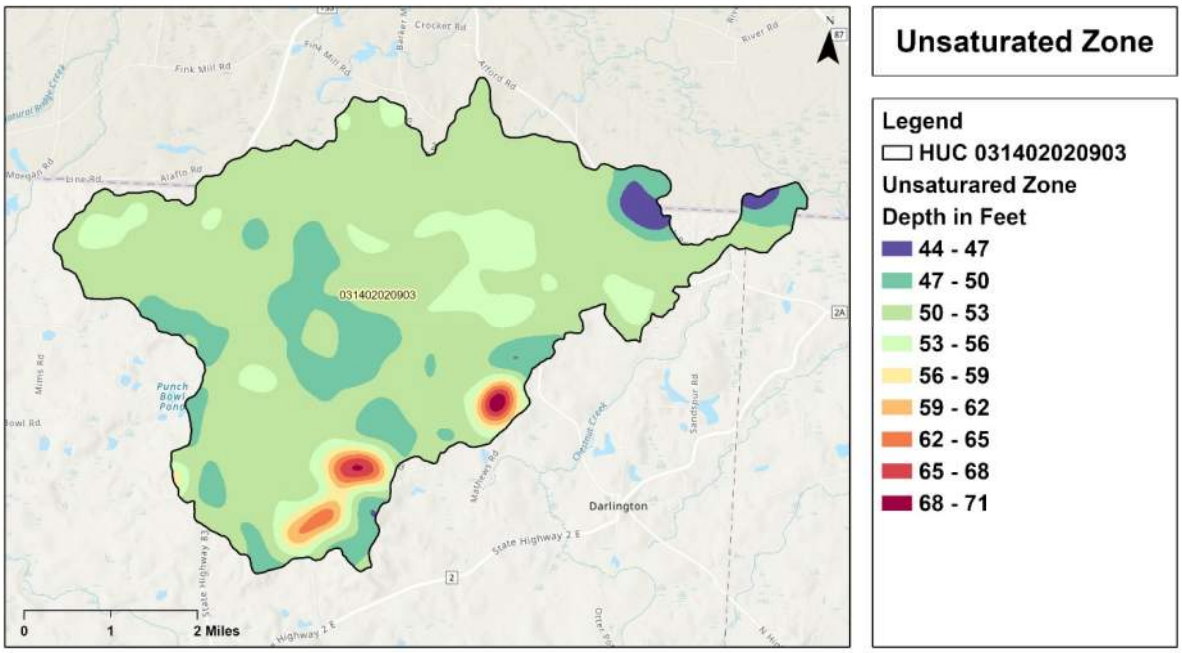

Figure 15. Unsaturated zone map for HUC 031402020903, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. The entire basin exhibits a favorable soil storage capacity, ranging between 44 to 71 inches of remaining capacity.

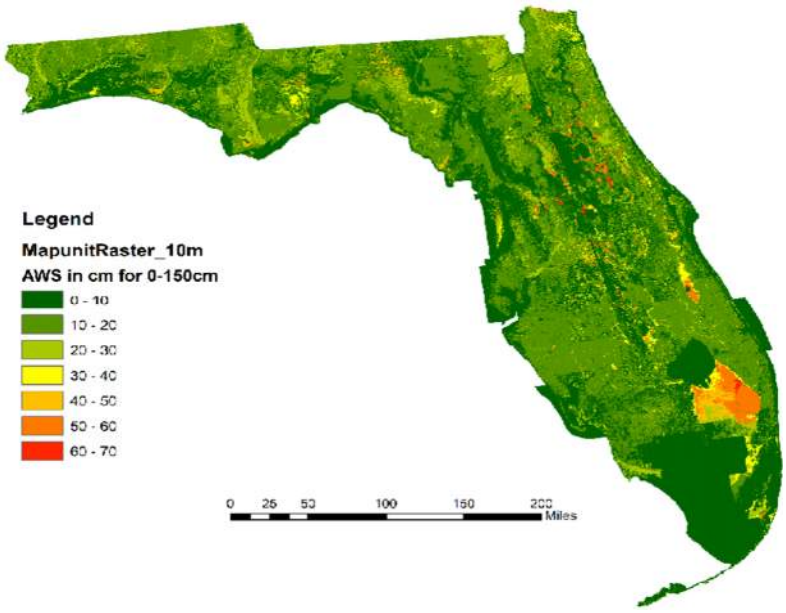

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

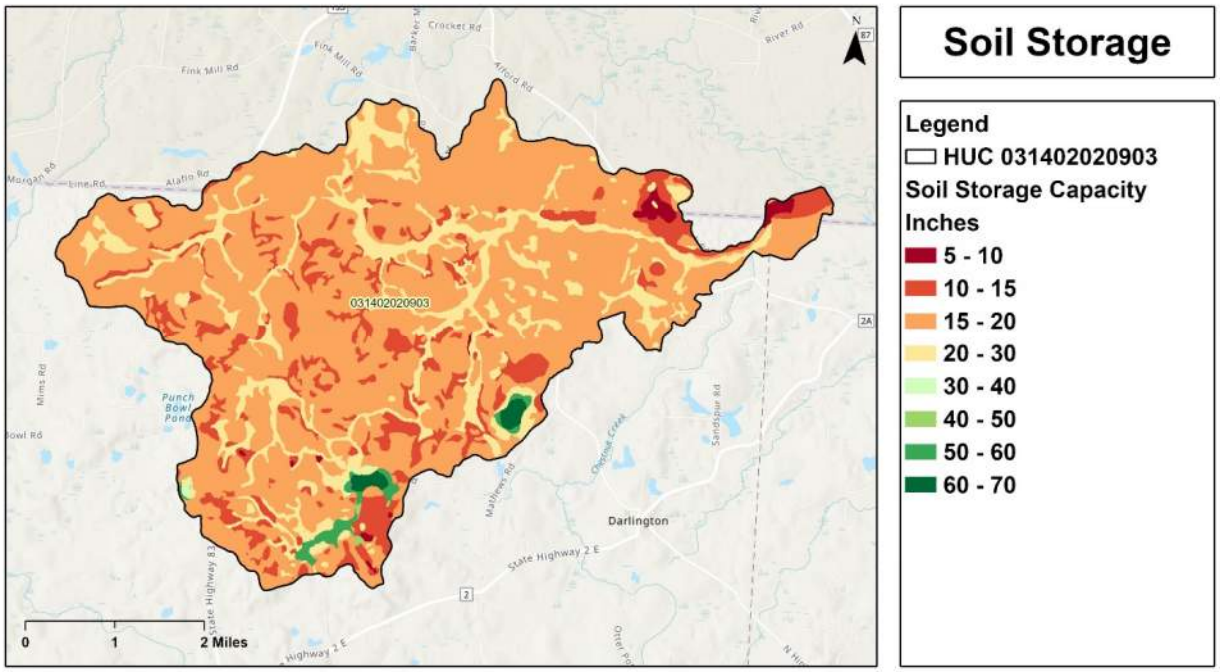

Figure 17. Water storage capacity of soil for the HUC 031402020903, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

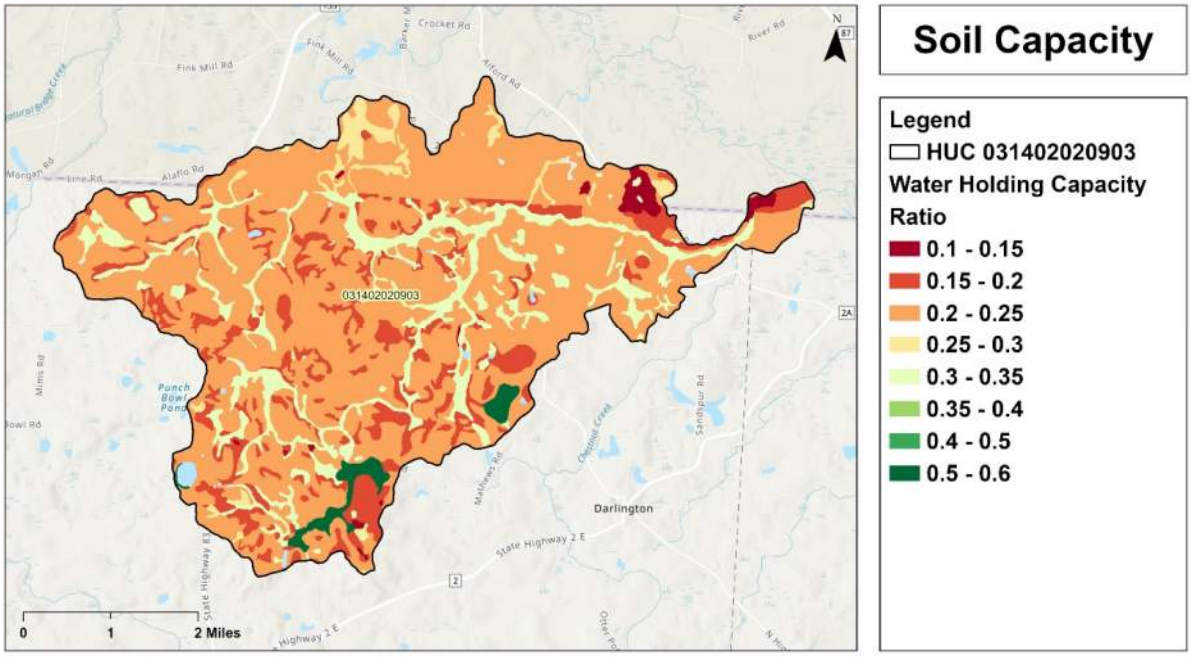

Figure 18. Water Holding Capacity (ratio) for the HUC 031402020903, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

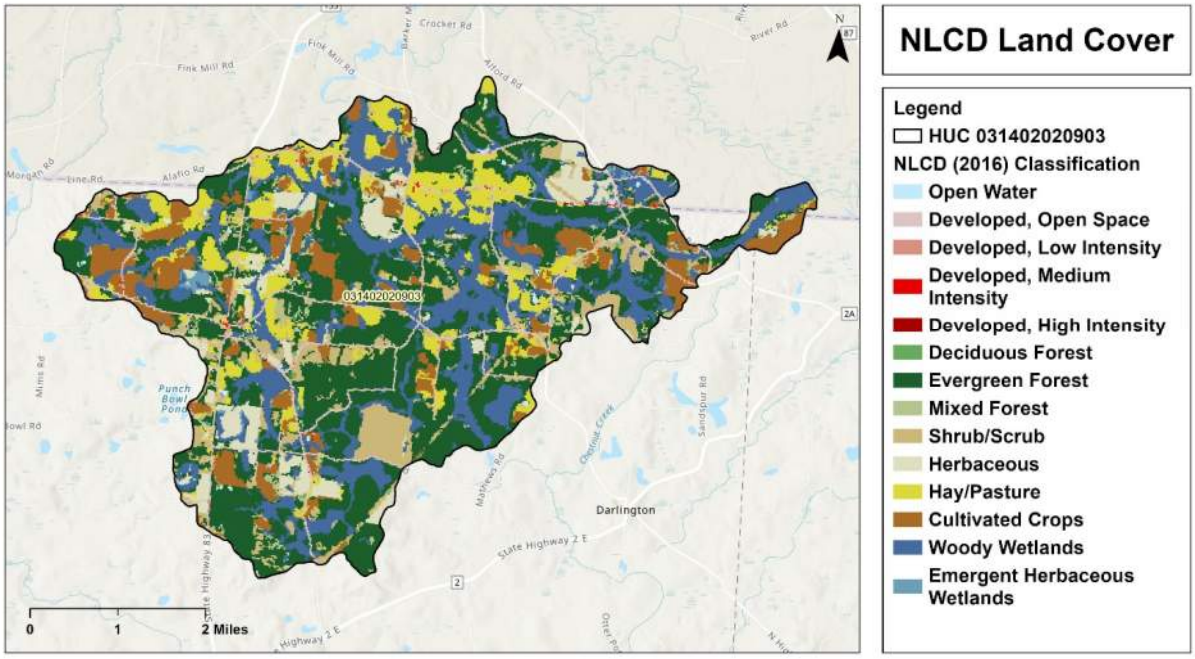

Figure 19. Land use in the HUC 031402020903 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD 2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

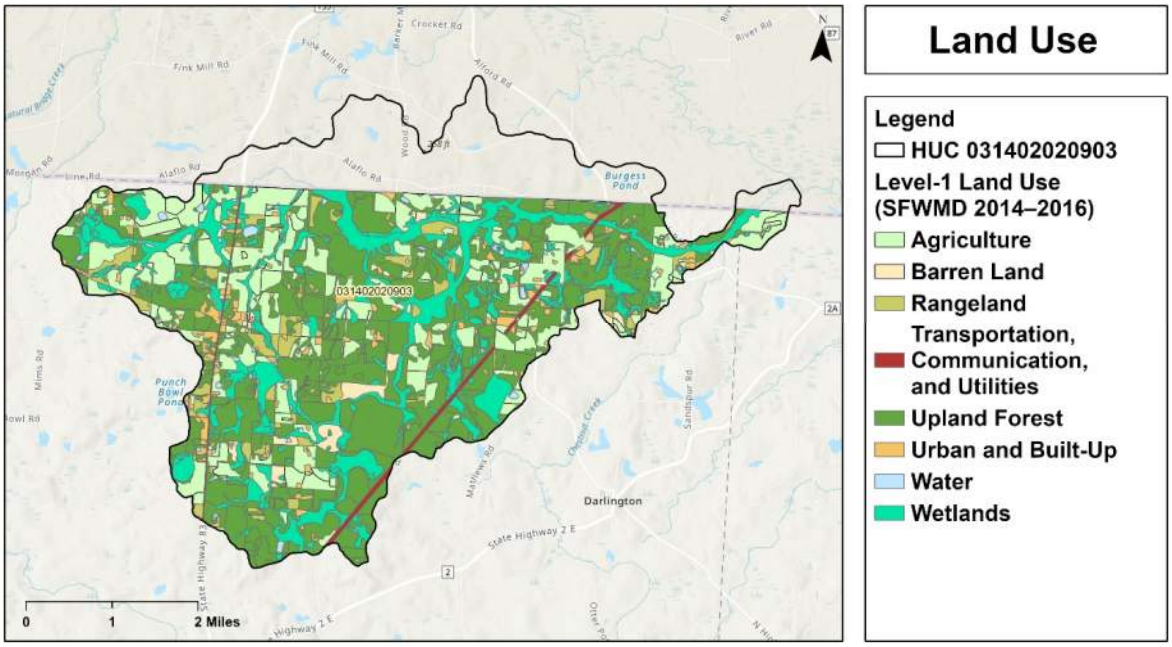

Figure 20. Land use in the HUC 031402020903 ((from the 2023 Florida Geographic Data Library (FGDL) database), processed by FAU.

Please be aware that the Alabama portion of the HUC was not considered in this land use study. Consequently, the following analysis pertains solely to the Florida portion of the HUC 031402020903 sub-watershed. In this area, the predominant land cover is upland forest, accounting for 37.70% of the region. Agriculture comes in second at 21.39%, followed by Transportation, Communication, and Utilities at 16.83%. Developed land is limited, with only 2.71% categorized as urban and built-up, as illustrated in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031402020903 subwatershed

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	3711.97	21.39%
Barren Land	216.82	1.25%
Rangeland	720.79	4.15%
Transportation, Communication, and Utilities	2921.21	16.83%
Upland Forest	6544.03	37.70%
Urban and Built-Up	470.47	2.71%
Water	109.57	0.63%
Wetlands	2662.94	15.34%
Grand Total:	**17357.80**	**100.00%**

(Source Data: 2023 Florida Geographic Data Library (FGDL) database))

Table 4. Roughness and CN Values for Each Land Use Code

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

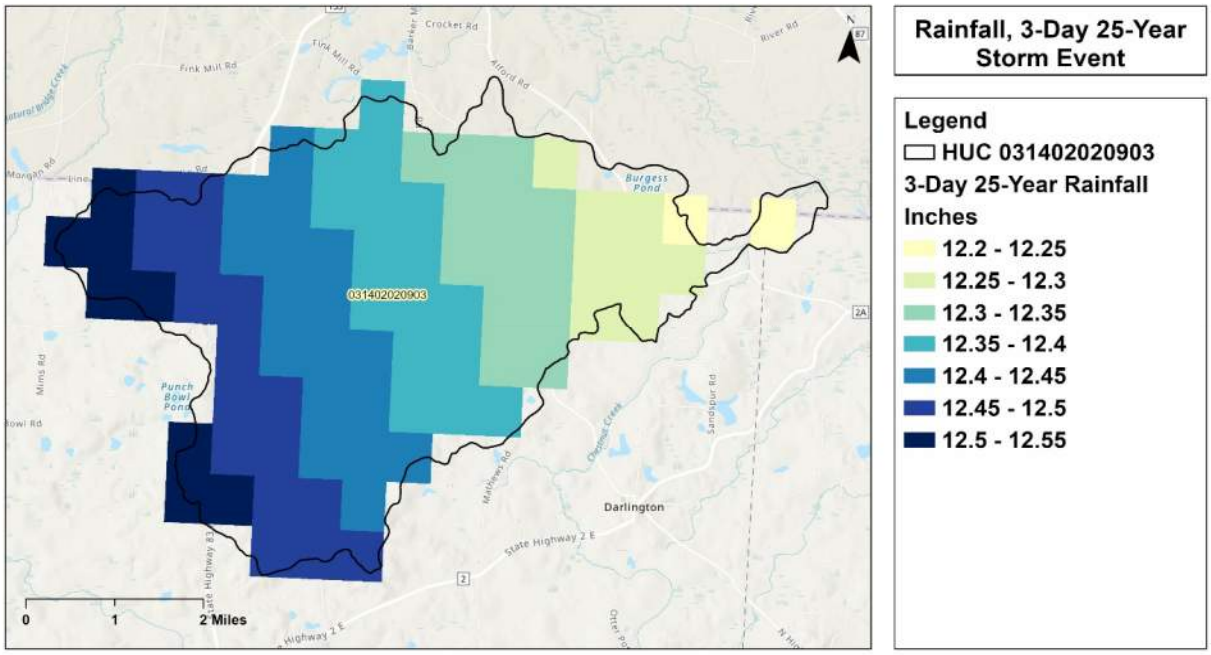

Figure 21. Rainfall distribution map across HUC 031402020903 sub-watershed, for 3-day 25-year storm event, processed by FAU.

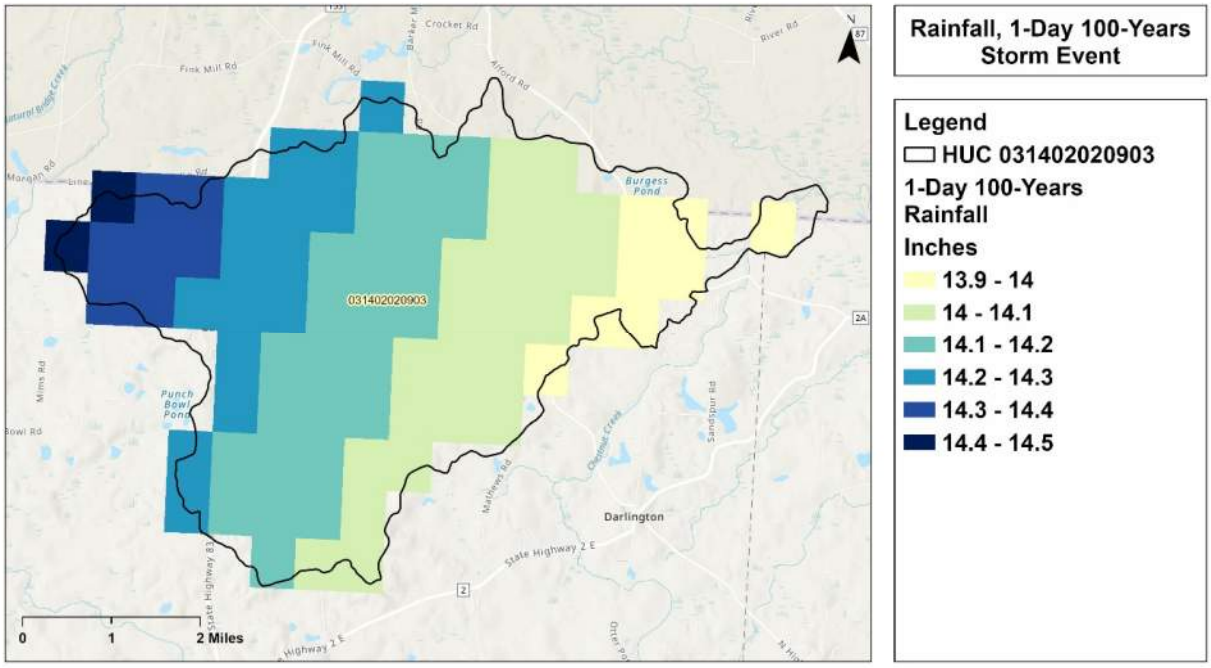

Figure 22. Rainfall distribution map across HUC 031402020903 sub-watershed, for 1-day 100-year storm event, processed by FAU.

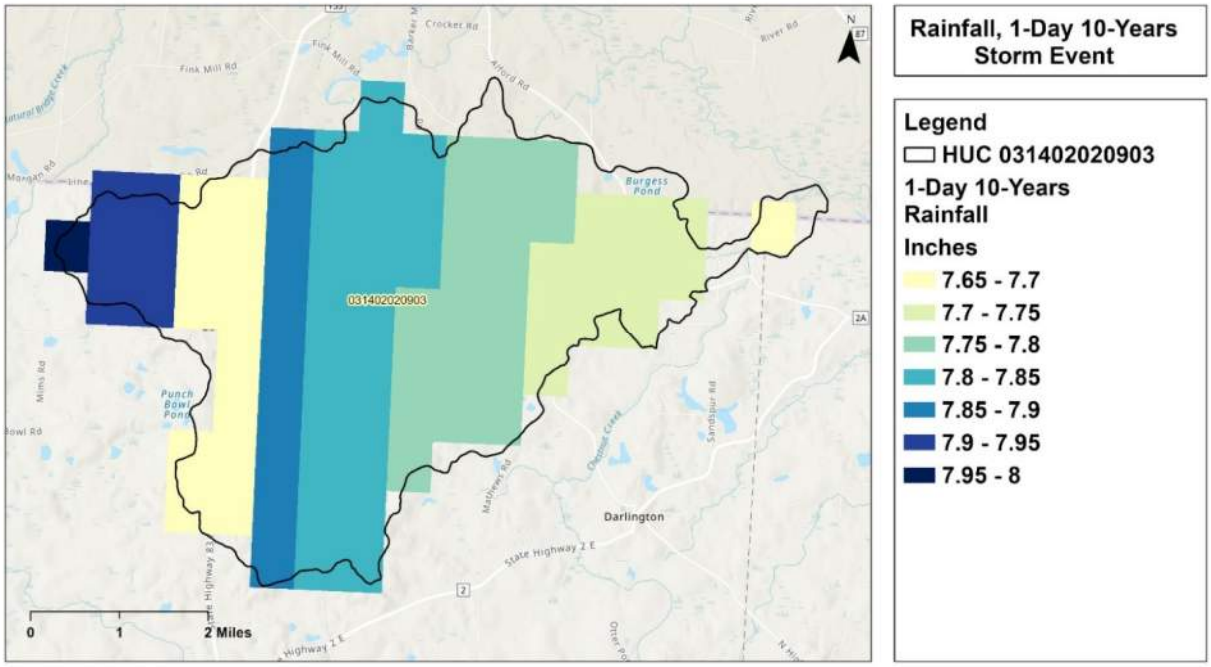

Figure 23. Rainfall distribution map across HUC 031402020903 sub-watershed, for 1-day 10-year storm event, processed by FAU.

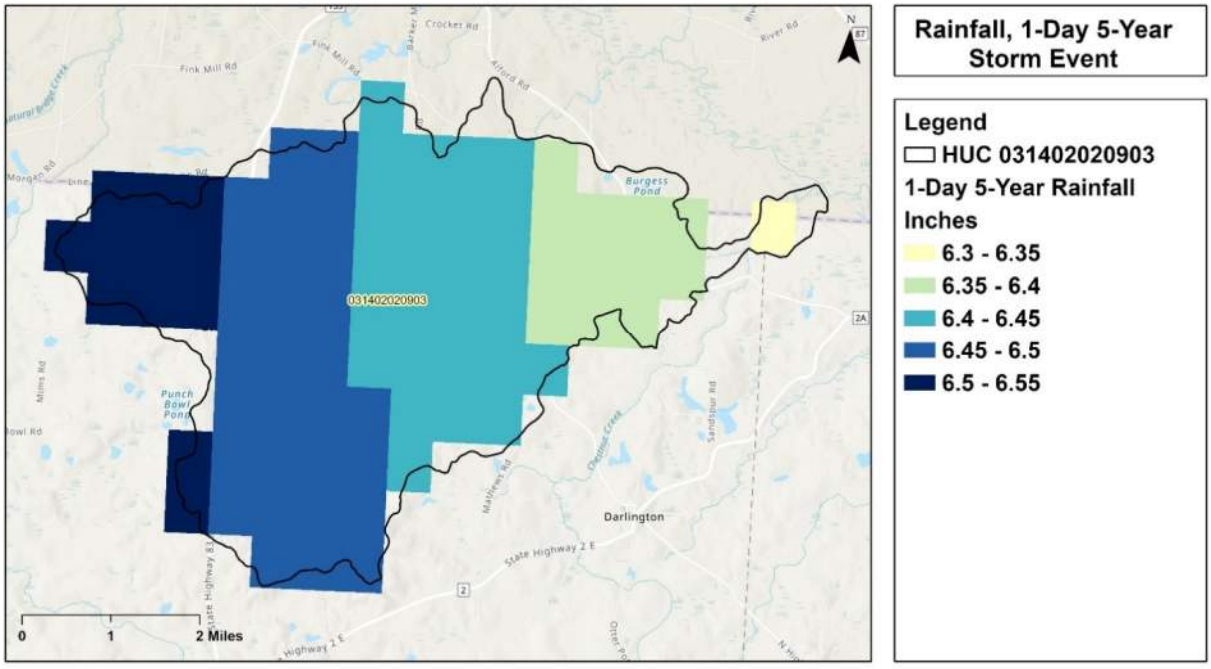

Figure 24. Rainfall distribution map across HUC 031402020903 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

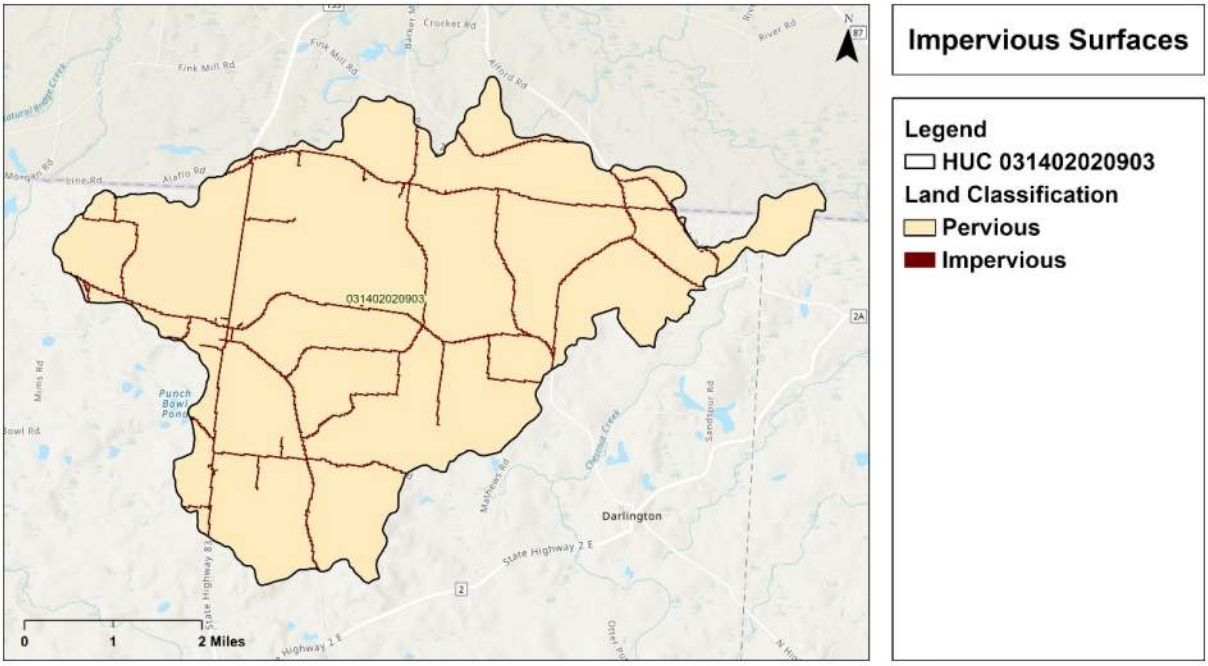

Figure 25. Impervious area map for the HUC 031402020903 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

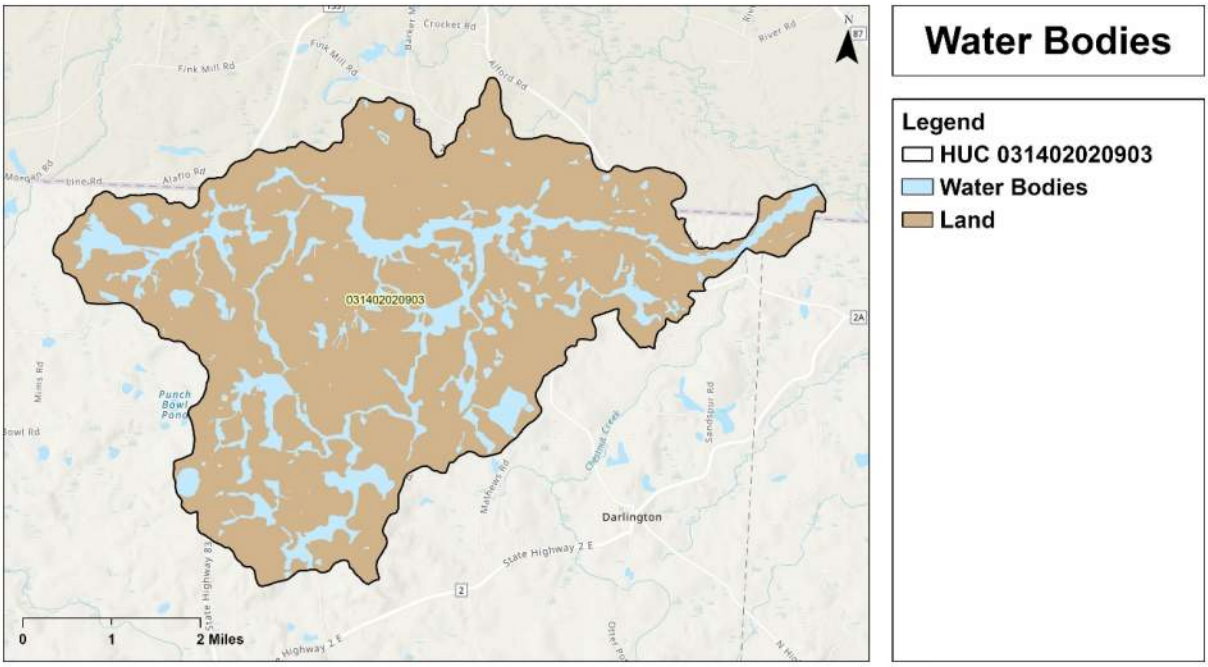

Figure 26. Water bodies map for the HUC 031402020903 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

(Source: US Census Bureau 2020, and Zip-codes.com)

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.

- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

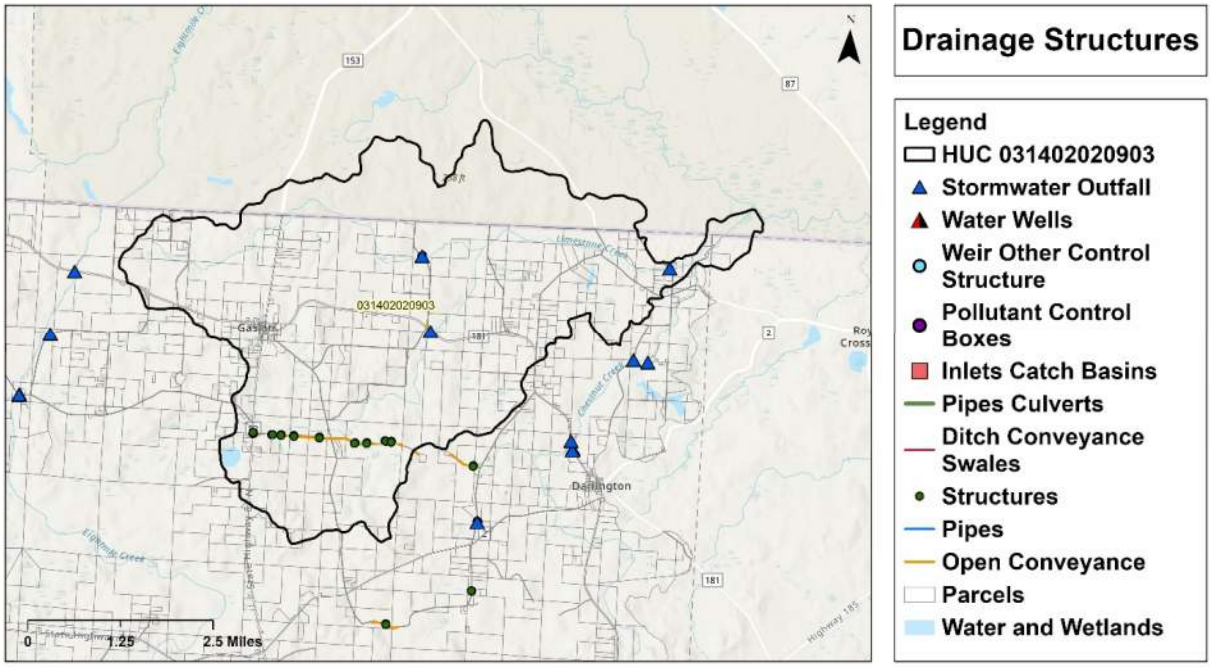

Figure 27. Stormwater Infrastructure for the HUC 031402020903. Processed by FAU.

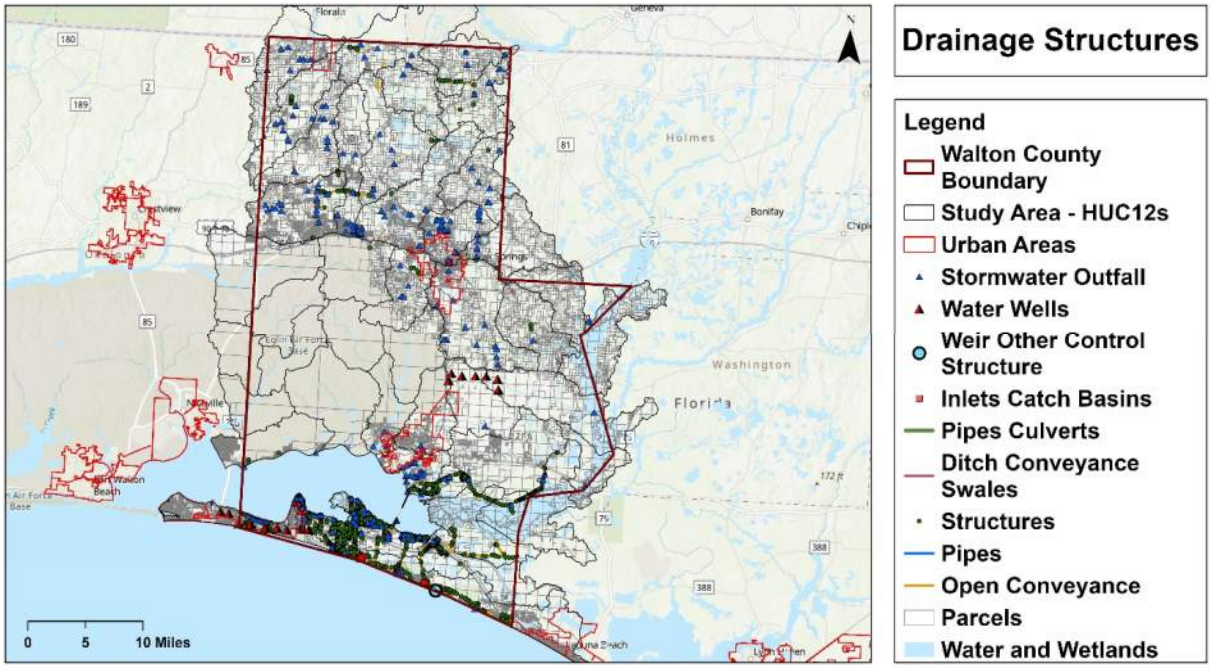

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020)

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapter 1, an analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031402020903 sub-watershed flood response to a series of rainfall events (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.3.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species

while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD DBHYDRO website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

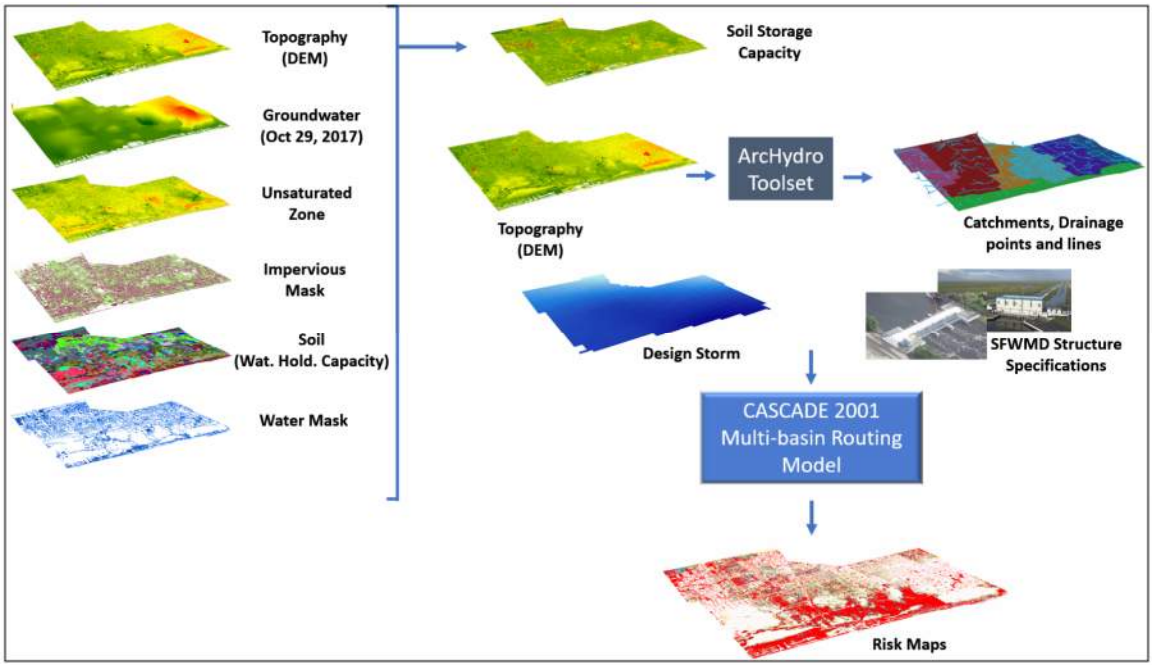

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are

critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

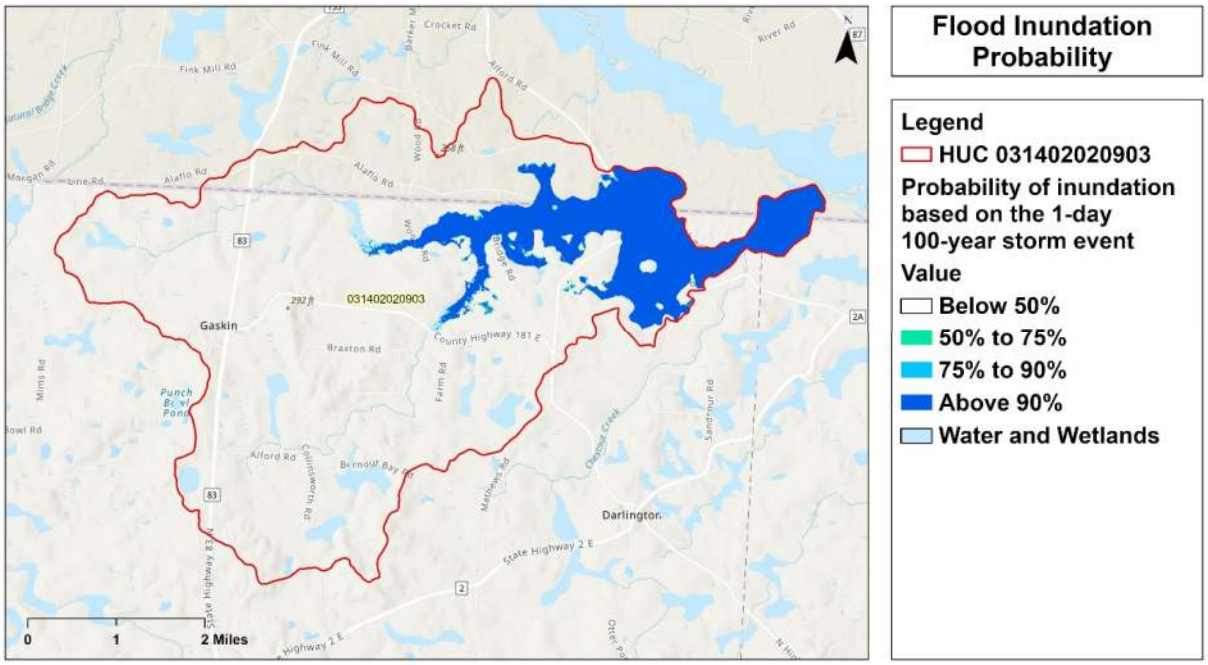

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031402020903, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate

the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 2.4 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not

eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a substantial volume of flooding is observed at the entrance of the creek within the HUC, following its natural flow path. As this basin is not connected to the ocean and its altitude is above 20 feet, the HUC is expected to remain unaffected by sea level rise, therefore SLR scenarios were not computed.

The design storm simulation determined that approximately 14.61% of the HUC total area or 3.30 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 14.32% of the HUC's total area, or 3.23 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 13.91% of the HUC's total area, or 3.14 mi^2, would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 13.91% of the HUC's total area, or 3.14 mi^2, would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031402020903 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	19.28	3.30	85.38%	14.61%
1-day 100-year	19.35	3.23	85.68%	14.32%
1-day 10-year	19.44	3.14	86.08%	13.91%
1-day 5-year	19.44	3.14	86.08%	13.91%

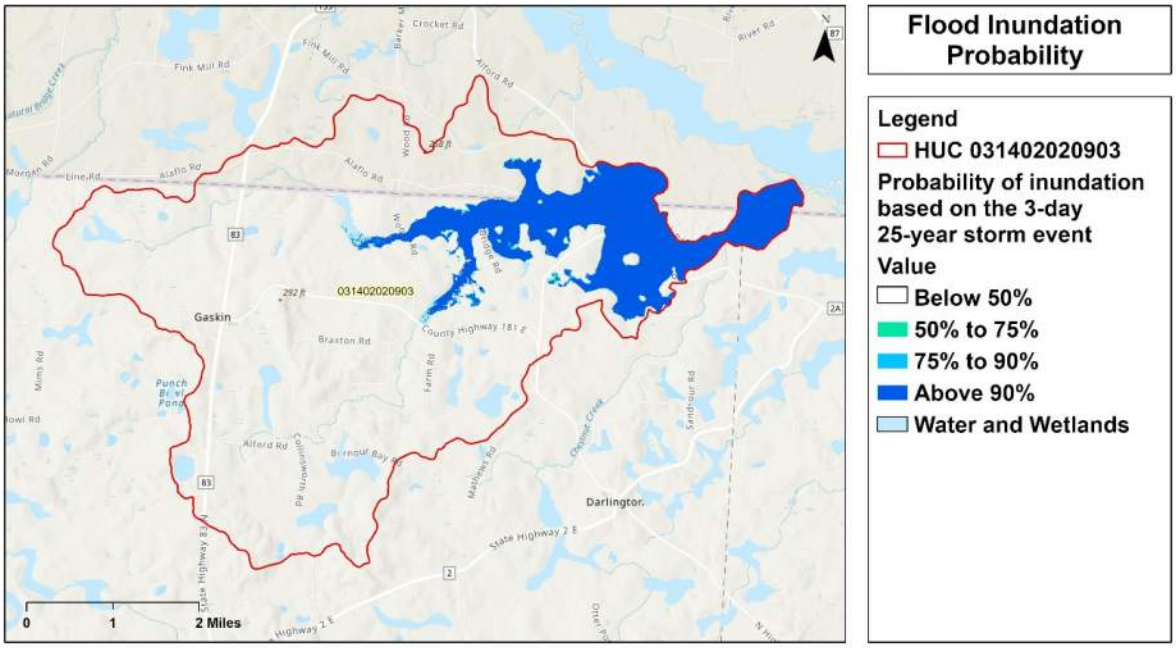

Figure 31. 3-day 25-year storm event for HUC 031402020903 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

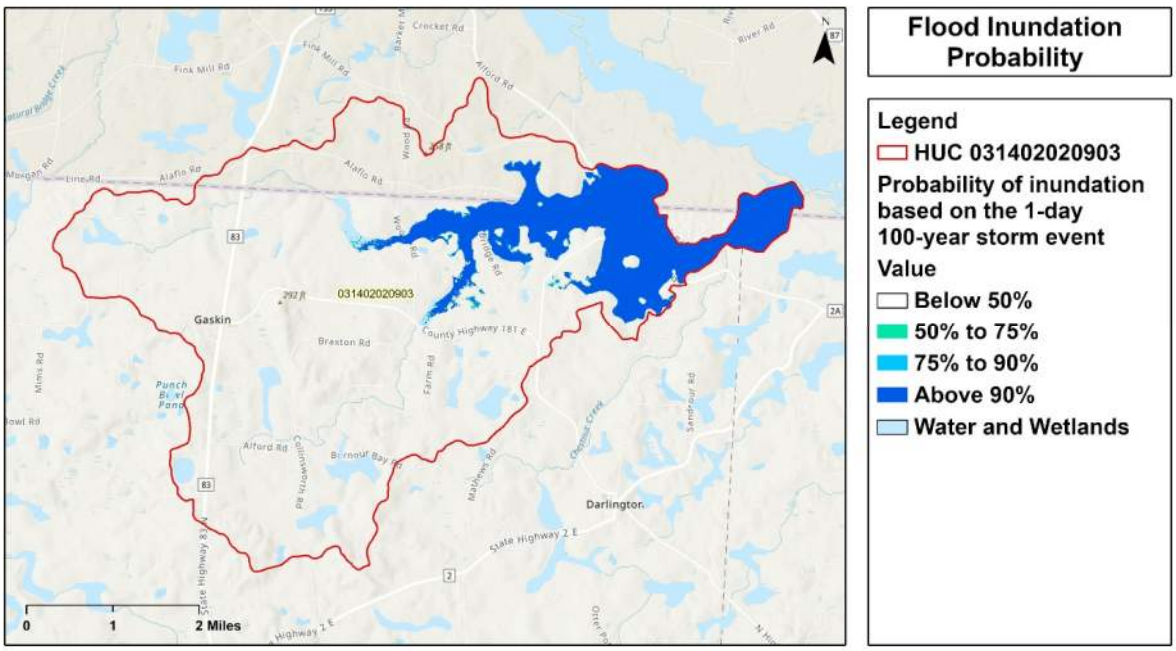

Figure 32. 1-day 100-year storm event for HUC 031402020903 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

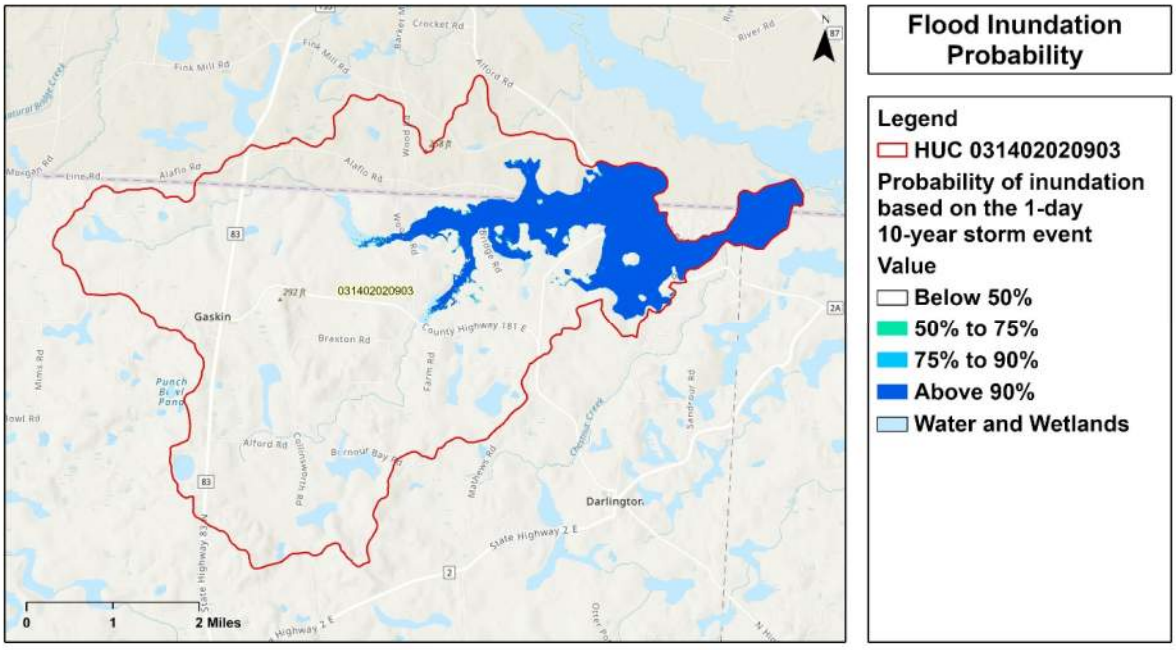

Figure 33. 1-day 10-year storm event for HUC 031402020903 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

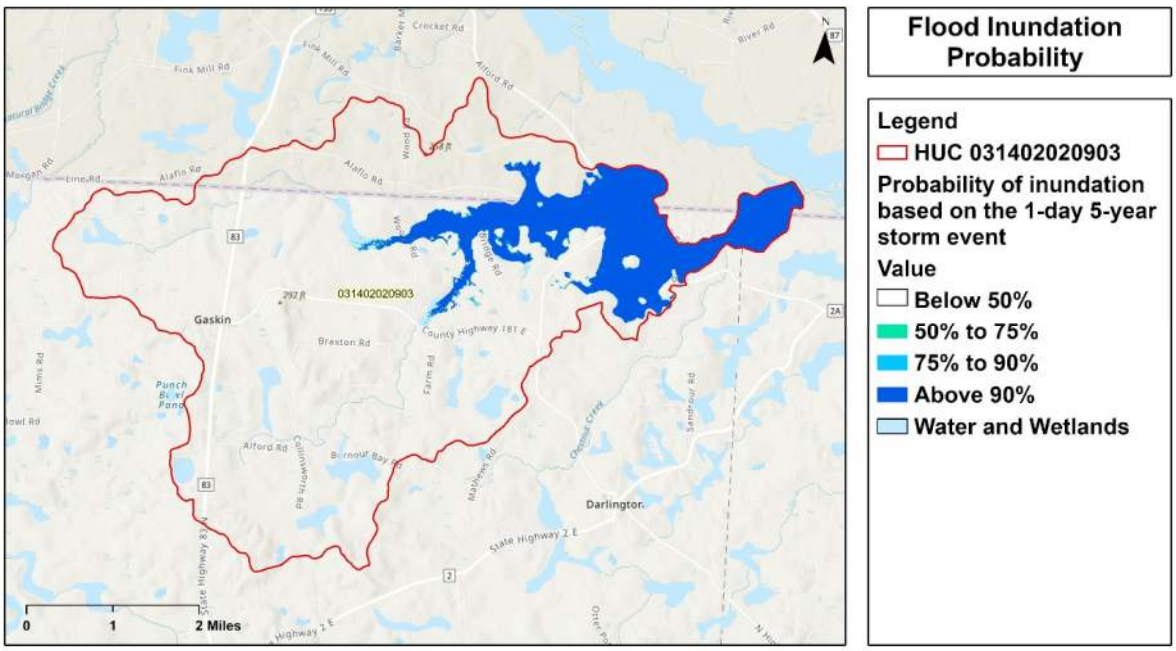

Figure 34. 1-day 5-year storm event for HUC 031402020903 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older,

poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3

28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6

60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6

97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031402020903 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (Figure 35) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 36) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

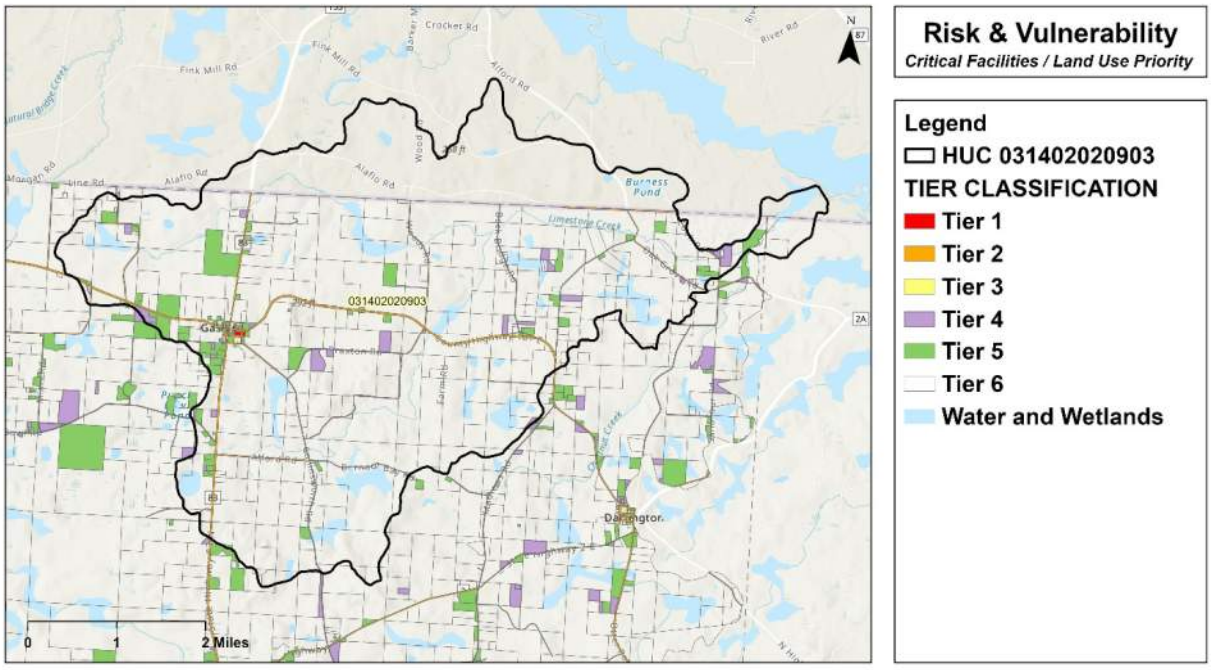

Figure 35. HUC 031402020903 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

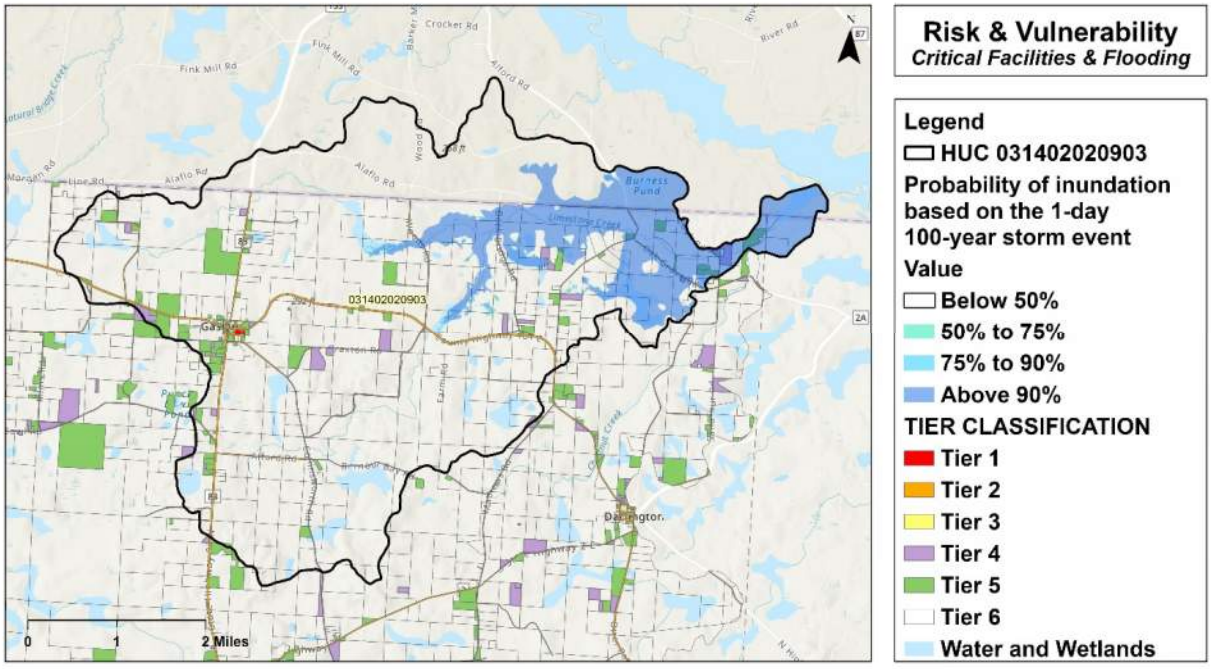

Figure 36. HUC 031402020903 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation.
Processed by FAU.

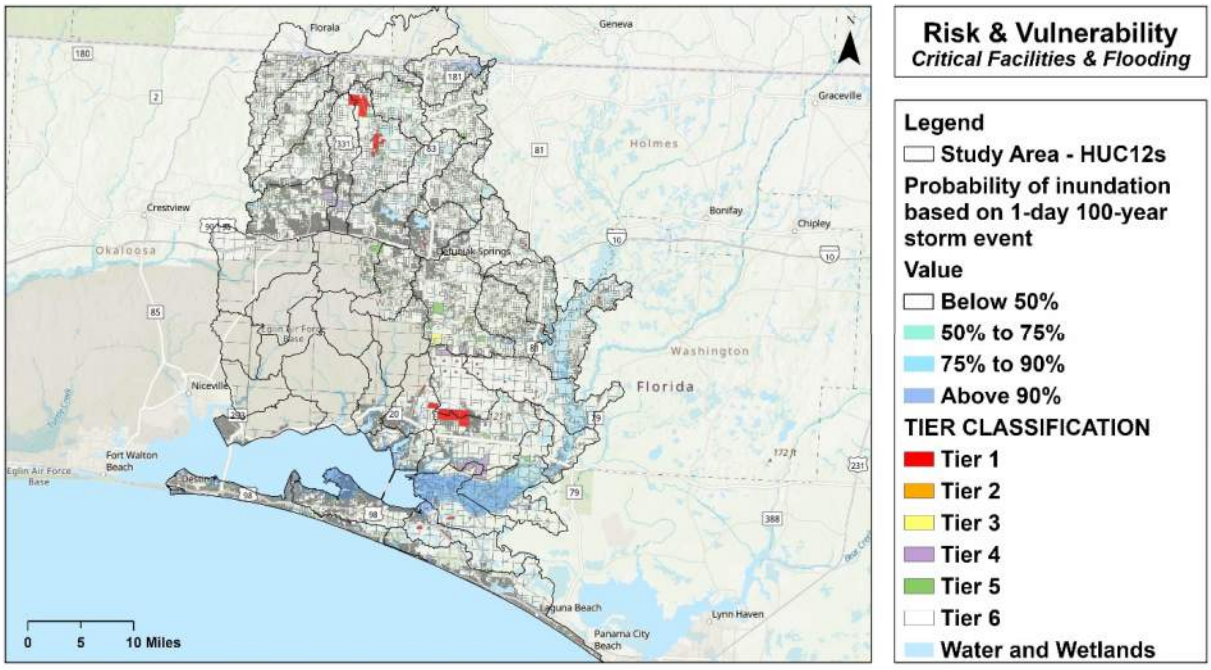

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

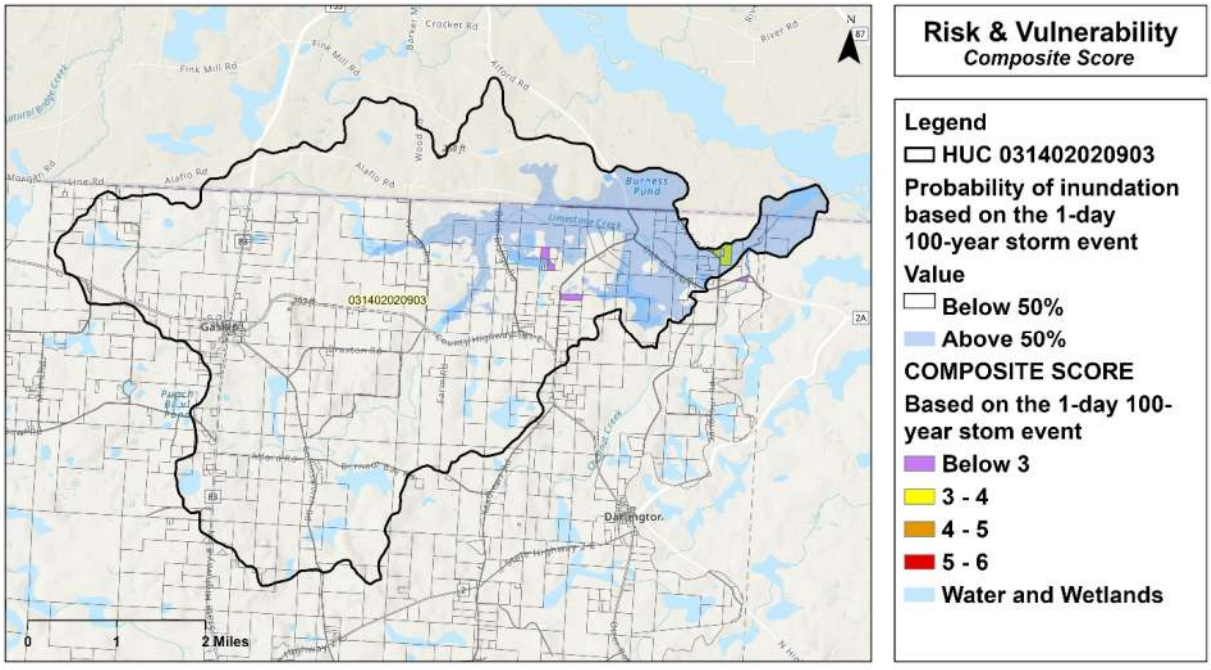

Figure 38. HUC 031402020903 sub-watershed Composite Score Risk map, with calculation based on 1-day 100-year storm event. Processed by FAU.

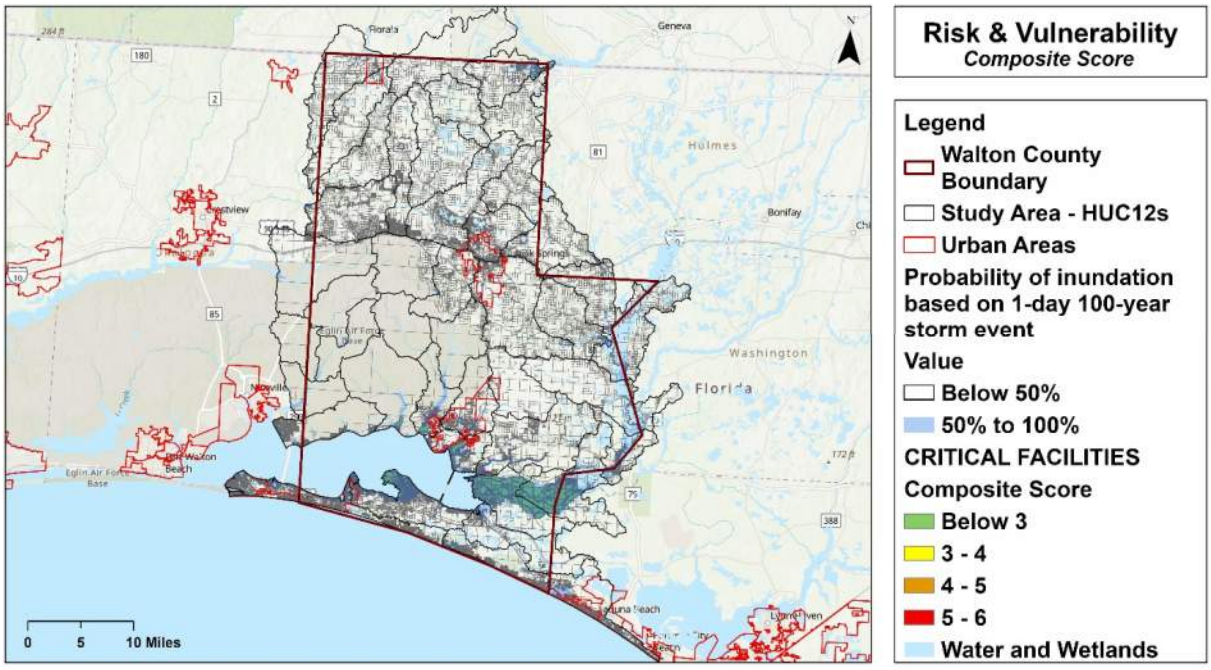

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

Please note that due to the scale of the map, the composite score layer is not properly visible in this map.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031402020903. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It is important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031402020903. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031402020903	14454.51
All of the 1-day 100-year storm event inundation	**2069.91**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	36.60
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	2033.31
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	2033.31

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that

have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

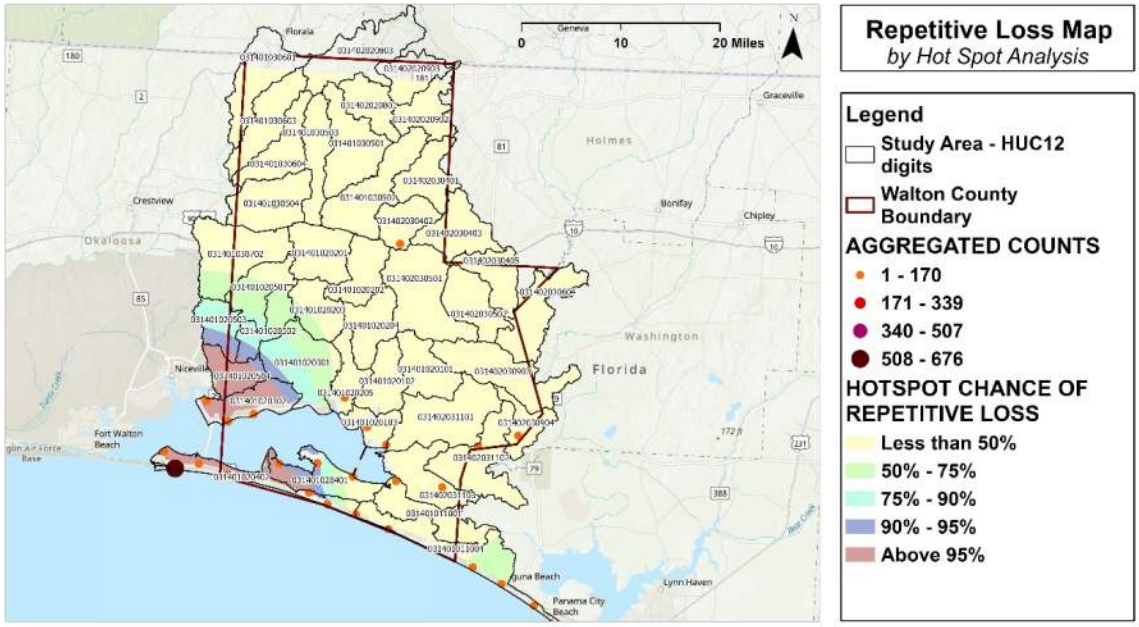

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5 Priority Projects

Although the basin does not features a significant amount of developed land, it is possible to note some parcels falling within the flood zone. In terms of priority for land use, there are parcels in tier 2 (roads) that need some attention, and tiers 4 and 5, signifying a lower priority for intervention. Although there are a few parcels classified as tier 1 of priority of land uses, there are not within the flood.

Examining the composite score, 14 parcels as total presents results, therefore, are within the flooding zone. Among them, three are within the score range of 5-6, and all of them are roads (Al County Road 10, Jasmine Drive, Cook Road), representing the highest priority for intervention. Furthermore, there are four parcels within the score range of 4-5, all of which are also roads (Woods Road, Penn Williams Road, Beck Bridge Road, Oak Grove Road). In the score range of 3-4, there are four parcels, all classified as mobile homes, and within the score below 3, there are 3 parcels, all of which are also mobile homes.

It is also important to mention that a good portion of the basin has not been included in the priority land use analysis and, consequently, in the composite score calculation. This omission is due to the project's reliance on land use data solely from Florida, and the basin has a portion on Alabama

as well. The categories of land use maps in Alabama would be different, making it impossible to match the data from two different databases in different states. As a result, there is a slight possibility that there may be priority projects on the Alabama side of the basin of which we are not aware.

APPENDIX AF

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031402030401

UPPER SANDY CREEK

Principal Investigator: Frederick Bloetscher, Ph.D., P.E.

Co-Principal Investigators: Weibo Liu, Ph.D., Daniel Meeroff, Ph.D., Diana Mitsova, Ph.D., S. Nagarajan, Ph.D., Hongbo Su, Ph.D., Ramesh Teegavarapu, Ph.D., Zhixiao Xie, Ph.D., Yan Yong, Ph.D., and Caiyun Zhang, Ph.D., Ahmet Urusan, Ph.D., Shannon Egger, Eva Suarez, Ph.D.

Research Assistant: Leticia Sabio

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 (031402030401) is highlighted among all the HUCs to help identifying its location. (Figure 3).

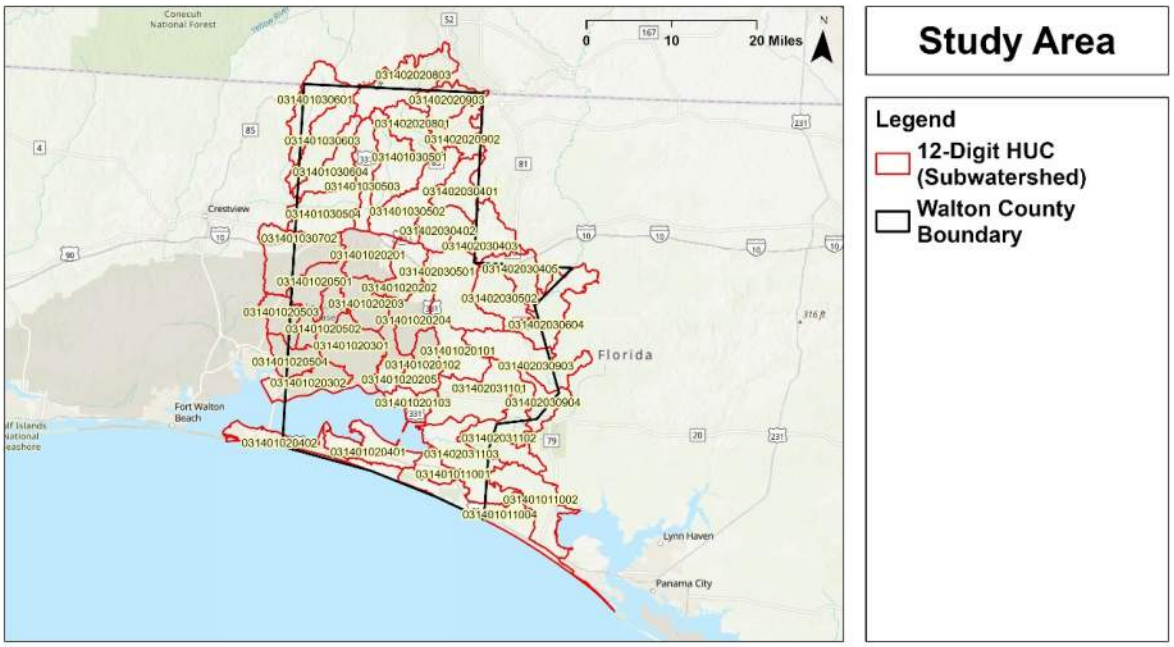

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

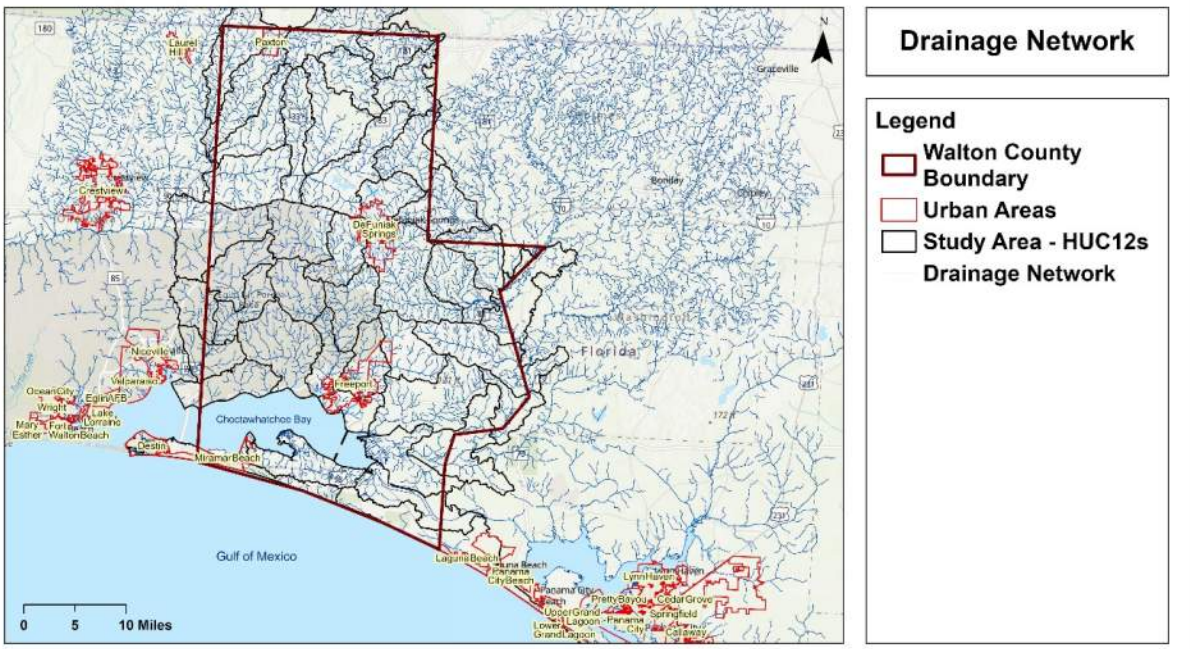

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

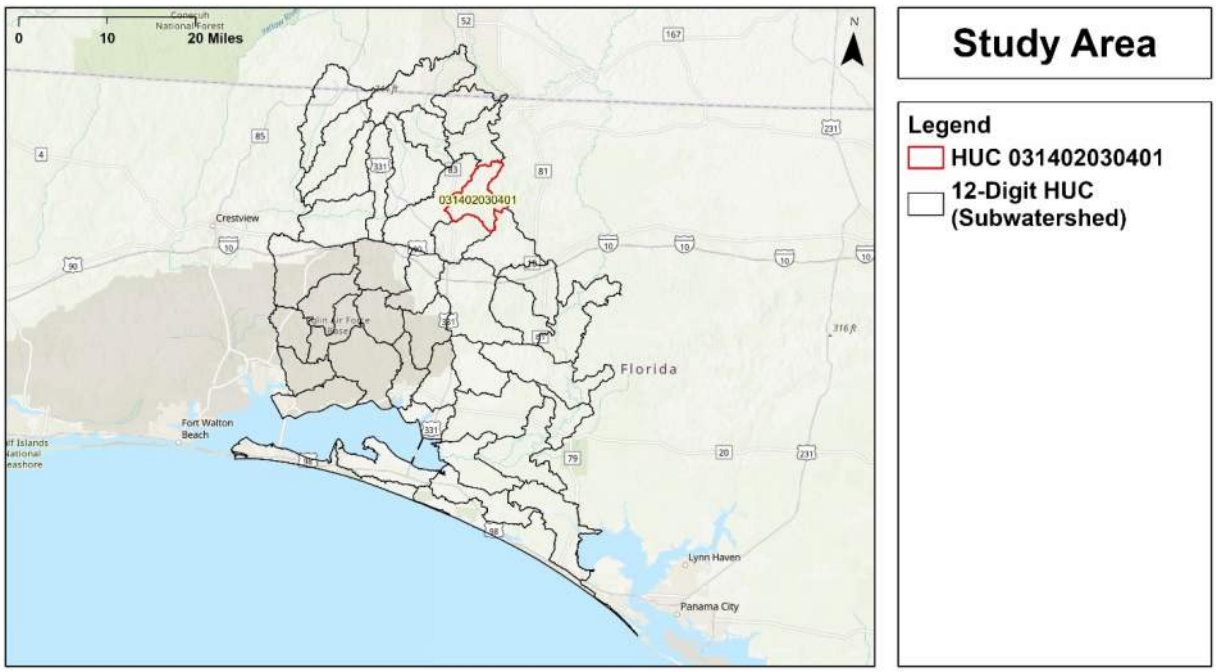

Figure 3. HUC 031402030401 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

(Source Data: FEMA)

Figures 12 and 13 is the county-wide report show the current and projected land use for the County. Based on the 2017 future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land Use in Walton County (Prepared by FAU from future land use map) versus land use in the entire watershed

Level 1 Land Use-Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

(Source Data: NWFWMD, 2017)

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 1.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

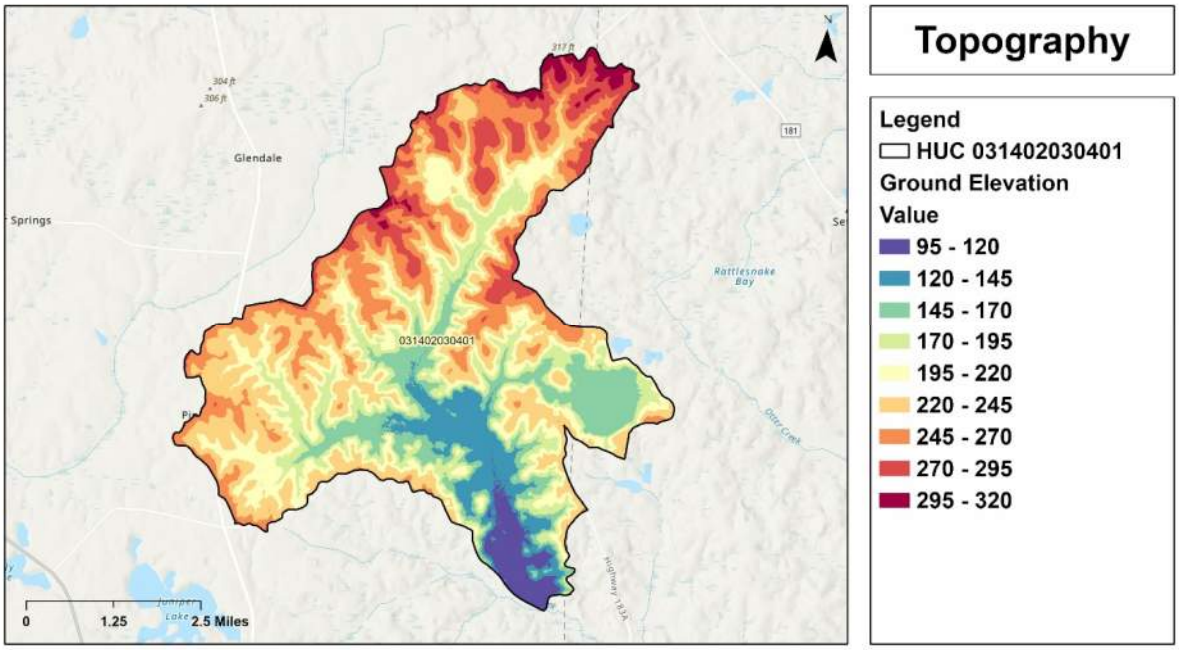

Figure 4. Topographic map of the HUC 031402030401 sub-watershed, processed by FAU

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031402030401 sub-watershed is shown in **Error! Reference source not found.**.

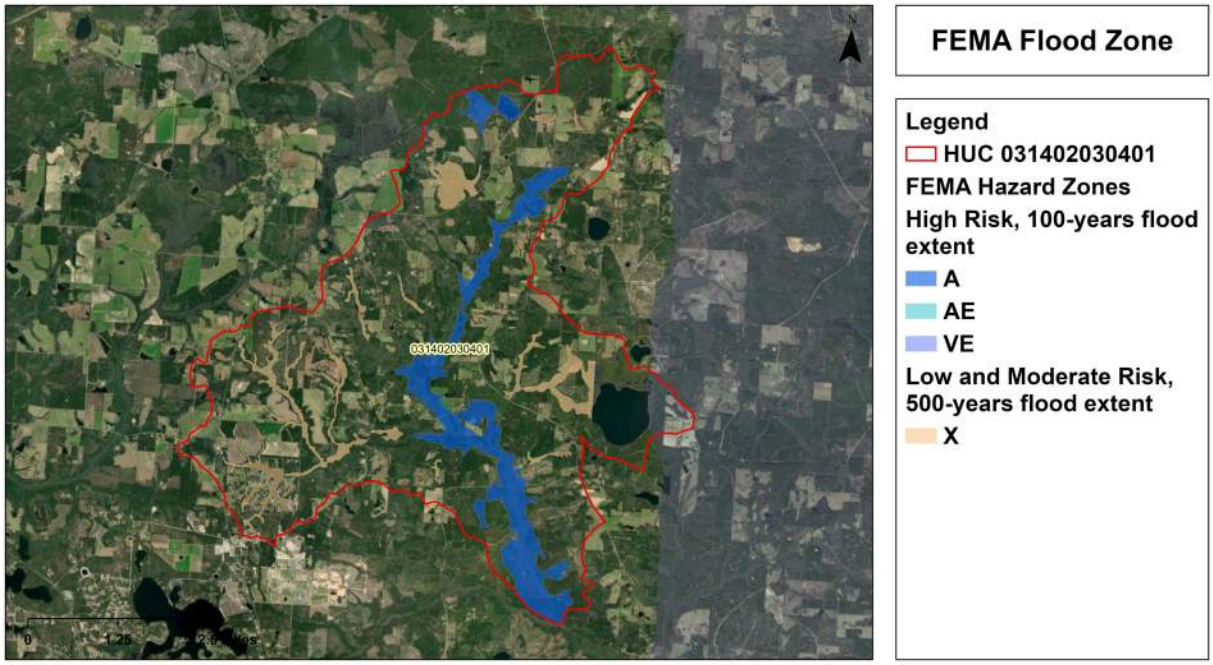

Figure 5. FEMA Flood Zone map (2020) for HUC 031402030401 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031402030401 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

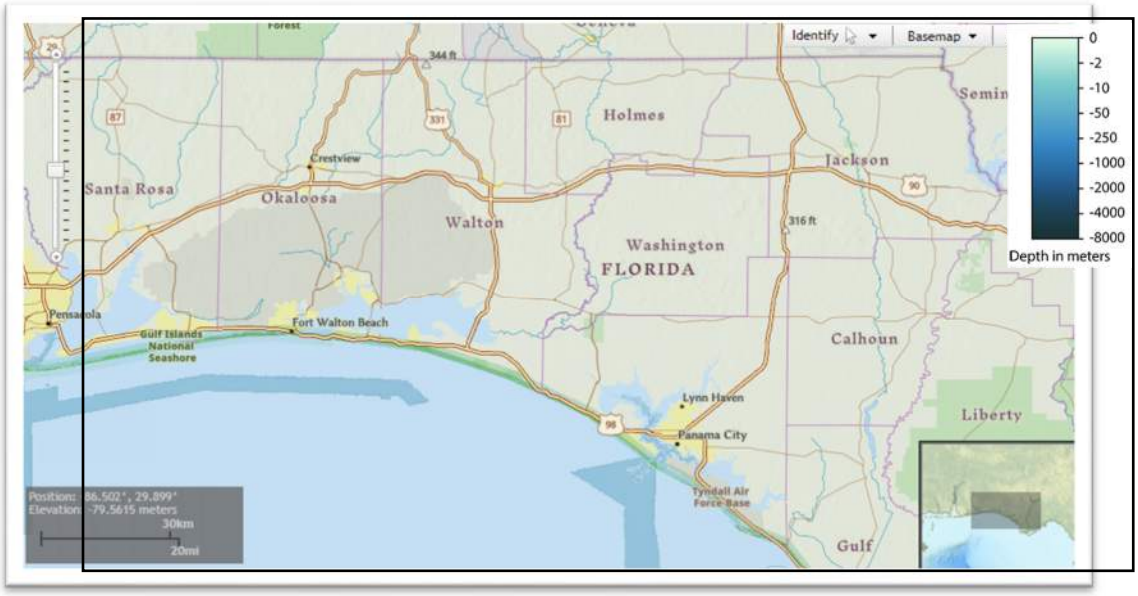

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

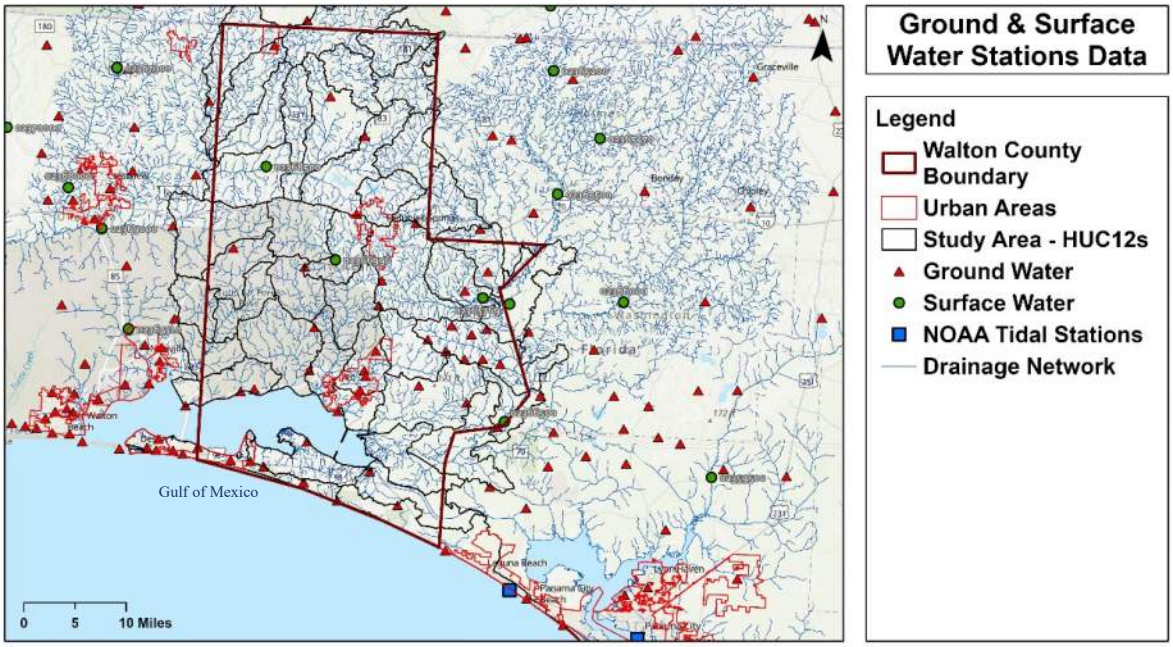

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031402030401 has no major rivers and canals, but creeks and branches, which include:

- Sandy Creek
- Anderson Mill Creek

- Camp Creek
- Huckleberry Creek
- Big Branch
- Long Branch
- Bay Branch
- Rattlesnake Branch

Given that stream flow data are critical for estimating flooding, Figure 8 shows the historical streamflow during June 2022 to July 2023 for USGS 02368500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031402030401, which is USGS 02368500 Shoal River.

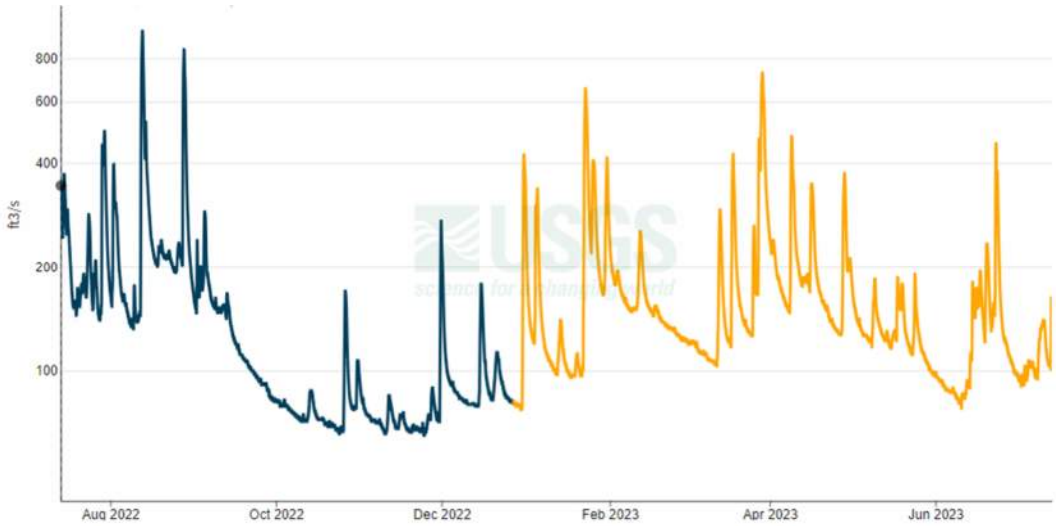

Figure 8. Average streamflow for Shoal River NR Mossy Head, Fla (USGS 02368500 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02368500/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to

process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031402030401 and points out the location of the ground water station in the surroundings. A groundwater-surface layer for the HUC 031402030401 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

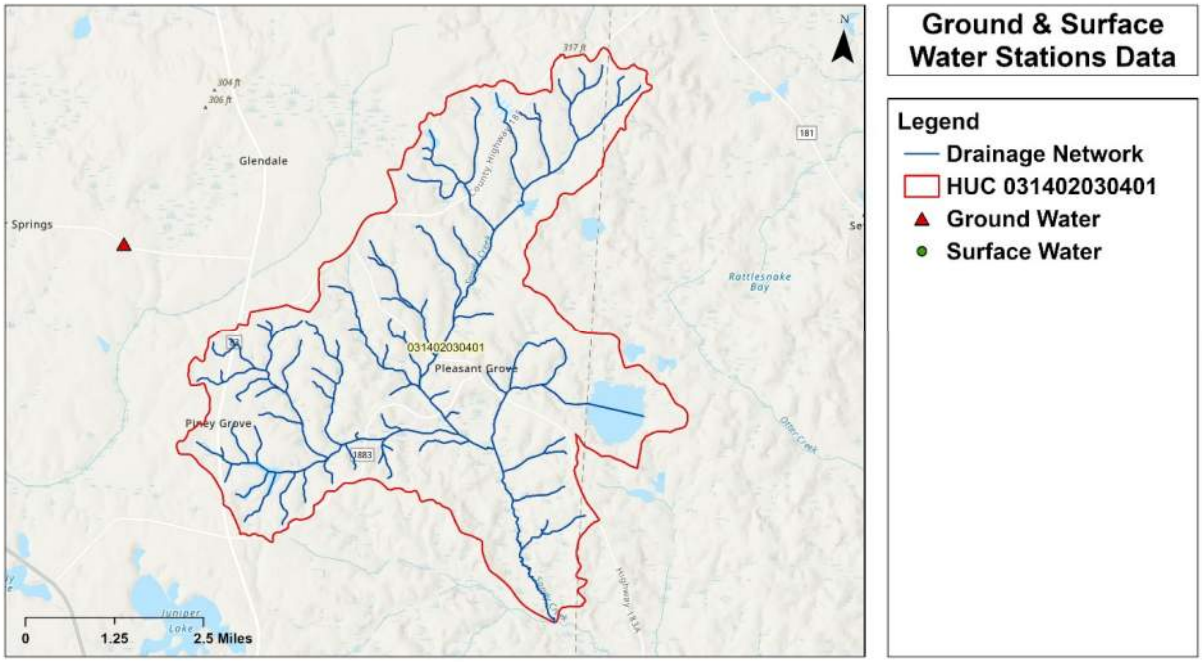

Figure 9. Ground and Surface Water Stations in the HUC 031402030401 sub-watershed, processed by FAU.

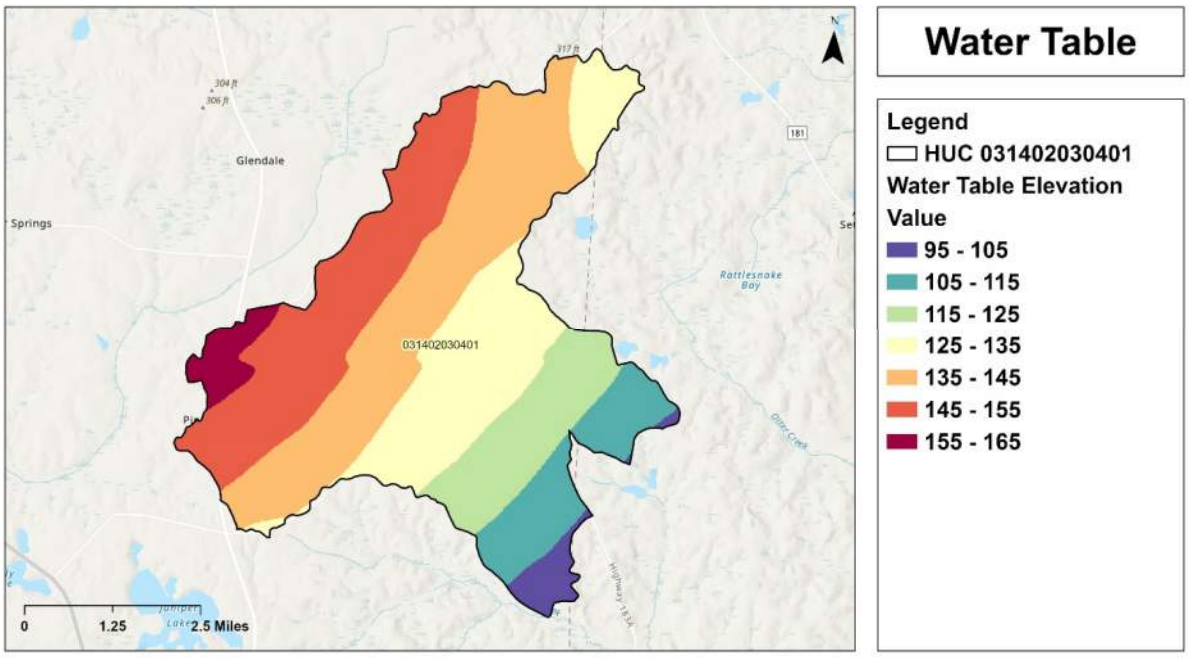

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031402030401 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the average precipitation over Walton County for every month of the year between 2011 and 2023.

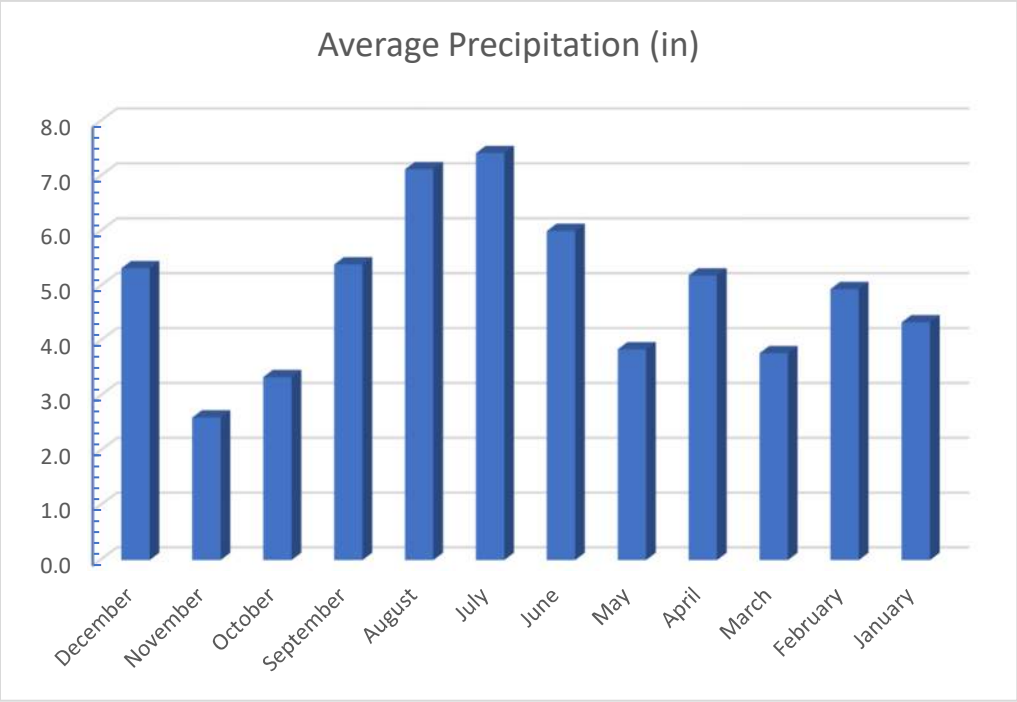

Figure 11. Monthly precipitation in Walton County, FL (2011-2023).
(Data Source: Florida Weather Data, available at https://data.usatoday.com/weather-data/walton-county/12131/1975-04-01/Table/)

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there are no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

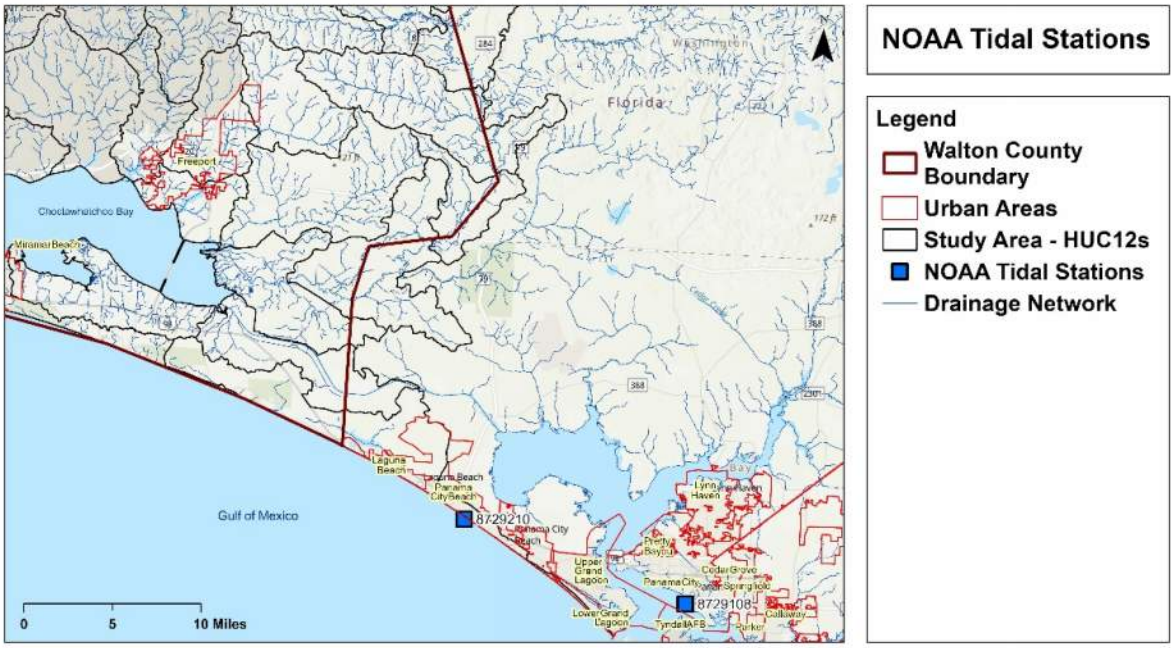

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

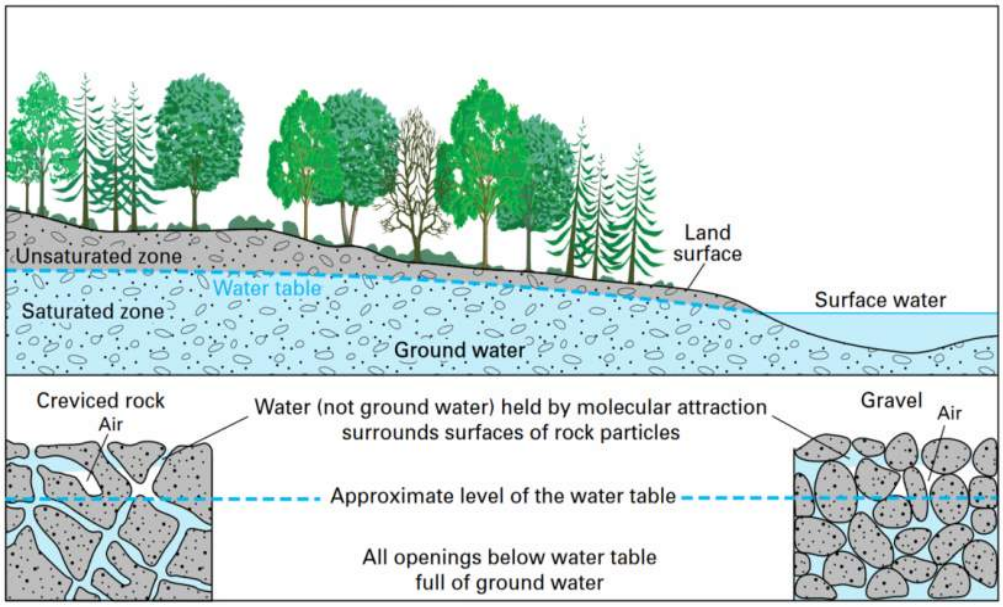

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

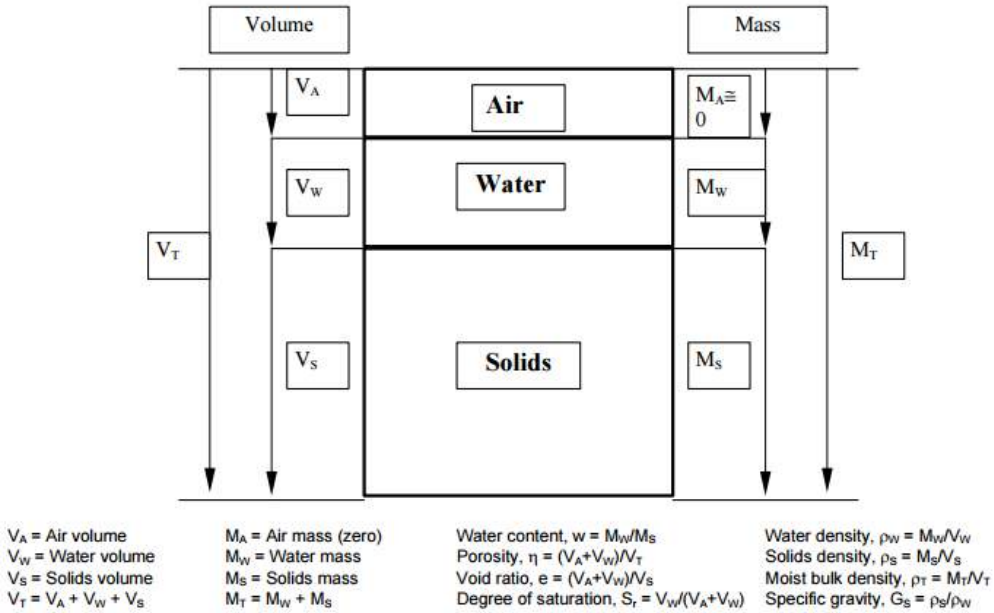

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

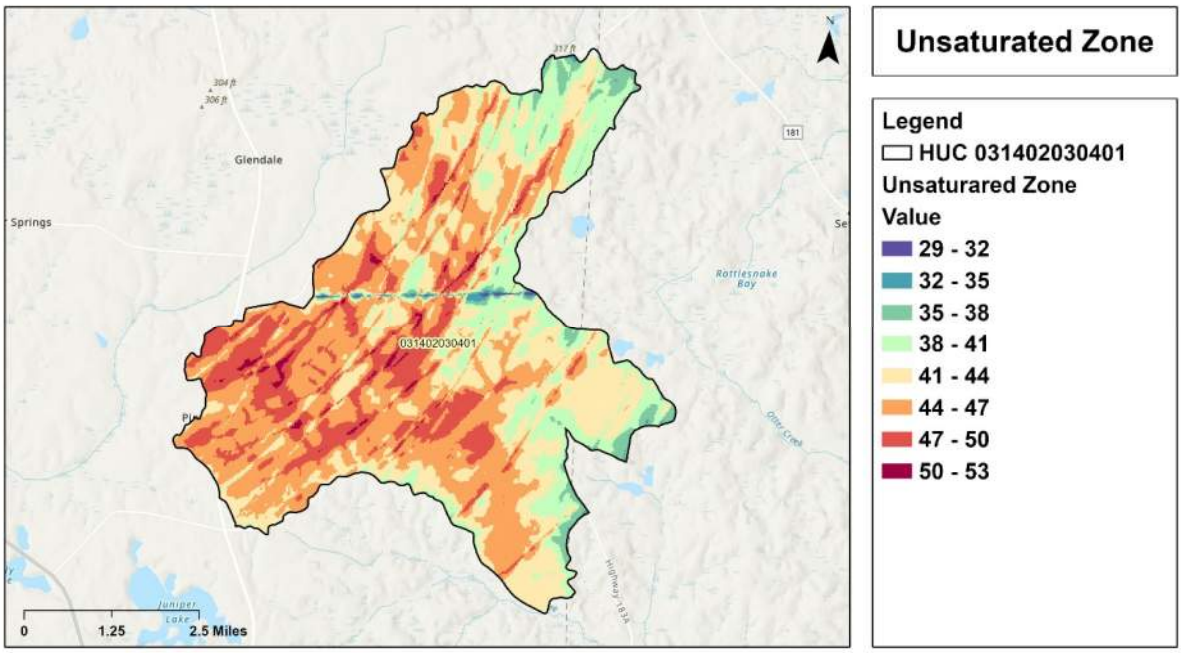

Figure 15. Unsaturated zone map for HUC 031402030401, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin exhibits moderately favorable soil storage capacity, ranging between 38 to 50 inches of remaining capacity.

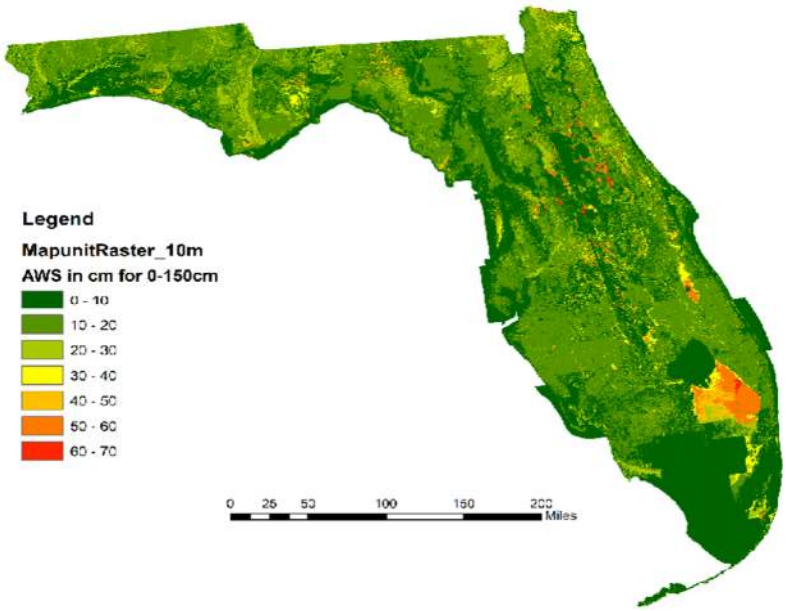

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

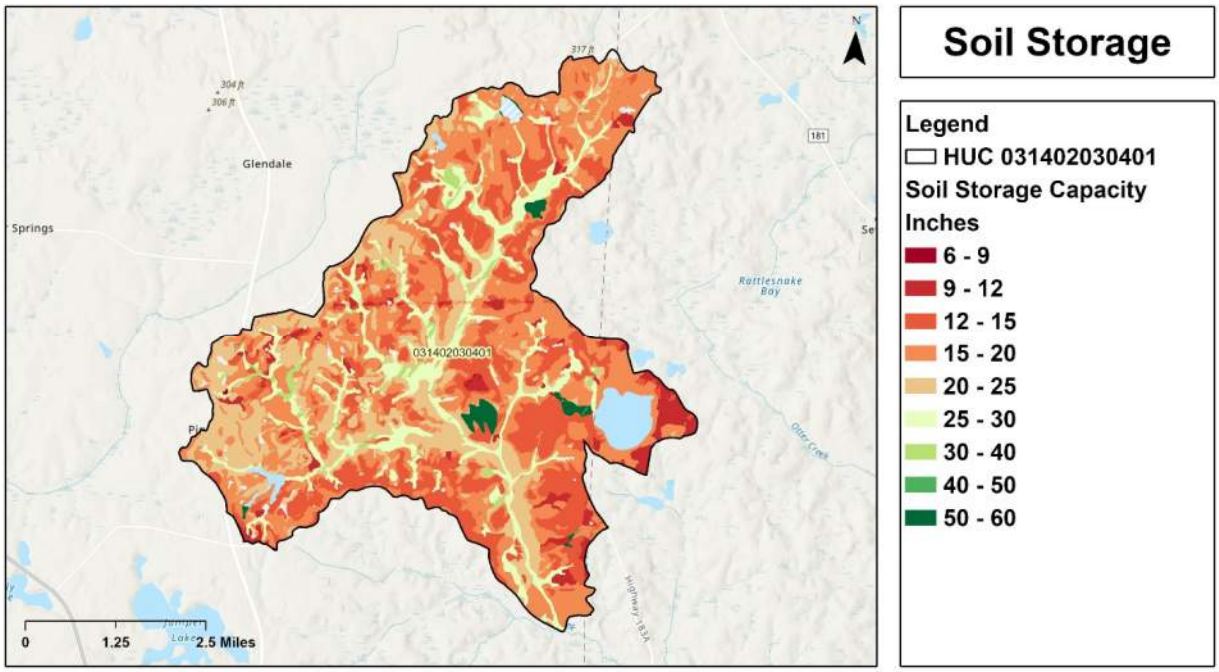

Figure 17. Water storage capacity of soil for the HUC 031402030401, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

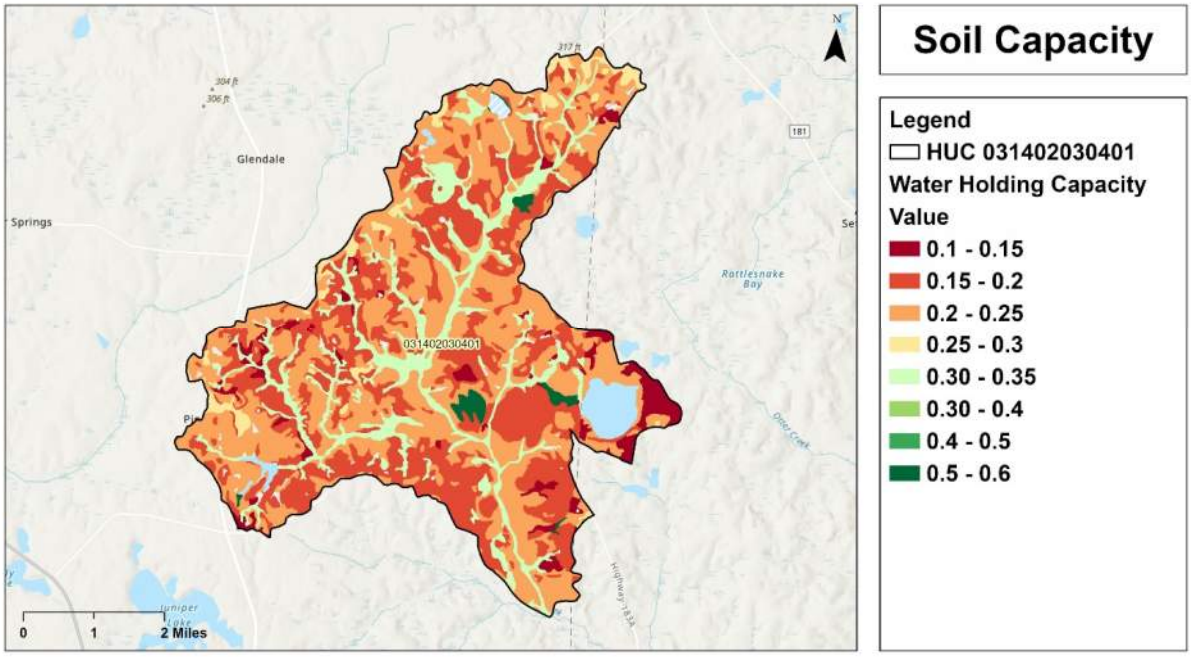

Figure 18. Water Holding Capacity (ratio) for the HUC 031402030401, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

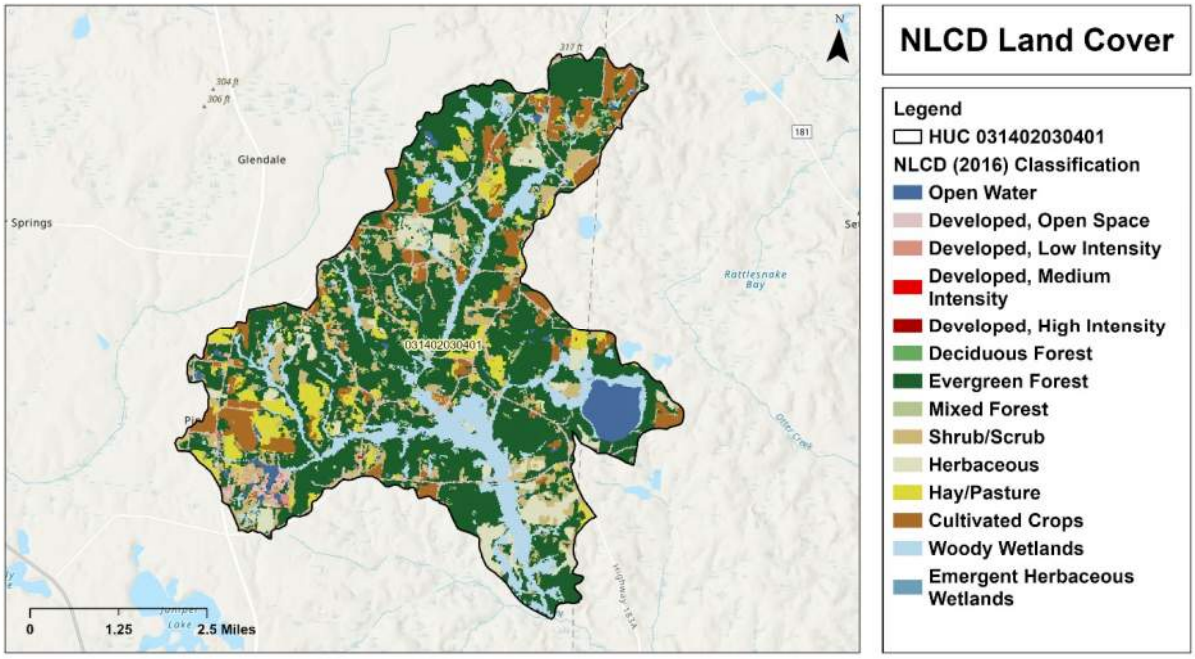

Figure 19. Land use in the HUC 031402030401 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

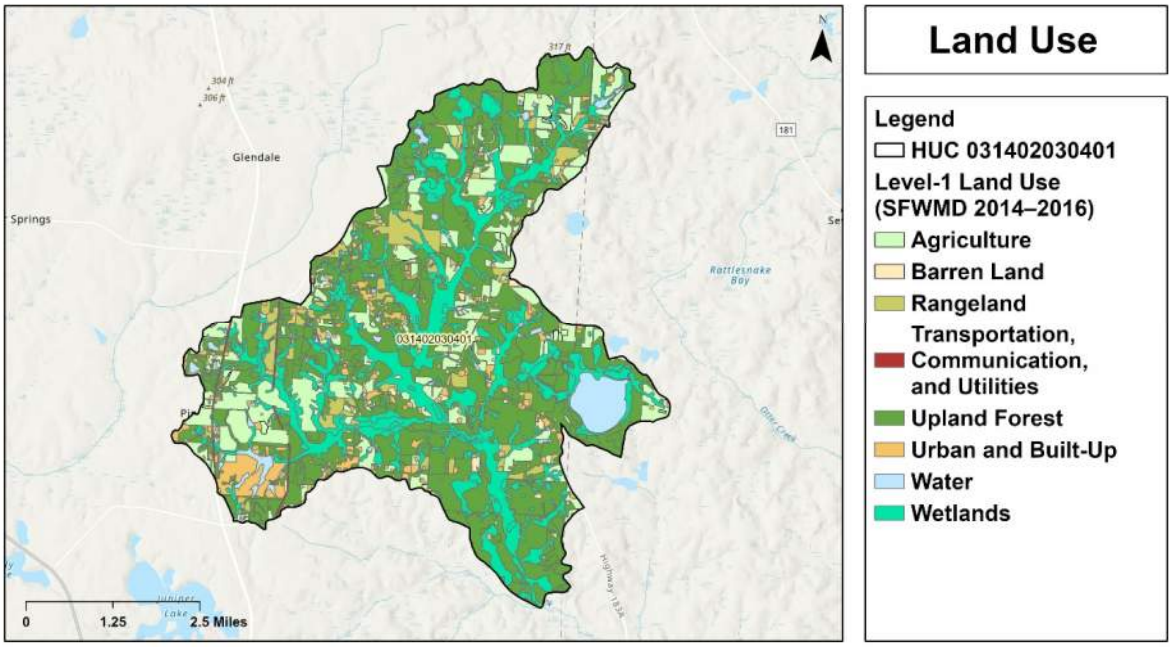

Figure 20. Land use in the HUC 031402030401 (from the 2023 Florida Geographic Data Library (FGDL) database), processed by FAU.

In the HUC 031402030401 sub-watershed, the predominant land cover is upland forest, accounting for 41.85% of the area. Wetlands comes in second at 19.44%, followed by agriculture at 16.15%, and Transportation, Communication, and Utilities at 11.86%. Developed land constitutes a minor portion, with only 4% categorized as urban and built-up, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031402030401 subwatershed.

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	3857.38	16.15%
Barren Land	63.62	0.27%
Rangeland	921.89	3.86%
Transportation, Communication, and Utilities	2832.22	11.86%
Upland Forest	9994.65	41.85%
Urban and Built-Up	956.15	4.00%
Water	611.62	2.56%
Wetlands	4642.66	19.44%
Grand Total:	**23880.19**	**100.00%**

(Source Data: 2023 Florida Geographic Data Library (FGDL) database))

Table 4. Roughness and CN Values for Each Land Use Code

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

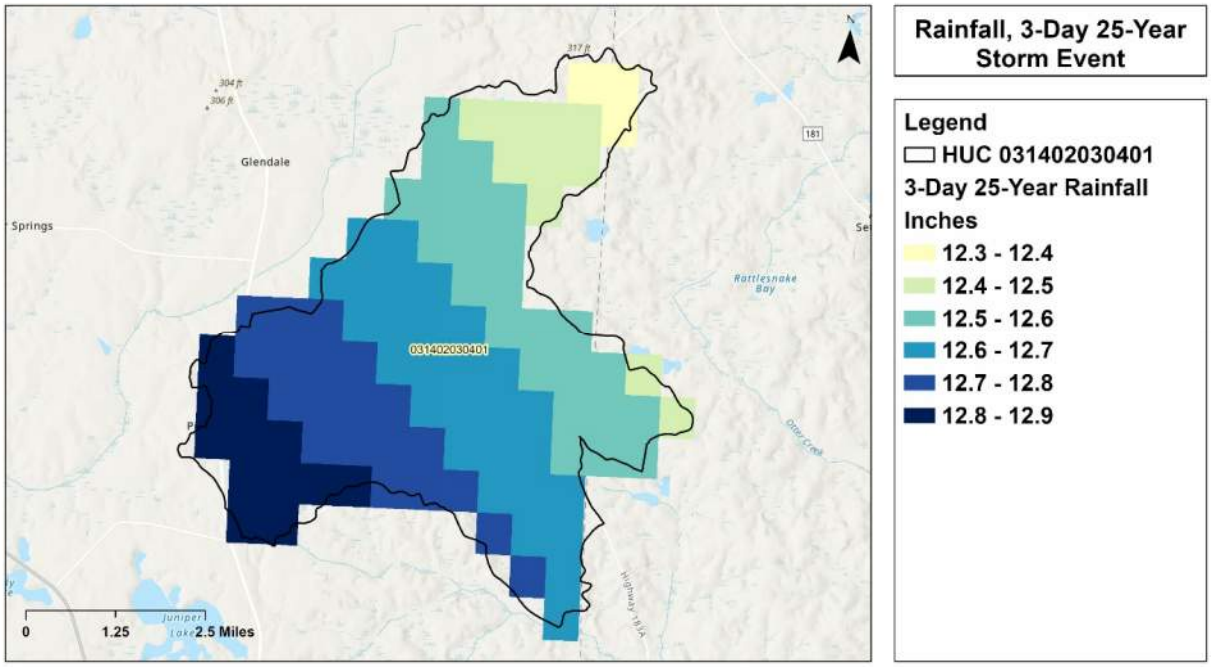

Figure 21. Rainfall distribution map across HUC 031402030401 sub-watershed, for 3-day 25-year storm event, processed by FAU.

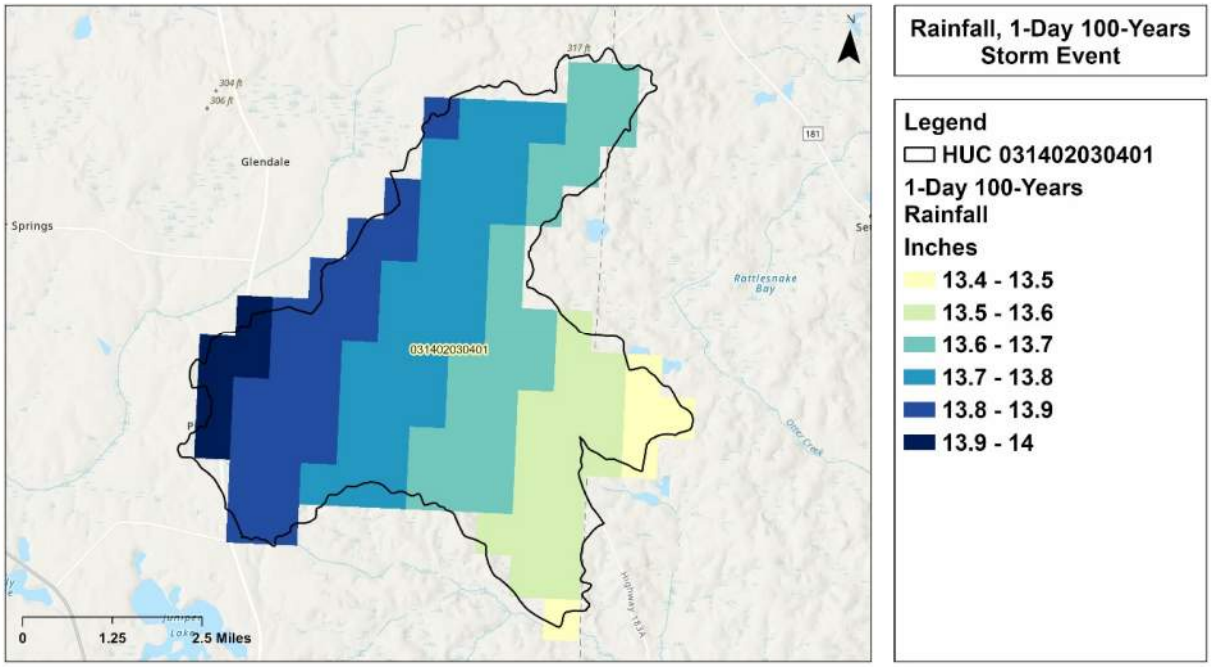

Figure 22. Rainfall distribution map across HUC 031402030401 sub-watershed, for 1-day 100-year storm event, processed by FAU.

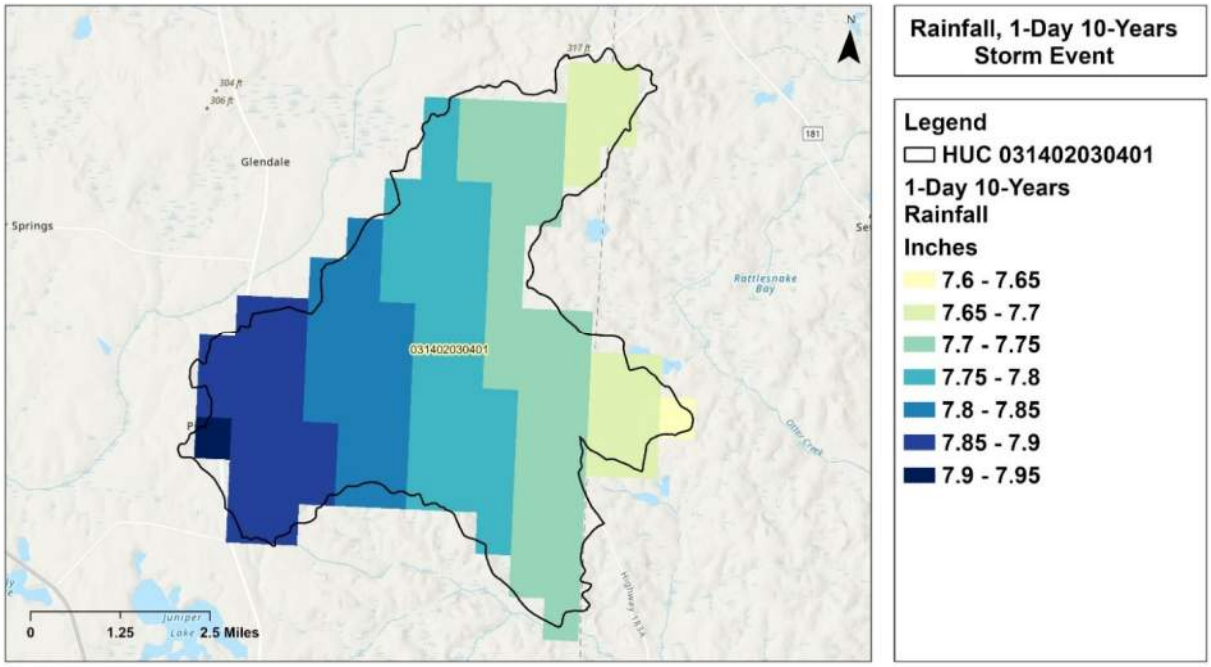

Figure 23. Rainfall distribution map across HUC 031402030401 sub-watershed, for 1-day 10-year storm event, processed by FAU.

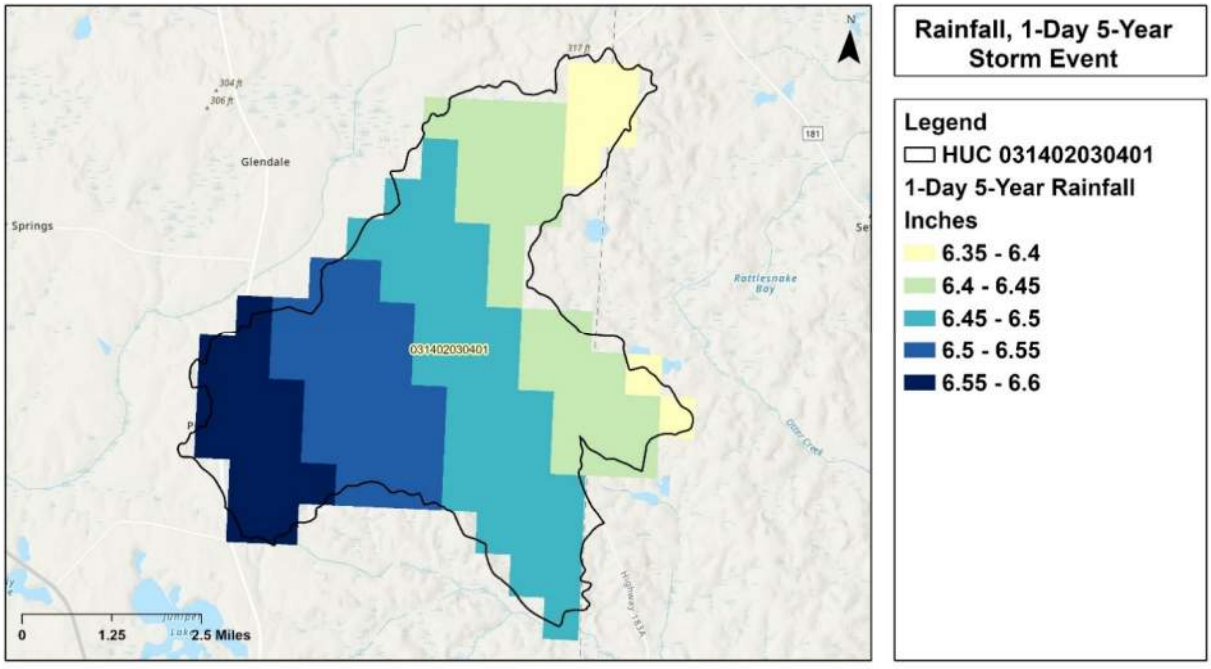

Figure 24. Rainfall distribution map across HUC 031402030401 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

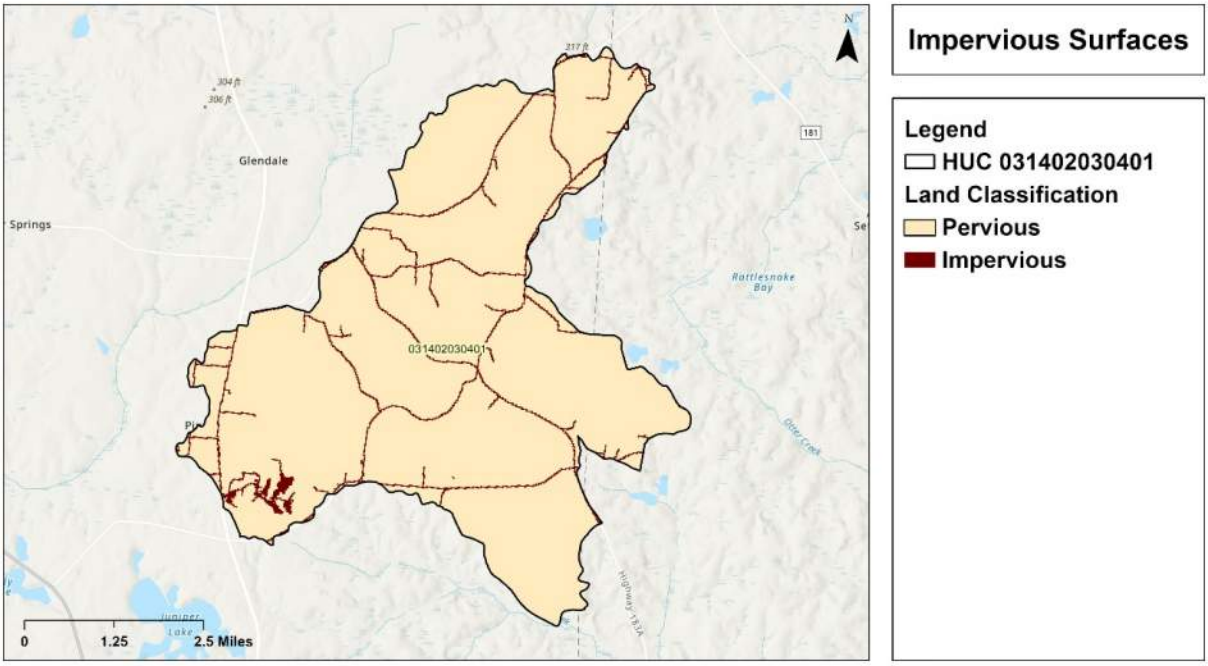

Figure 25. Impervious area map for the HUC 031402030401 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

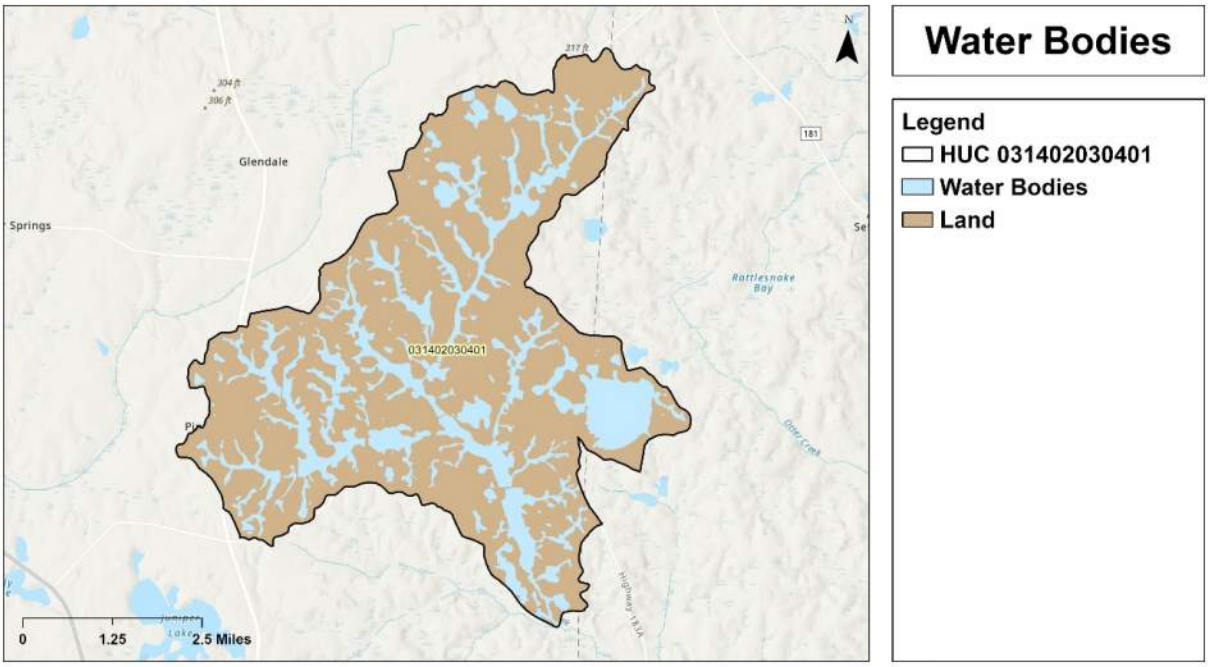

Figure 26. Water bodies map for the HUC 031402030401 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

(Source: US Census Bureau 2020, and Zip-codes.com)

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.

- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

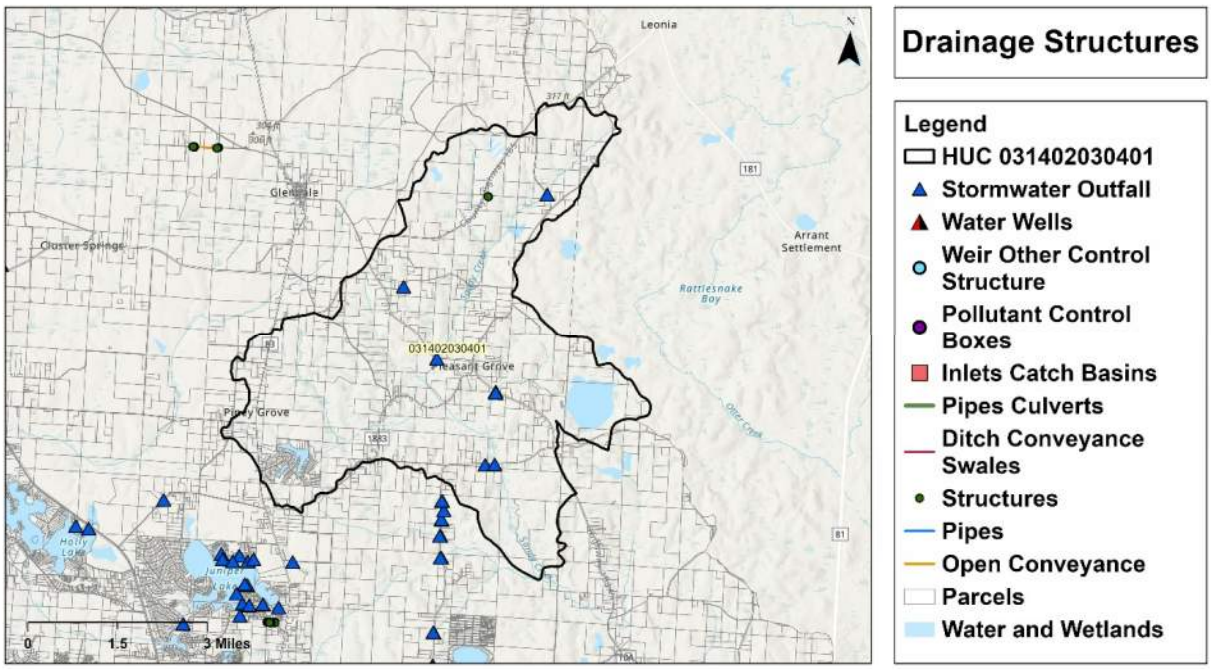

Figure 27. Stormwater Infrastructure for the HUC 031402030401. Processed by FAU.

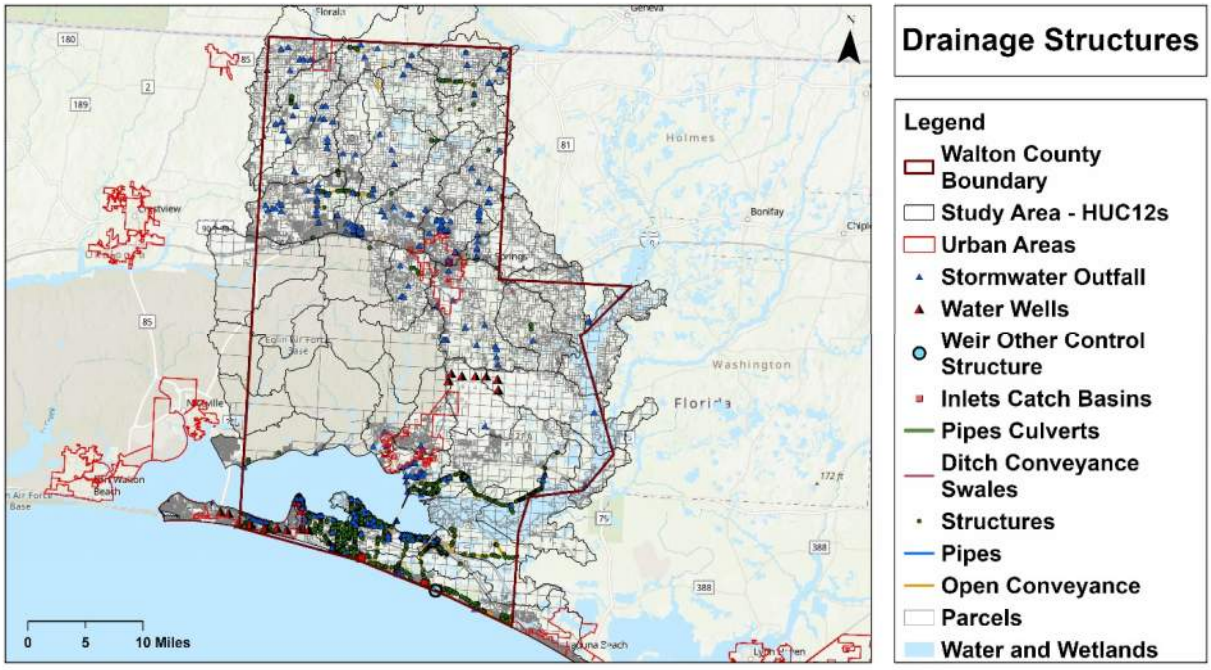

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020)

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1, analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031402030401 sub-watershed flood response to a series of rainfall events (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.3.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD DBHYDRO website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

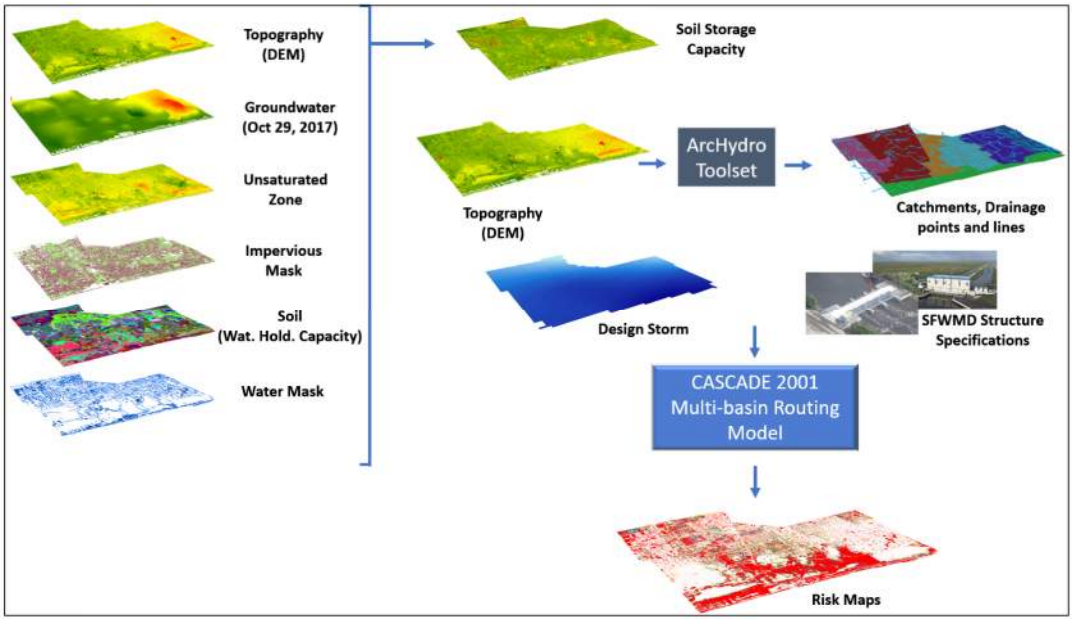

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

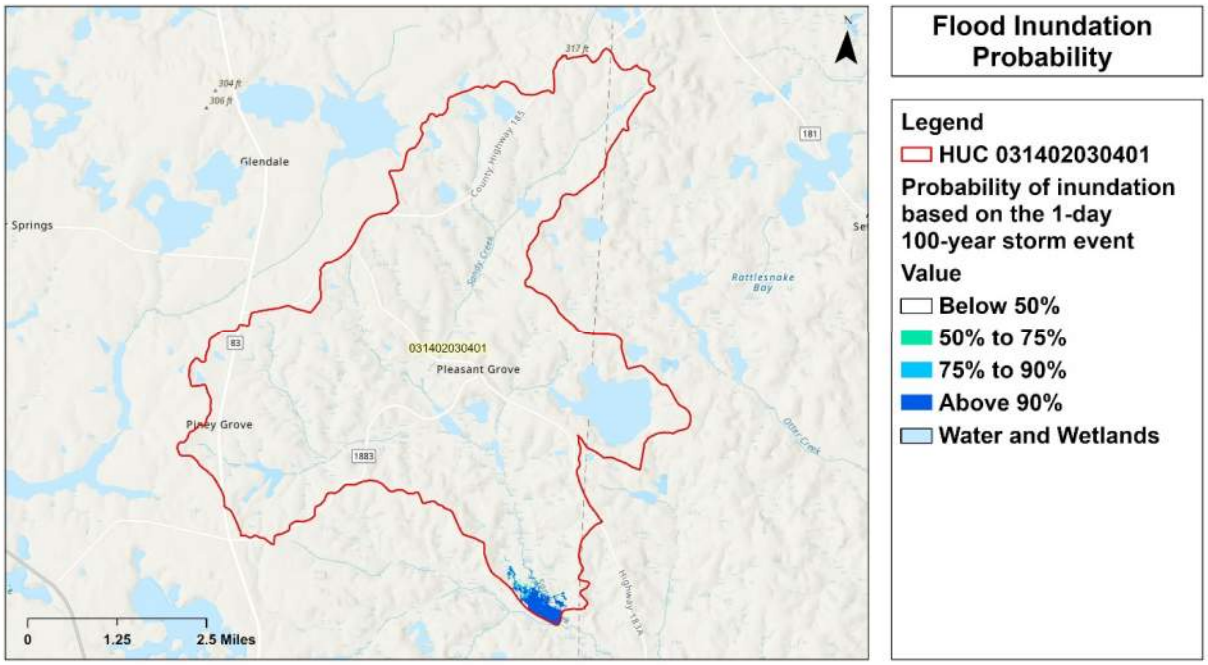

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031402030401, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes

and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 2.4 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in

the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a small portion of flooding is noted at the creek entrance to the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, the HUC is expected to remain unaffected by sea level rise, therefore SLR scenarios were not computed.

The design storm simulation determined that approximately 0.71% of the HUC total area or 0.19 mi² has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 0.76% of the HUC's total area, or 0.20 mi² would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.52% of the HUC's total area, or 0.14 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 052% of the HUC's total area, or 0.14 mi², would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031402030401 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	26.79	0.19	99.29%	0.71%
1-day 100-year	26.78	0.20	99.24%	0.76%
1-day 10-year	26.84	0.14	99.48%	0.52%

1-day 5-year	26.84	0.14	99.48%	0.52%

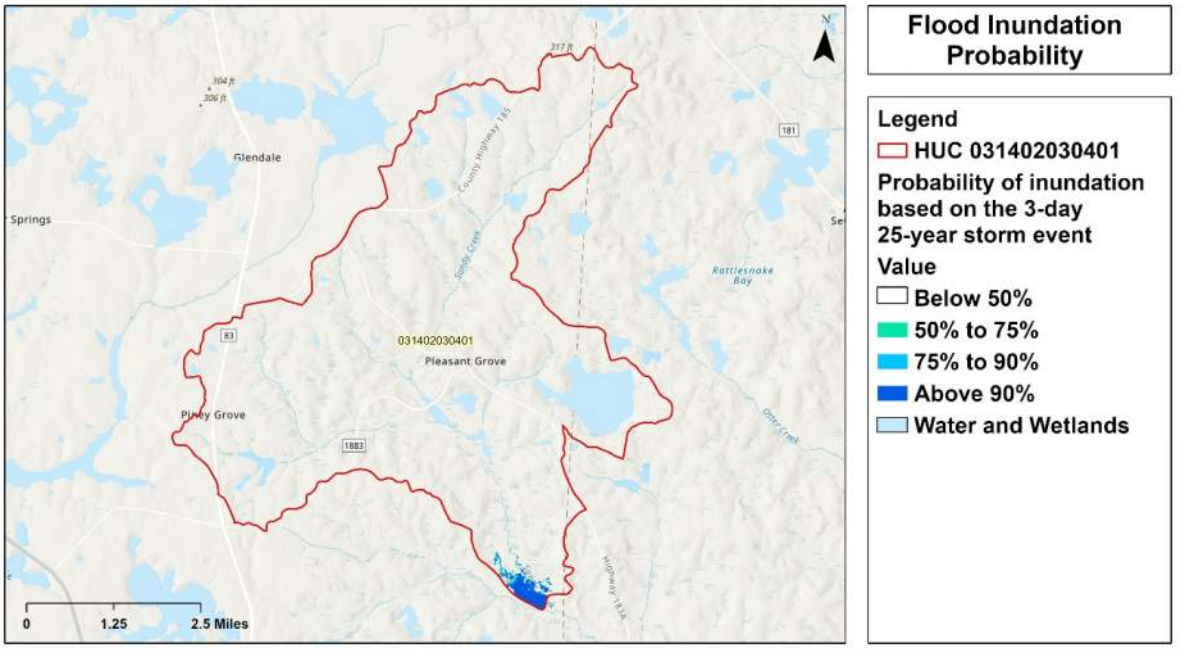

Figure 31. 3-day 25-year storm event for HUC 031402030401 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

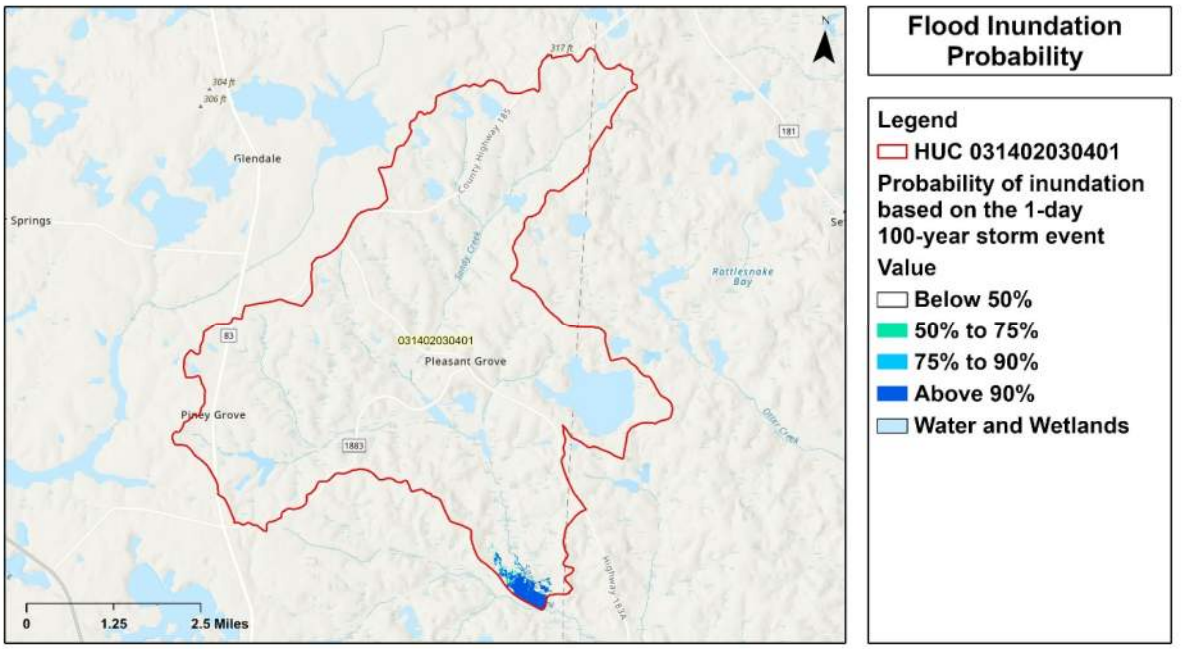

Figure 32. 1-day 100-year storm event for HUC 031402030401 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

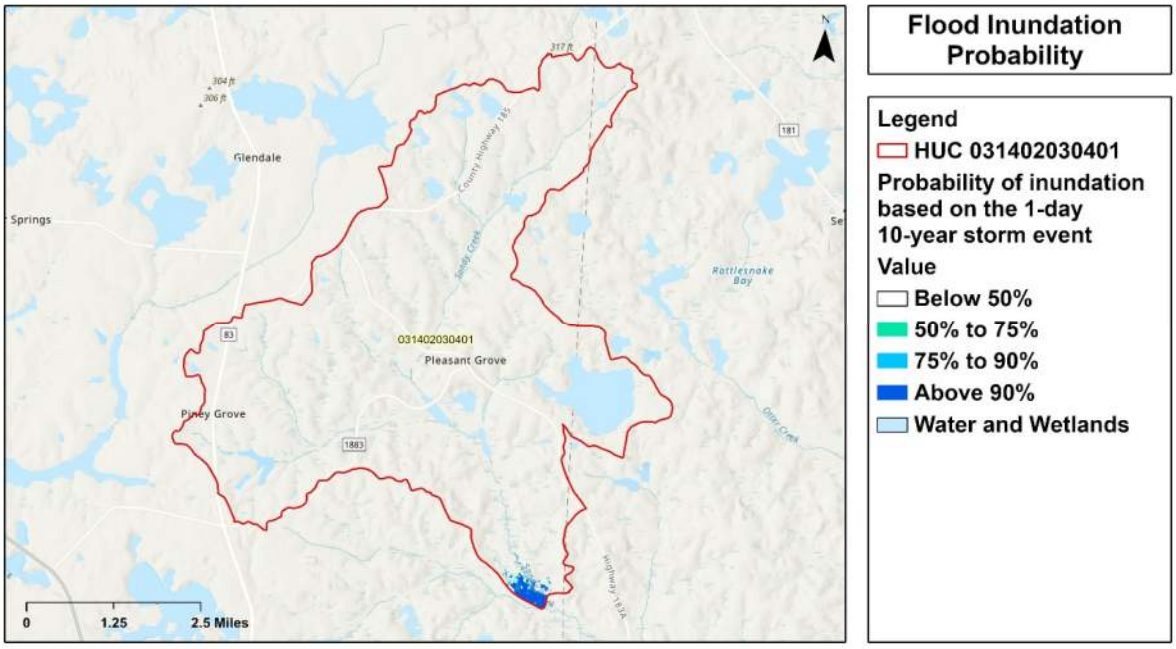

Figure 33. 1-day 10-year storm event for HUC 031402030401 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

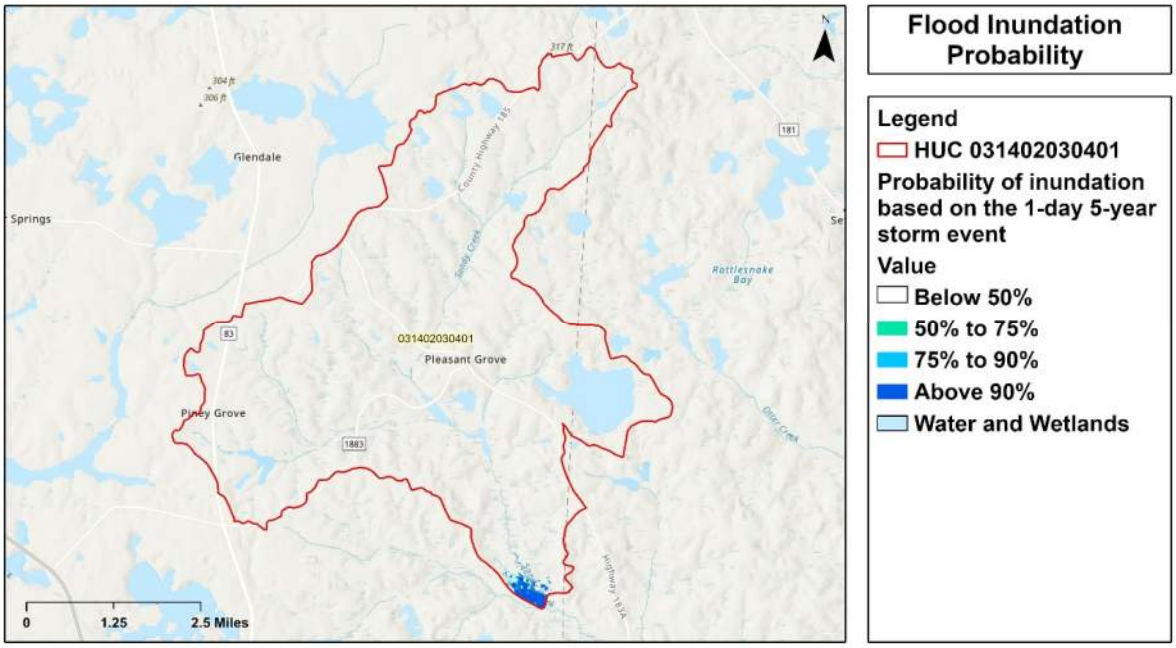

Figure 34. 1-day 5-year storm event for HUC 031402030401 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6

10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3

45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6

82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031402030401 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.**is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.**illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

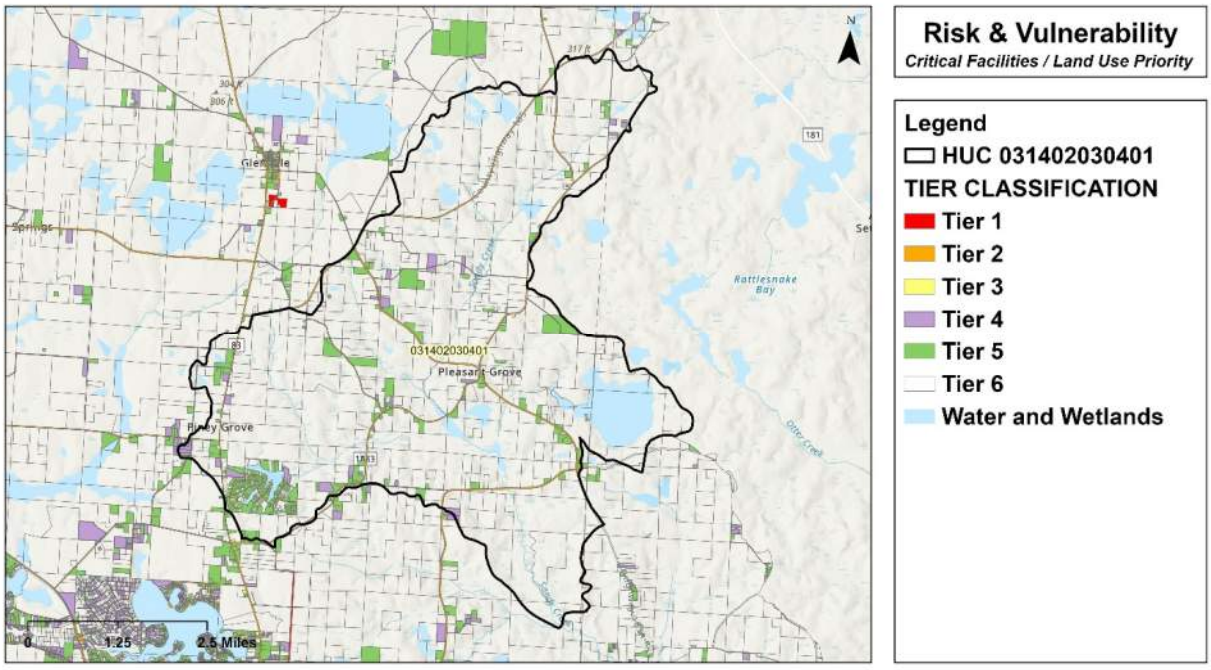

Figure 35. HUC 031402030401 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

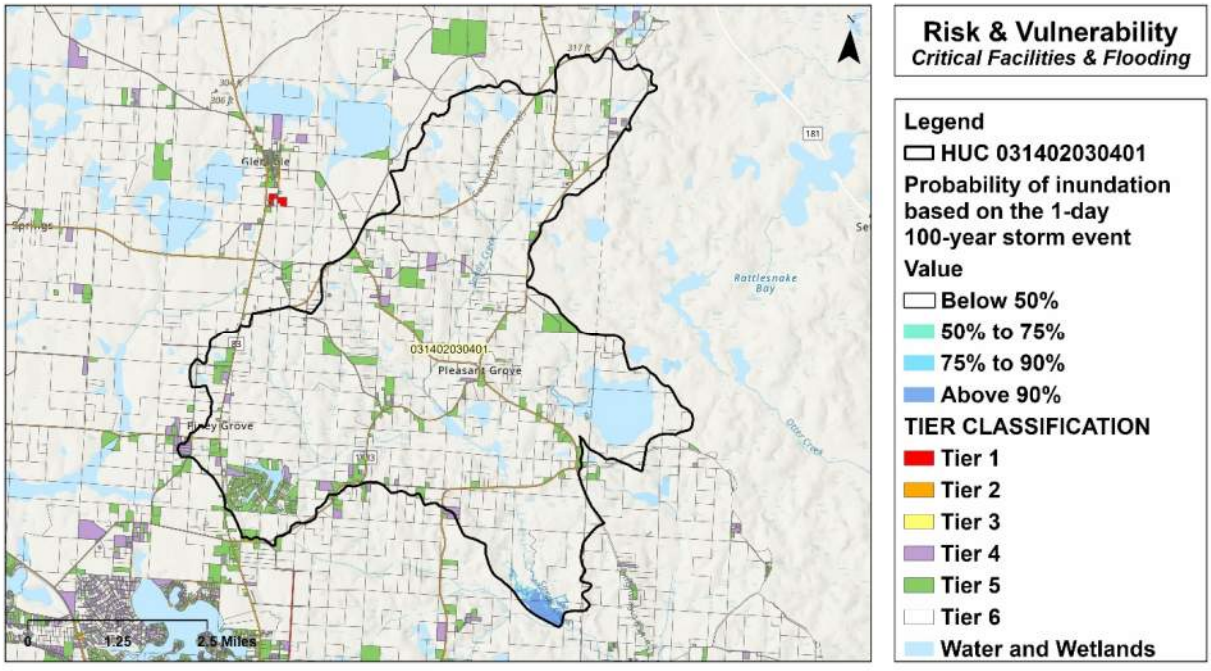

Figure 36. HUC 031402030401 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

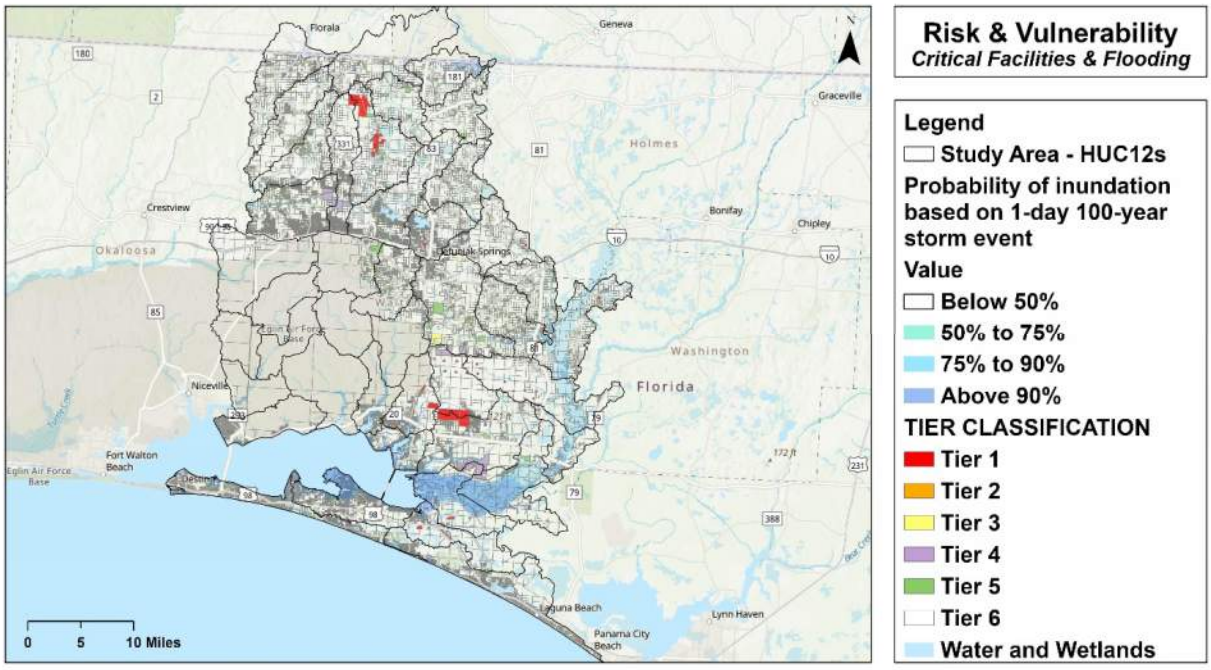

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

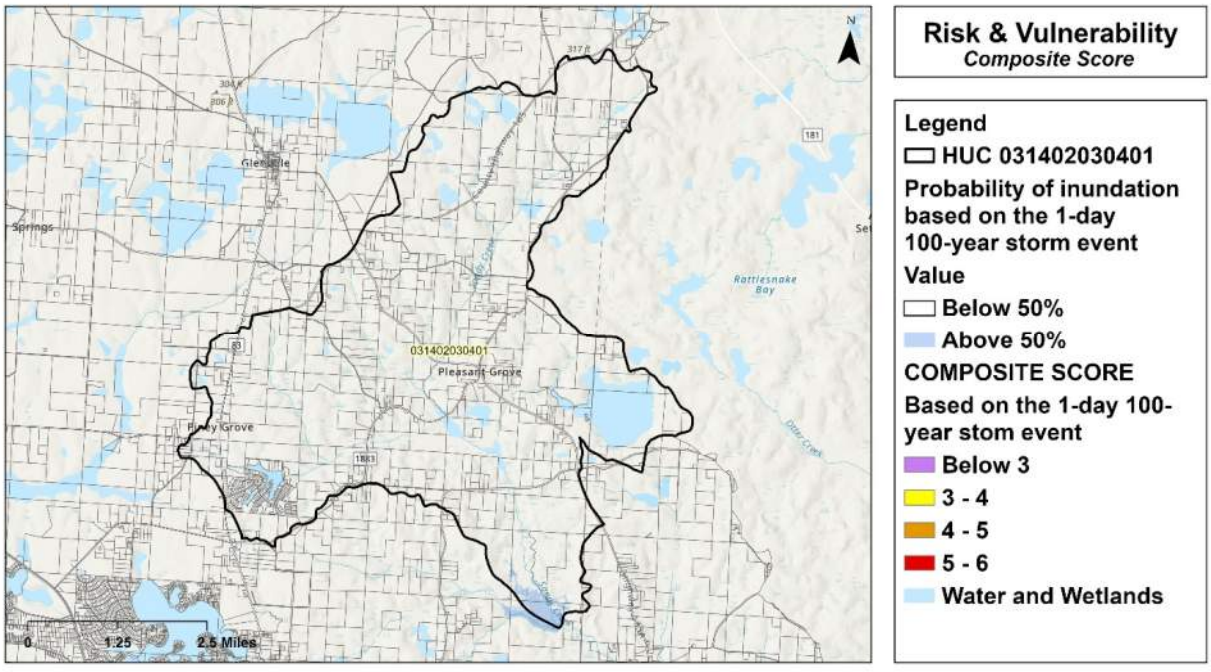

Figure 38. HUC 031402030401 sub-watershed Composite Score Risk map, with calculation based on 1-day 100-year storm event. Processed by FAU.

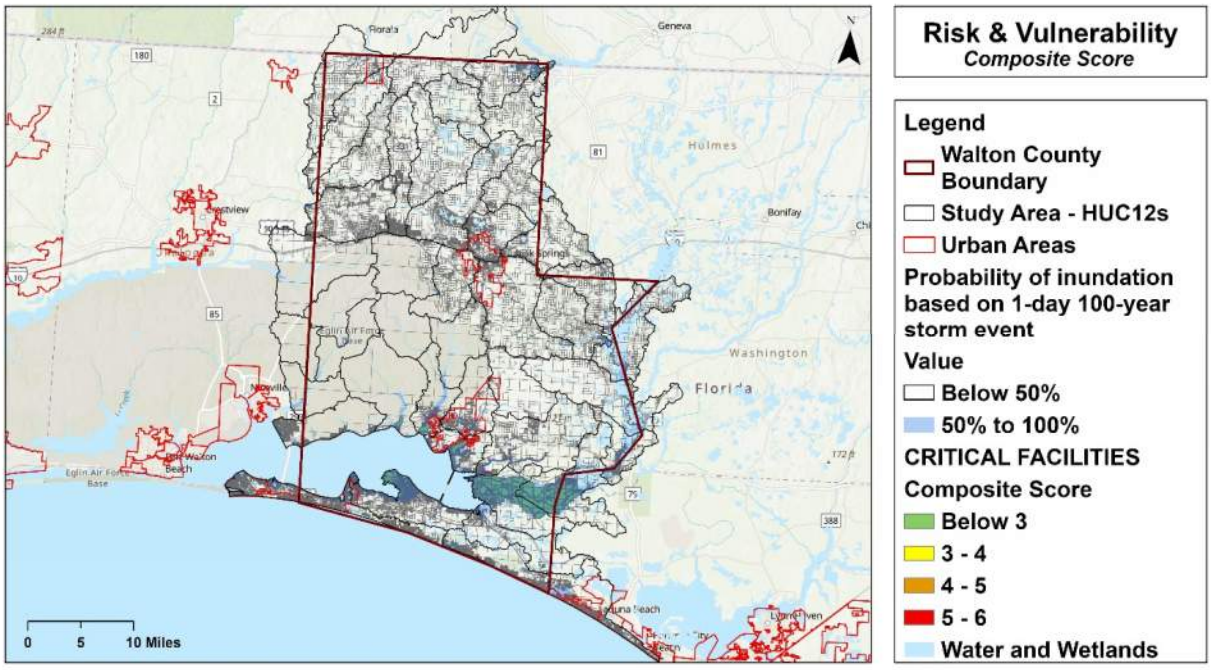

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

Please note that due to the scale of the map, the composite score layer is not properly visible in this map.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031402030401. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031402030401. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031402030401	17267.54
All of the 1-day 100-year storm event inundation	**130.73**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	130.73
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	130.73

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

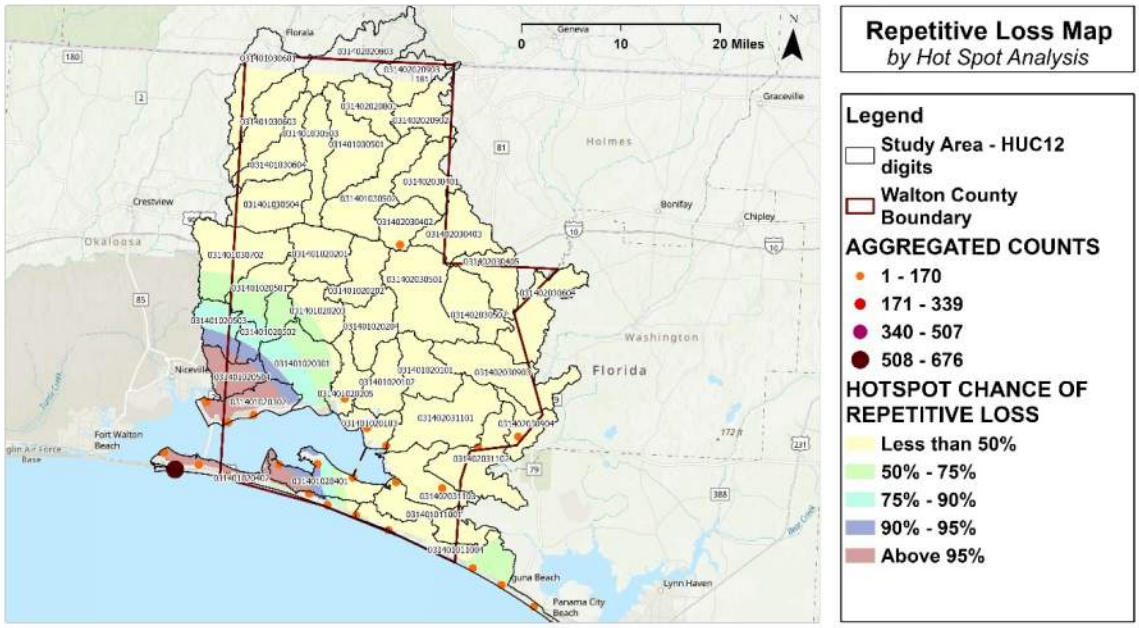

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5 Priority Projects

Although there are a good amount of parcels falling within tiers 2 (roads), 4 and 5 of priority of land uses, none of them are within the flooding zone, once flooding in the area is minor and not alarming. Consequently, when considering the composite score, it is notable that the results are null, indicating no priority for intervention within the basin.

APPENDIX AG

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031402030402

JUNIPER LAKE-SANDY CREEK

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Research Assistant: Leticia Sabio

This resource was funded in part, through a grant agreement from the Florida Division of Emergency Management's (FDEM) Bureau of Mitigation, by a grant provided by through the Hazard Mitigation Grant Program (HMGP) DR-4337-004-P, as approved by FDEM and the Federal Emergency Management Agency (FEMA) to create and update Watershed Master Plans (WMP) throughout the state of Florida. The views, statements, findings, conclusions, and recommendations expressed herein are those of the authors and do not necessarily reflect the views of the State of Florida, FEMA, or any of their sub-agencies.

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031402030402) is highlighted among all the HUCs to help identifying its location.

The city of DeFuniak Springs shares a portion of its boundary with the basin. Demographics data and other considerations of DeFuniak Springs, along with other cities in Walton County, will be covered in subsequent discussions.

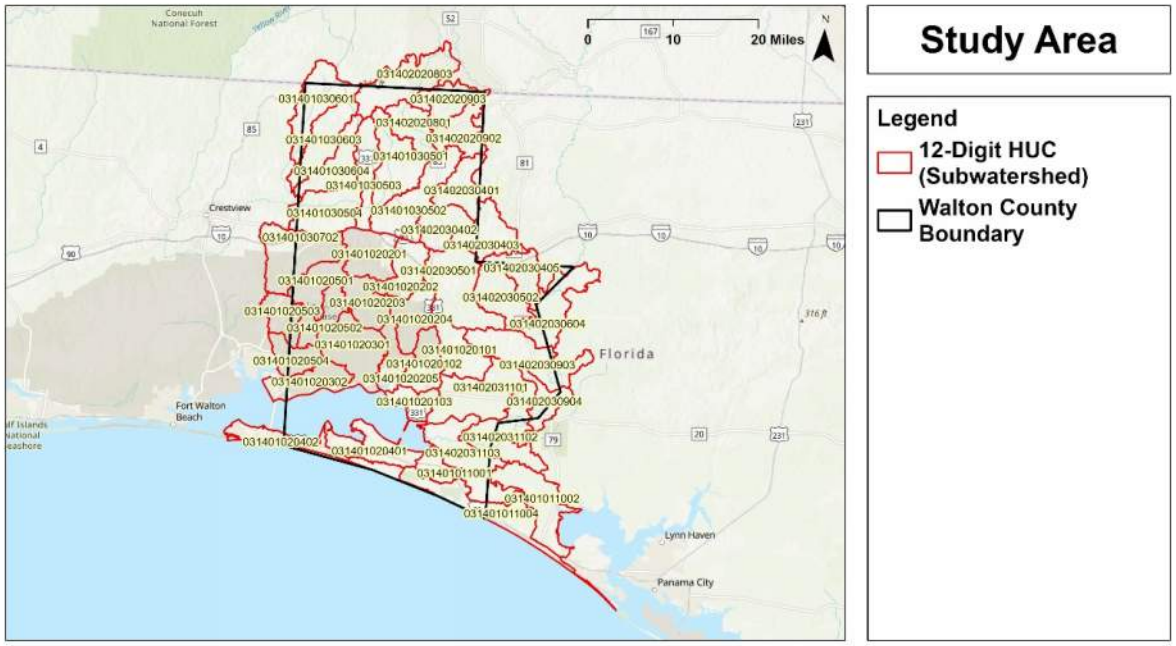

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

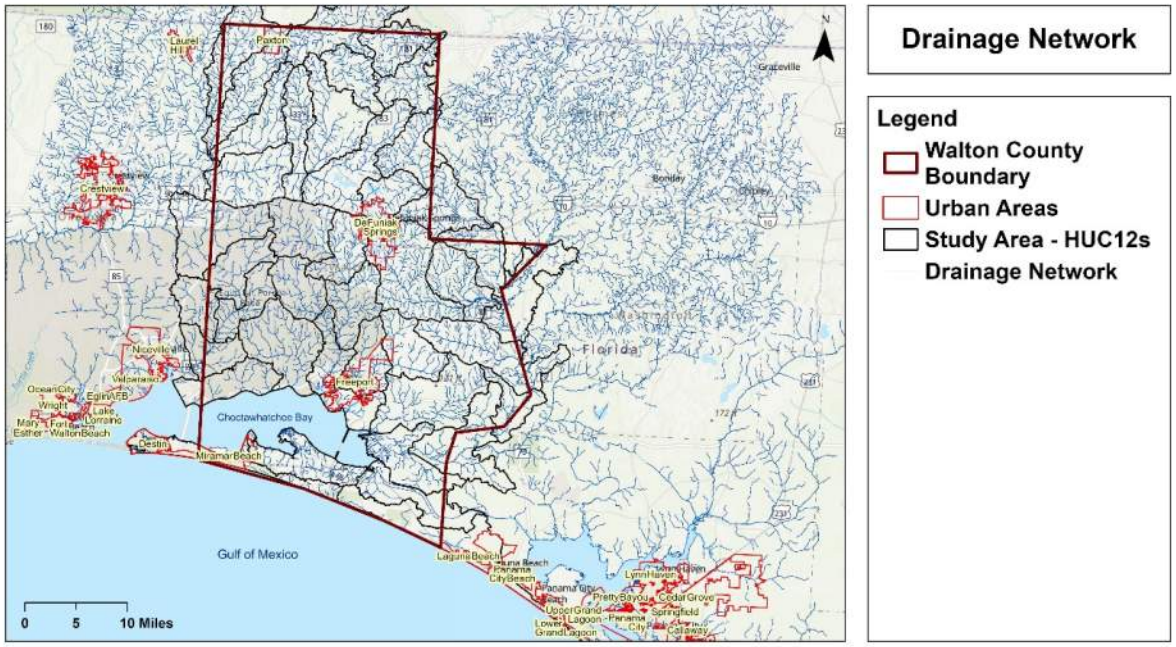

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

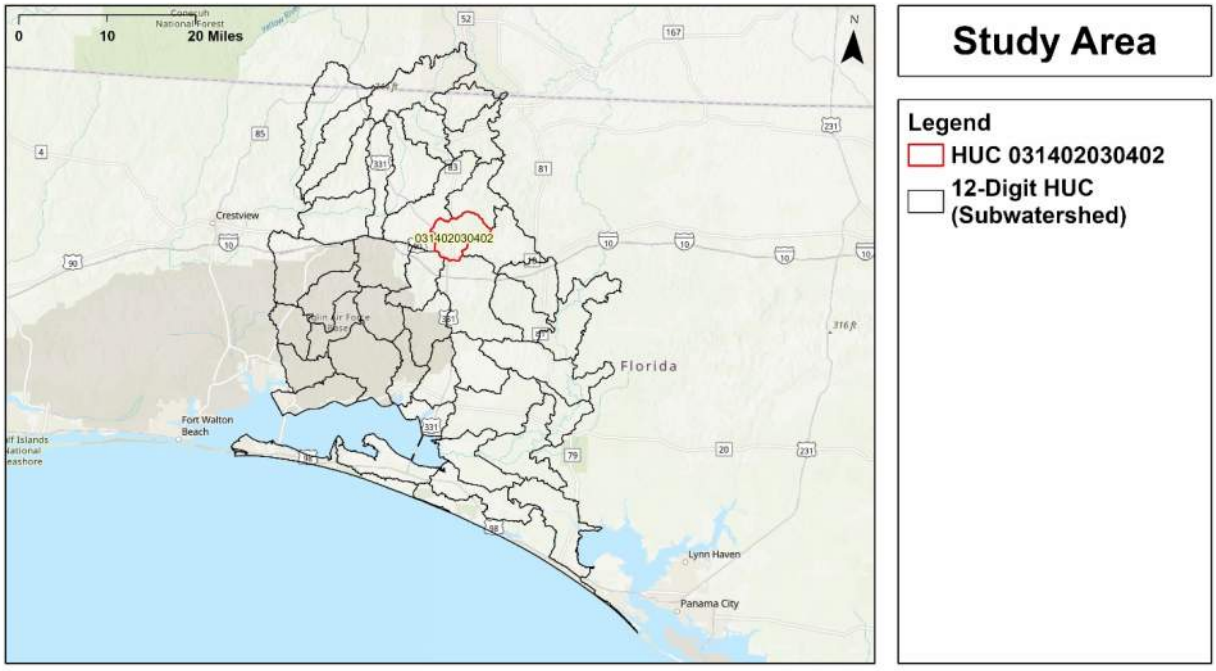

Figure 3. HUC 031402030402 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Based on the 2014-2016 SFWMD Level 1 land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with

high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

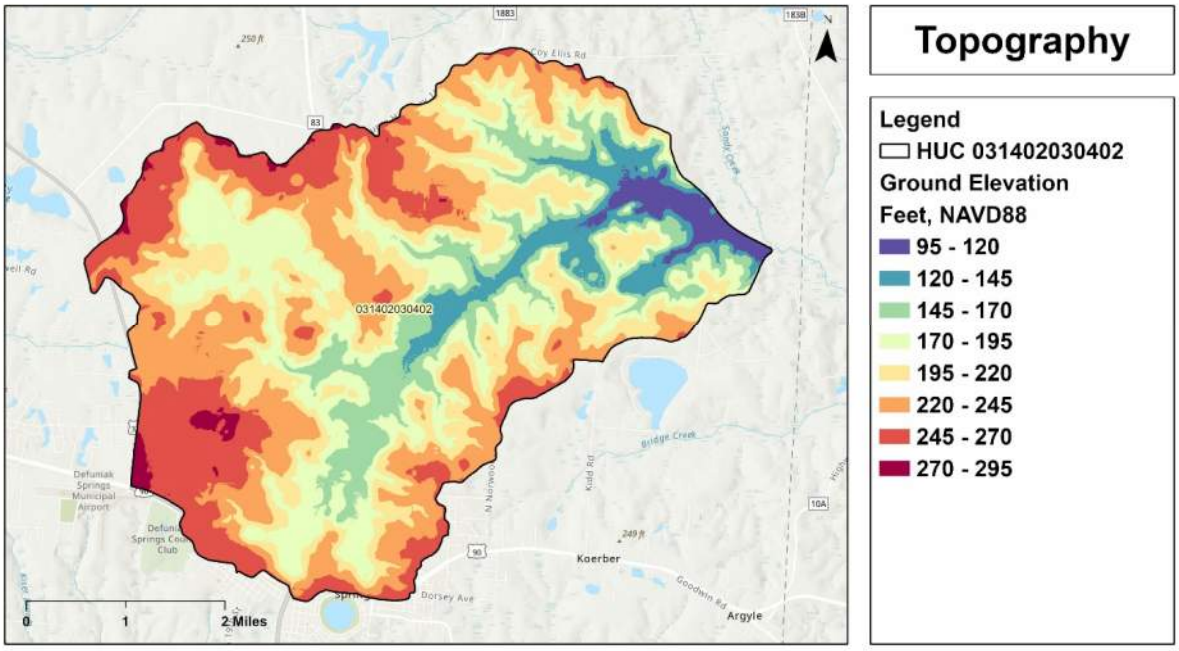

Figure 4. Topographic map of the HUC 031402030402 sub-watershed, processed by FAU

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology.

Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031402030402 sub-watershed is shown in **Error! Reference source not found.**.

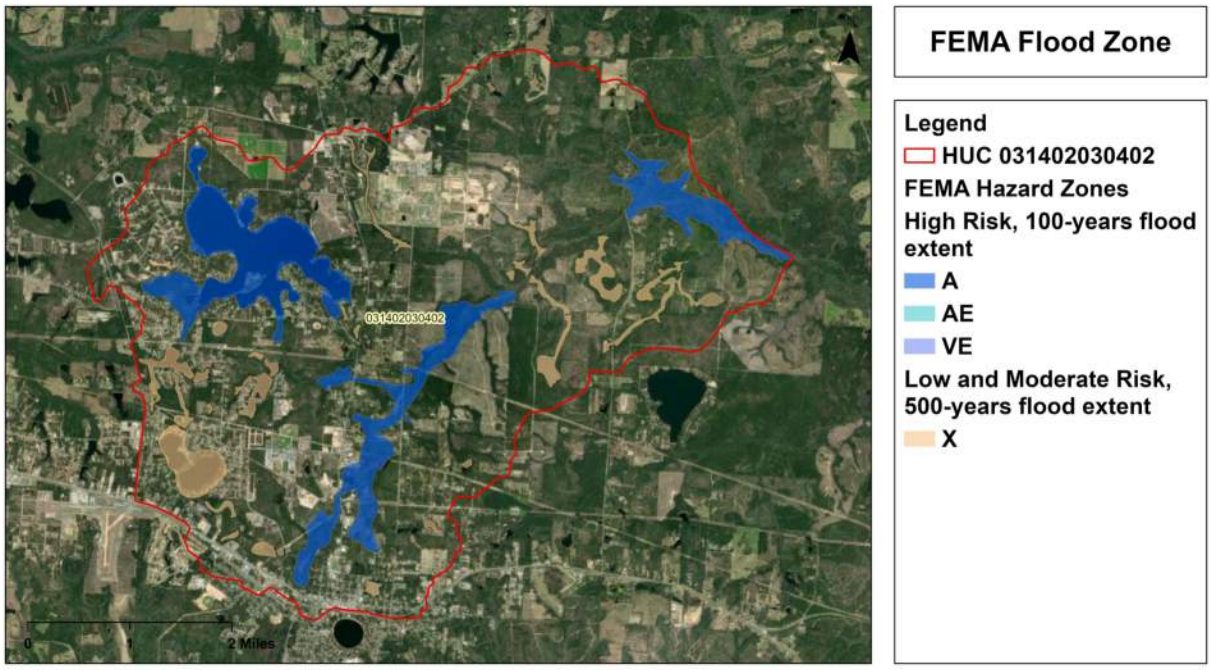

Figure 5. FEMA Flood Zone map (2020) for HUC 031402030402 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal

area, including the sub-watershed 031402030402 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

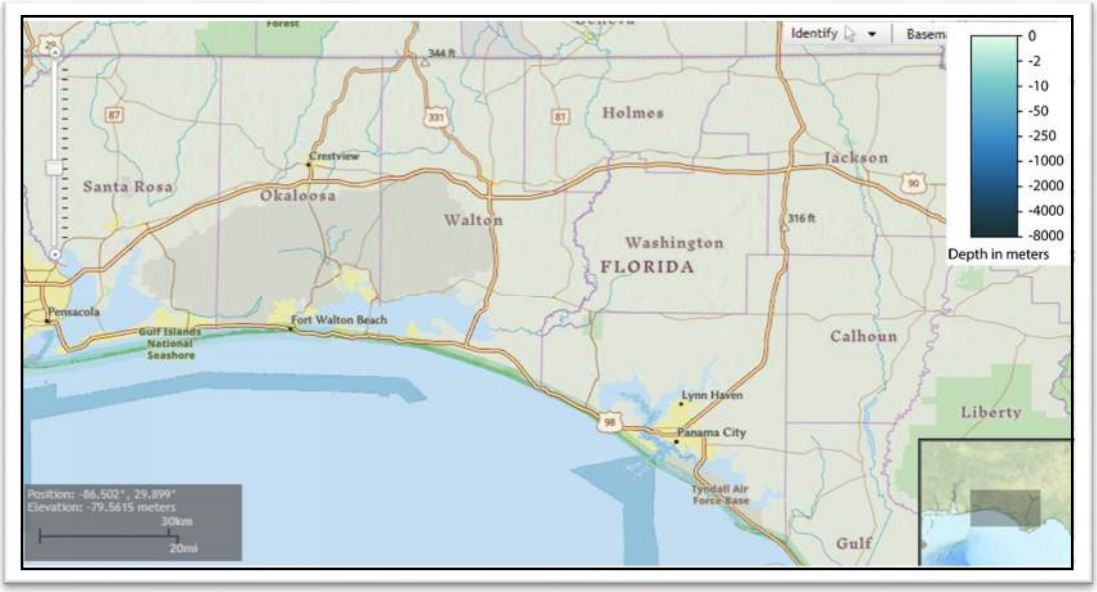

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle. Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

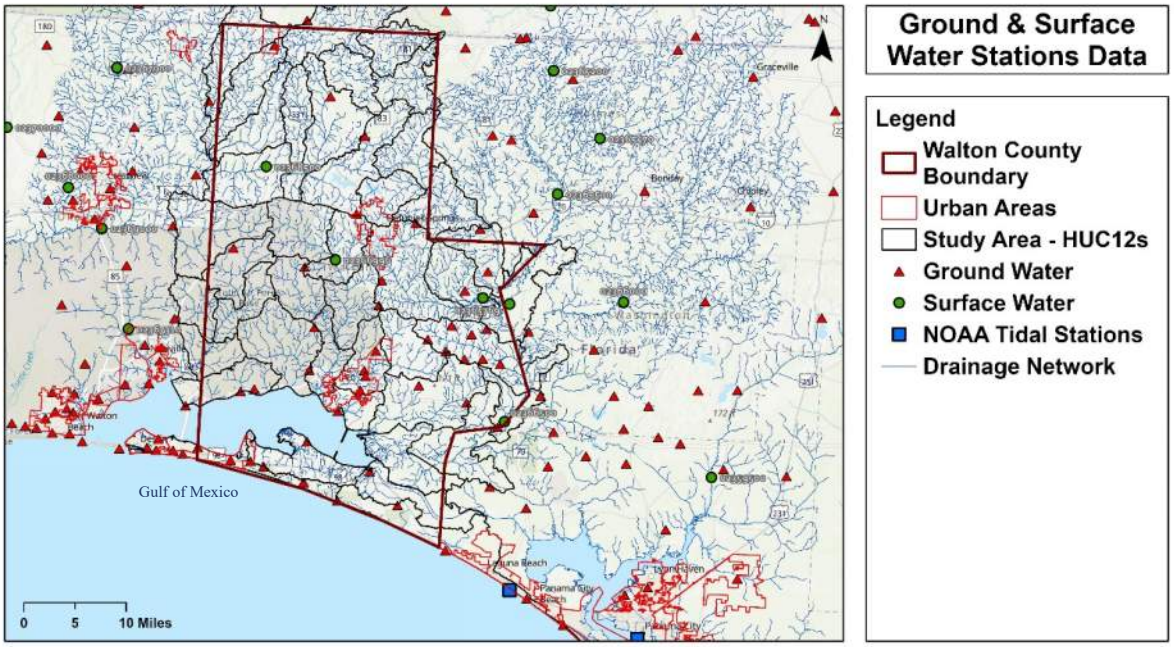

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031402030402 has no major rivers and canals, but creeks, include:

- West Sandy Creek

- Andrews Mill Creek
- Poley Bran

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366966. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031402030402, which is USGS 02366966 Alaqua Creek Near Pleasant Ridge, FL.

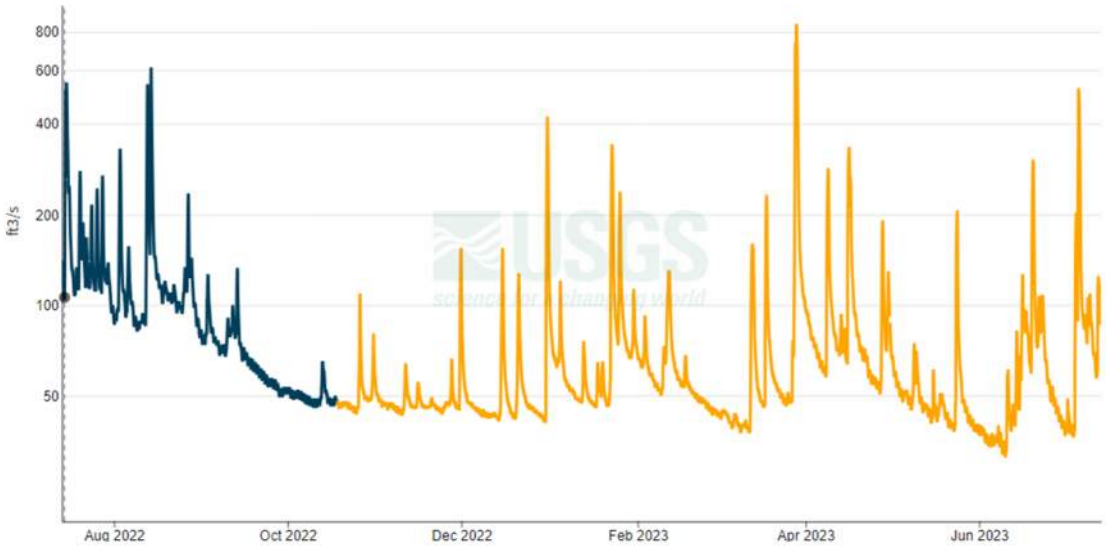

Figure 8. Average streamflow for Alaqua Creek Near Pleasant Ridge, FL (USGS 02366966 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366996/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station

(or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031402030402 and points out the location of the ground water station in the surroundings. A groundwater-surface layer for the HUC 031402030402 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

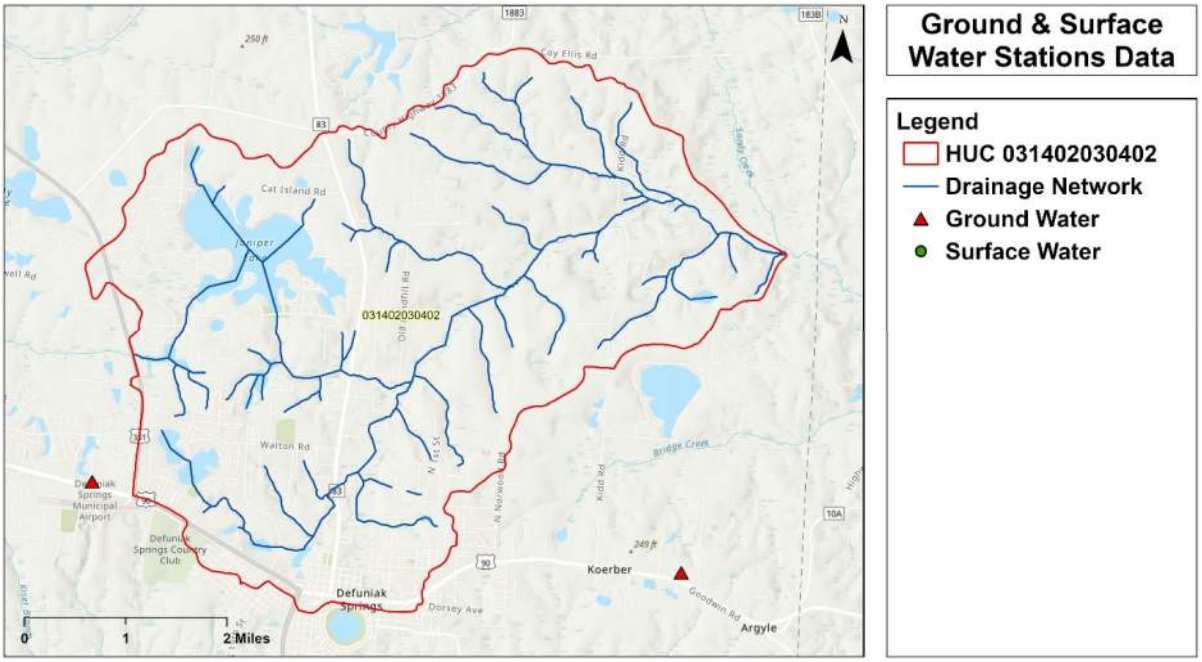

Figure 9. Ground and Surface Water Stations in the HUC 031402030402 sub-watershed, processed by FAU.

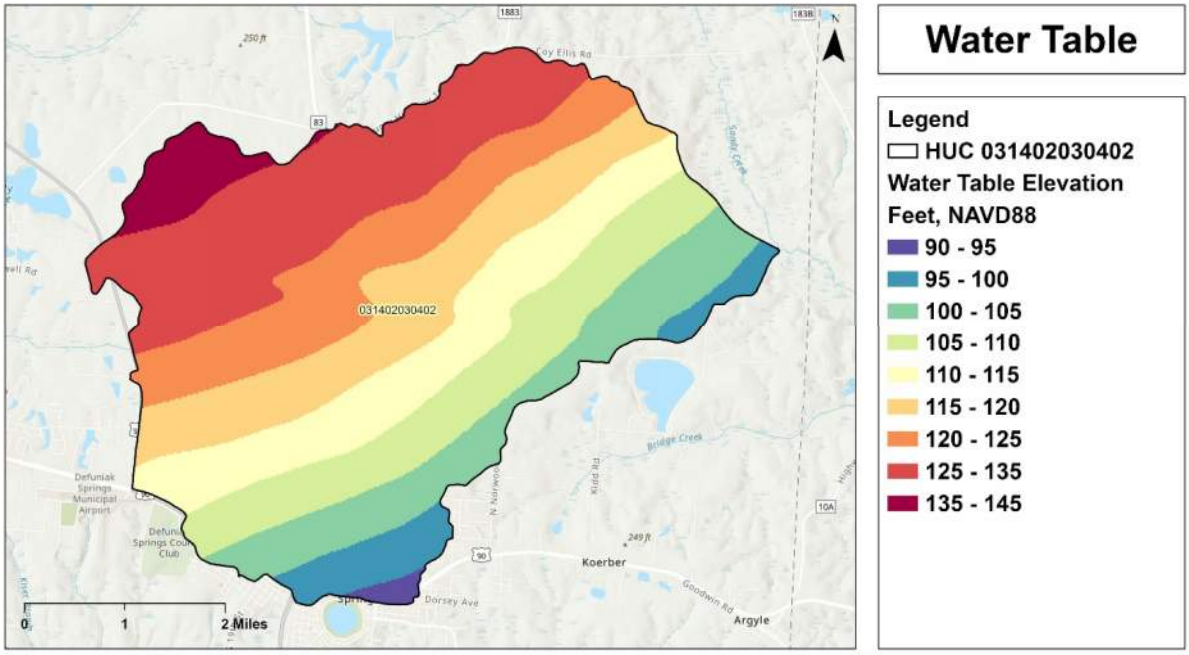

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031402030402 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

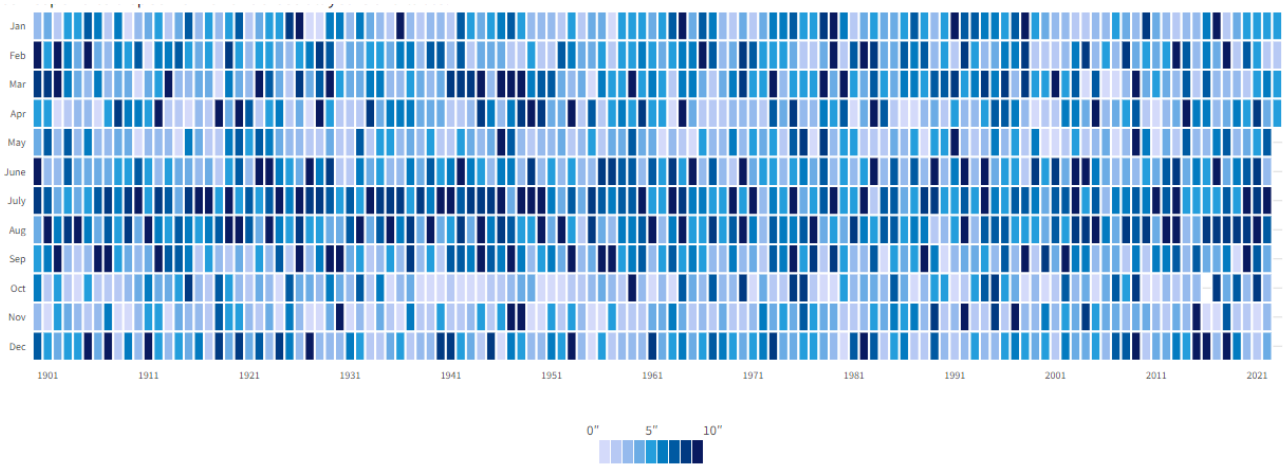

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/).

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

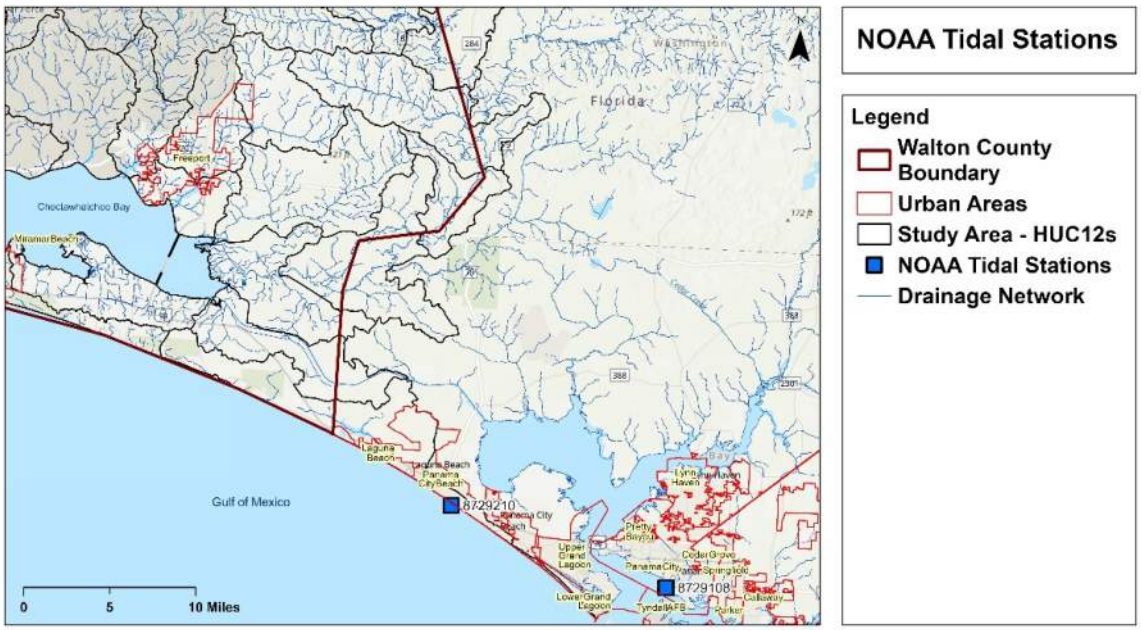

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

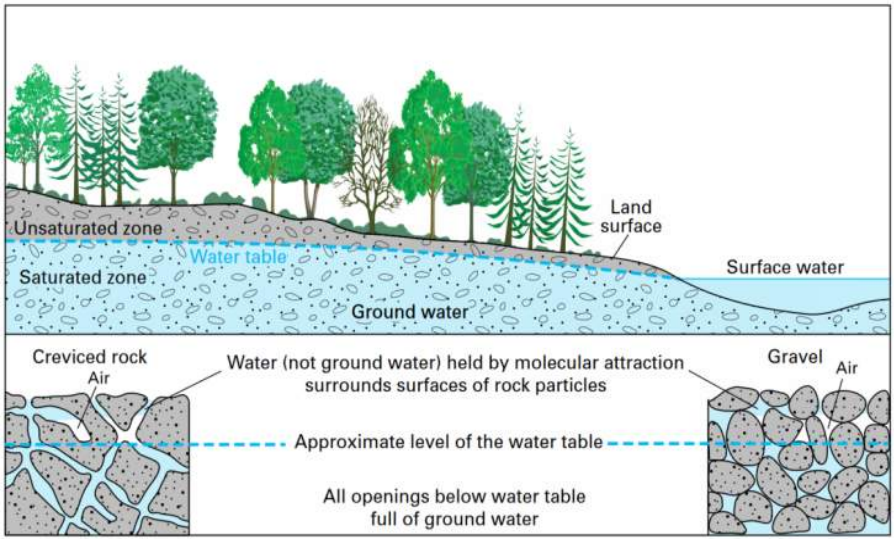

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

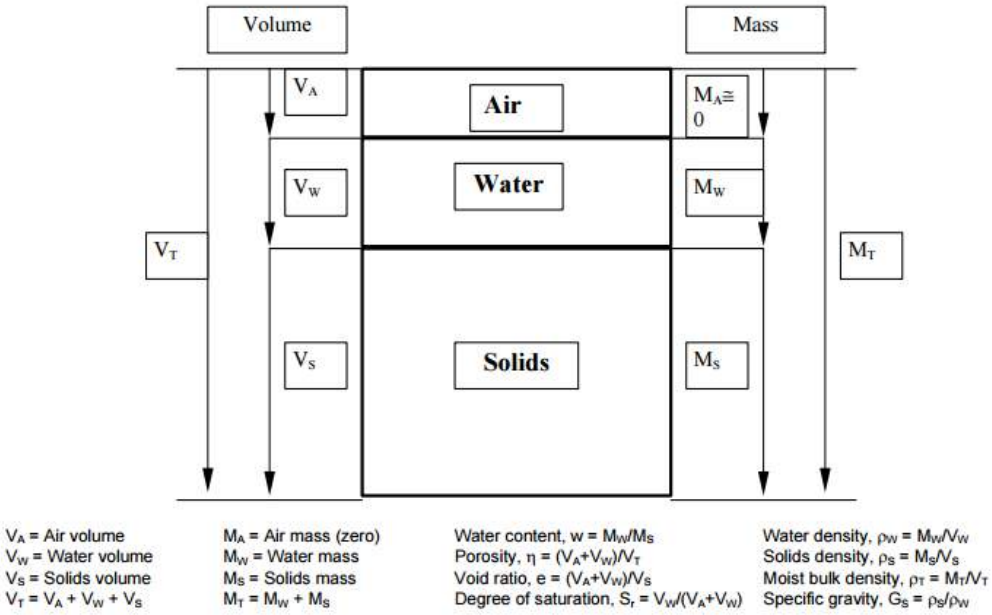

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). Figure 15 shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

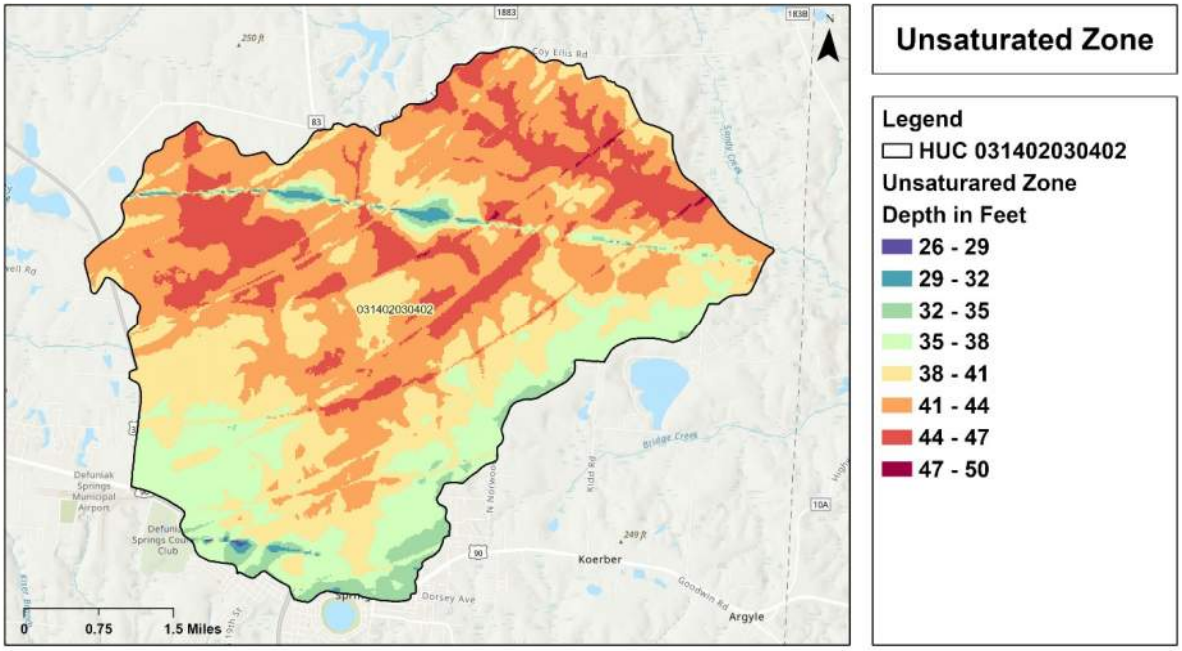

Figure 15. Unsaturated zone map for HUC 031402030402, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately favorable soil storage capacity, falling within the range of 35 to 47 feet of remaining capacity.

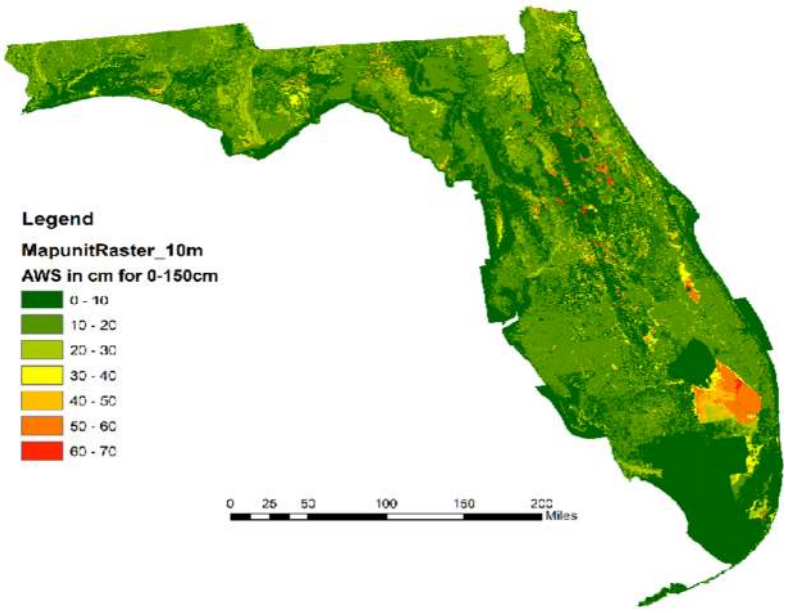

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

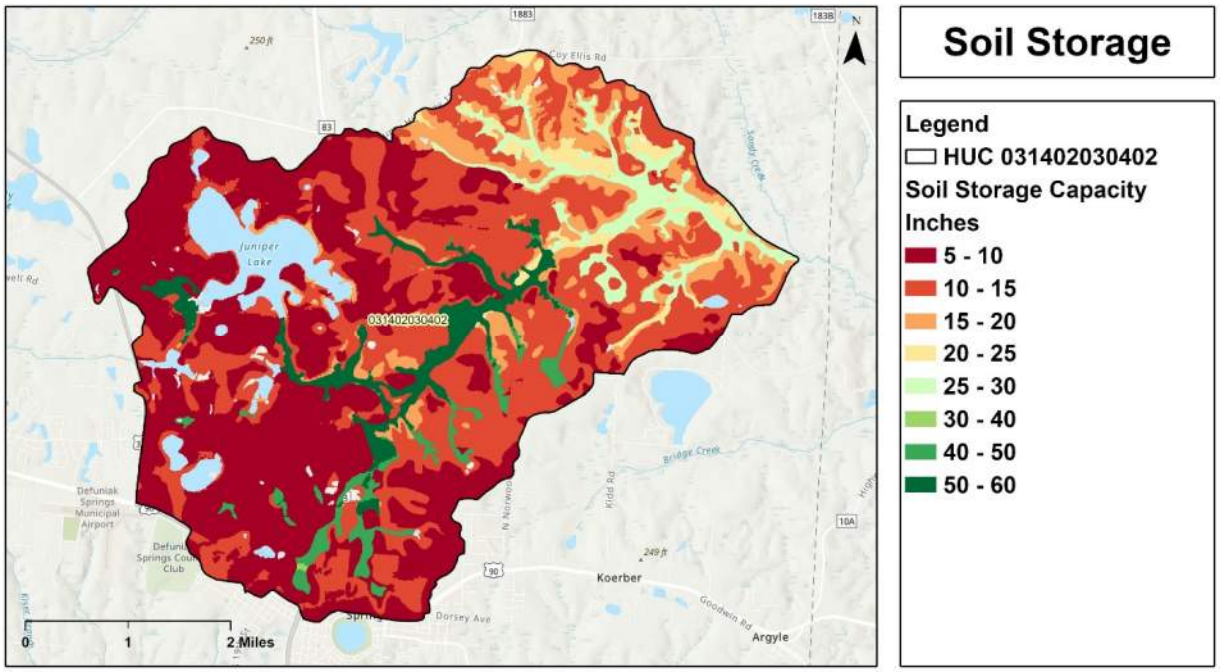

Figure 17. Water storage capacity of soil for the HUC 031402030402, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

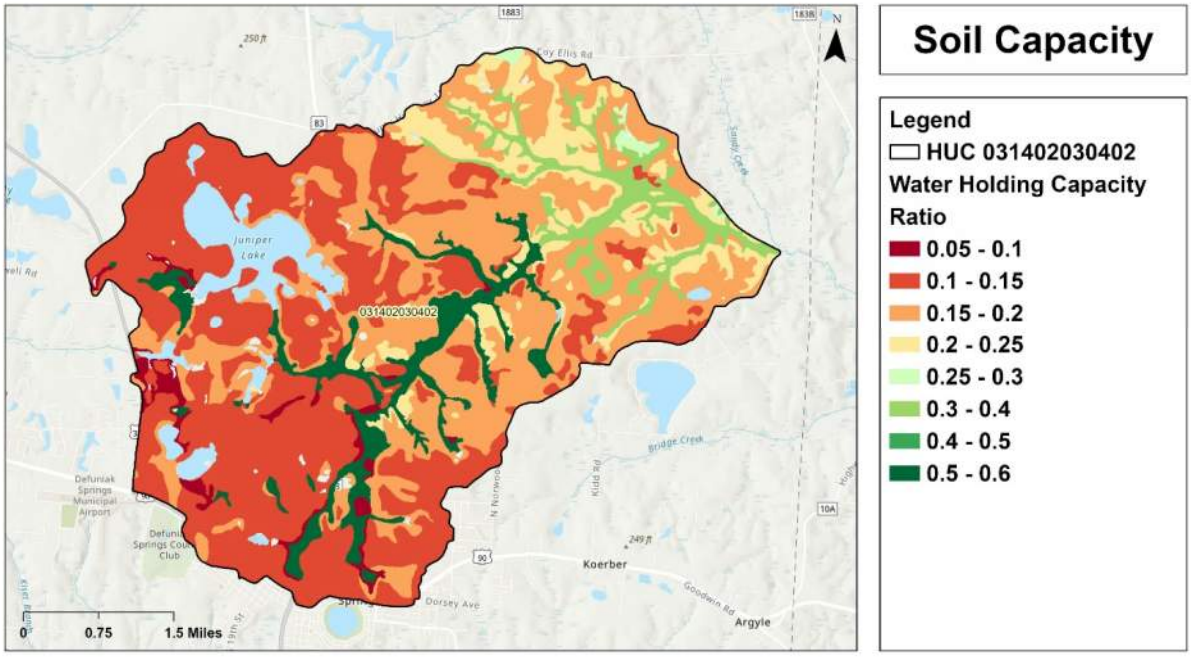

Figure 18. Water Holding Capacity (ratio) for the HUC 031402030402, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

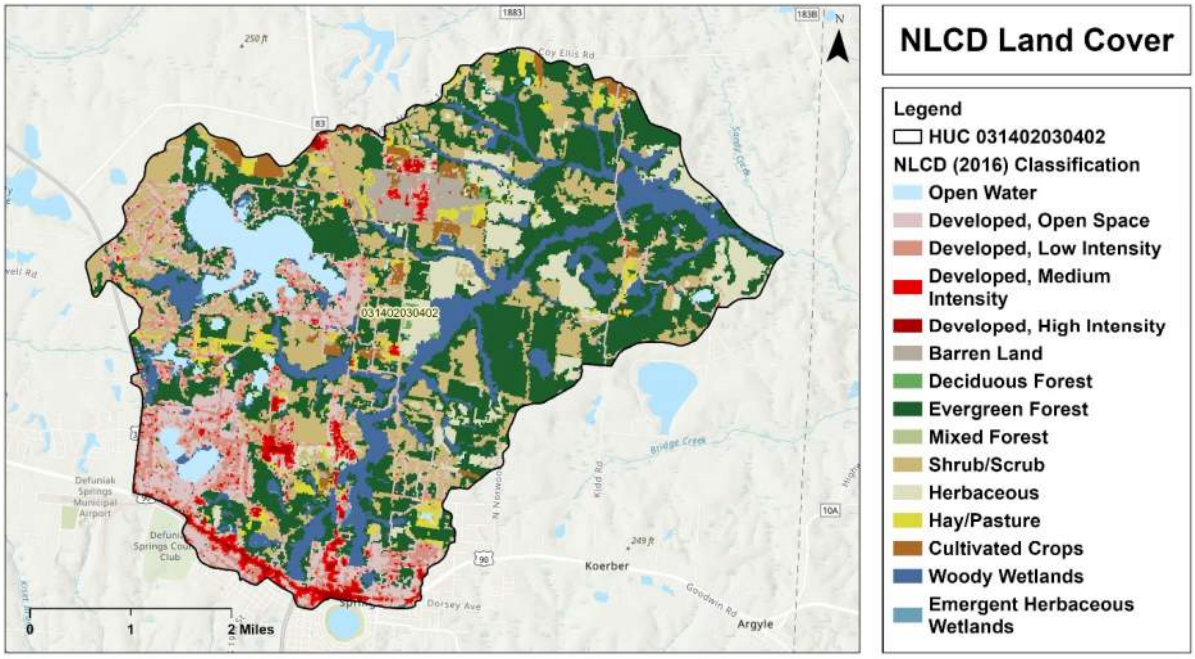

Figure 19. Land use in the HUC 031402030402 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

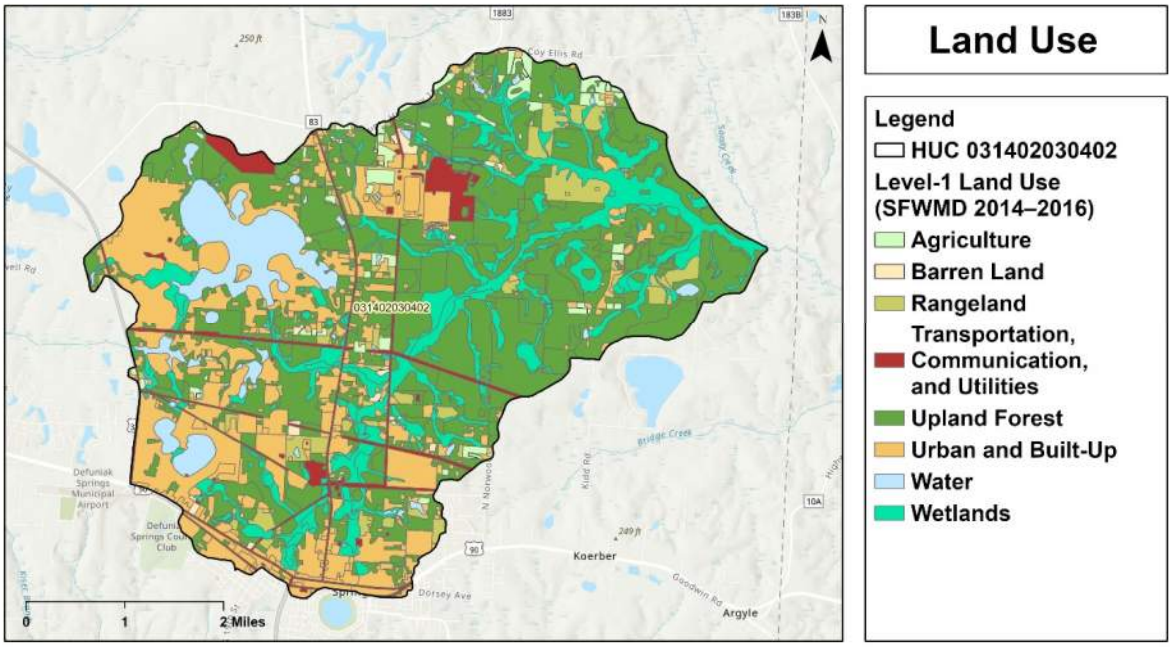

Figure 20. Land use in the HUC 031402030402 (2023 Florida Geographic Data Library (FGDL)), processed by FAU.

In the HUC 031402030402 sub-watershed, the predominant land cover is upland forest, accounting for 35.85% of the area, followed by wetlands that comes in second with 19.55%. Developed land constitutes also a great portion of the basin, with 18.97% categorized as urban and built-up, and 16.26 % as Transportation, Communication, and Utilities, once the basin takes a small portion of the city DeFuniak Springs. The percentage of area by land use type is as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031402030402 subwatershed (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	488.95	2.17%
Barren Land	84.63	0.38%
Rangeland	651.63	2.89%
Transportation, Communication, and Utilities	3667.31	16.26%
Upland Forest	8084.01	35.85%
Urban and Built-Up	4279.27	18.97%
Water	886.65	3.93%
Wetlands	4409.95	19.55%
Grand Total:	**22552.40**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

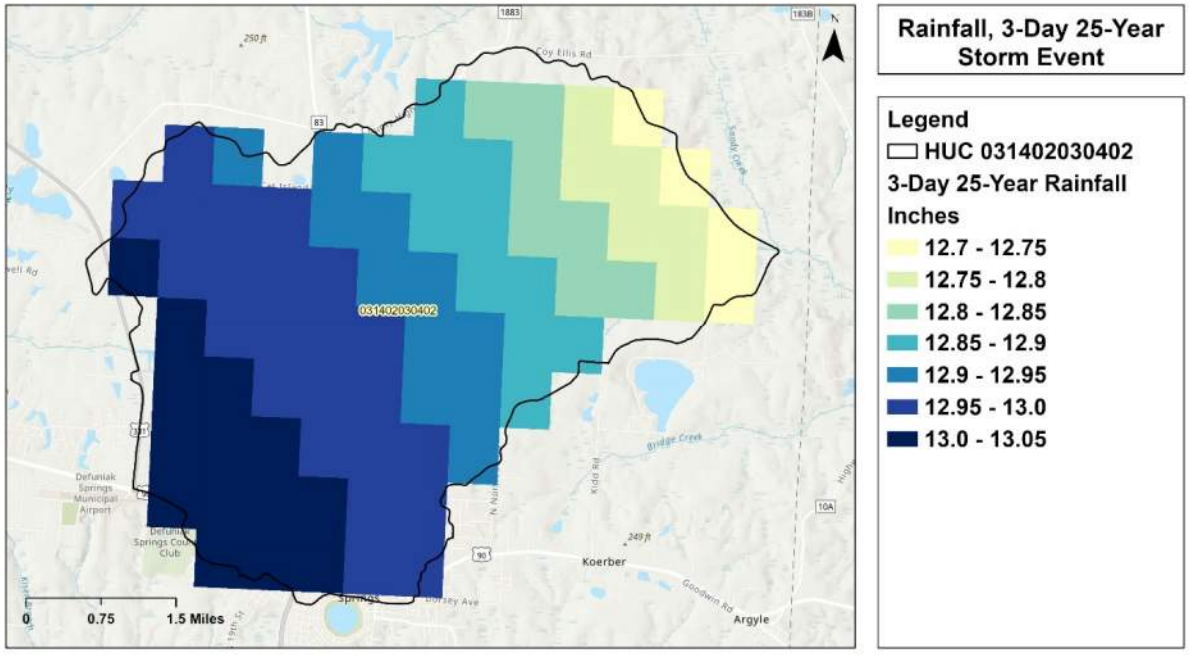

Figure 21. Rainfall distribution map across HUC 031402030402 sub-watershed, for 3-day 25-year storm event, processed by FAU.

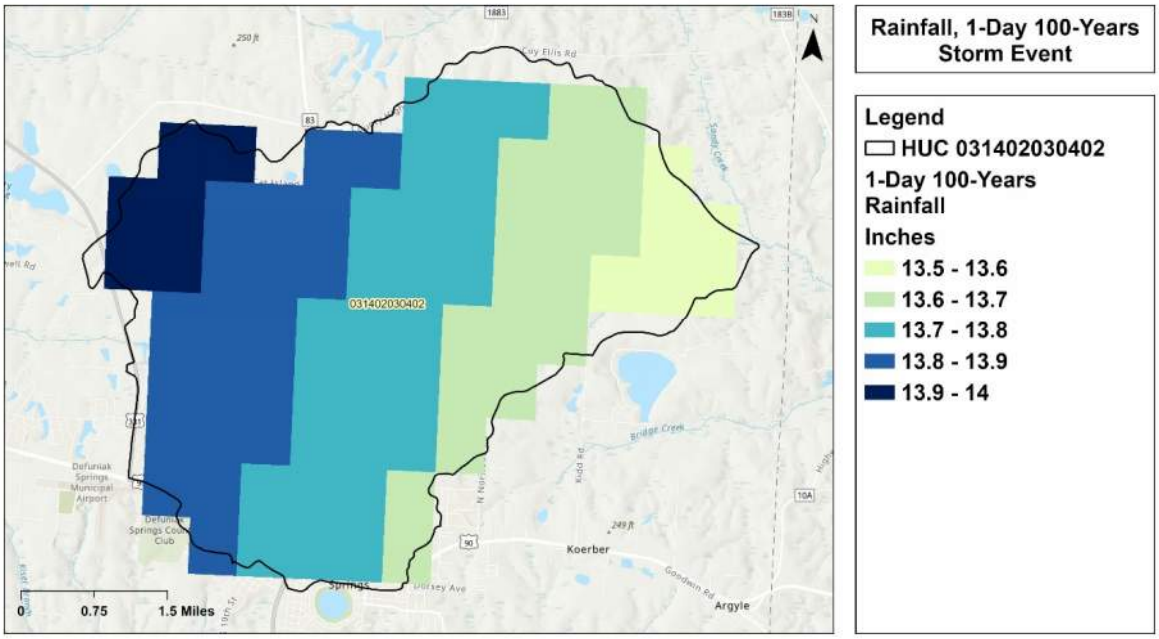

Figure 22. Rainfall distribution map across HUC 031402030402 sub-watershed, for 1-day 100-year storm event, processed by FAU.

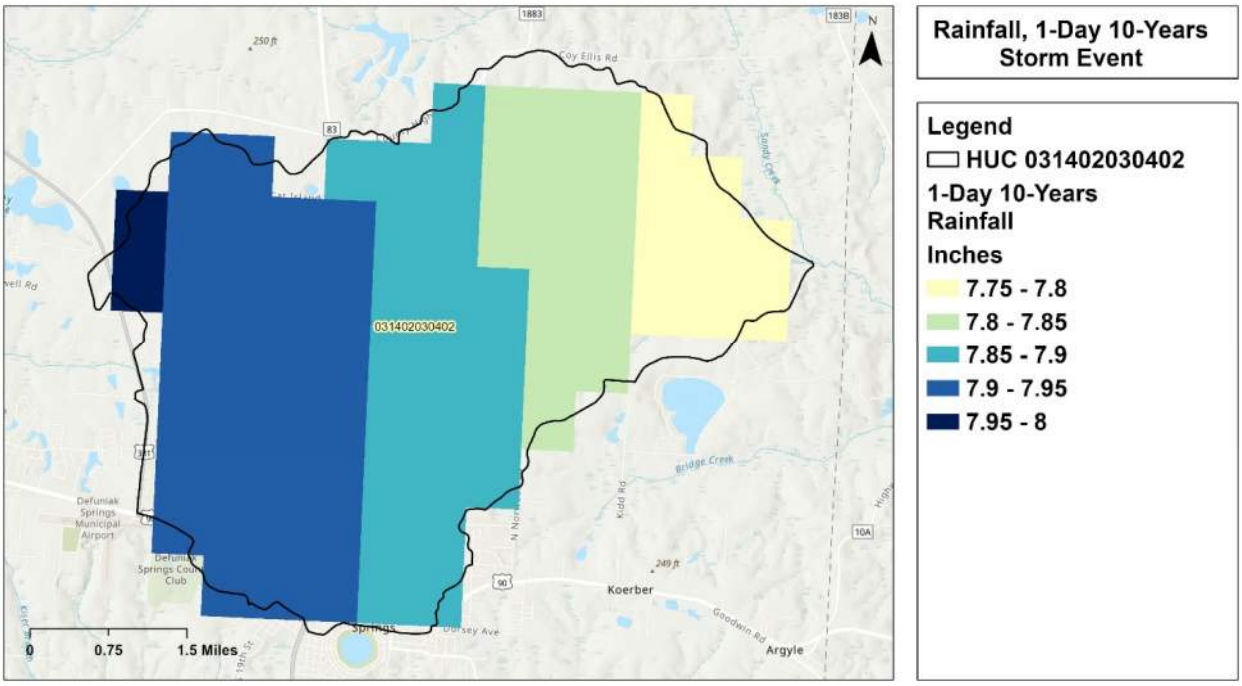

Figure 23. Rainfall distribution map across HUC 031402030402 sub-watershed, for 1-day 10-year storm event, processed by FAU.

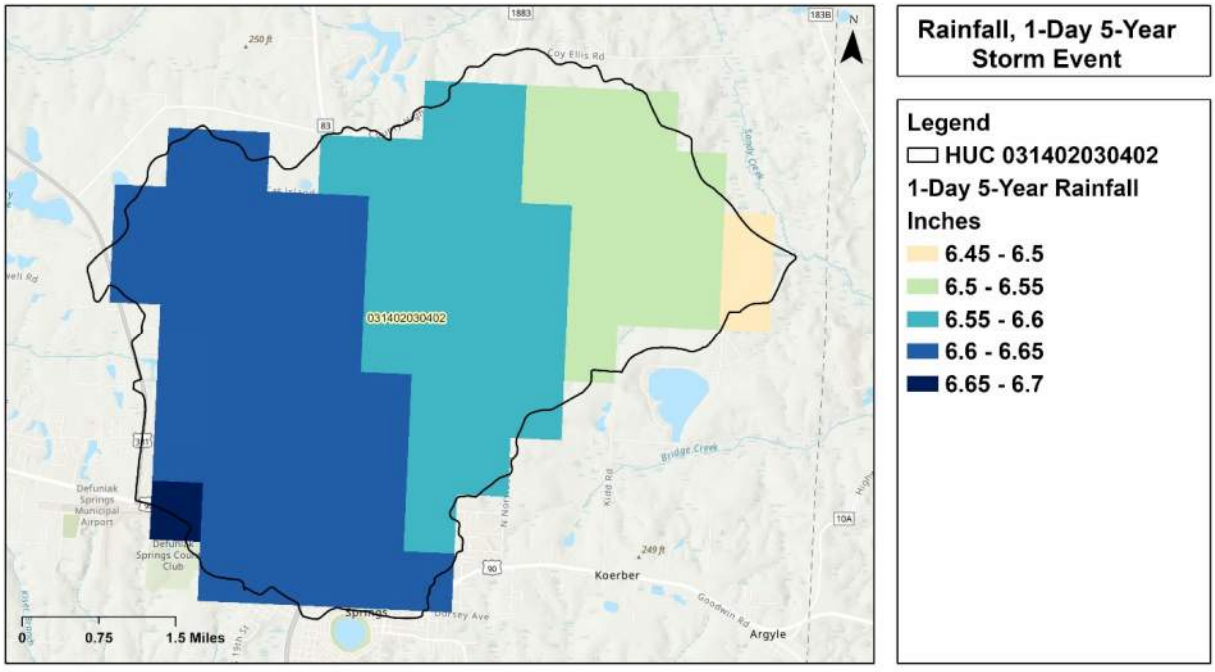

Figure 24. Rainfall distribution map across HUC 031402030402 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, whi1ch serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically

aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

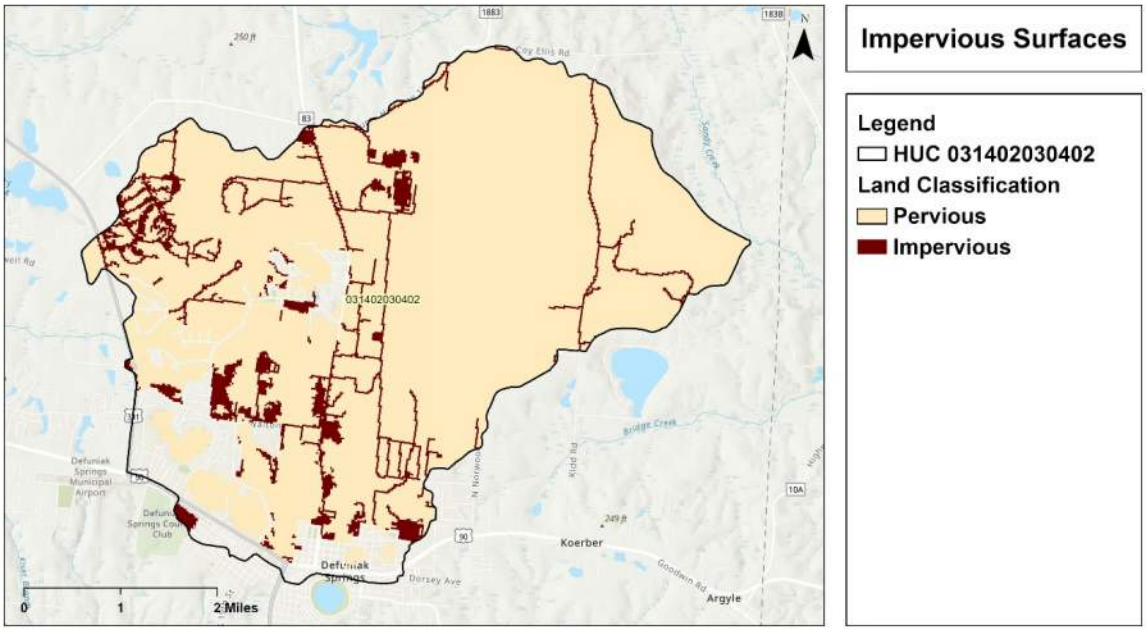

Figure 25. Impervious area map for the HUC 031402030402 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 2.4.

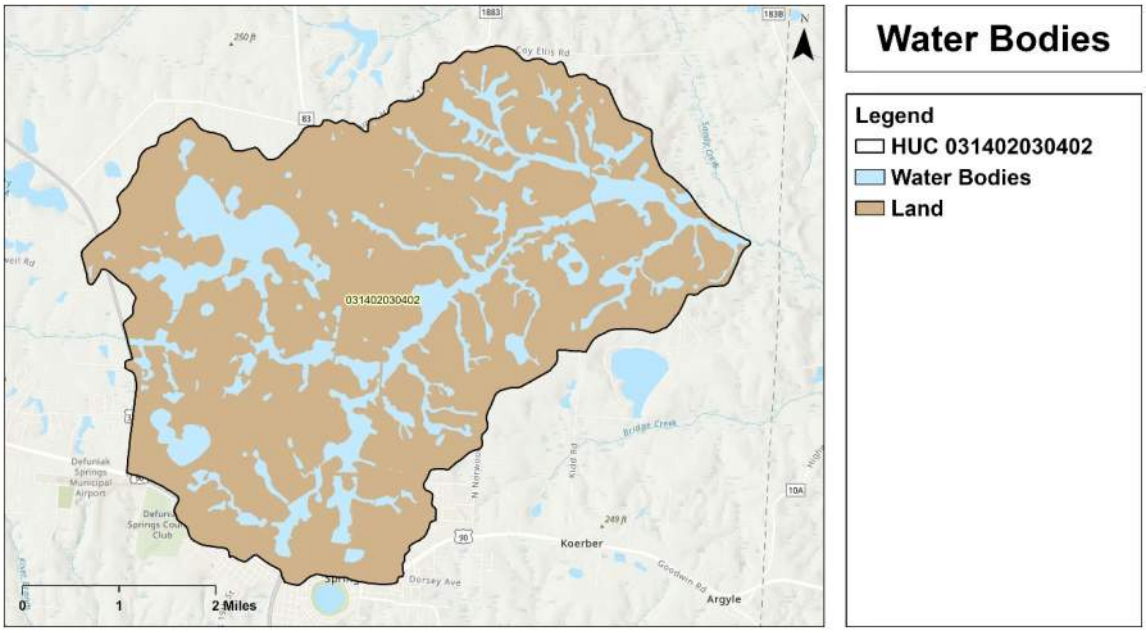

Figure 26. Water bodies map for the HUC 031402030402 sub-watershed, processed by FAU.

1.10. Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.
** Census Designated Place.

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

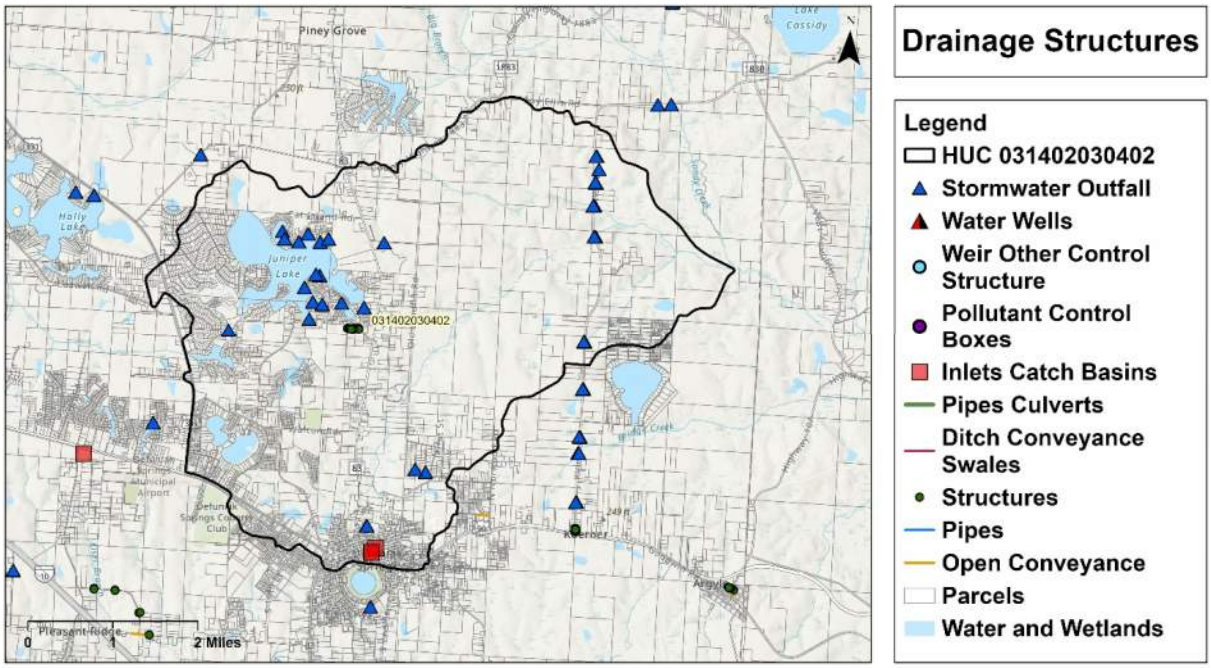

Figure 27. Stormwater Infrastructure for the HUC 031402030402. Processed by FAU.

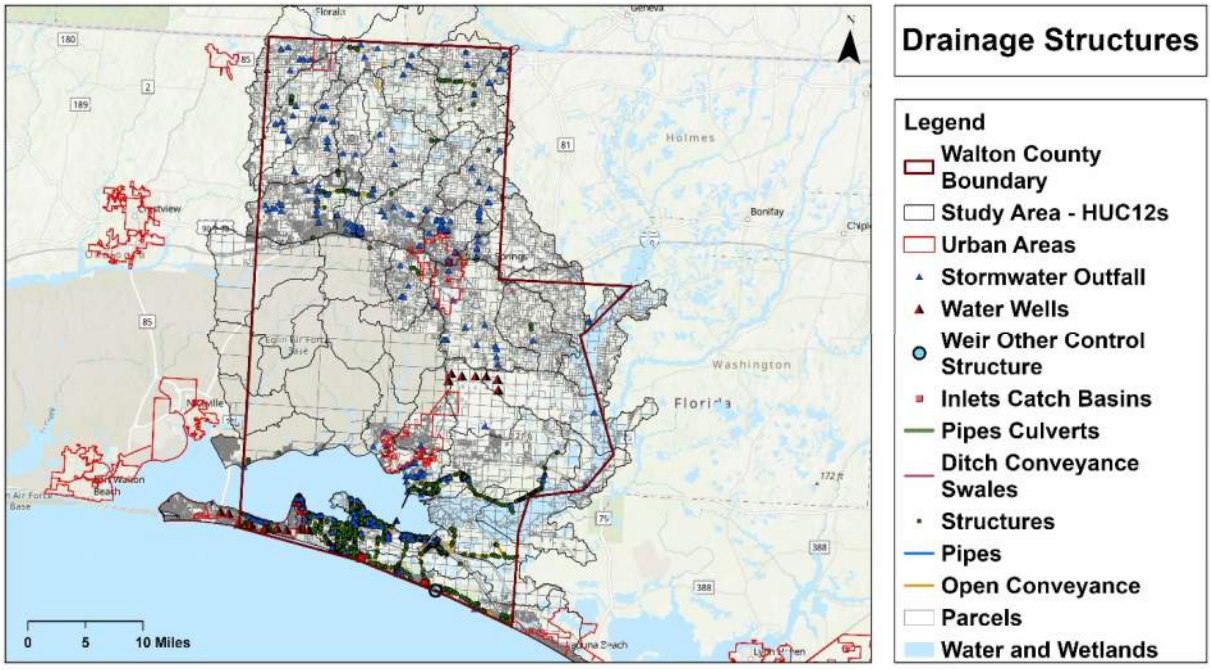

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401030402 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. Figure 29 shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

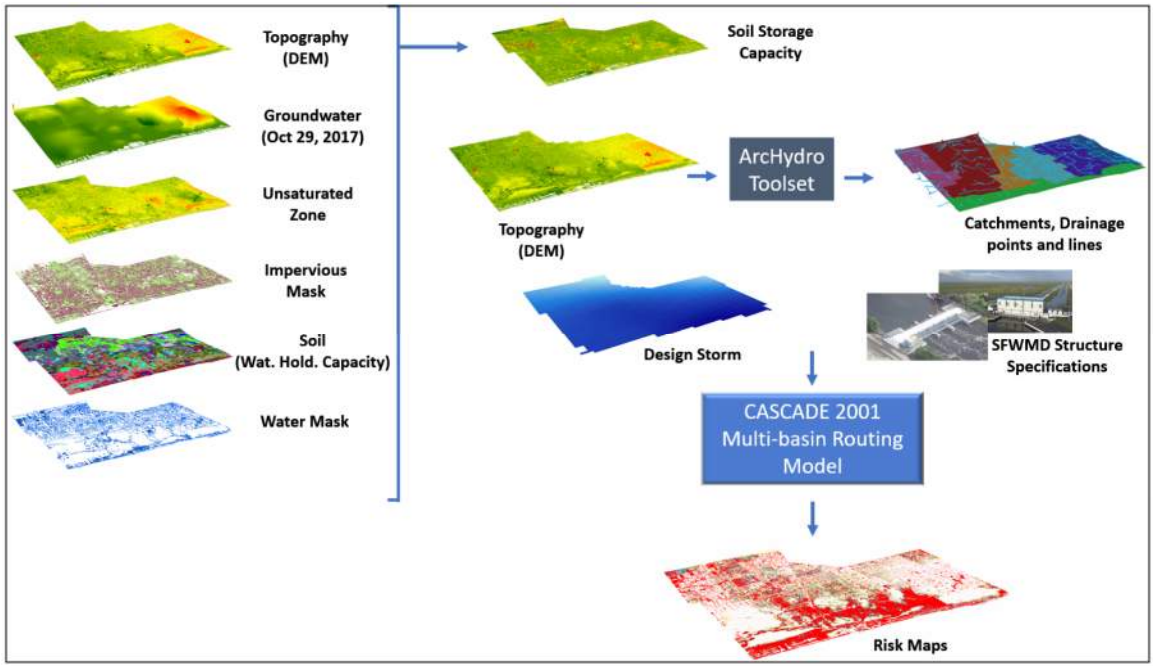

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)

= 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

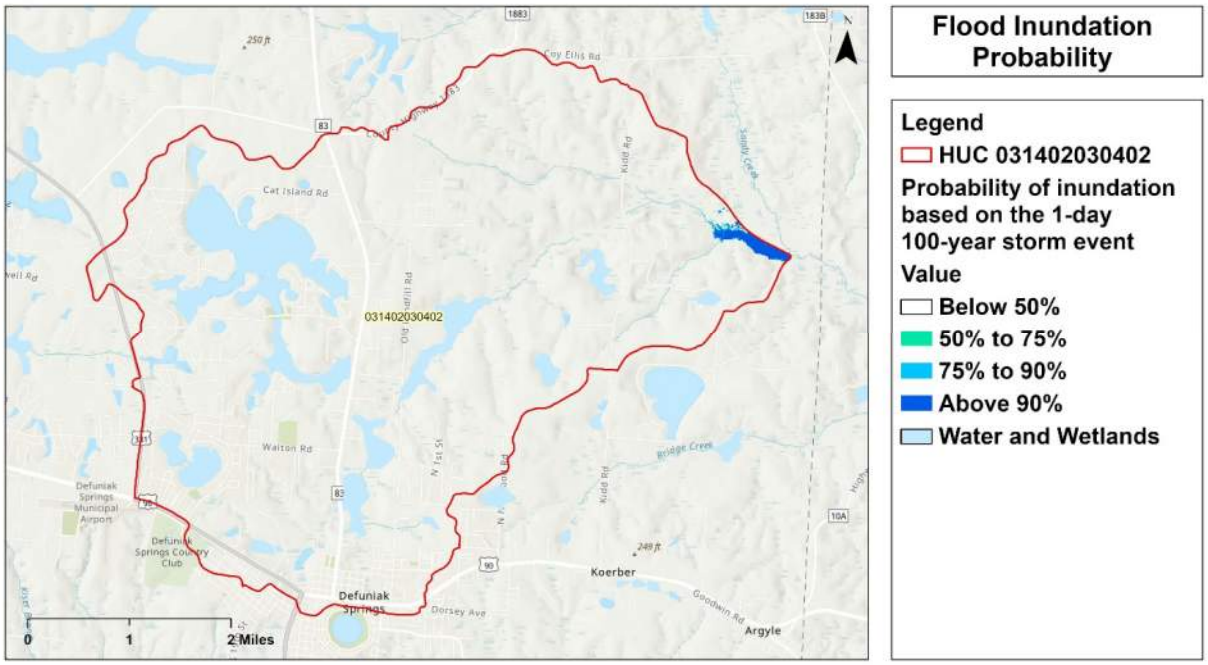

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031402030402, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data

to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a small portion of flooding is noted at the creek entrance to the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, the HUC is expected to remain unaffected by sea level rise, therefore SLR scenarios were not computed.

The design storm simulation determined that approximately 0.44% of the HUC total area or 0.097 mi² has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 0.45% of the HUC's total area, or 0.1 mi² would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.38% of the HUC's total area, or 0.083 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0.37% of the HUC's total area, or 0.082 mi², would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events..

Table 7. HUC 031401030402 expected inundated area by storm event.

Storm Event	Area with probability of	Area with probability of	Area with probability of	Area with probability of

	inundation below 50% (Sq Mi)	inundation above 50% (Sq Mi)	inundation below 50% (%)	inundation above 50% (%)
3-day 25-year	21.872	0.097	99.56%	0.44%
1-day 100-year	21.869	0.100	99.55%	0.45%
1-day 10-year	21.886	0.083	99.62%	0.38%
1-day 5-year	21.887	0.082	99.63%	0.37%

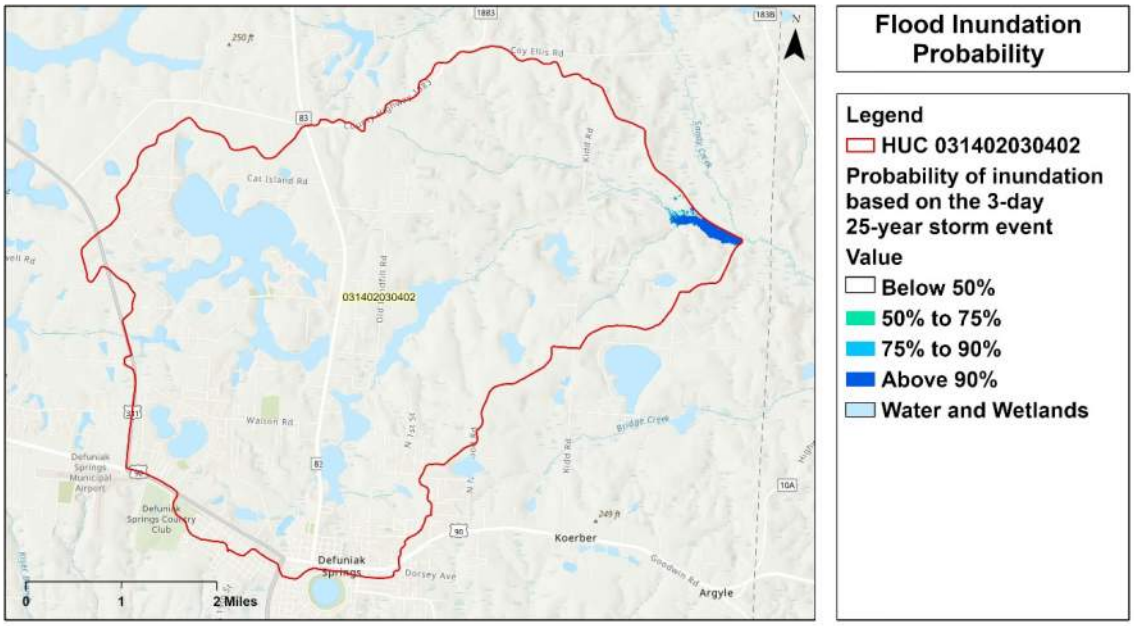

Figure 31. 3-day 25-year storm event for HUC 031402030402 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

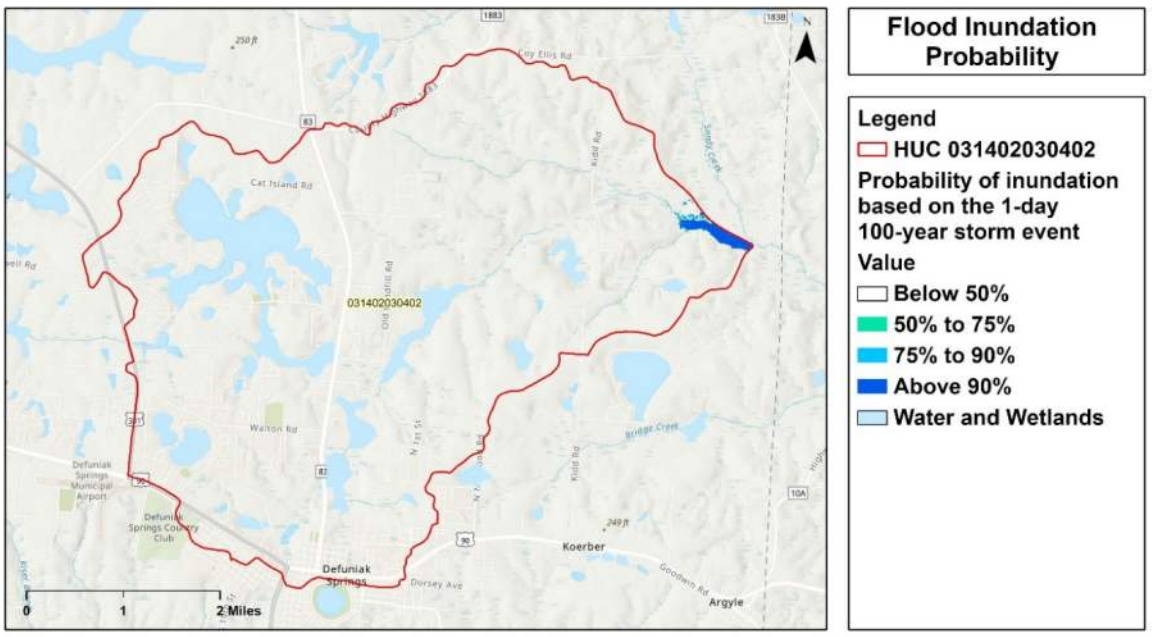

Figure 32. 1-day 100-year storm event for HUC 031402030402 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

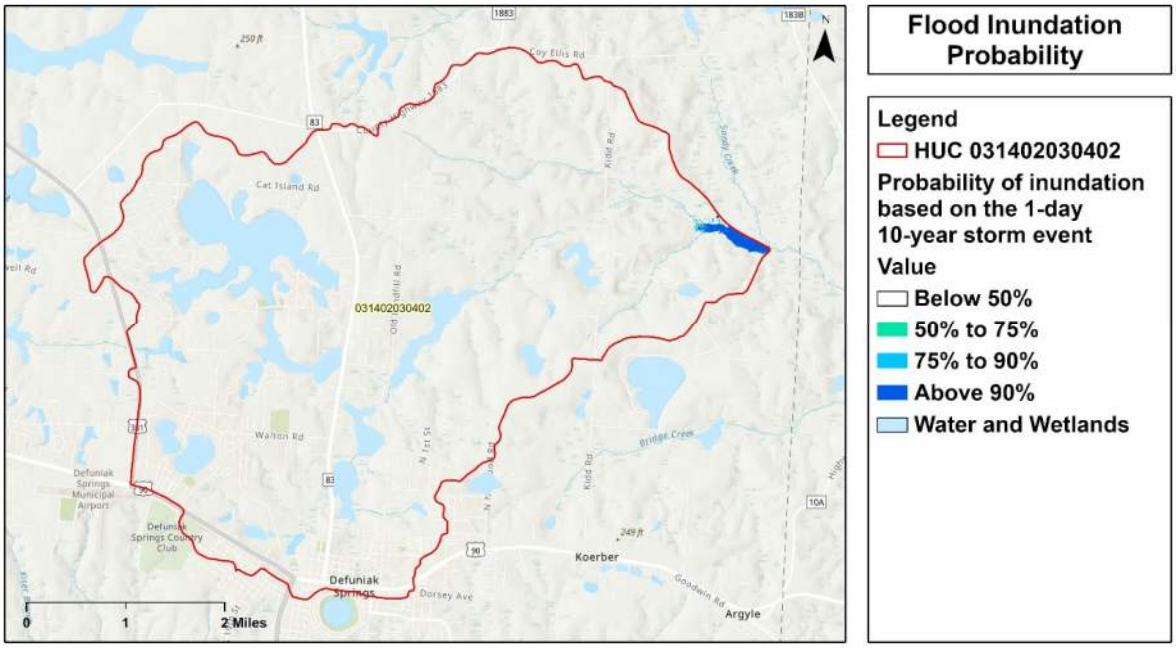

Figure 33. 1-day 10-year storm event for HUC 031402030402 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

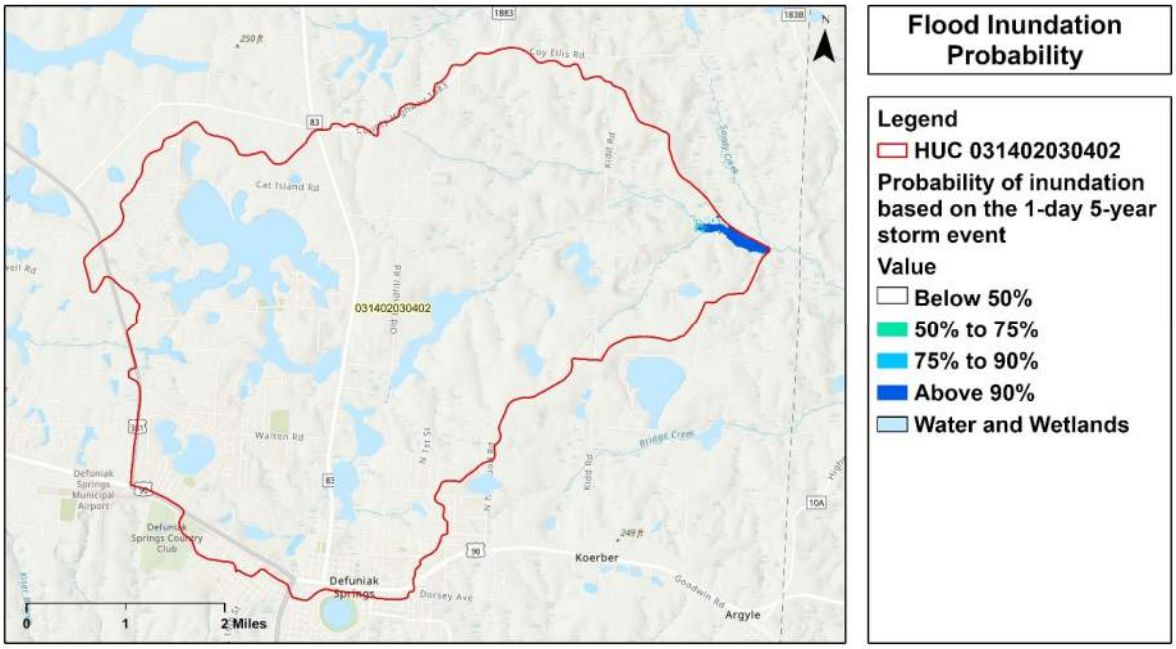

Figure 34. 1-day 5-year storm event for HUC 031402030402 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered
essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older,

poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service,	3

	Electric Repair, Laundries, Laundromats	
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6

50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1

84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031402030402 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.**is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.**illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.**

is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

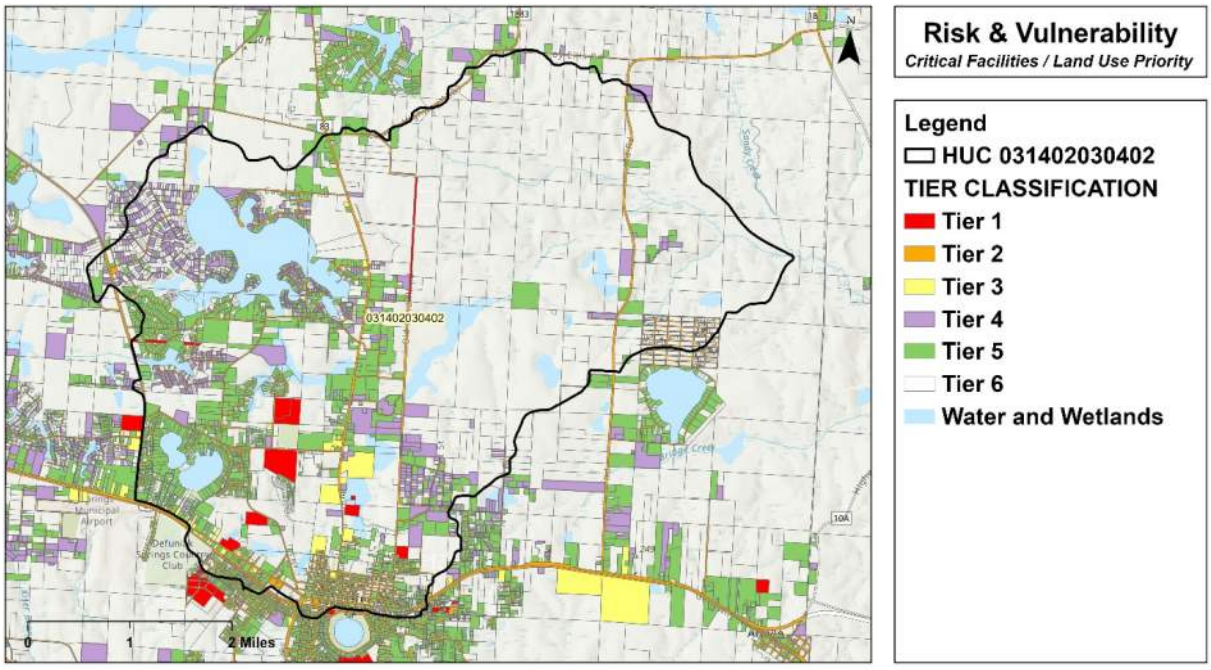

Figure 35. HUC 031402030402 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

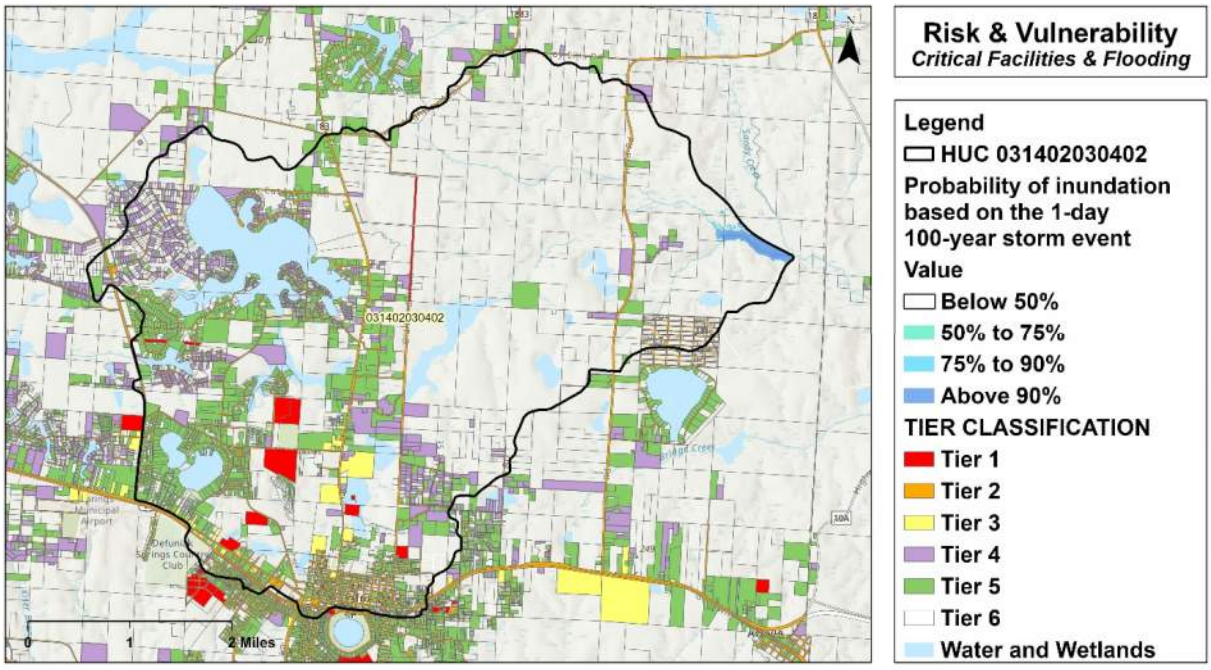

Figure 36. HUC 031402030402 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

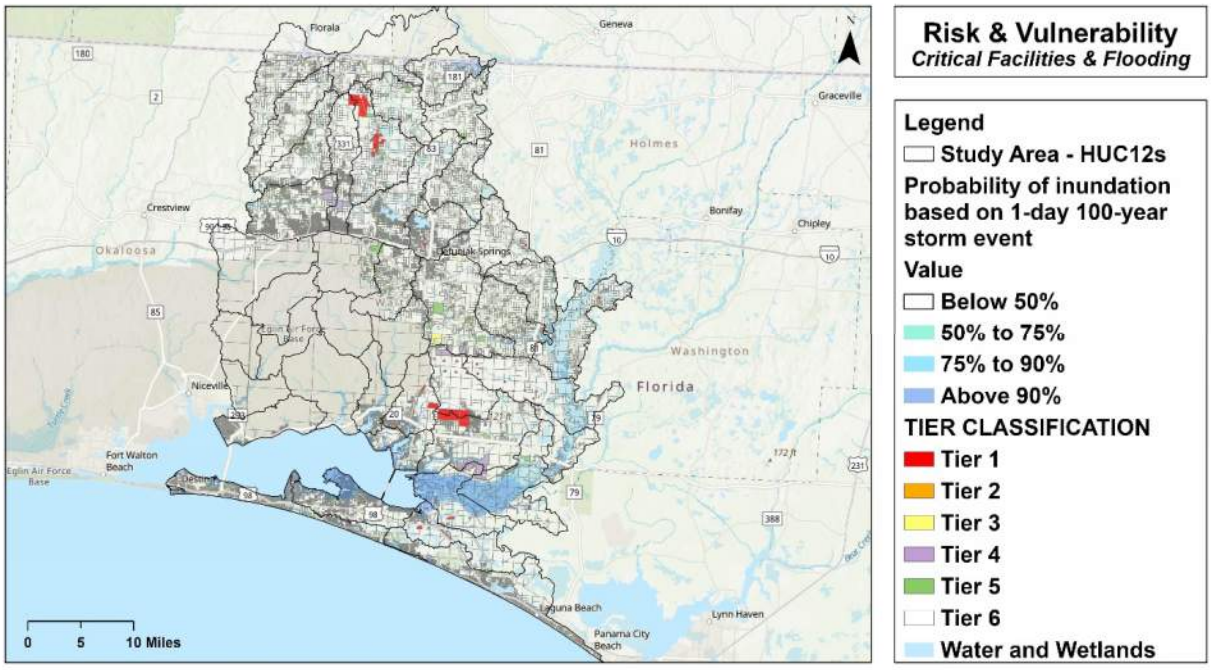

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

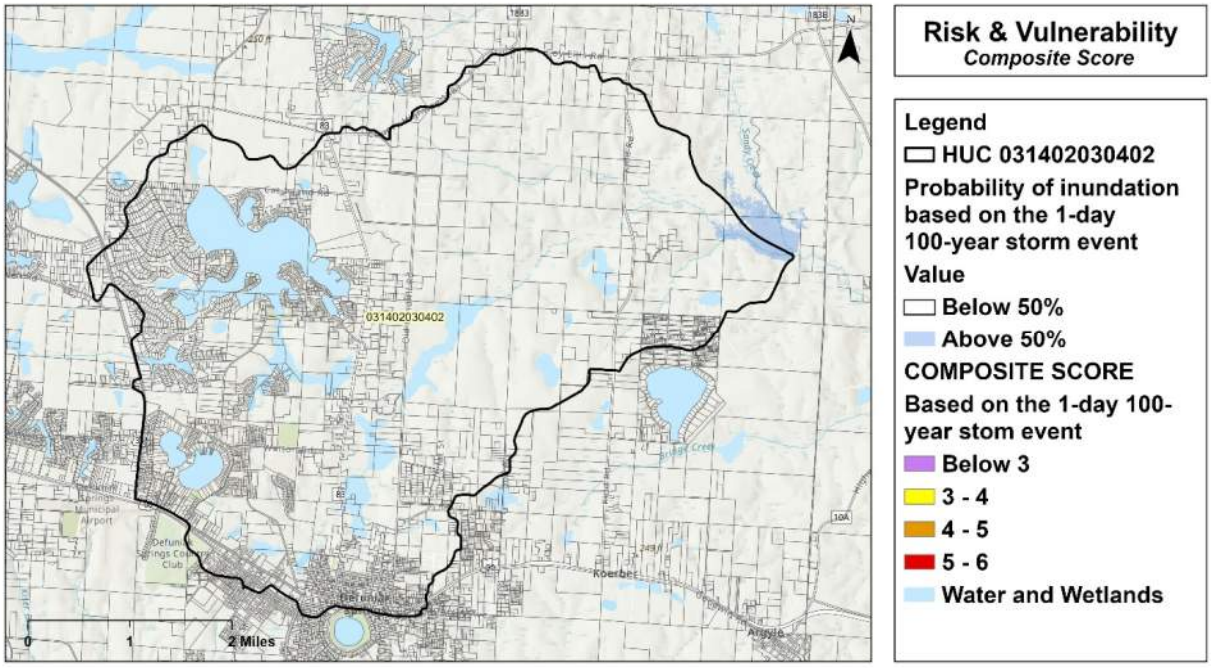

Figure 38. HUC 031402030402 sub-watershed Composite Score Risk map, with calculation based on 1-day 100-year storm event. Processed by FAU.

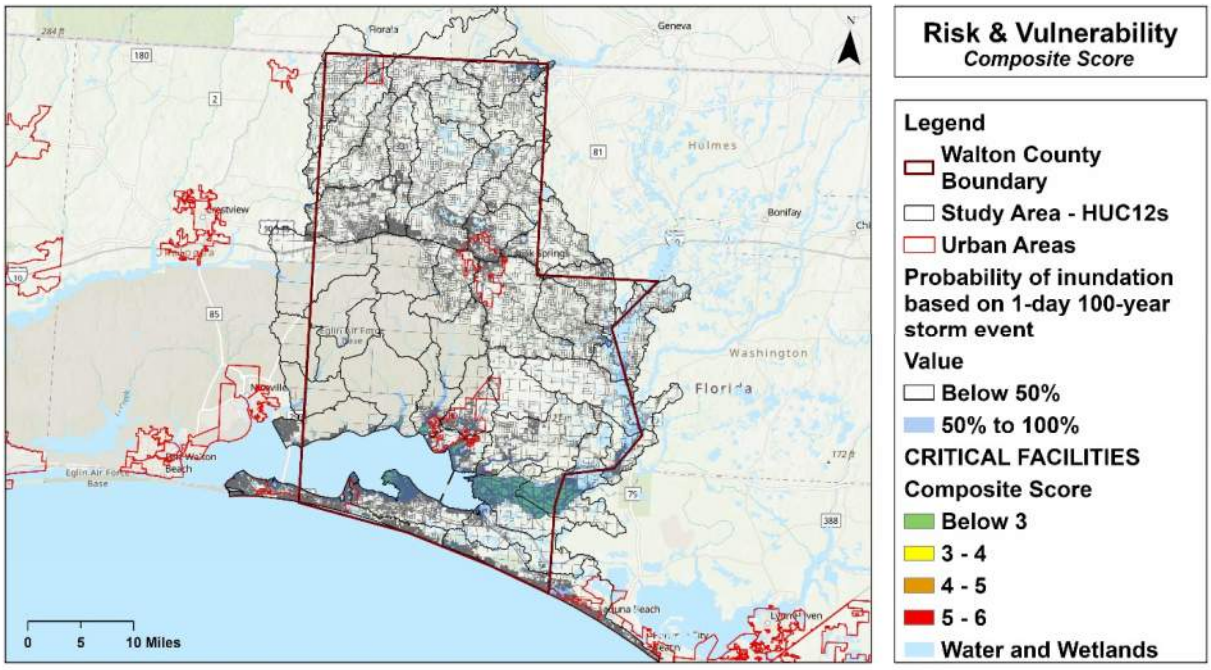

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.
Please note that due to the scale of the map, the composite score layer is not properly visible in this map.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

2.4.2 Drill-down – DeFuniak Springs

For enhanced visualization of the urban areas within this HUC 031402030402, Figure 40 to Figure 44 illustrate the same results for critical facilities (land use priorities) and composite scores, but on a reduced scale, which better facilitates the examination of finer details within the urban area (DeFuniak Springs). These maps cover both the 1-day 100-year scenario and the 1-day 100-year + 5 feet SLR scenario, although the results for Sea Level Rise is null due to distance of the basin to the coast and its high elevation.

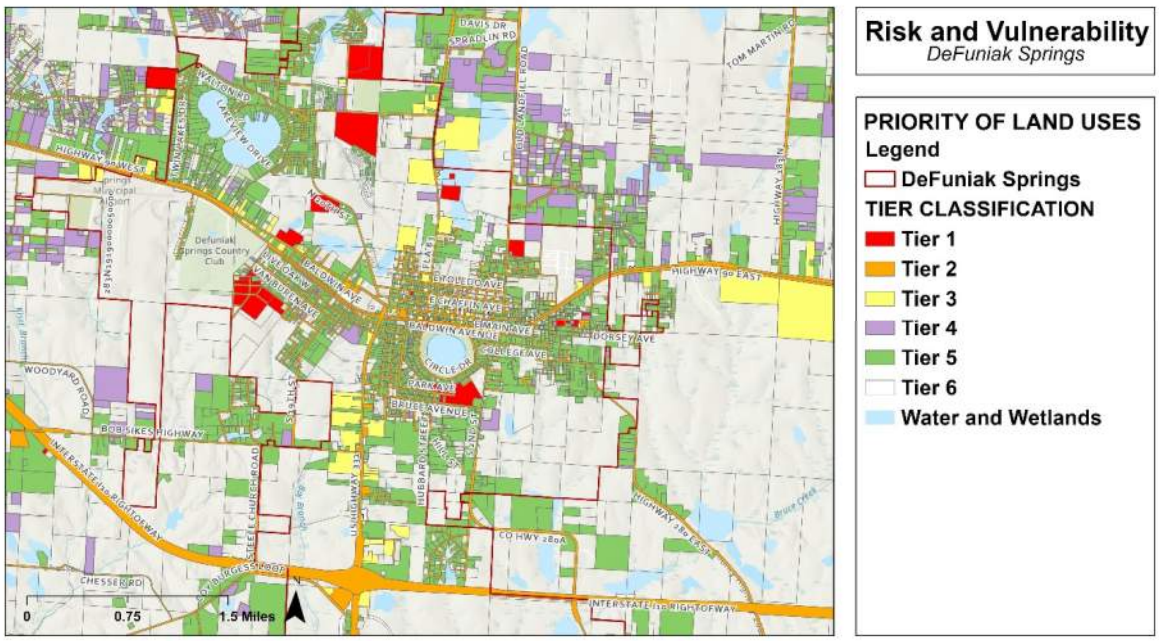

Figure 40. Critical Facilities (priority of land uses) map for DeFuniak Springs. Processed by FAU.

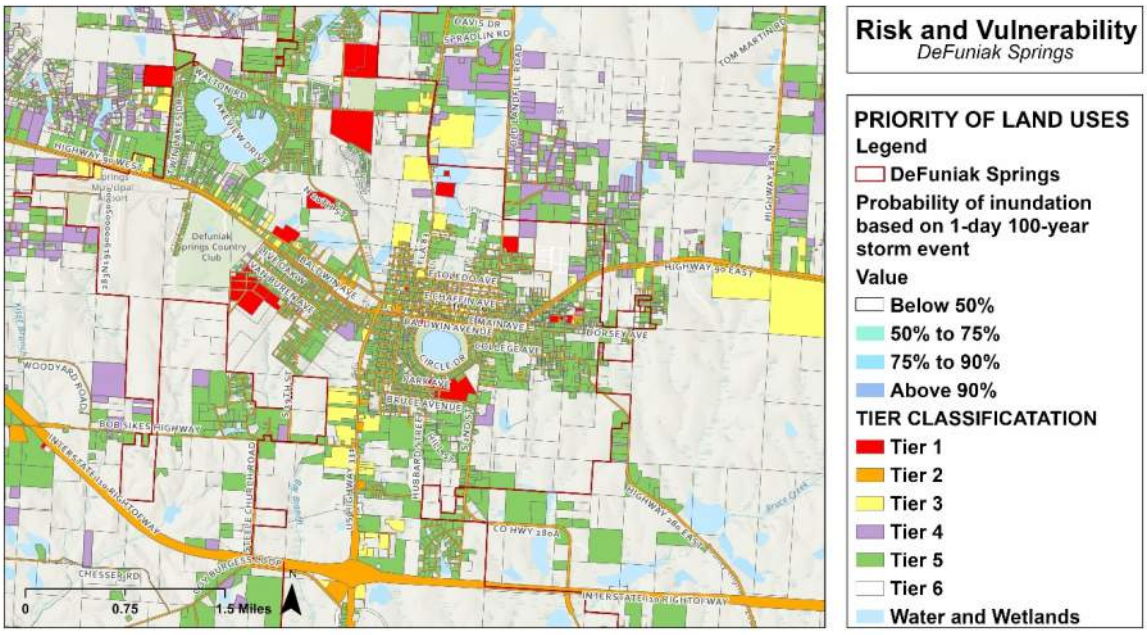

Figure 41. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event for DeFuniak Springs. Processed by FAU.

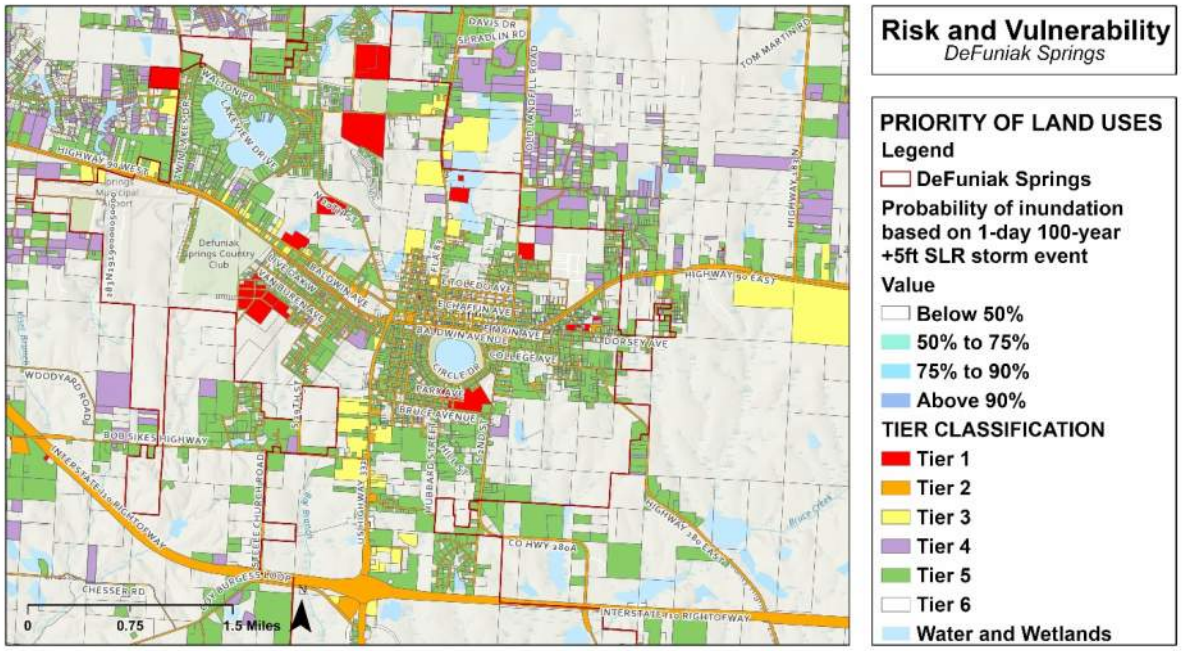

Figure 42. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event + 5ft SLR for DeFuniak Springs. Processed by FAU.

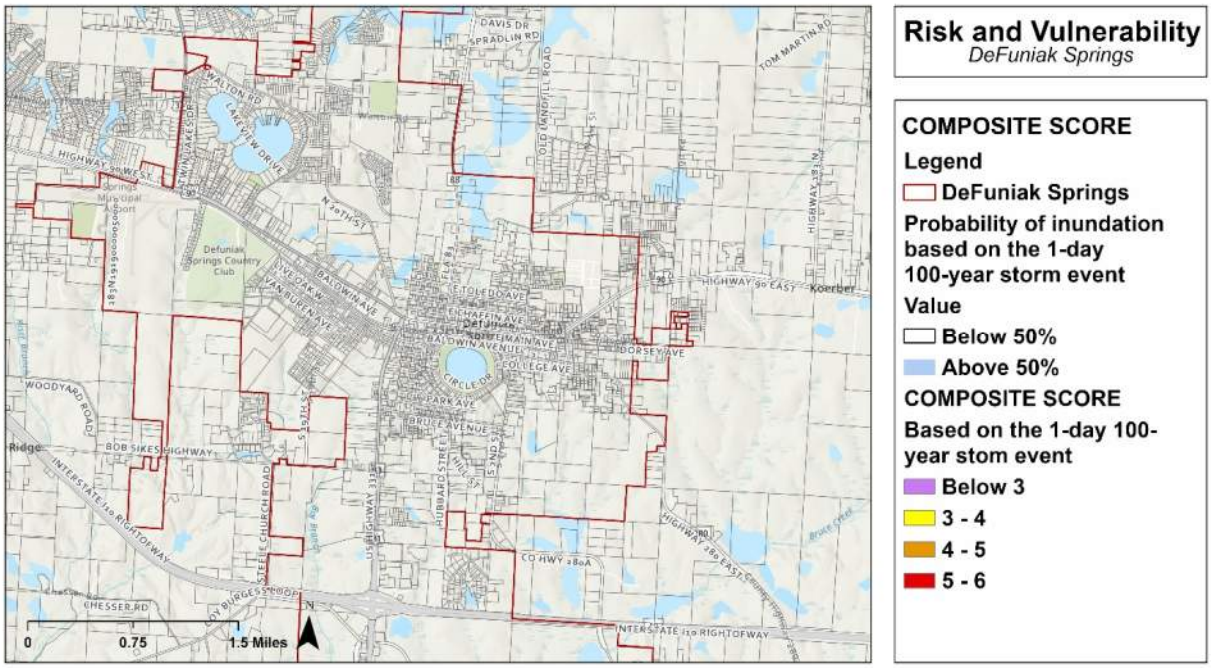

Figure 43. Composite Score map based on 1-day 100-year storm event, overlaid in flooding layer for DeFuniak Springs. Processed by FAU.

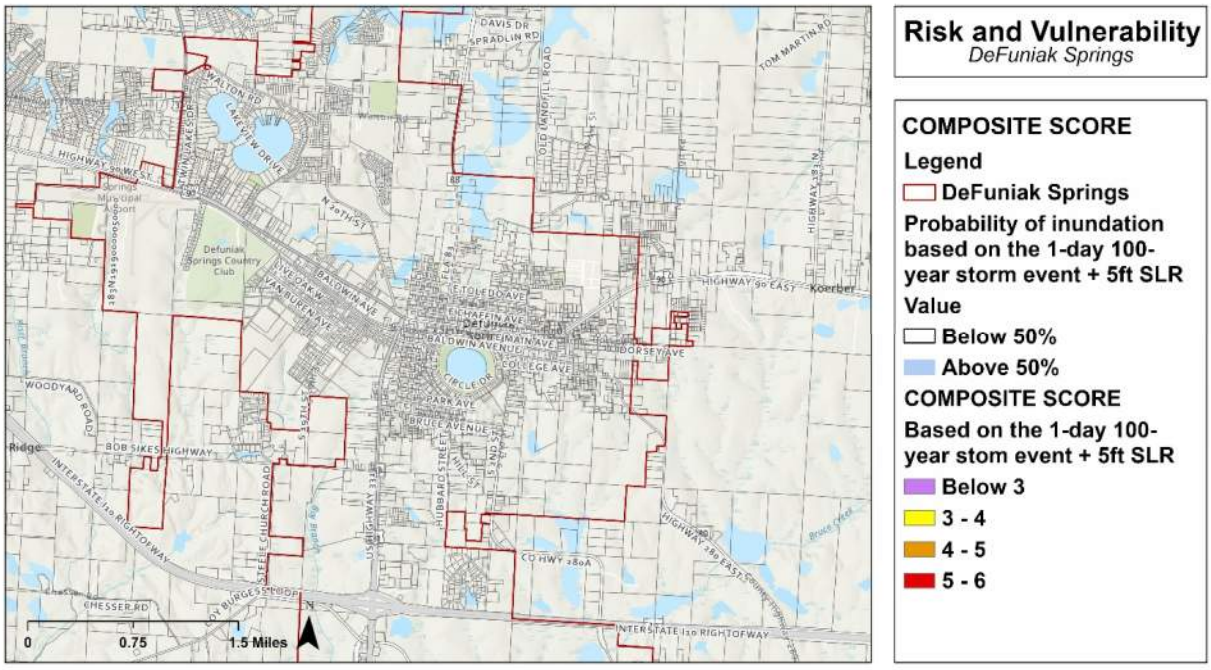

Figure 44. Composite Score map based on 1-day 100-year storm event + 5 feet SLR, overlaid in flooding layer for DeFuniak Springs. Processed by FAU.

The composite score results for this location are null, as the city of DeFuniak Springs shows no indication of flooding in both the 1-day 100-year and 1-day 100-year + 5ft SLR flooding scenarios.

2.4.3 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031402030402. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**.. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.4 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031402030402. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031402030402	14060.25
All of the 1-day 100-year storm event inundation	**63.86**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	63.86
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	63.86

2.4.5 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. Figure 45 indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

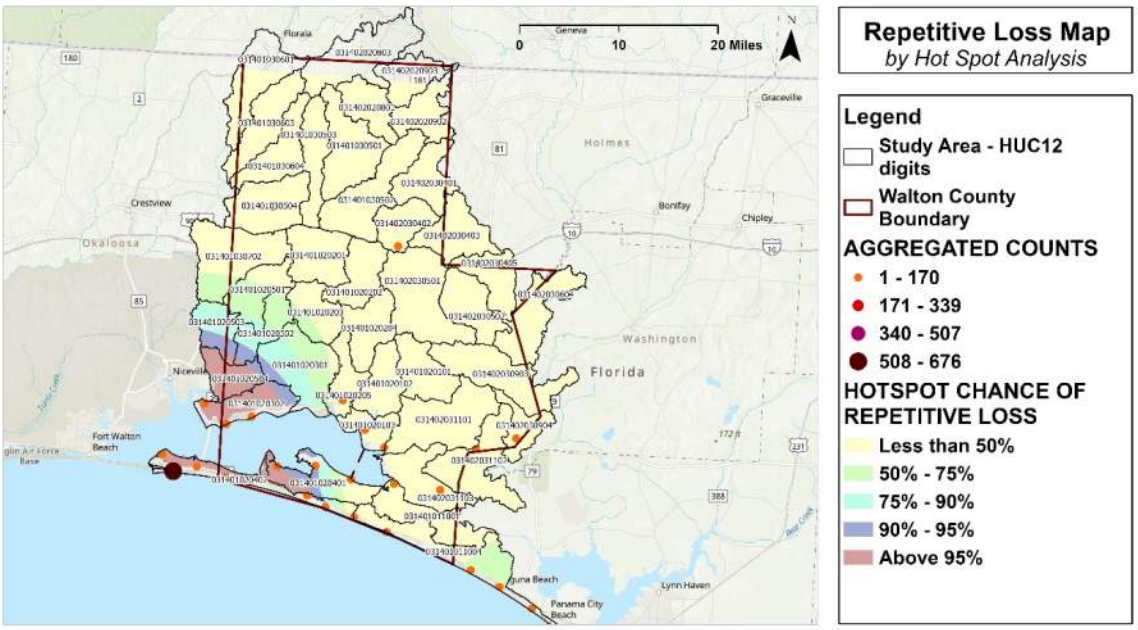

Figure 45. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.6 Priority Projects

Although the basin features a significant amount of developed land, including a portion of the city of DeFuniak Springs, none of the priority parcels fall within the flood zone. Flooding in the area is minor and not alarming. Consequently, when considering the composite score, it is notable that the results are null, indicating no priority for intervention within the basin.

APPENDIX AH

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031402030403

MIDDLE SANDY CREEK

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Co-Principal Investigators: Weibo Liu, Ph.D., Daniel Meeroff, Ph.D., Diana Mitsova, Ph.D., S. Nagarajan, Ph.D., Hongbo Su, Ph.D., Ramesh Teegavarapu, Ph.D., Zhixiao Xie, Ph.D., Yan Yong, Ph.D., and Caiyun Zhang, Ph.D., Ahmet Urusan, Ph.D., Shannon Egger, Eva Suarez, Ph.D.

Research Assistant: Leticia Sabio

This resource was funded in part, through a grant agreement from the Florida Division of Emergency Management's (FDEM) Bureau of Mitigation, by a grant provided by through the Hazard Mitigation Grant Program (HMGP) DR-4337-004-P, as approved by FDEM and the Federal Emergency Management Agency (FEMA) to create and update Watershed Master Plans (WMP) throughout the state of Florida. The views, statements, findings, conclusions, and recommendations expressed herein are those of the authors and do not necessarily reflect the views of the State of Florida, FEMA, or any of their sub-agencies.

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 (031402030403) is highlighted among all the HUCs to help identifying its location. (Figure 3).

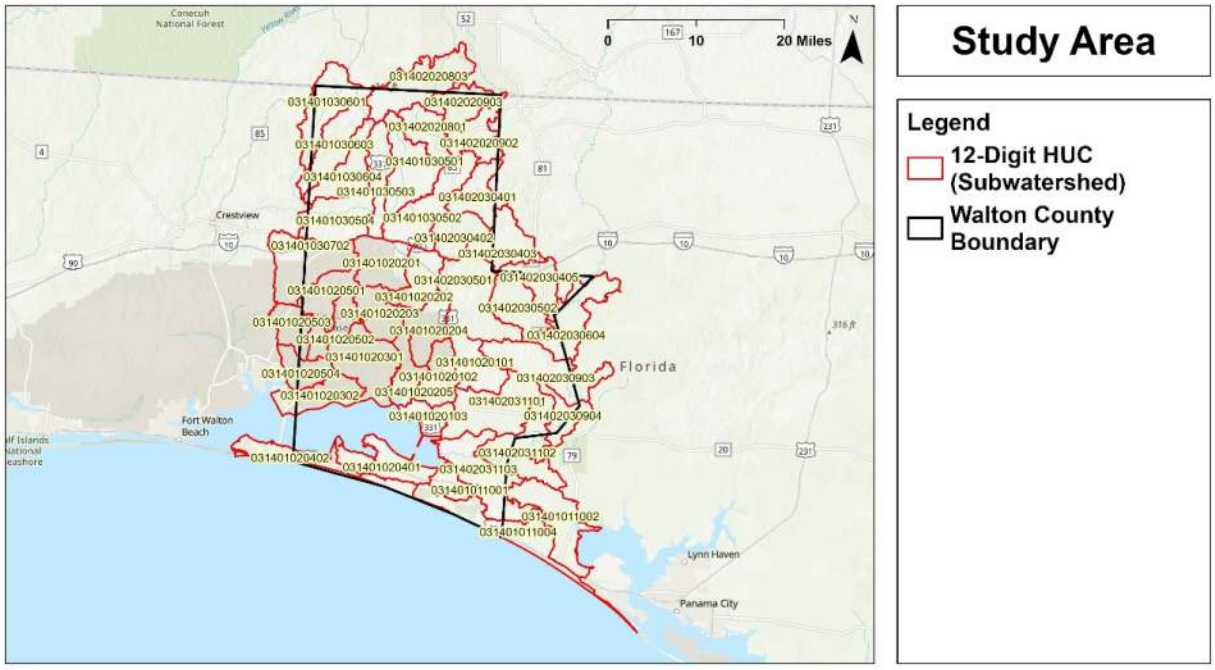

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

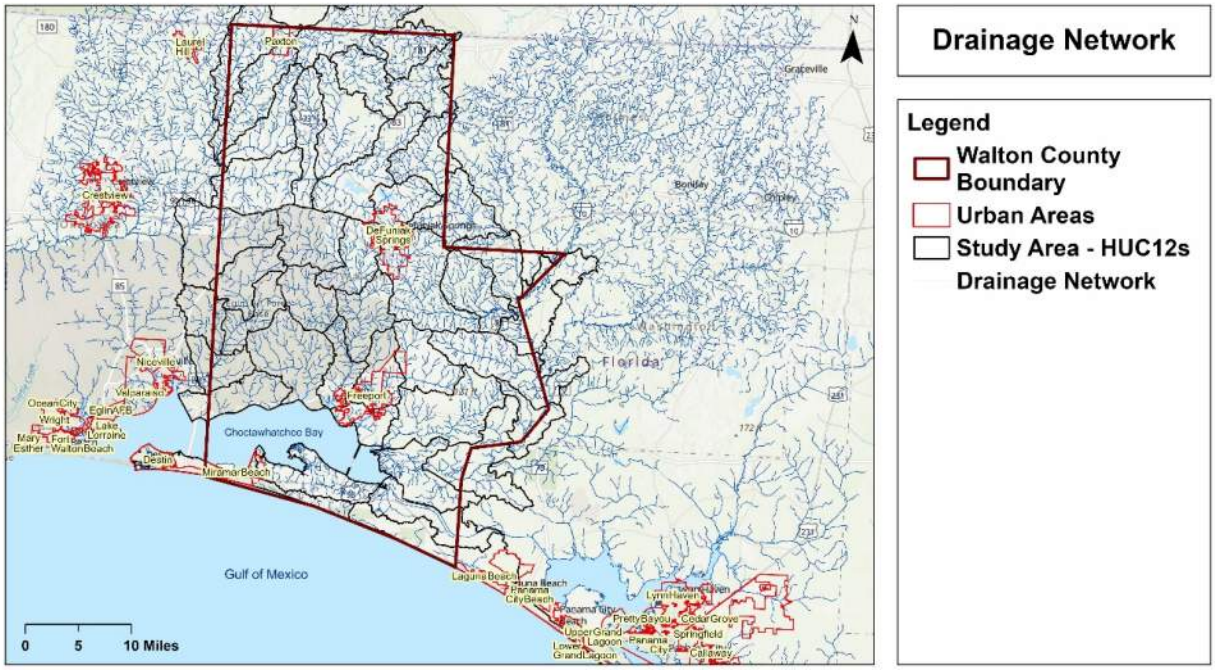

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

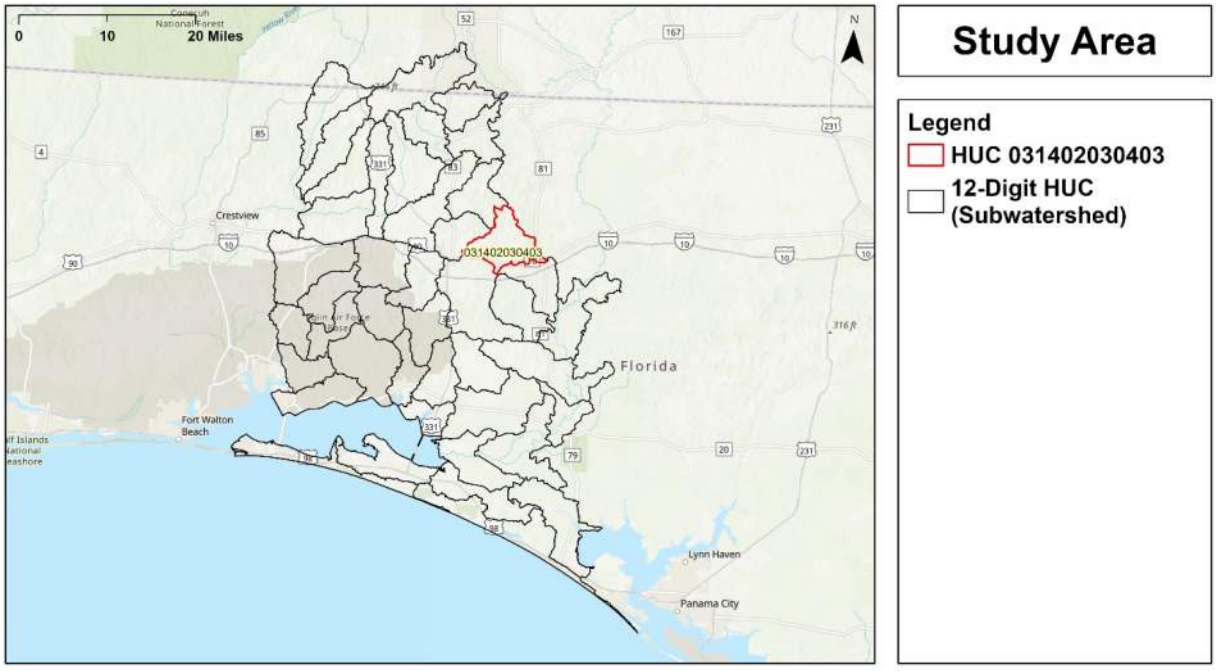

Figure 3. HUC 031402030403 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state,

with a height of 345 feet in its northern end. With a population of 75,305 residents according to the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife

management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

(Source Data: FEMA)

Figures 12 and 13 is the county-wide report show the current and projected land use for the County. Based on the 2017 future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land Use in Walton County (Prepared by FAU from future land use map) versus land use in the entire watershed

Level 1 Land Use-Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

(Source Data: (NWFWMD 2017)

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 1.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.

- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

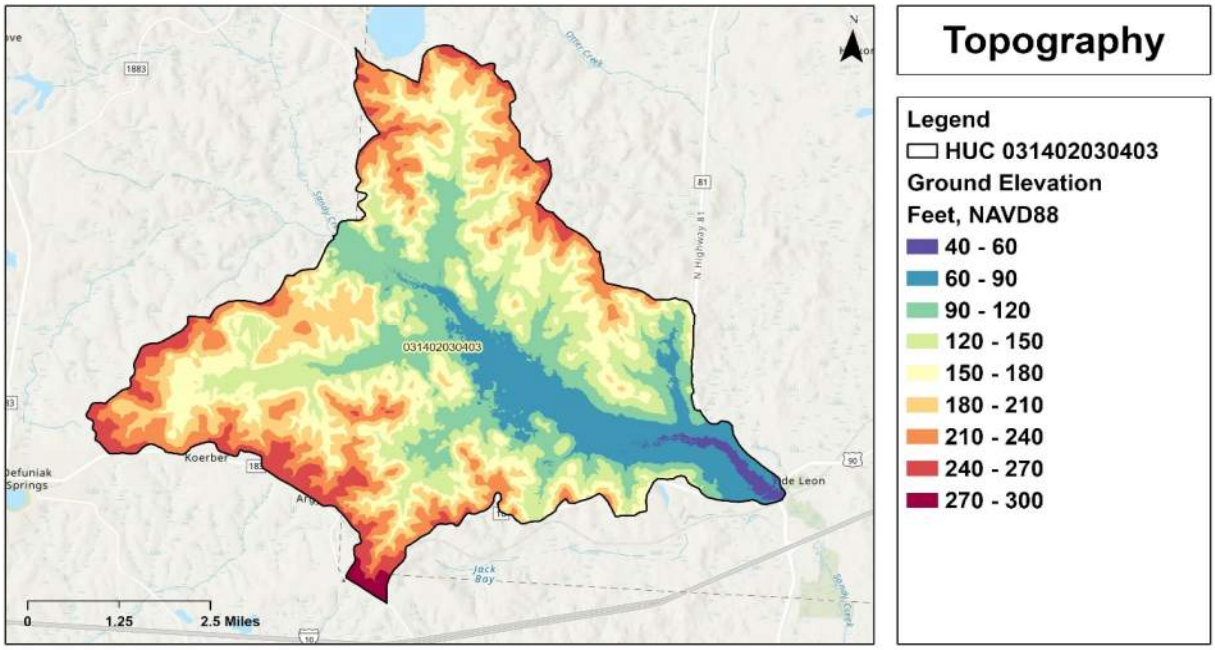

Figure 4. Topographic map of the HUC 031402030403 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031402030403 sub-watershed is shown in **Error! Reference source not found.**.

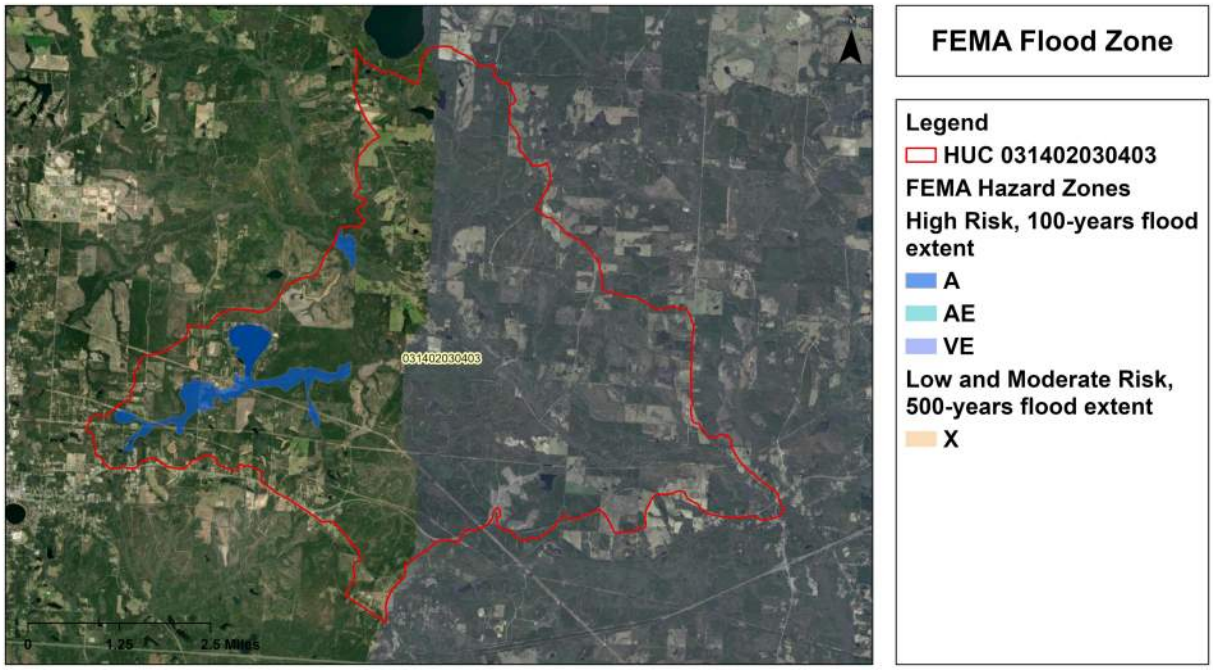

Figure 5. FEMA Flood Zone map (2020) for HUC 031402030403 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031402030403 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including

various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

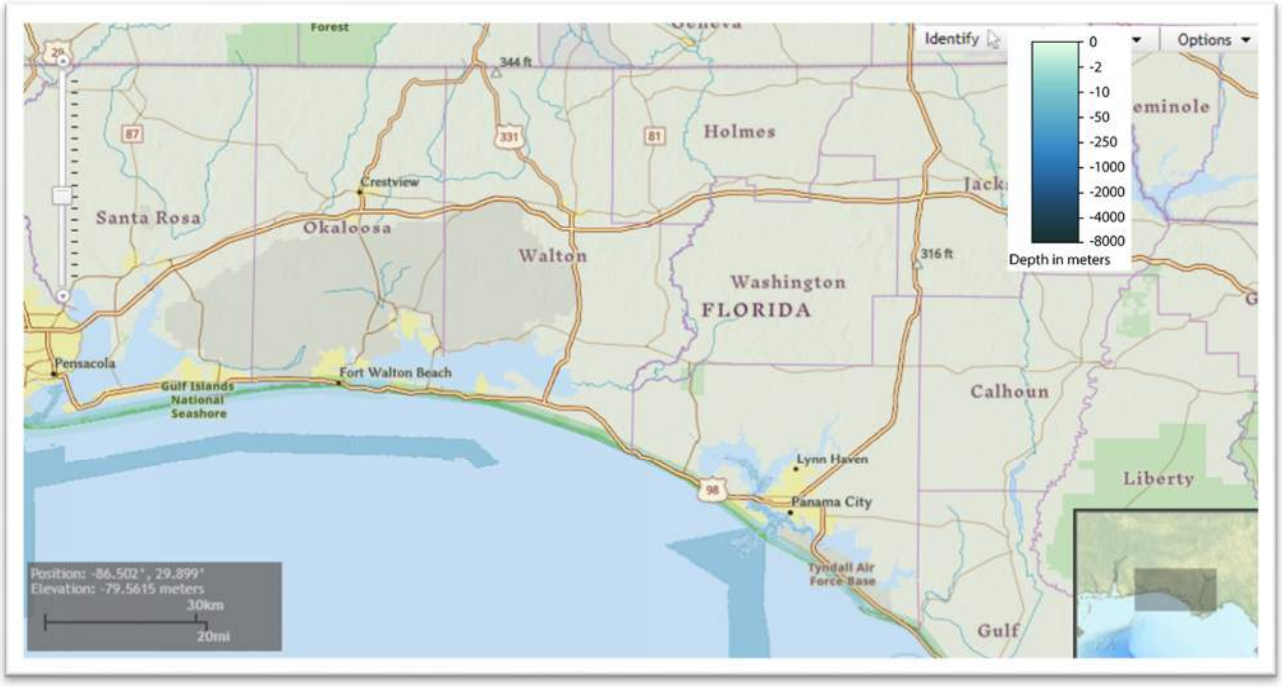

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle. Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

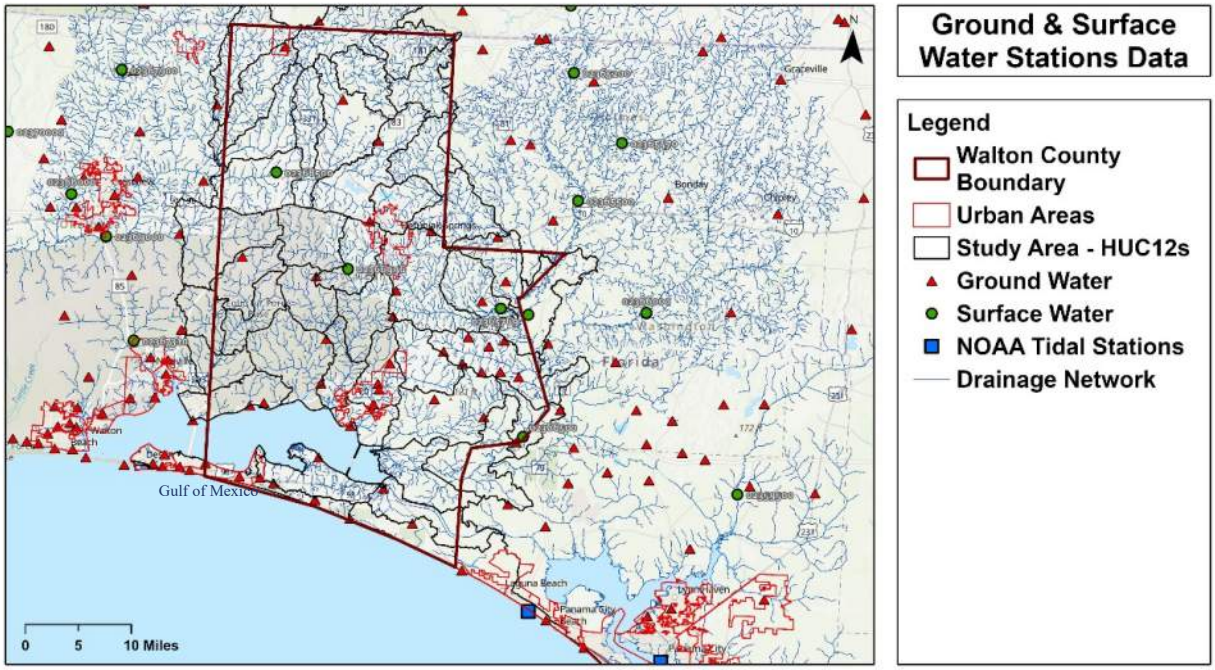

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031402030403 has no major rivers and canals, but creeks, which include:

- Sandy Creek

- Bridge Creek
- Padgett Creek
- Parrish Branch
- Black Branch
- Cow Branch

Given that stream flow data are critical for estimating flooding, Figure 8 shows the historical streamflow during June 2022 to July 2023 for USGS 02366966. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031402030403, which is USGS 02366966 Alaqua Creek Near Pleasant Ridge, FL.\

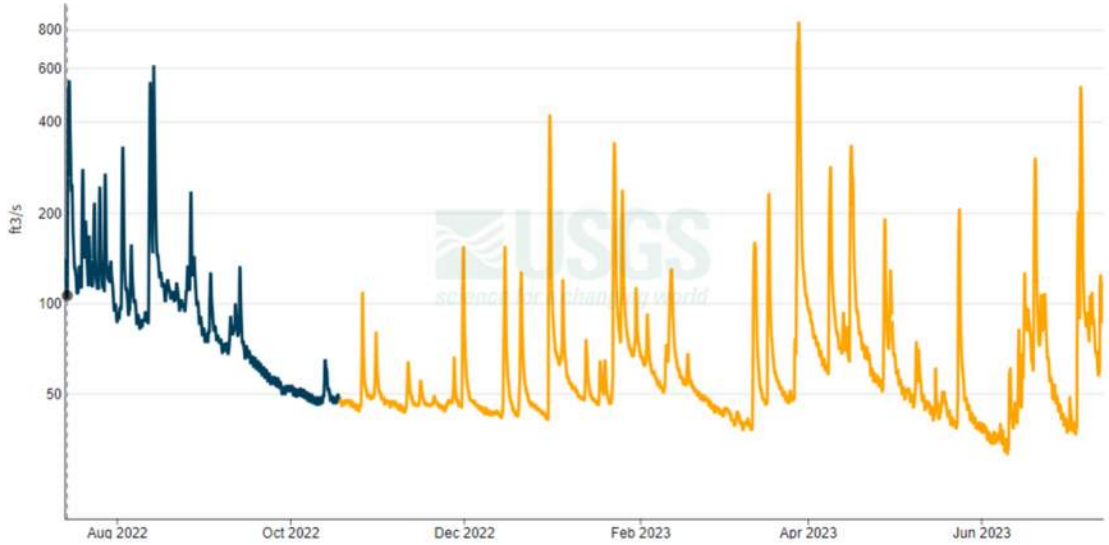

Figure 8. Average streamflow for Alaqua Creek Near Pleasant Ridge, FL (USGS 02366966 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366996/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the

database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031402030403 and points out the location of the ground water station in the surroundings. A groundwater-surface layer for the HUC 031402030403 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

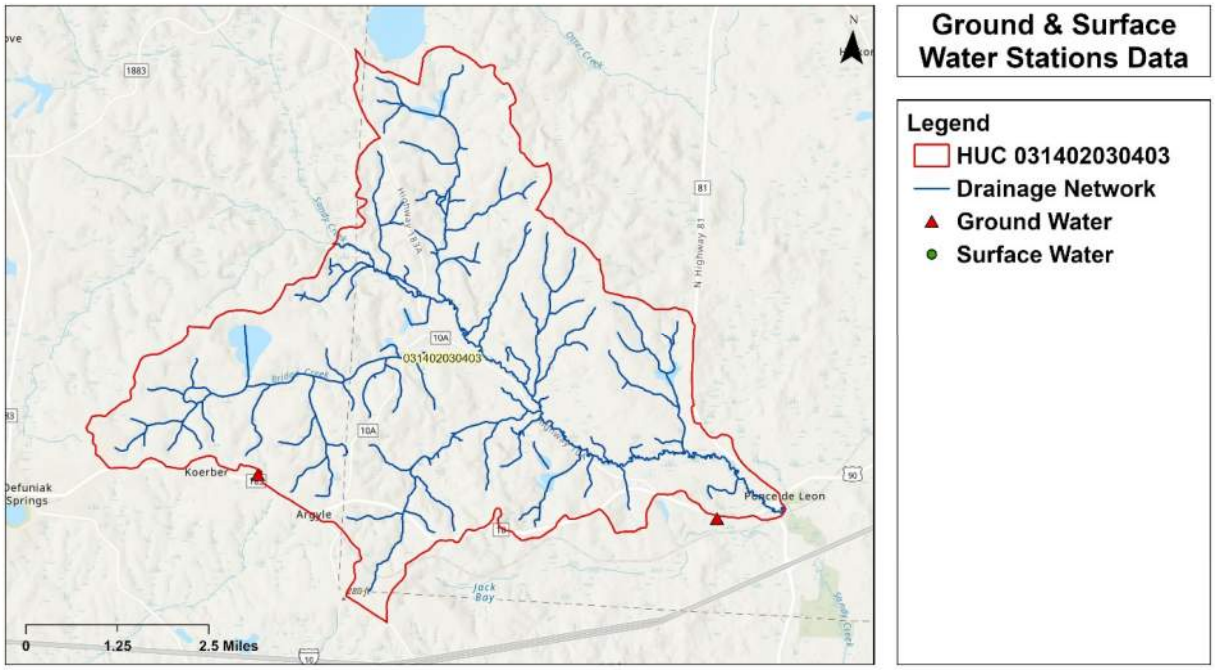

Figure 9. Ground and Surface Water Stations in the HUC 031402030403 sub-watershed, processed by FAU.

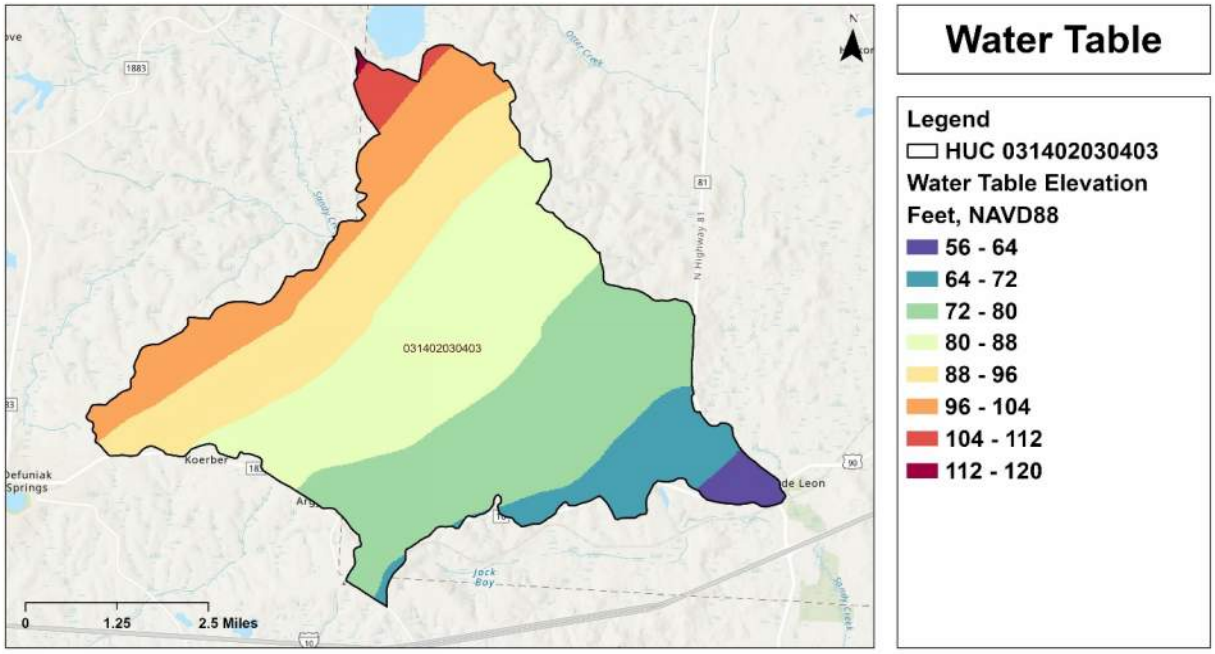

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031402030403 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the average precipitation over Walton County for every month of the year between 2011 and 2023.

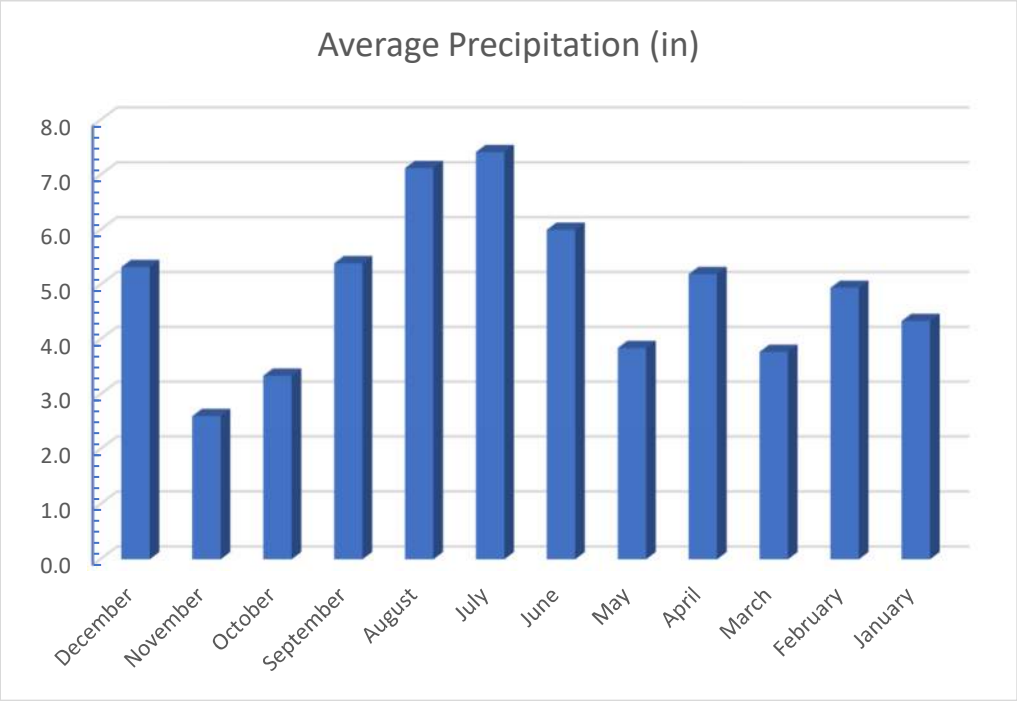

Figure 11. Monthly precipitation in Walton County, FL (2011-2023).
(Data Source: Florida Weather Data, available at https://data.usatoday.com/weather-data/walton-county/12131/1975-04-01/Table/)

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows

the two closest tide stations to Walton County. Since there are no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

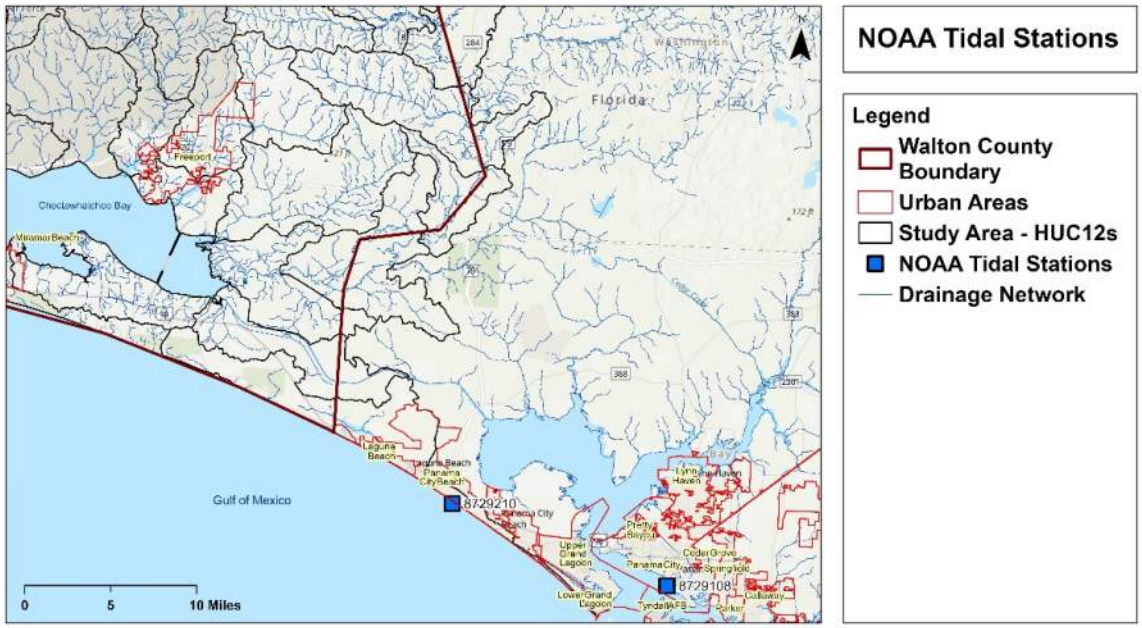

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

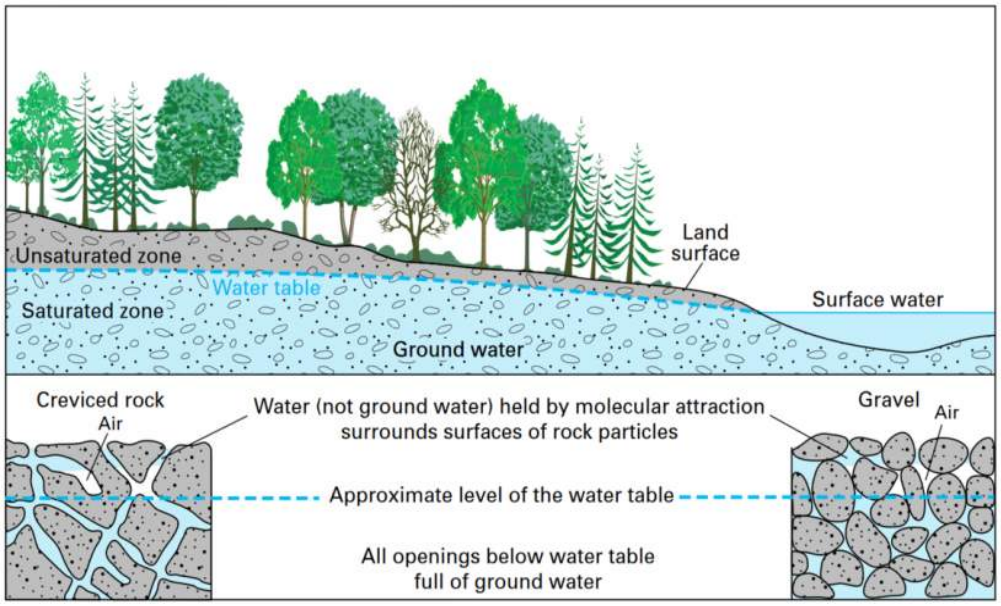

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

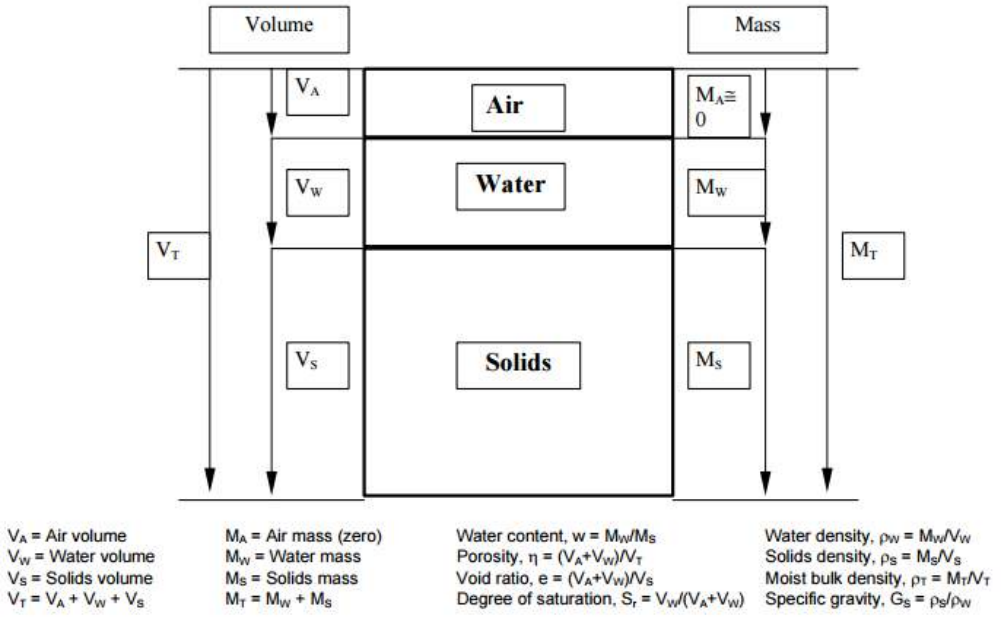

Figure 14. Saturated zone soil phase diagram and definitions.

Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

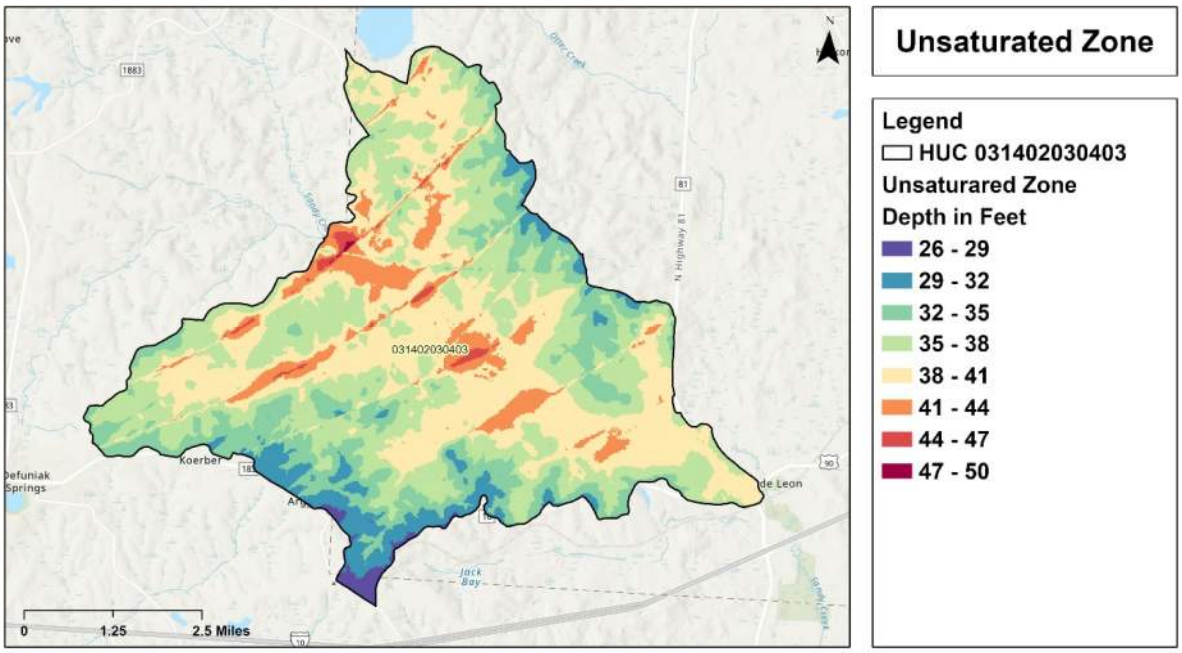

Figure 15. Unsaturated zone map for HUC 031402030403, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately favorable soil storage capacity, falling within the range of 32 to 44 feet of remaining capacity.

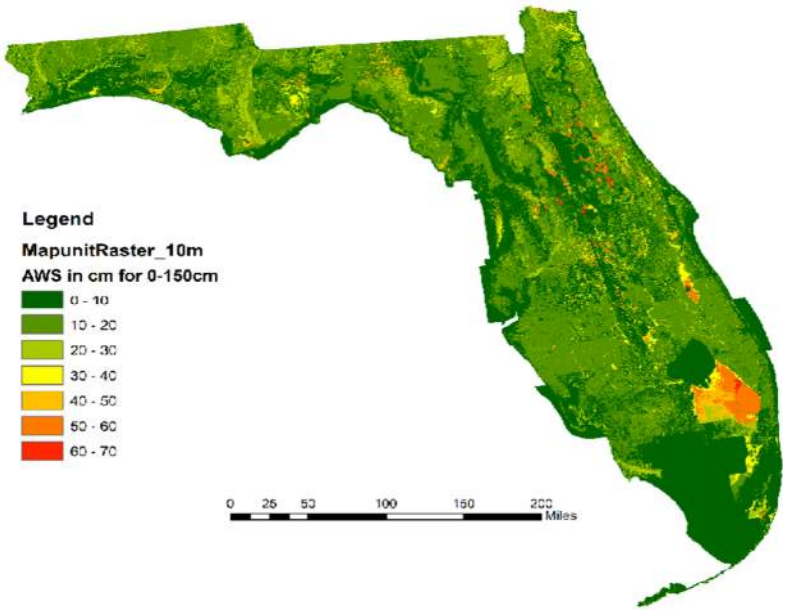

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

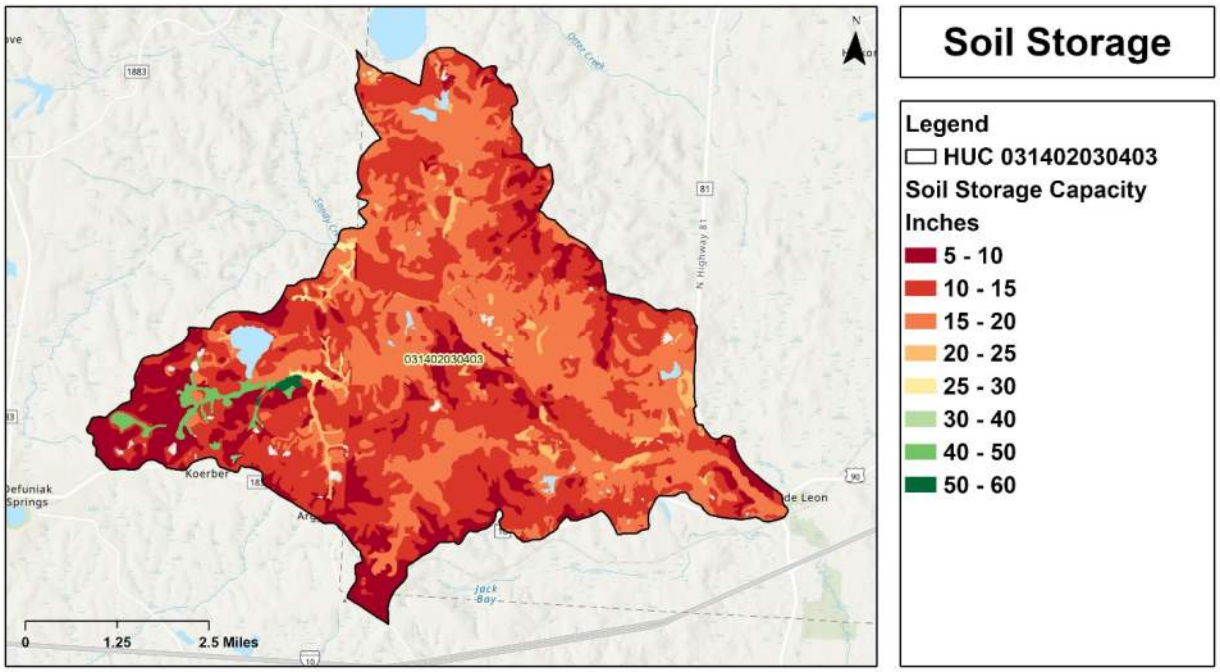

Figure 17. Water storage capacity of soil for the HUC 031402030403, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

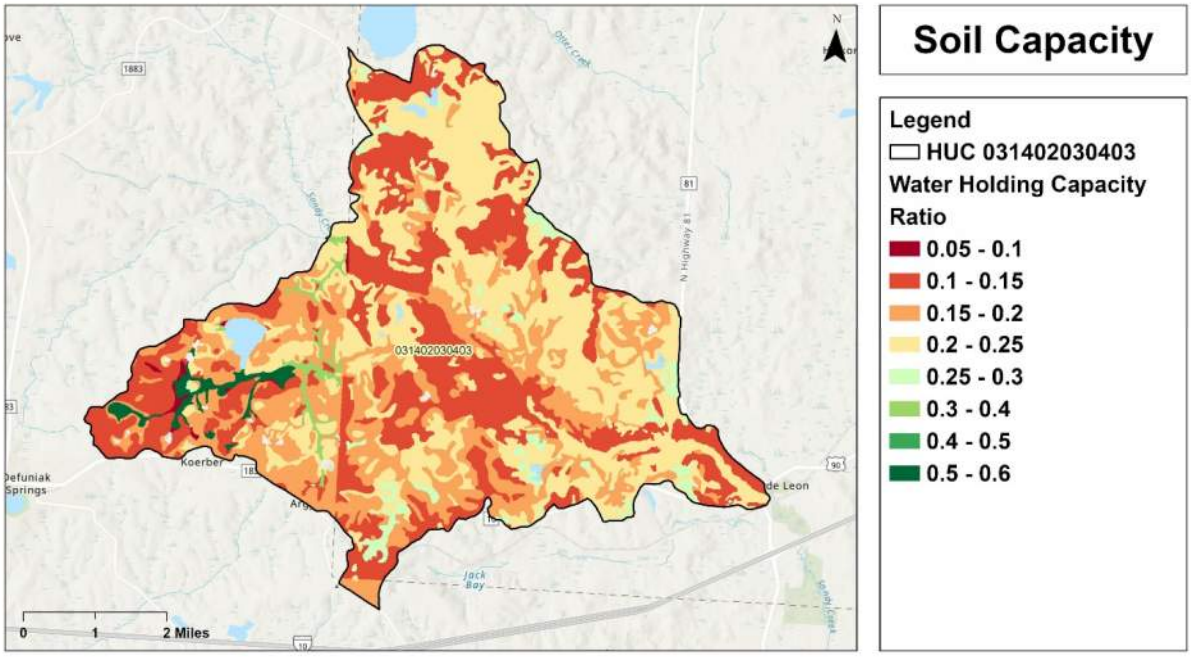

Figure 18. Water Holding Capacity (ratio) for the HUC 031402030403, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

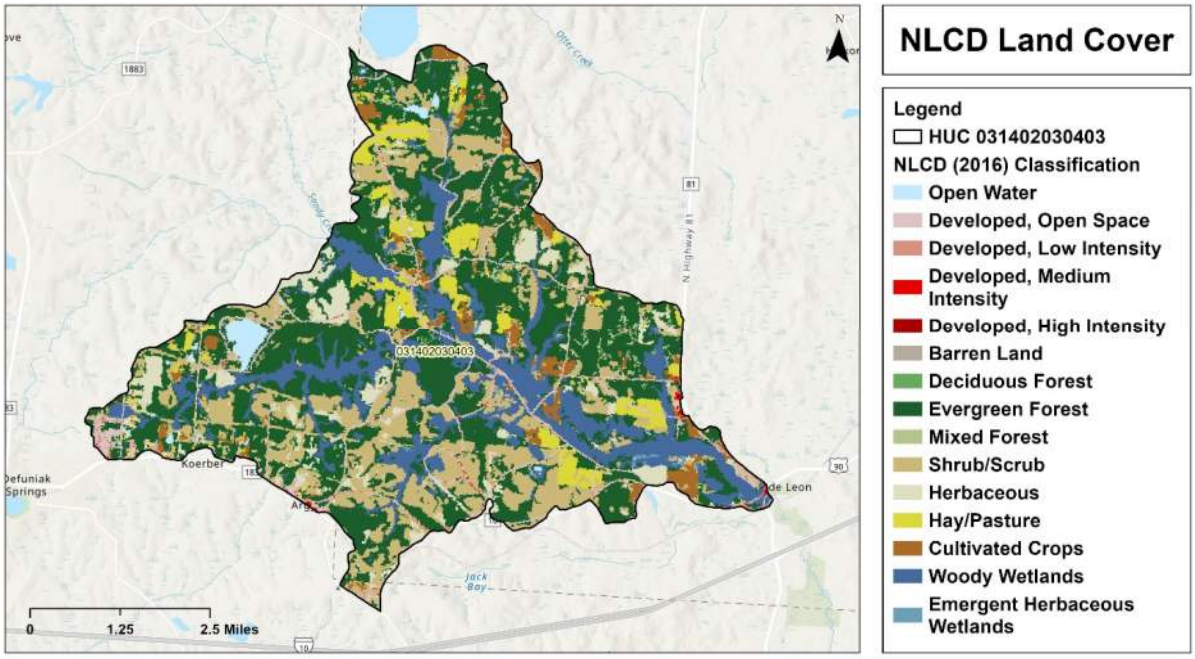

Figure 19. Land use in the HUC 031402030403 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

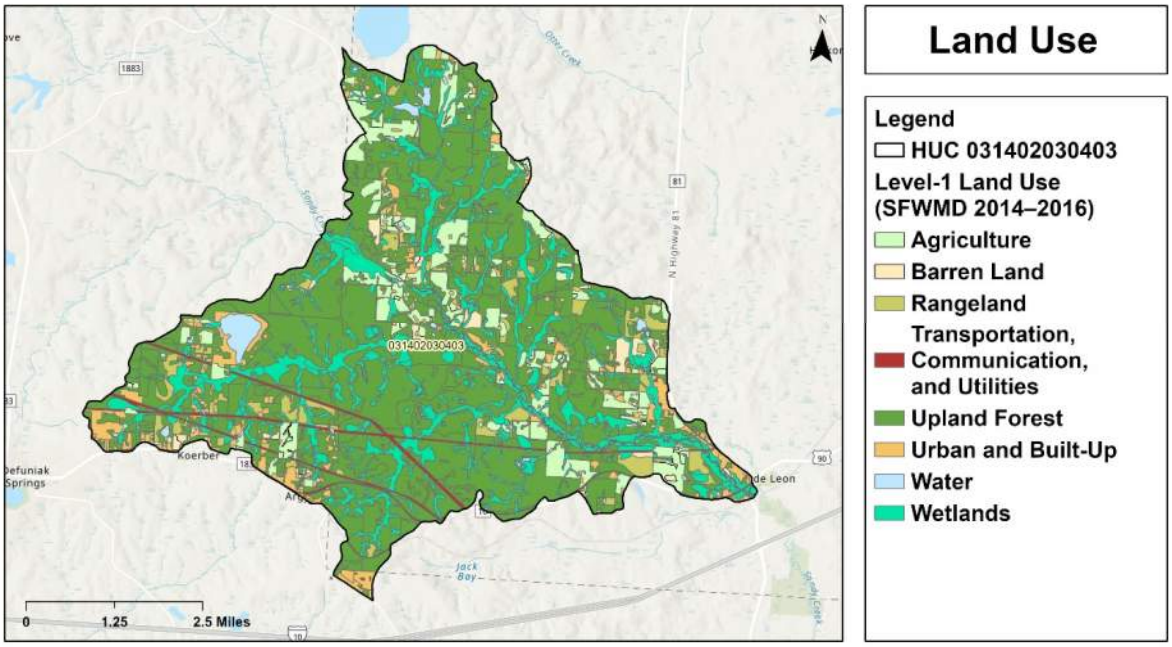

Figure 20. Land use in the HUC 031402030403 (from the 2023 Florida Geographic Data Library (FGDL) database), processed by FAU.

In the HUC 031402030403 sub-watershed, the predominant land cover is upland forest, accounting for 45.38% of the area. Wetland comes in second at 18.82%, followed by Transportation, Communication, and Utilities at 10.39% and water at 10.33%. Developed land constitutes a minor portion, with only 4.04% categorized as urban and built-up, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031402030403 subwatershed.

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	2331.77	7.40%
Barren Land	251.39	0.80%
Rangeland	896.00	2.84%
Transportation, Communication, and Utilities	3273.12	10.39%
Upland Forest	14300.48	45.38%
Urban and Built-Up	1274.71	4.04%
Water	3254.26	10.33%
Wetlands	5931.85	18.82%
Grand Total:	**31513.58**	**100.00%**

(Source Data: 2023 Florida Geographic Data Library (FGDL) database))

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

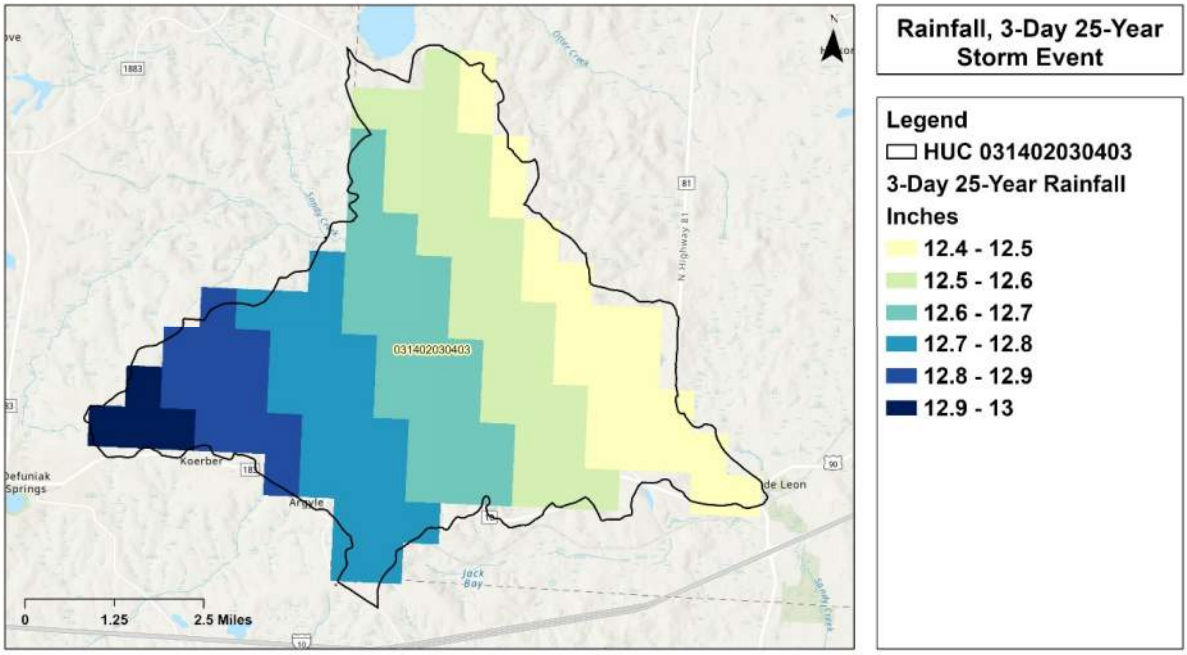

Figure 21. Rainfall distribution map across HUC 031402030403 sub-watershed, for 3-day 25-year storm event, processed by FAU.

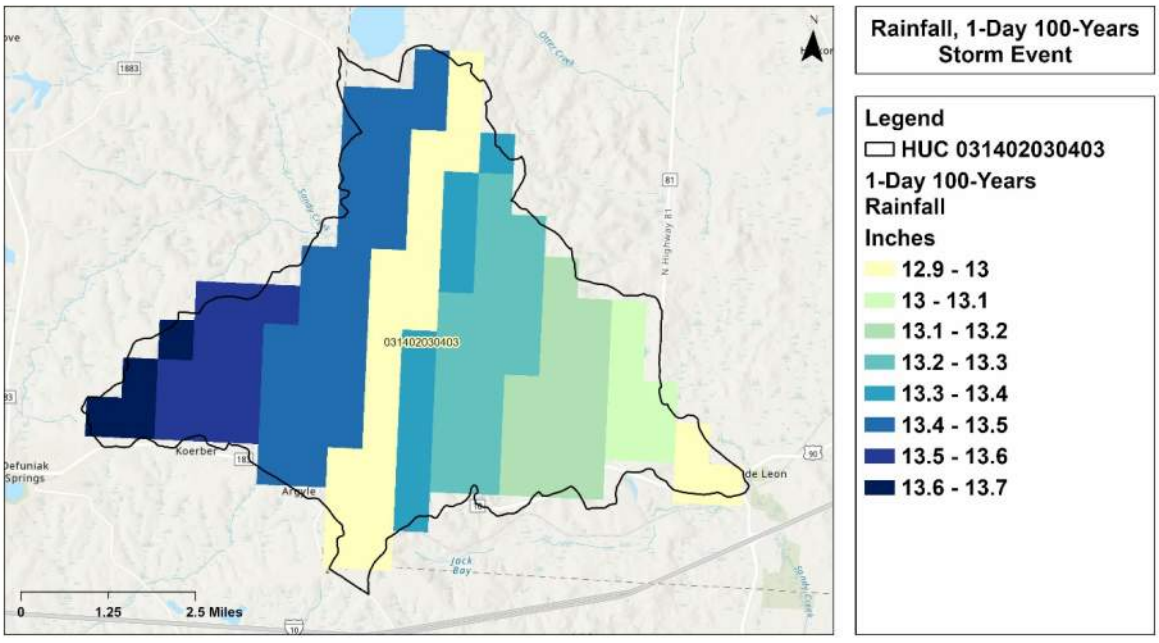

Figure 22. Rainfall distribution map across HUC 031402030403 sub-watershed, for 1-day 100-year storm event, processed by FAU.

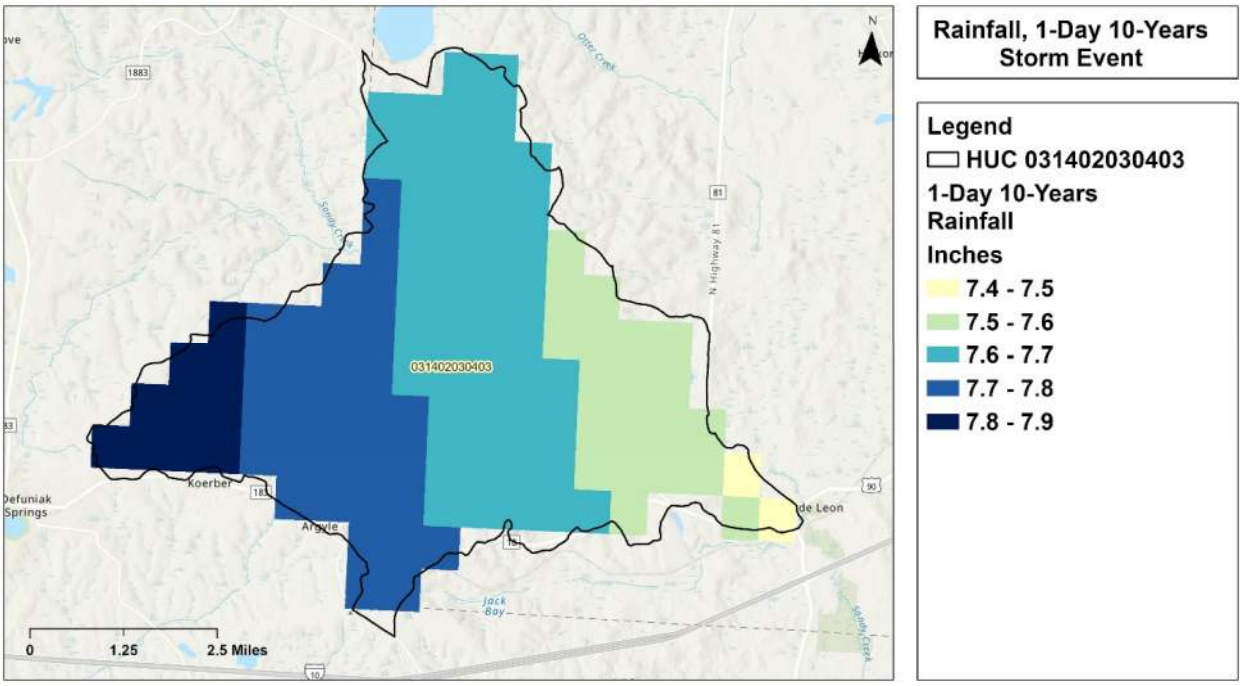

Figure 23. Rainfall distribution map across HUC 031402030403 sub-watershed, for 1-day 10-year storm event, processed by FAU.

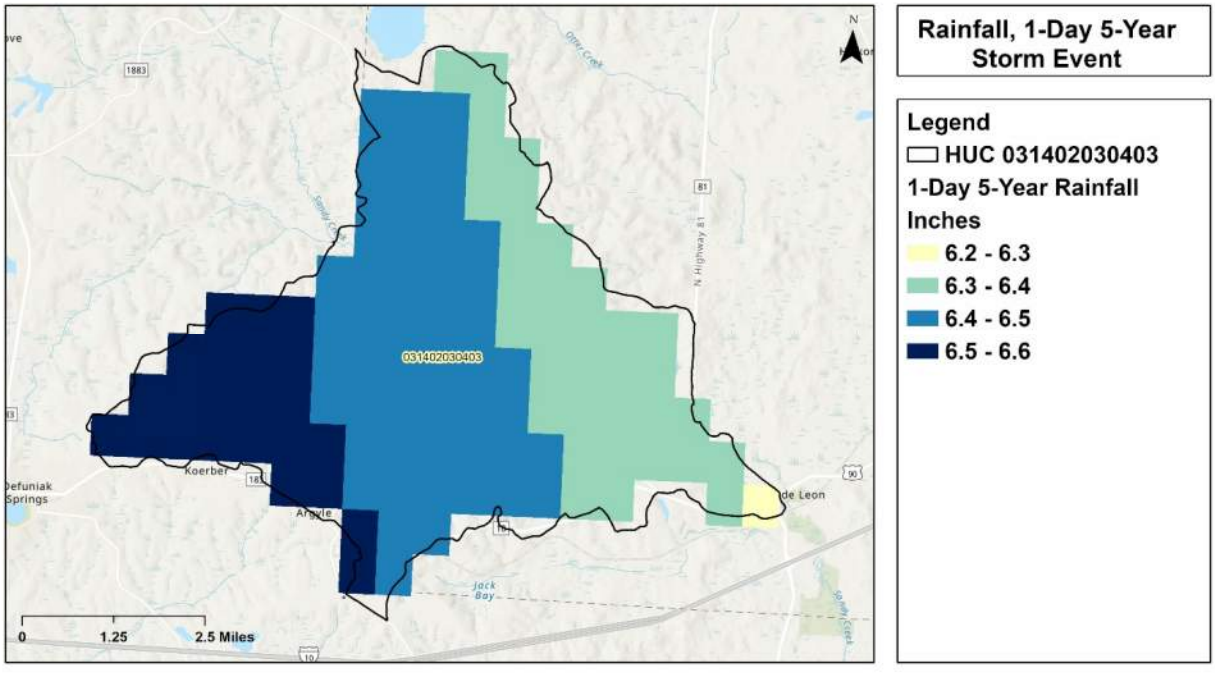

Figure 24. Rainfall distribution map across HUC 031402030403 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

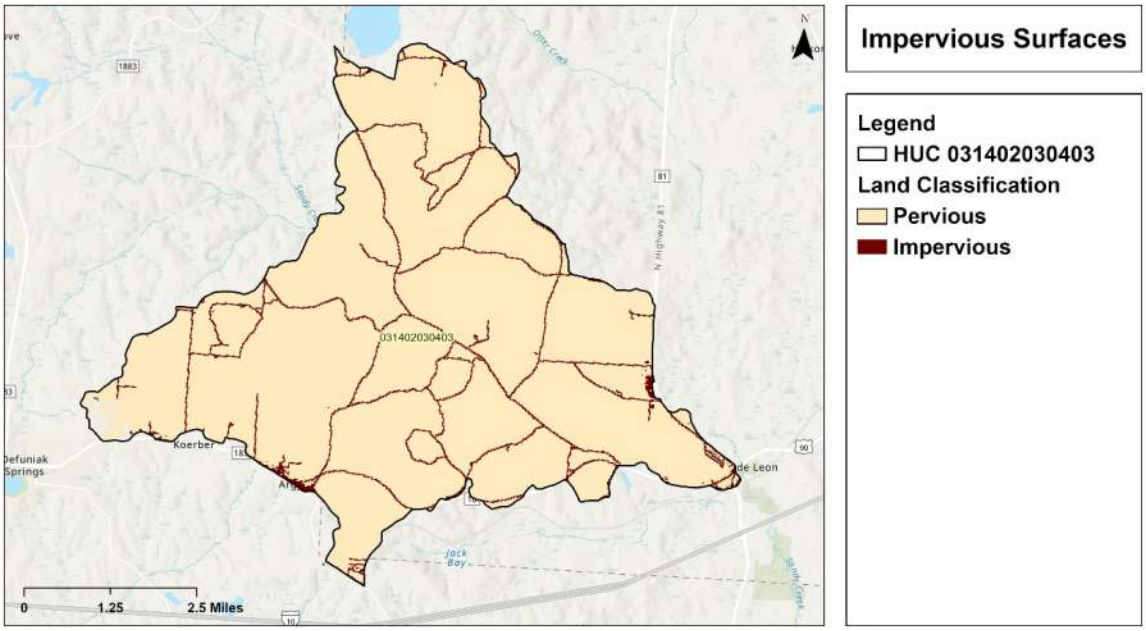

Figure 25. Impervious area map for the HUC 031402030403 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

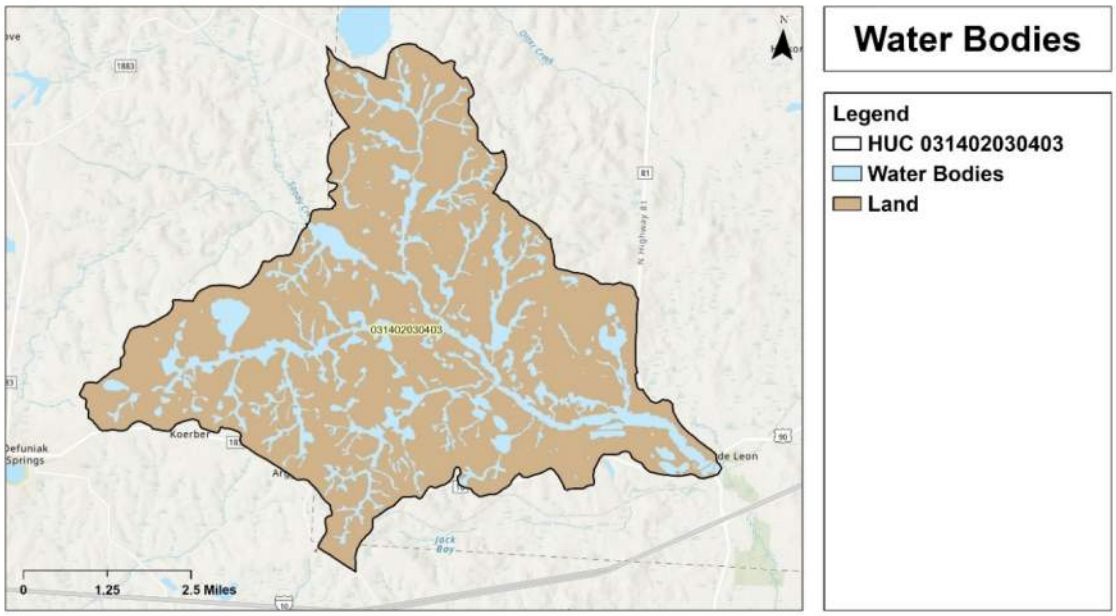

Figure 26. Water bodies map for the HUC 031402030403 sub-watershed, processed by FAU.

1.10. Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

(Source: US Census Bureau 2020, and Zip-codes.com)

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.

- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

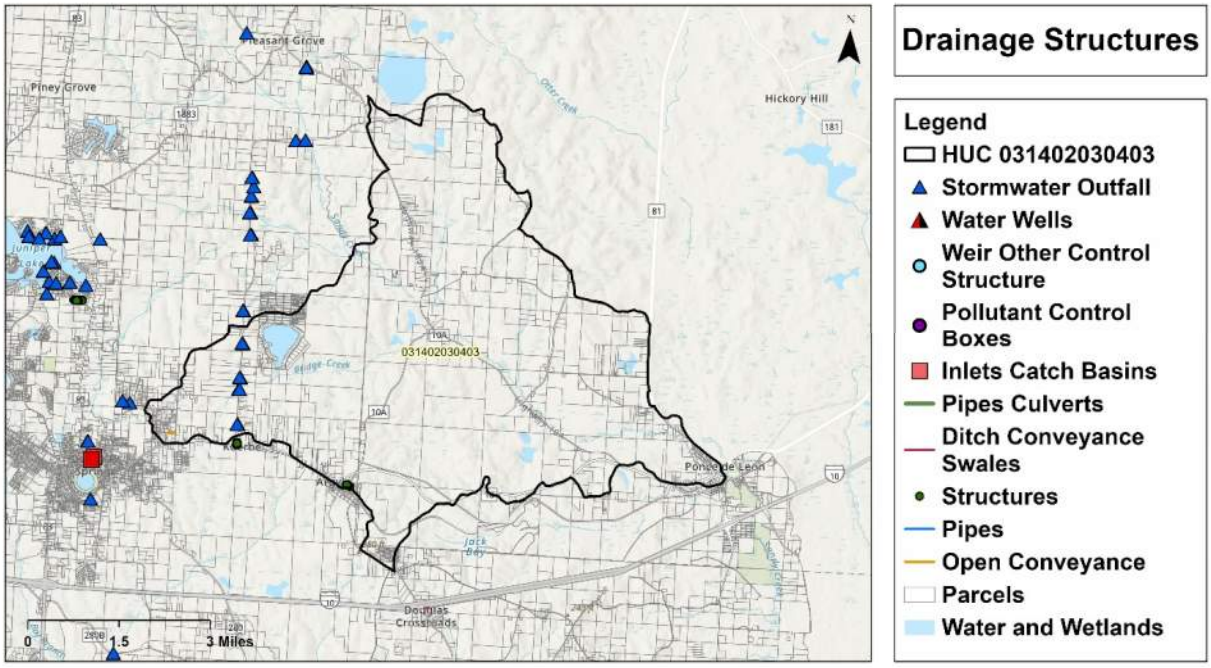

Figure 27. Stormwater Infrastructure for the HUC 031402030403. Processed by FAU.

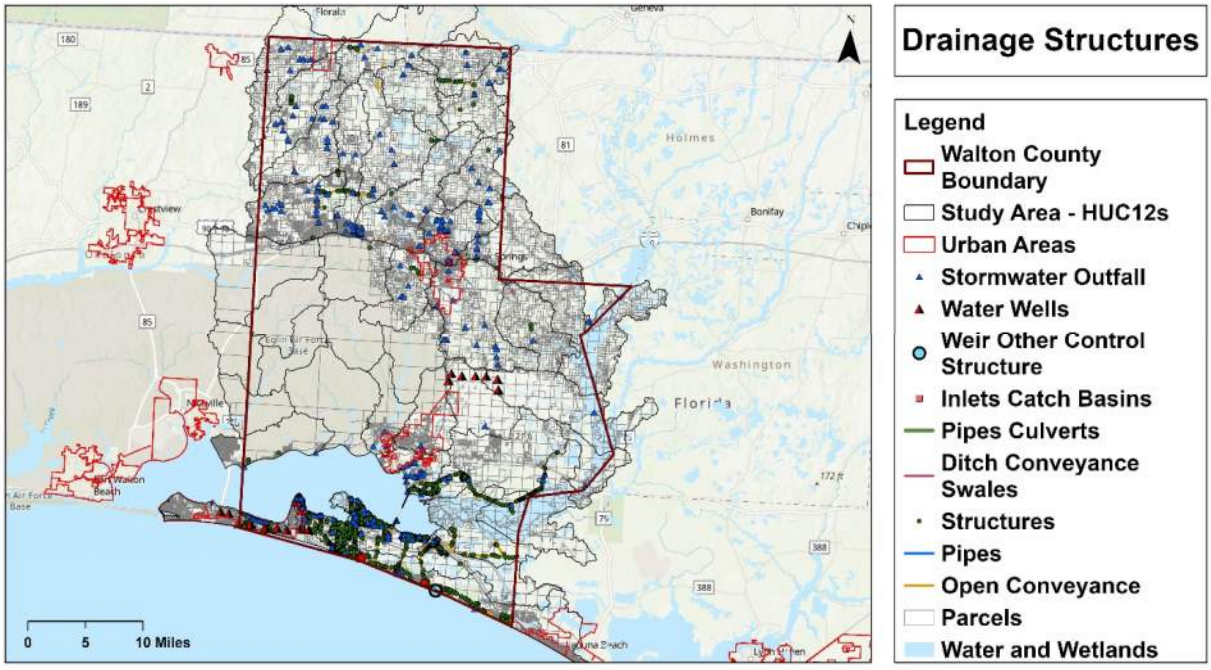

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020)

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1, analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031402030403 sub-watershed flood response to a series of rainfall events (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.3.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD DBHYDRO website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

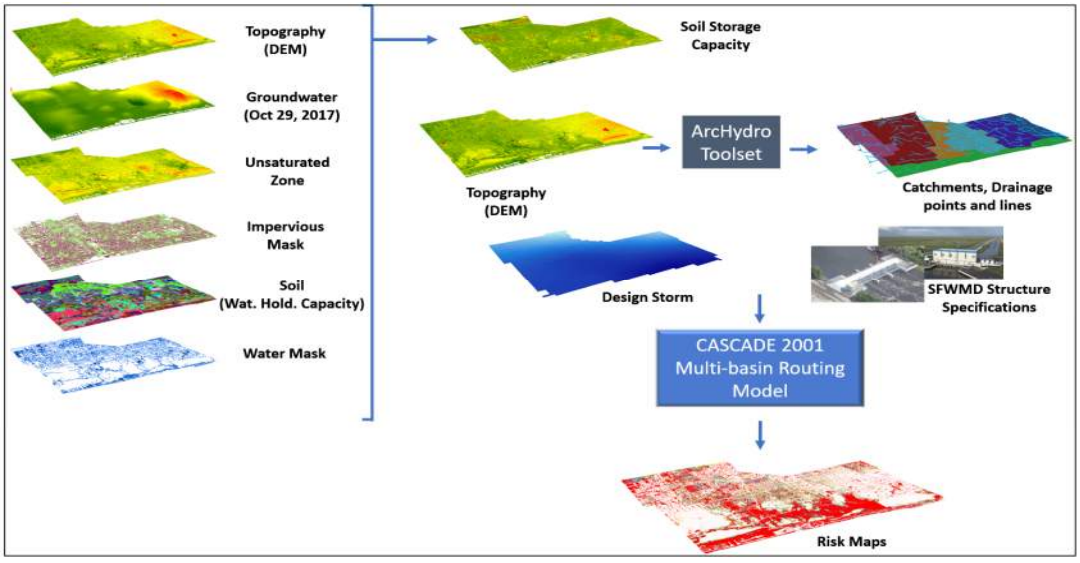

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

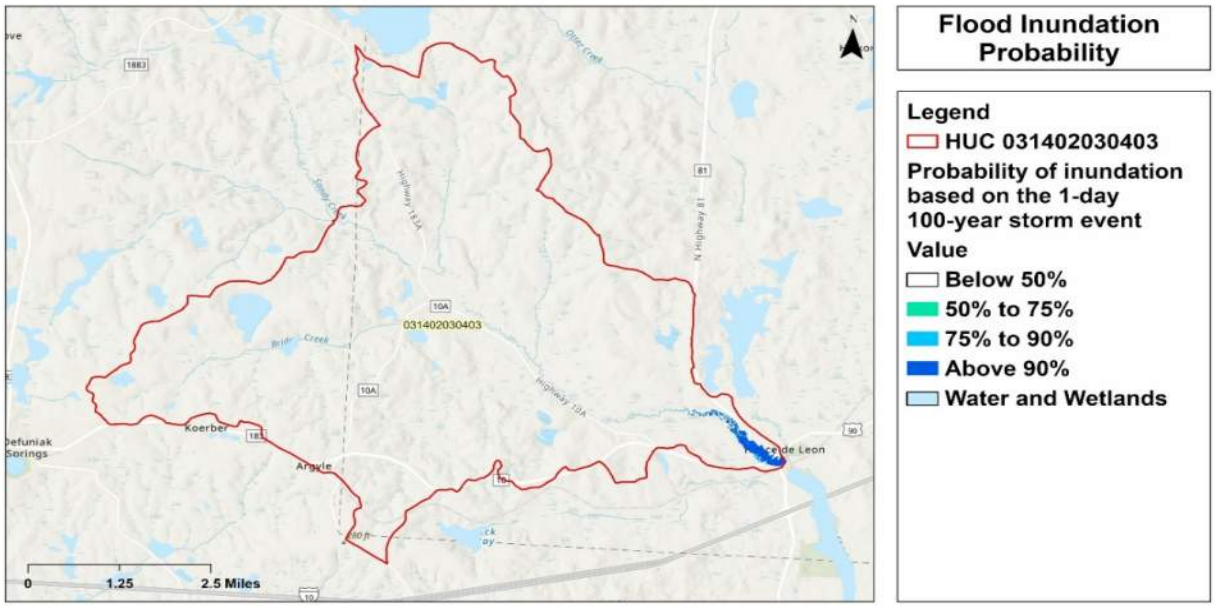

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031402030403, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is

used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 2.4 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99.

There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a small portion of flooding is noted at the creek entrance to the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, the HUC is expected to remain unaffected by sea level rise, therefore SLR scenarios were not computed.

The design storm simulation determined that approximately 0.5% of the HUC total area or 0.15 mi² has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 0.5% of the HUC's total area, or 0.15 mi² would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.4% of the HUC's total area, or 0.13 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0.4% of the HUC's total area, or 0.13 mi², would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031402030403 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	31.65	0.15	99.5%	0.5%
1-day 100-year	31.65	0.15	99.5%	0.5%
1-day 10-year	31.67	0.13	99.6%	0.4%
1-day 5-year	31.67	0.13	99.6%	0.4%

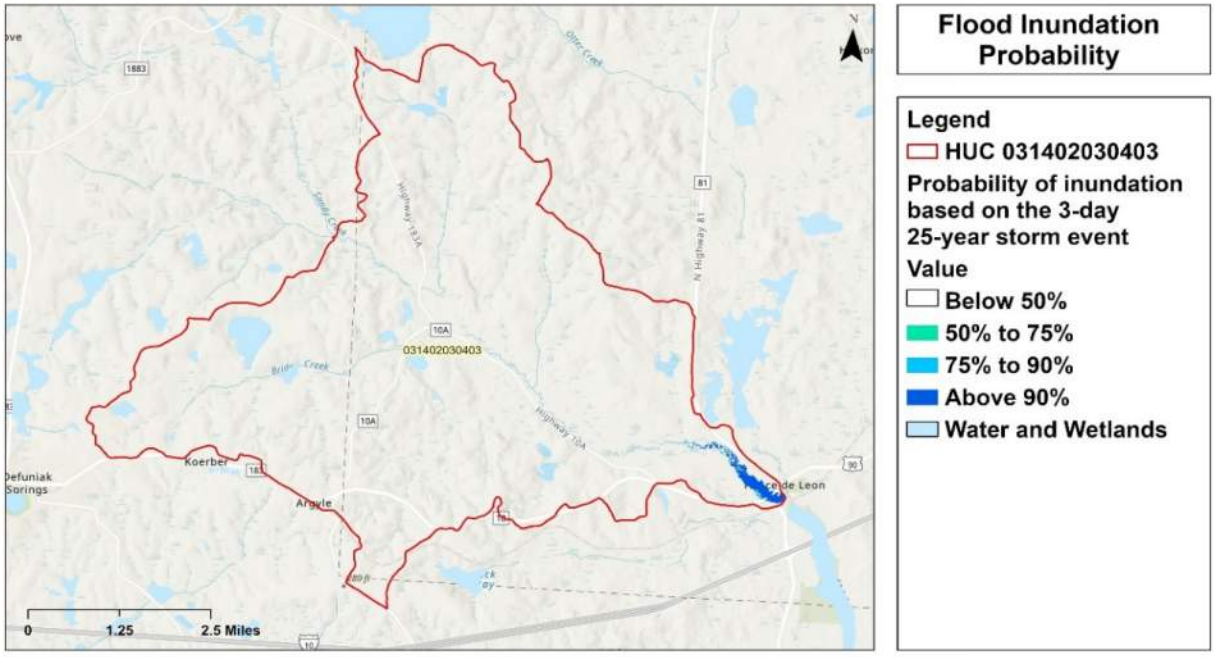

Figure 31. 3-day 25-year storm event for HUC 031402030403 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

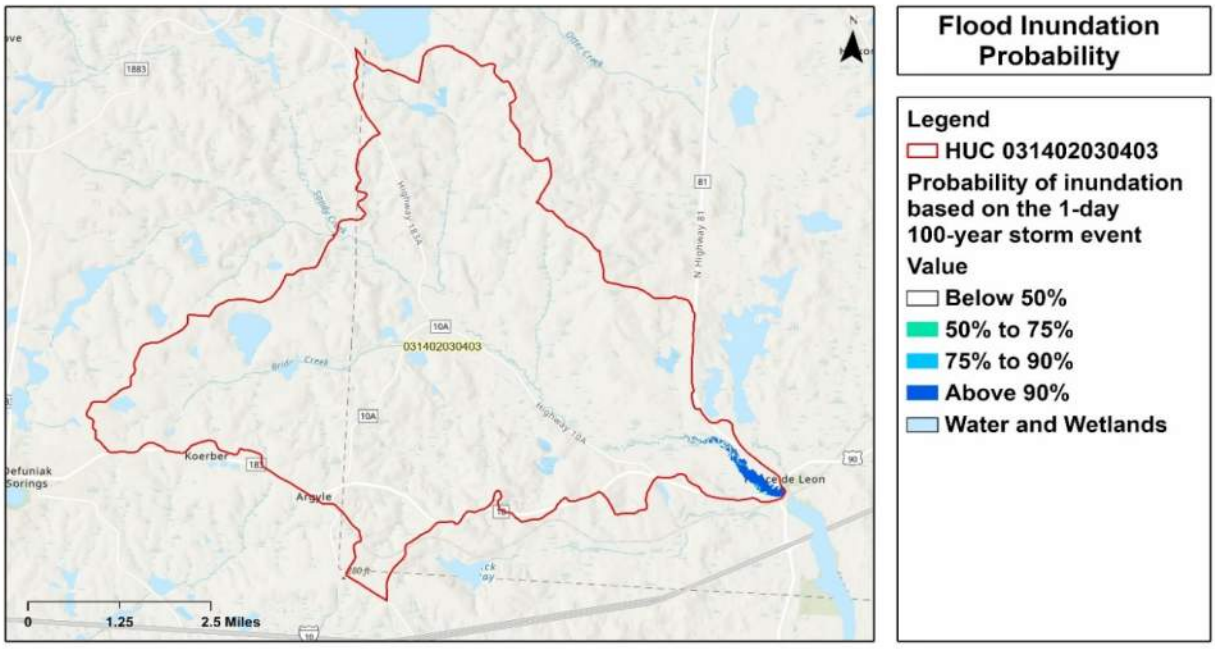

Figure 32. 1-day 100-year storm event for HUC 031402030403 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

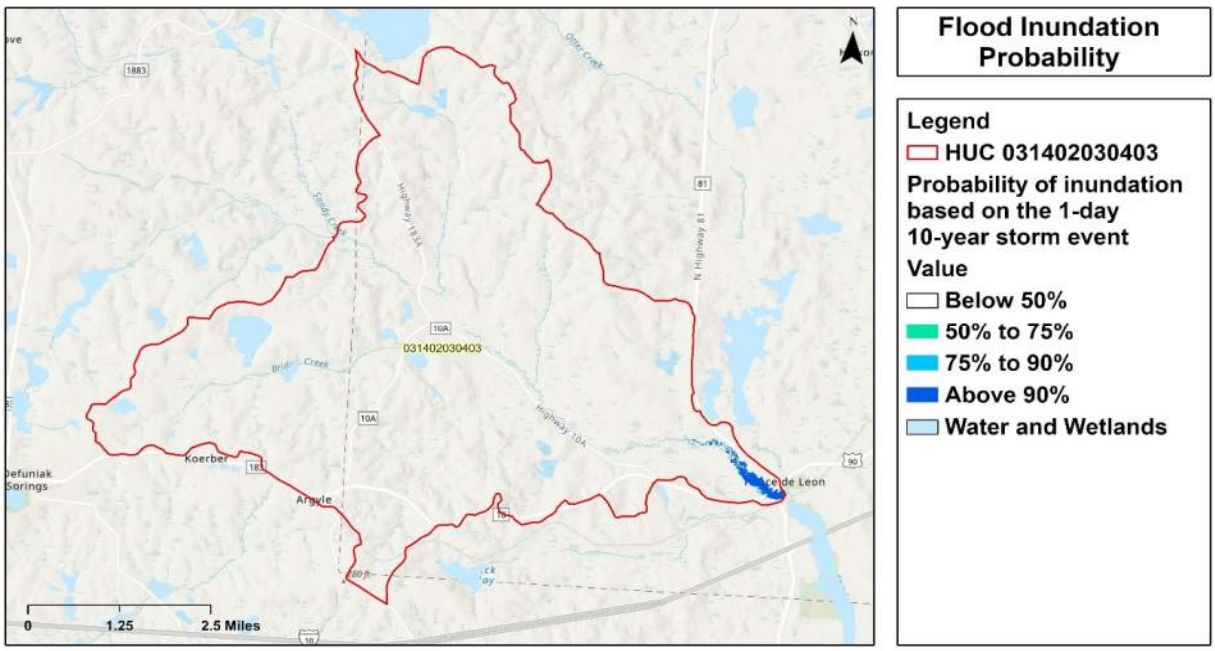

Figure 33. 1-day 10-year storm event for HUC 031402030403 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

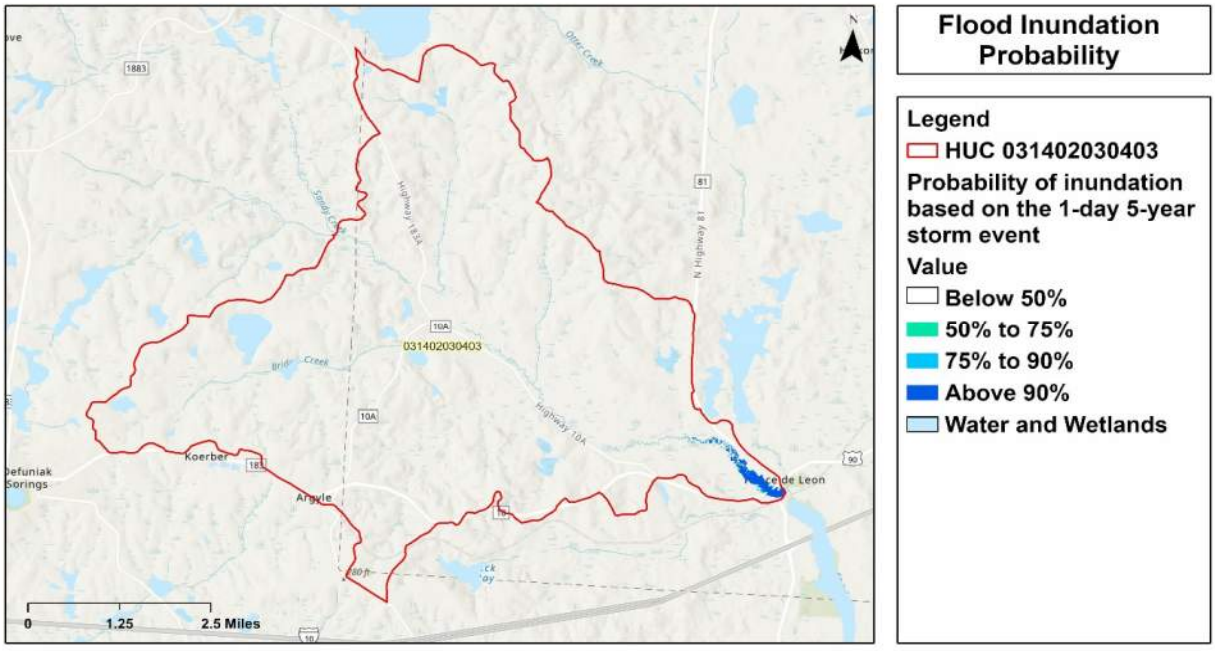

Figure 34. 1-day 5-year storm event for HUC 031402030403 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6

11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3

45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6

82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2
DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6

11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3

45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6

82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031402030403 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.**is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.**illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

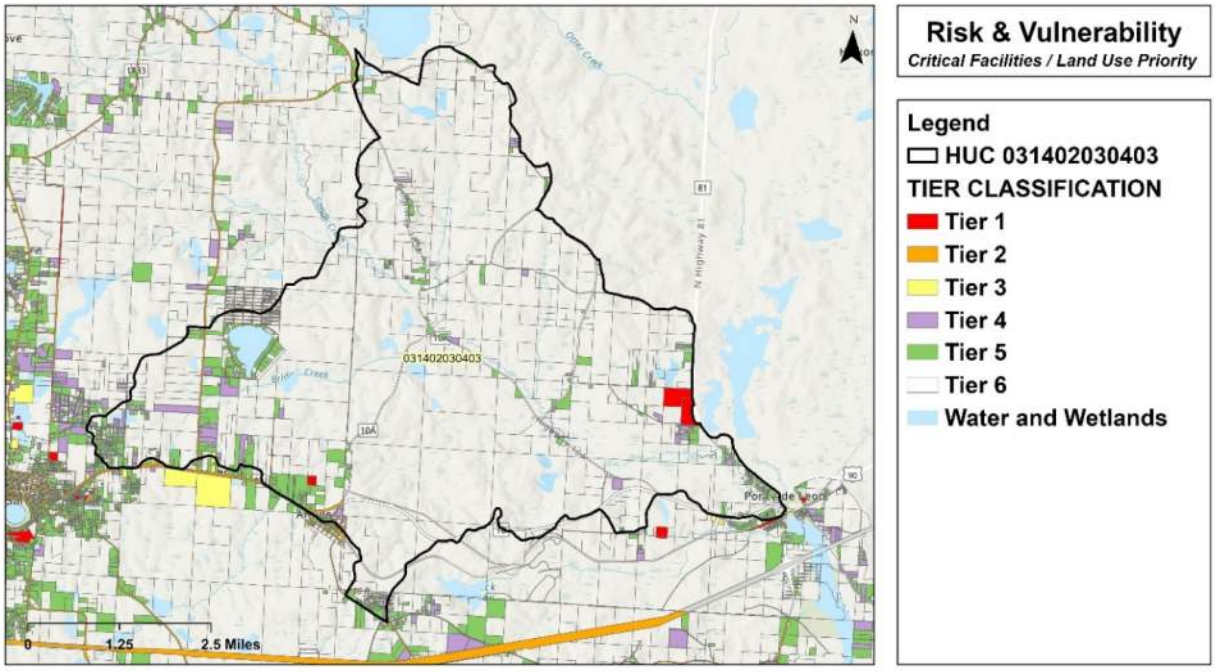

Figure 35. HUC 031402030403 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

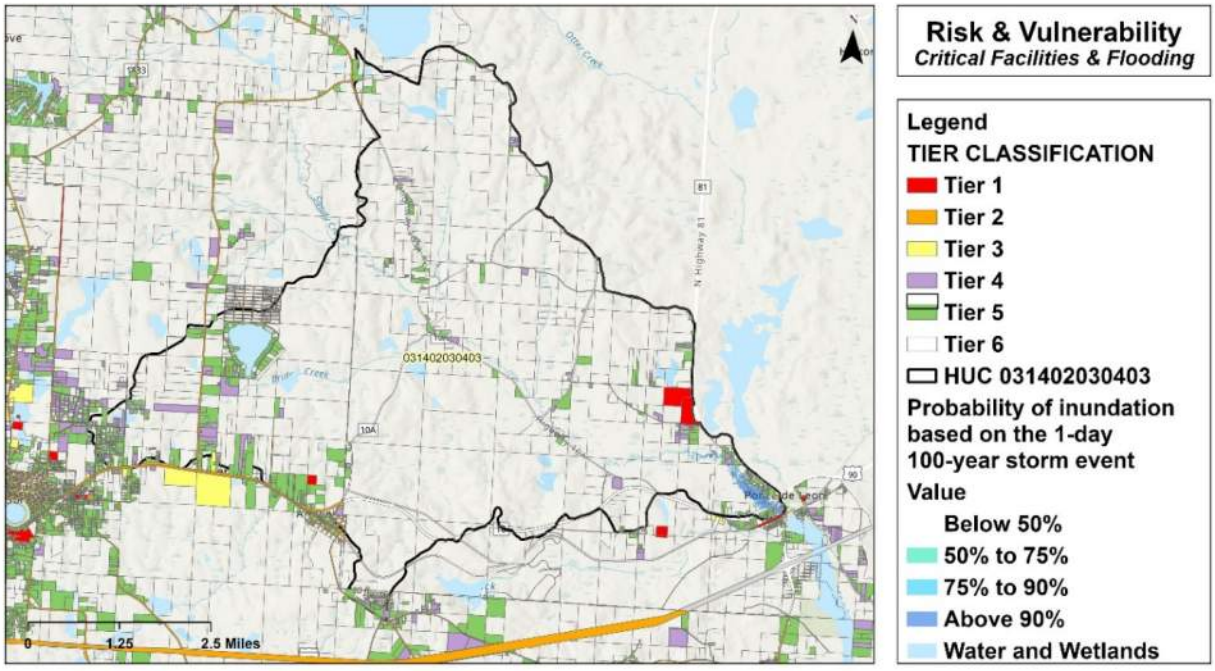

Figure 36. HUC 031402030403 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

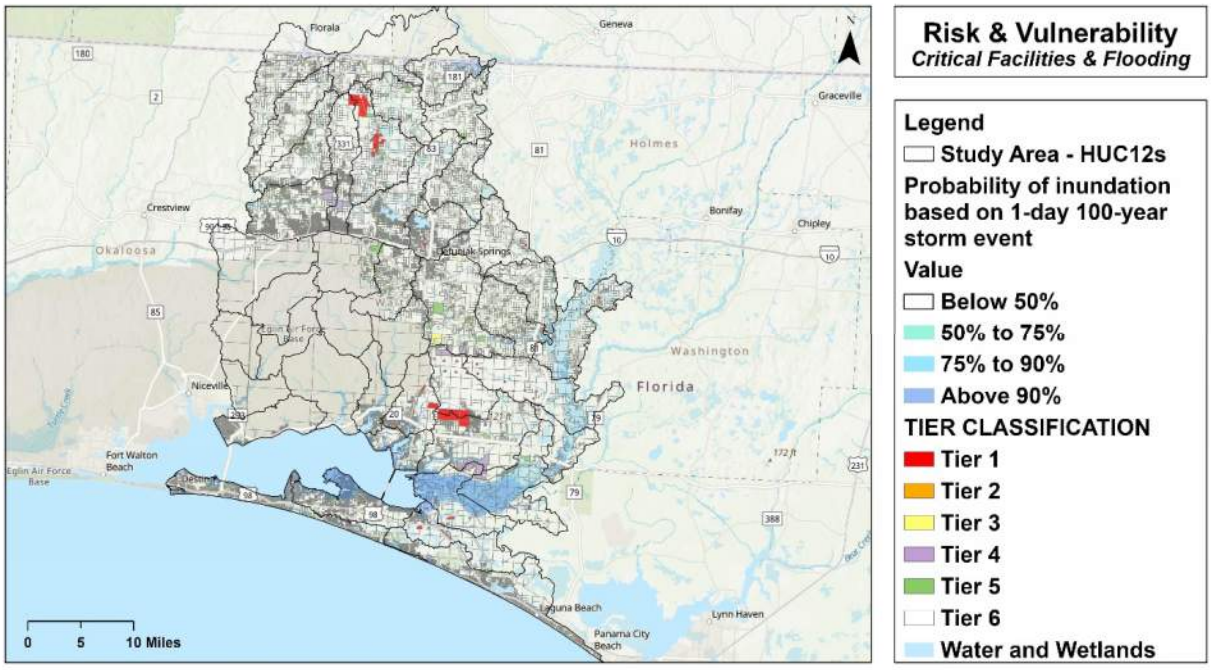

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

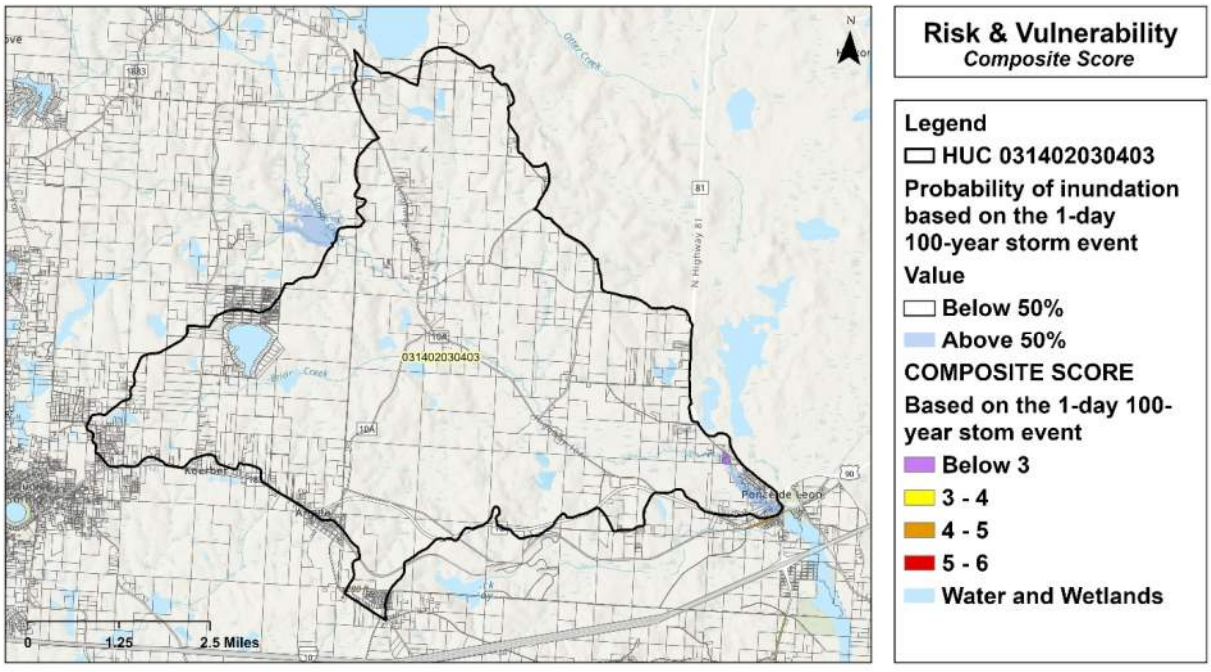

Figure 38. HUC 031402030403 sub-watershed Composite Score Risk map, with calculation based on 1-day 100-year storm event. Processed by FAU.

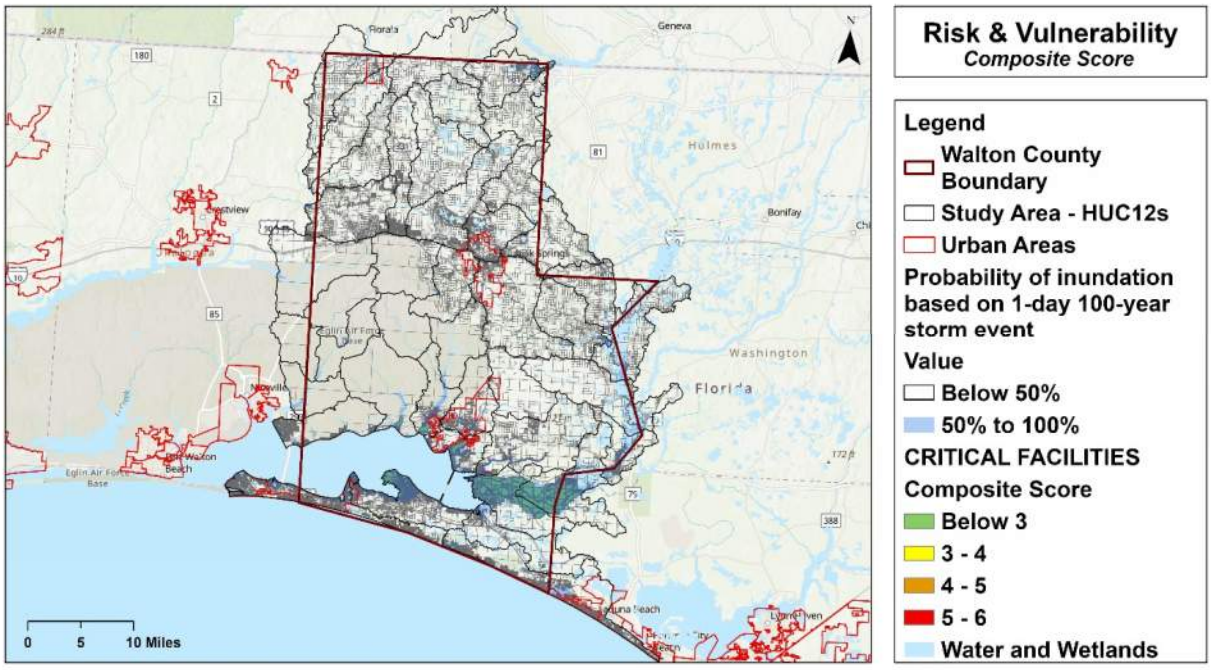

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.
Please note that due to the scale of the map, the composite score layer is not properly visible in this map.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031402030403. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031402030403. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031402030403	20352.88
All of the 1-day 100-year storm event inundation	**97.47**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	97.47
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	97.47

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

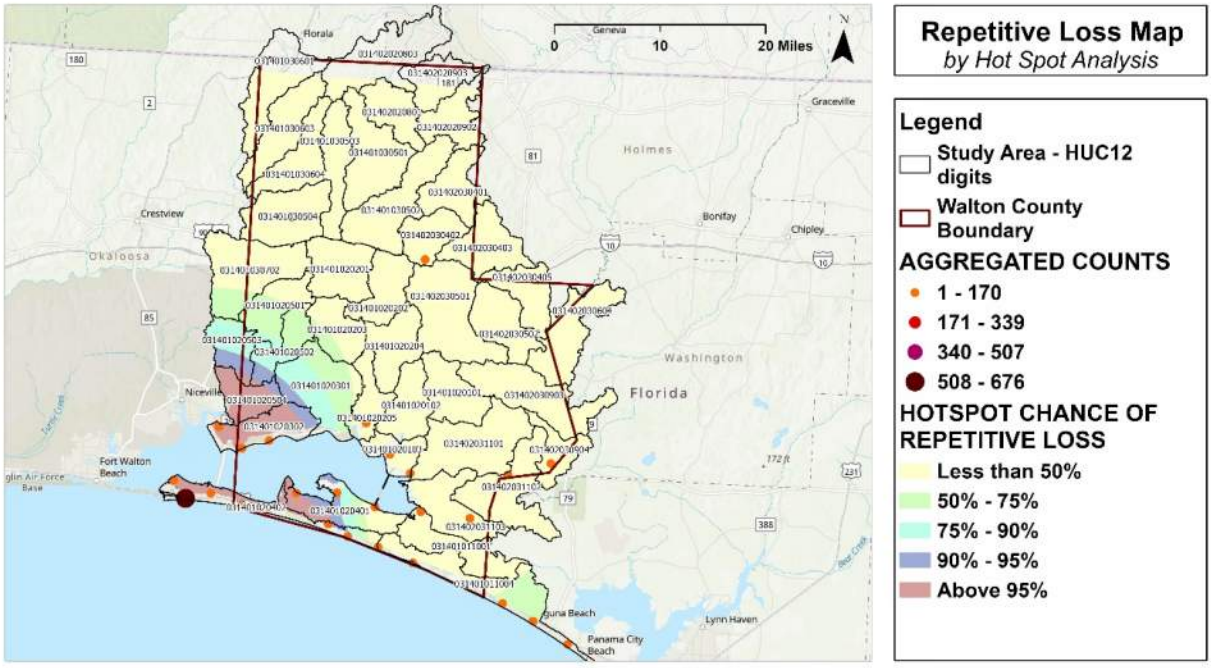

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5 Priority Projects

Although there are a good number of parcels falling within tiers classification 1 to 5 priority of land uses, only a few of them are within the flooding zone, once flooding in the area is relatively minor and not alarming. Consequently, when considering the composite score, it is notable that most of the results are null. There are only five exceptions within the basin: a utility parcel with score 4-5, and four mobile home parcels, all of them with scores below 3.

APPENDIX AI

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031402030405

LOWER SANDY CREEK

Principal Investigator: Frederick Bloetscher, Ph.D., P.E.

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Research Assistant: Leticia Sabio

This resource was funded in part, through a grant agreement from the Florida Division of Emergency Management's (FDEM) Bureau of Mitigation, by a grant provided by through the Hazard Mitigation Grant Program (HMGP) DR-4337-004-P, as approved by FDEM and the Federal Emergency Management Agency (FEMA) to create and update Watershed Master Plans (WMP) throughout the state of Florida. The views, statements, findings, conclusions, and recommendations expressed herein are those of the authors and do not necessarily reflect the views of the State of Florida, FEMA, or any of their sub-agencies.

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 (031402030405) is highlighted among all the HUCs to help identifying its location. (Figure 3).

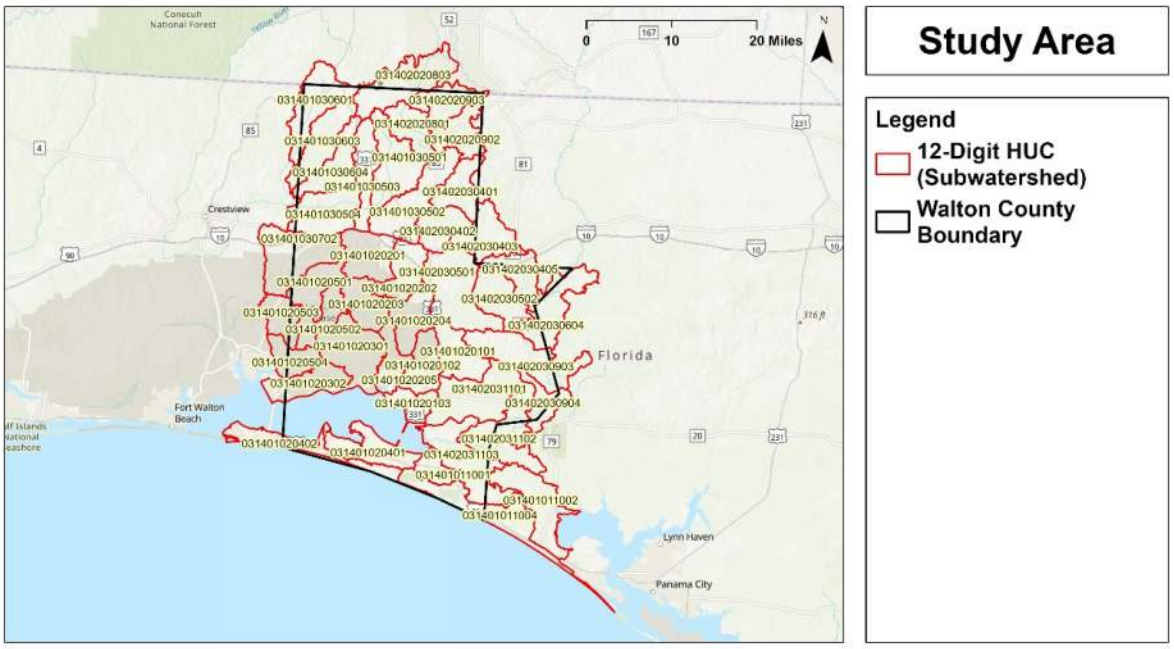

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

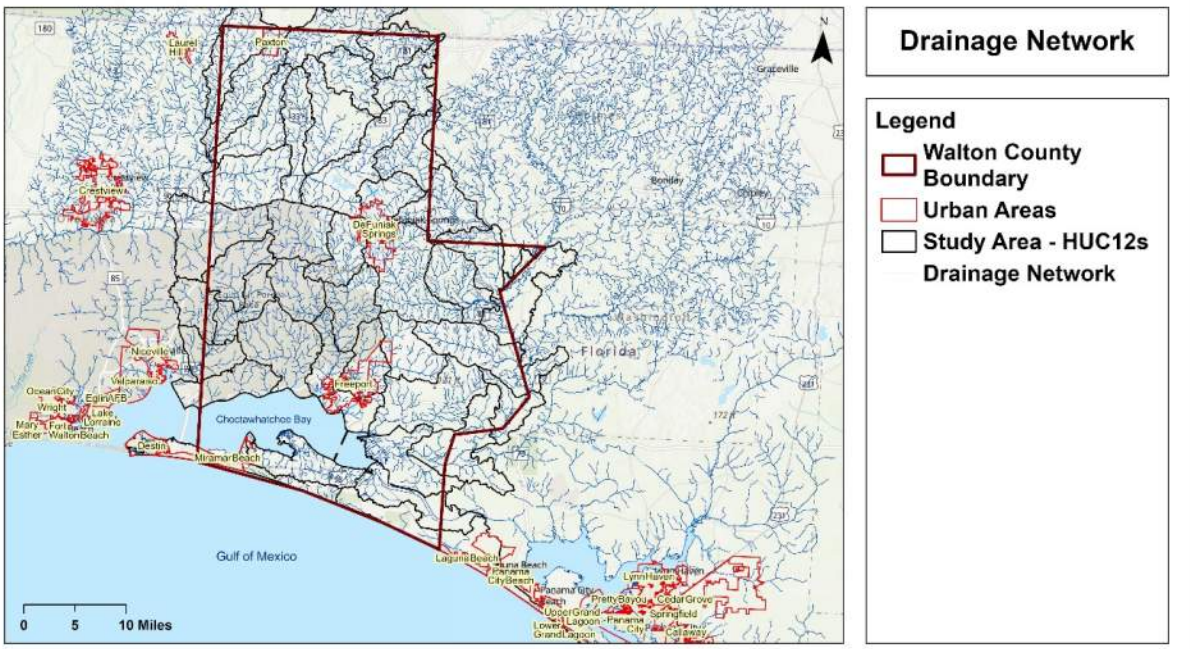

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

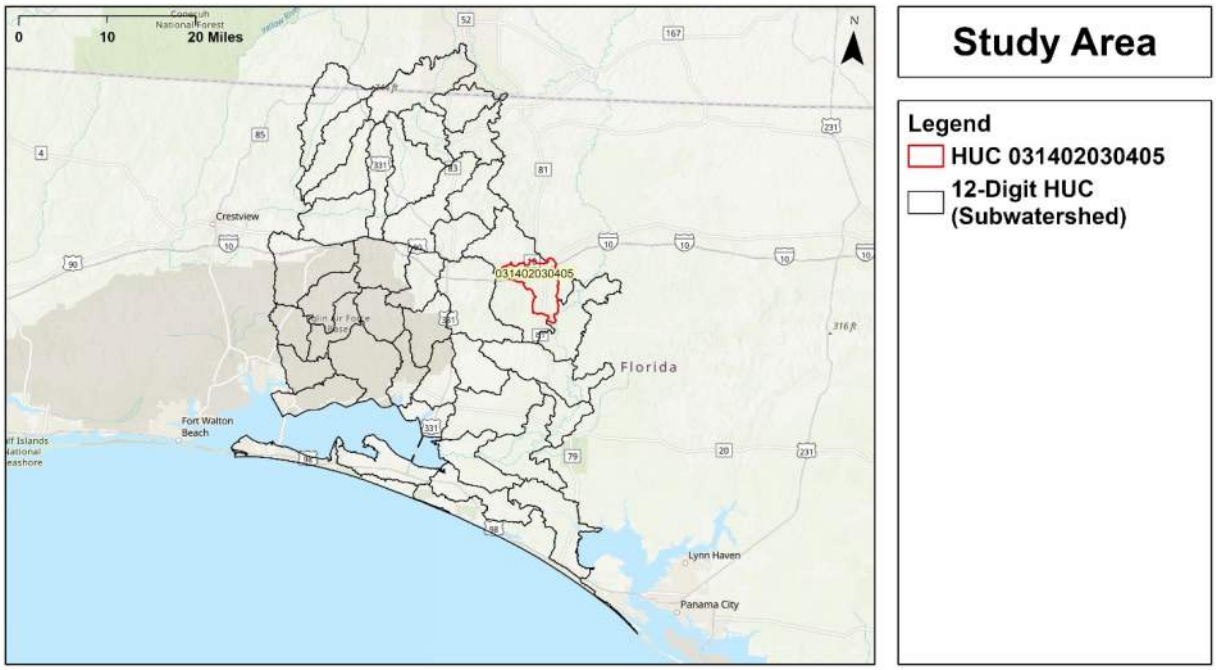

Figure 3. HUC 031402030405 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

(Source Data: FEMA)

Figures 12 and 13 is the county-wide report show the current and projected land use for the County. Based on the 2017 future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**..

Table 2. Land Use in Walton County (Prepared by FAU from future land use map) versus land use in the entire watershed

Level 1 Land Use-Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

(Source Data: (NWFWMD 2017)

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 1.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

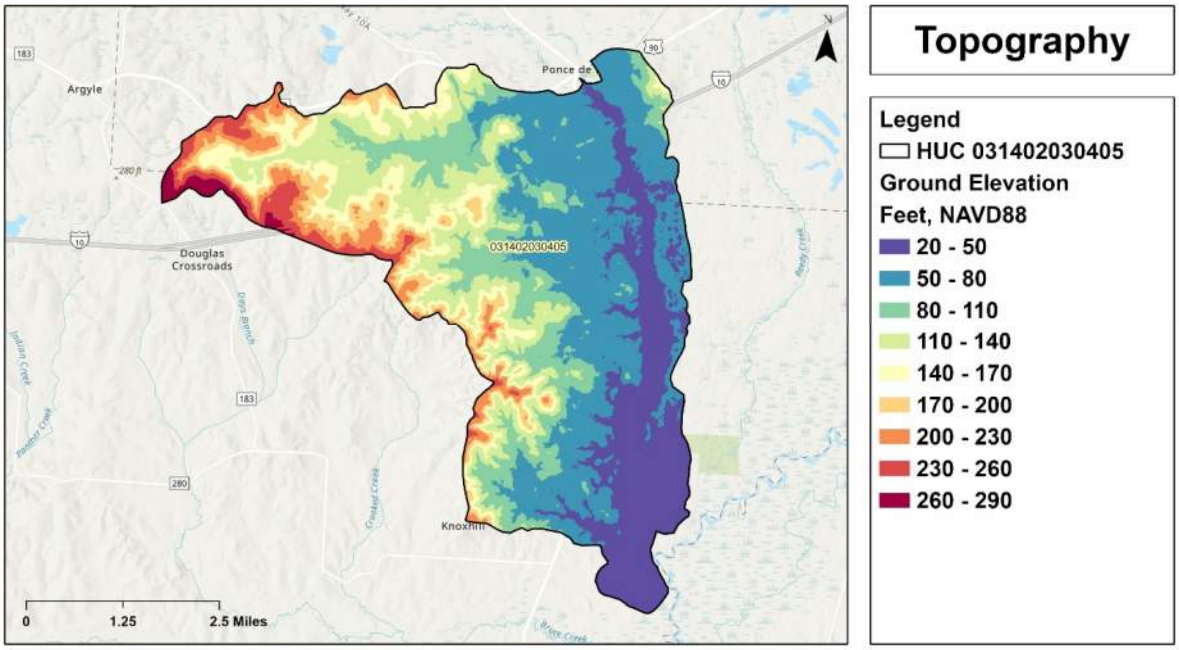

Figure 4. Topographic map of the HUC 031402030405 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031402030405 sub-watershed is shown in **Error! Reference source not found.**.

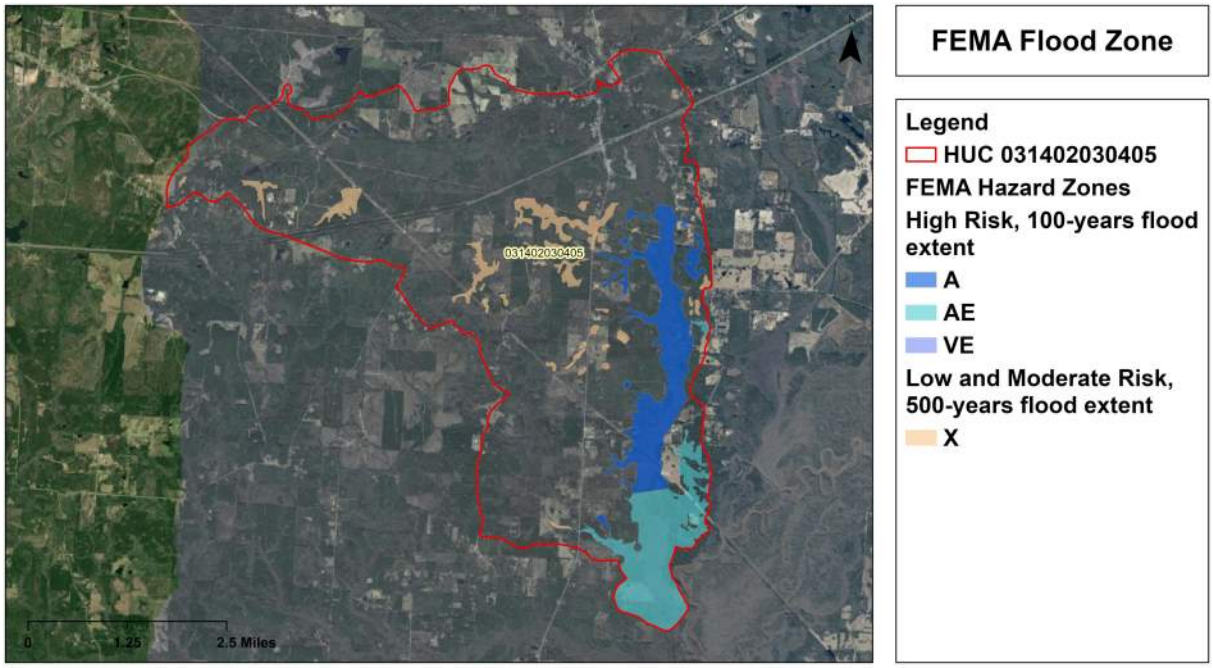

Figure 5. FEMA Flood Zone map (2020) for HUC 031402030405 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031402030405 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including

various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

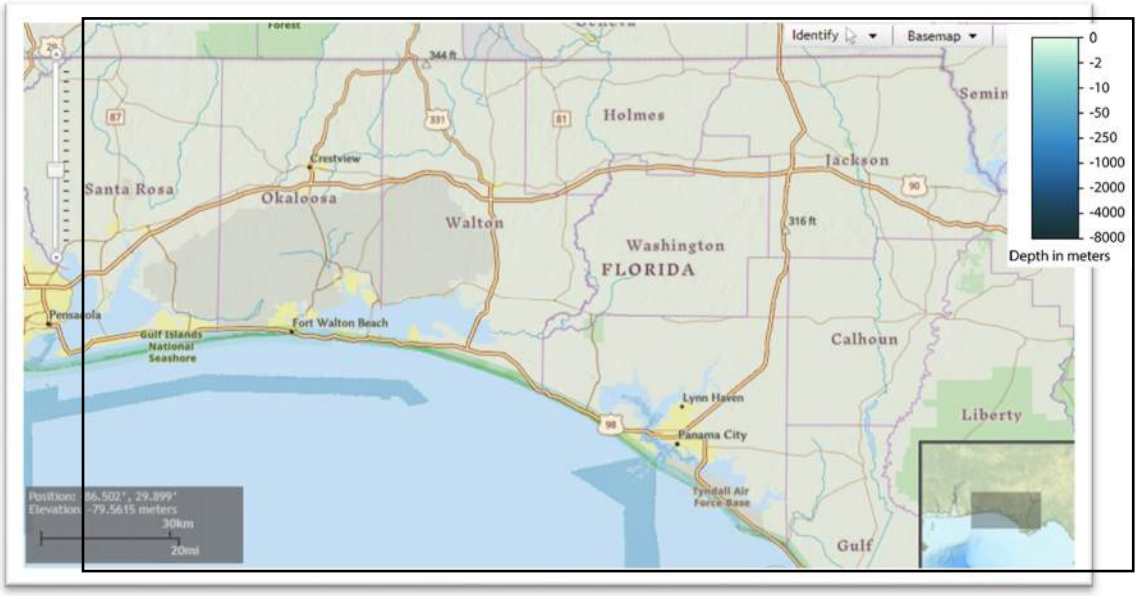

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle. Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

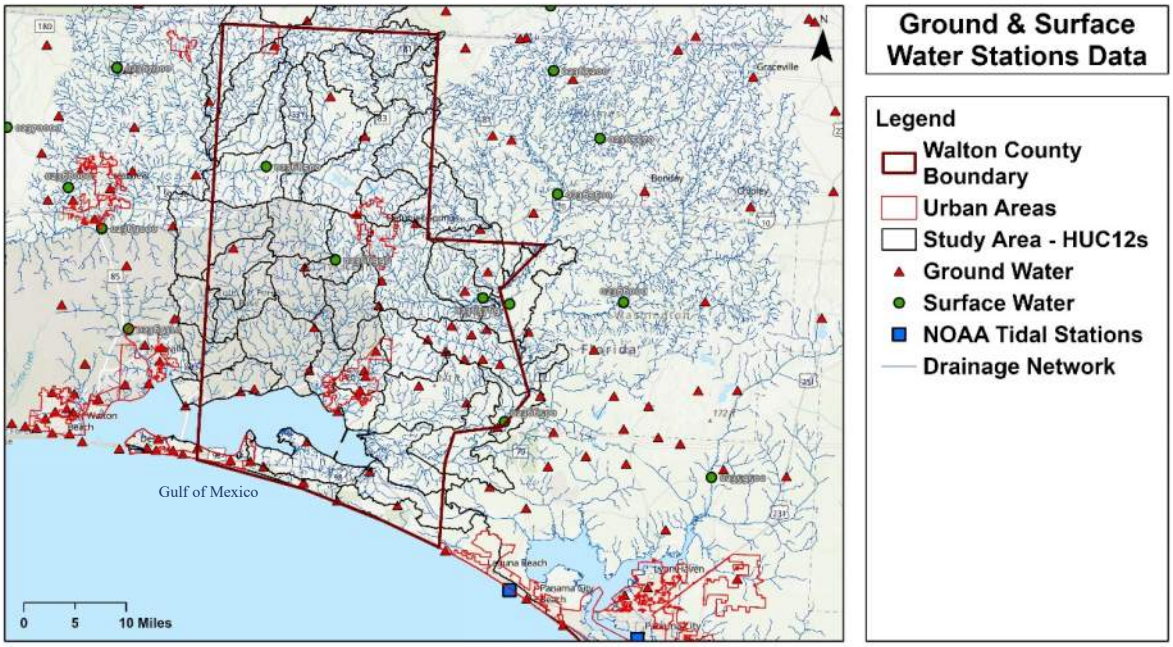

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031402030405 has no major rivers and canals, but creeks and branches which include:

- Sandy Creek
- Camp Branch

- White Creek
- Hughes Ditch
- Oak Grove Branch
- Mill Creek

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02365769. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031402030405, which is USGS 02365769 Bruce Creek at SH 81 NR Redbay, FL.

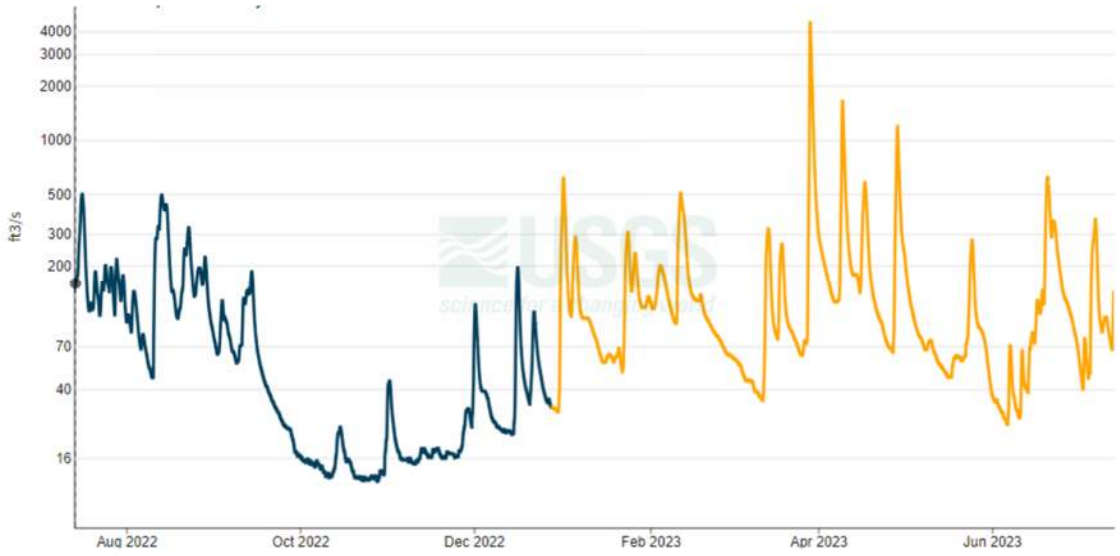

Figure 8. Average streamflow for Bruce Creek at SH 81 NR Redbay, FL (USGS 02365769 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (hhttps://waterdata.usgs.gov/monitoring-location/02365769/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure

detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031402030405 and points out the location of the ground water station in the surroundings. A groundwater-surface layer for the HUC 031402030405 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

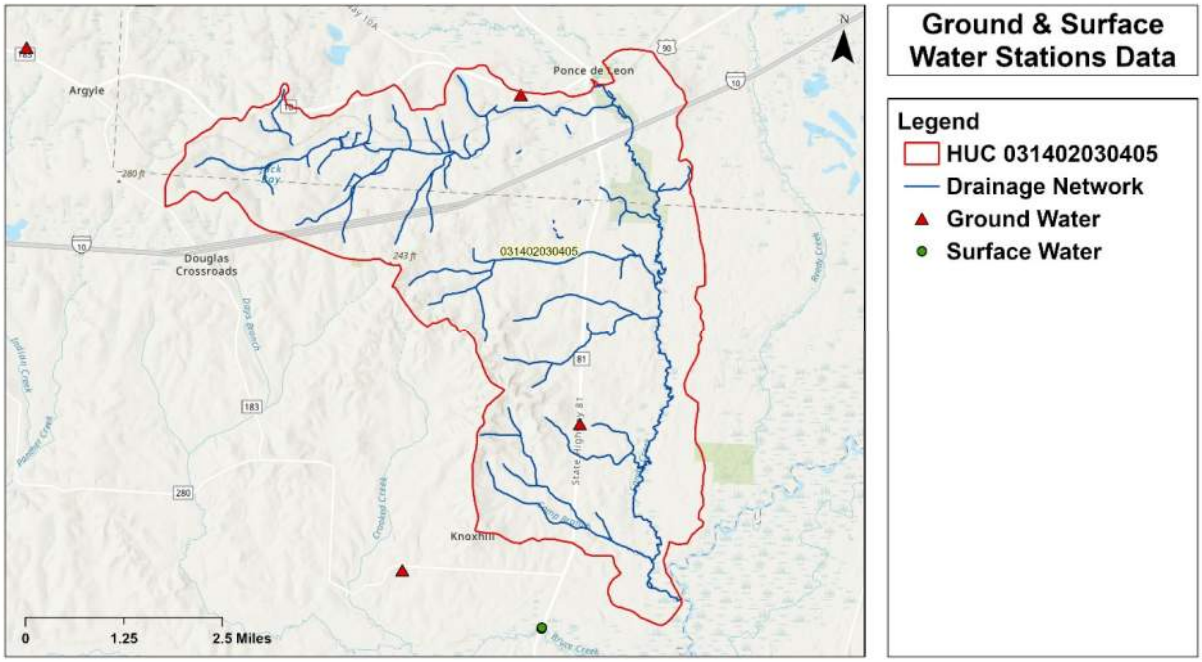

Figure 9. Ground and Surface Water Stations in the HUC 031402030405 sub-watershed, processed by FAU.

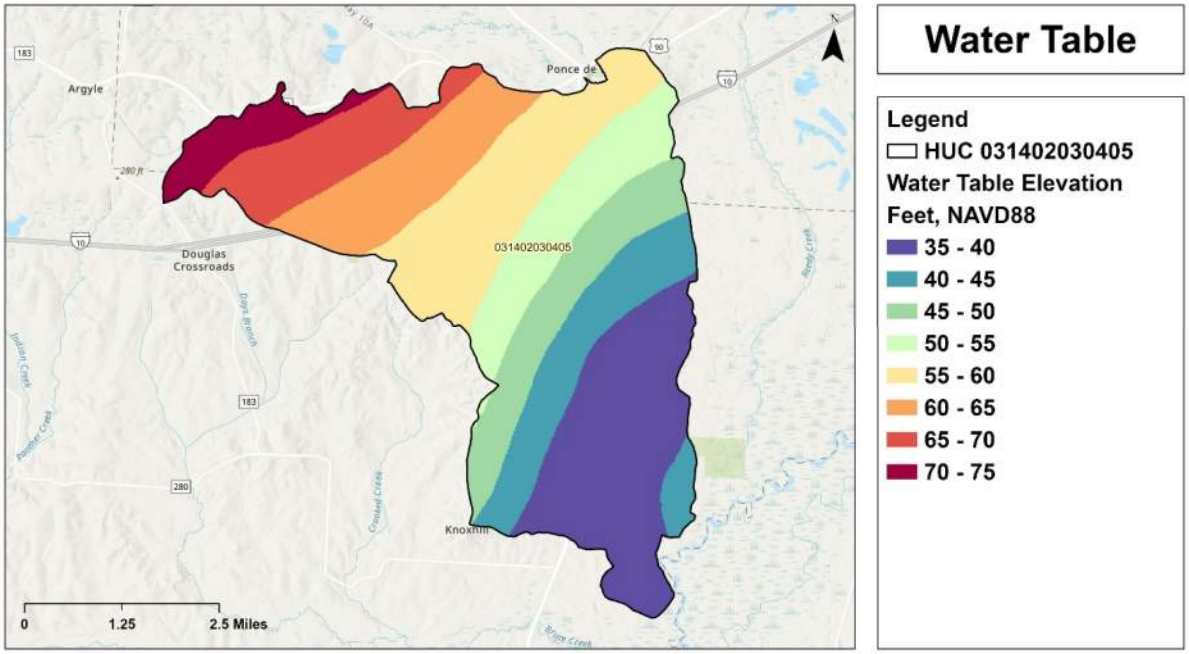

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031402030405 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the average precipitation over Walton County for every month of the year between 2011 and 2023.

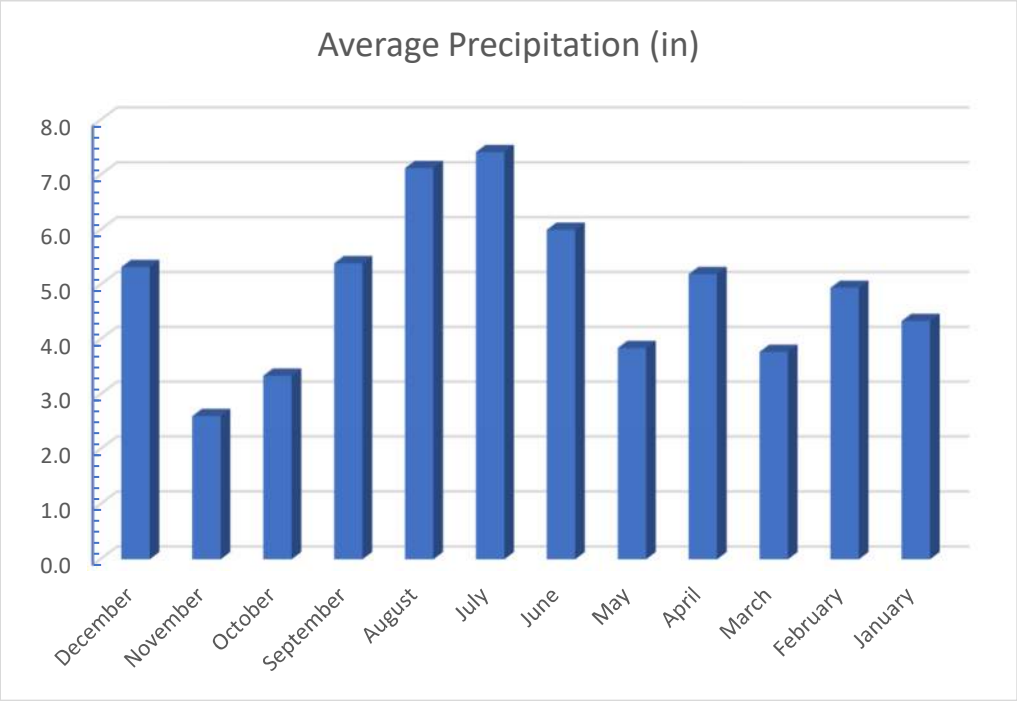

Figure 11. Monthly precipitation in Walton County, FL (2011-2023).
(Data Source: Florida Weather Data, available at https://data.usatoday.com/weather-data/walton-county/12131/1975-04-01/Table/)

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows

the two closest tide stations to Walton County. Since there are no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

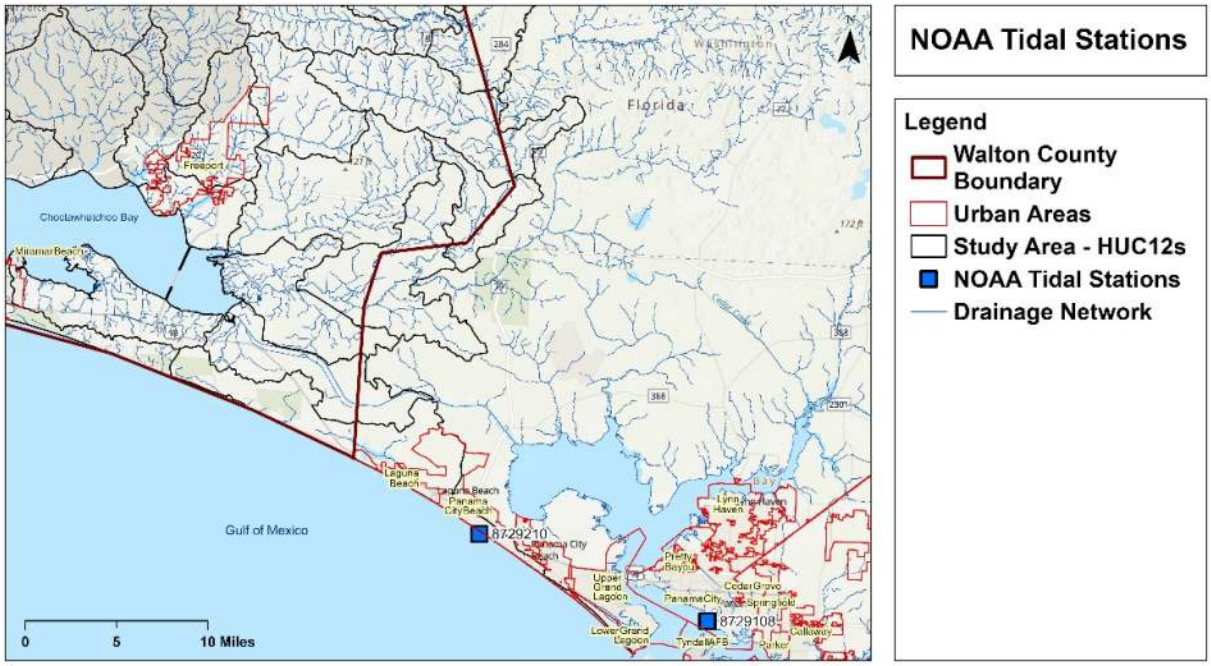

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

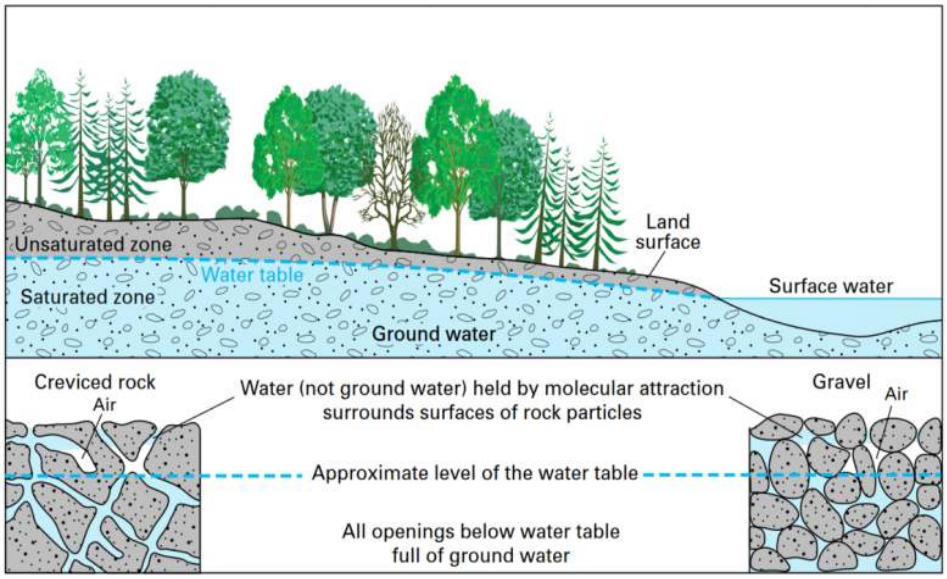

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

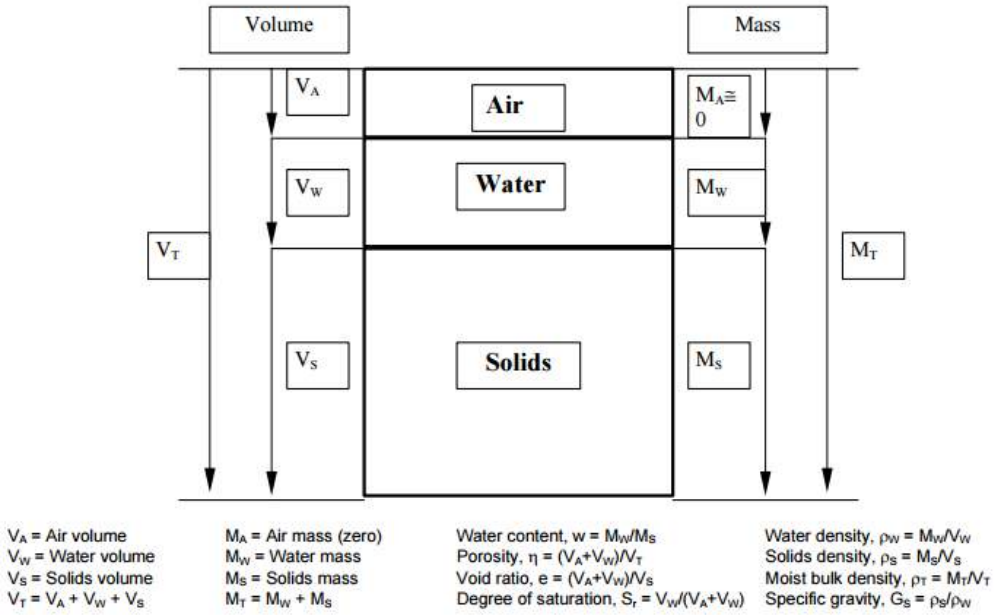

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

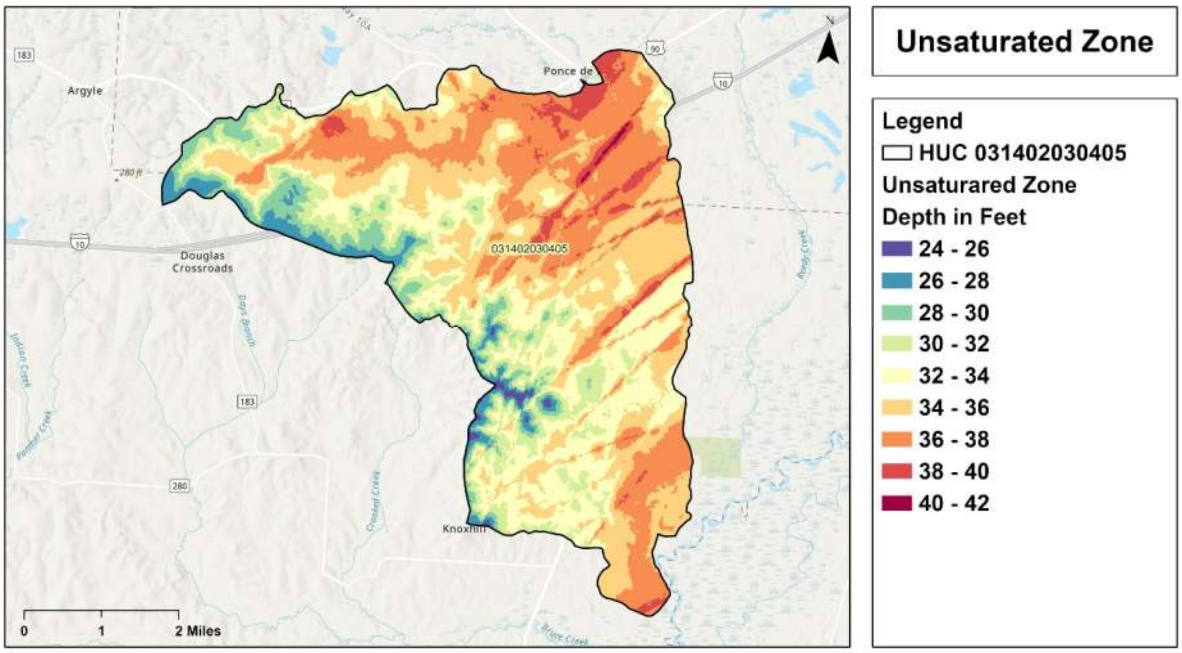

Figure 15. Unsaturated zone map for HUC 031402030405, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately favorable soil storage capacity, falling within the range of 30 to 40 feet of remaining capacity.

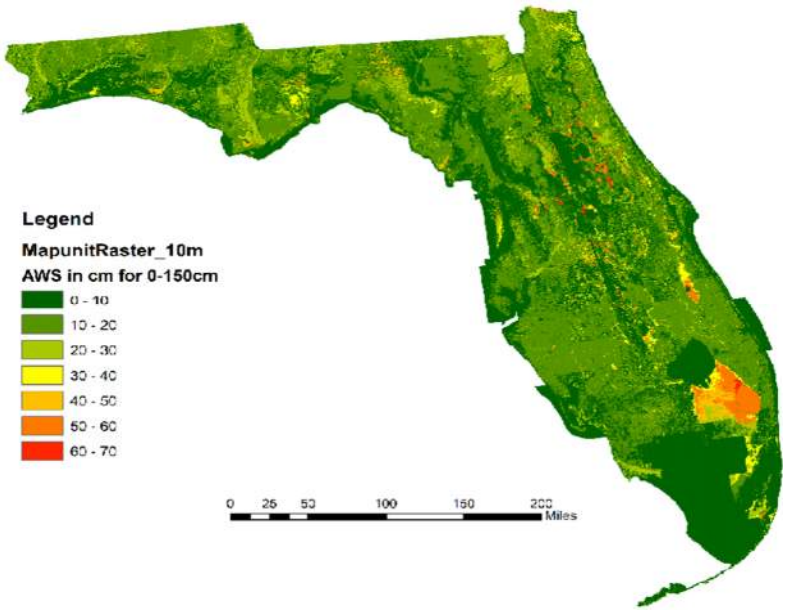

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

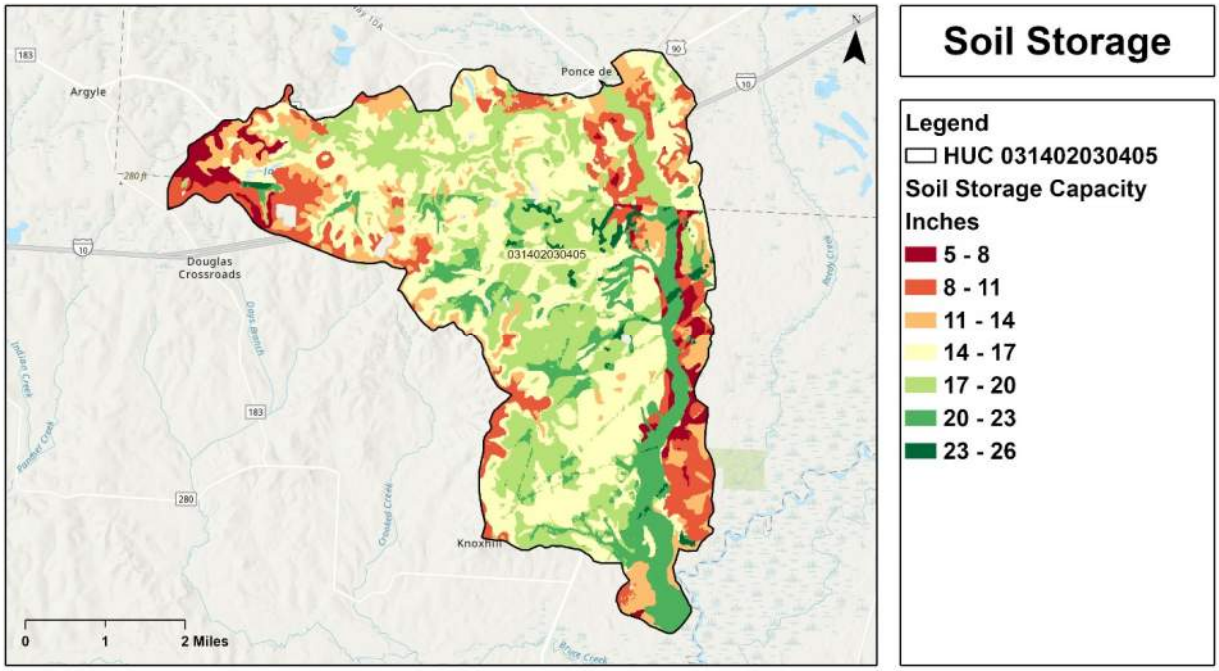

Figure 17. Water storage capacity of soil for the HUC 031402030405, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

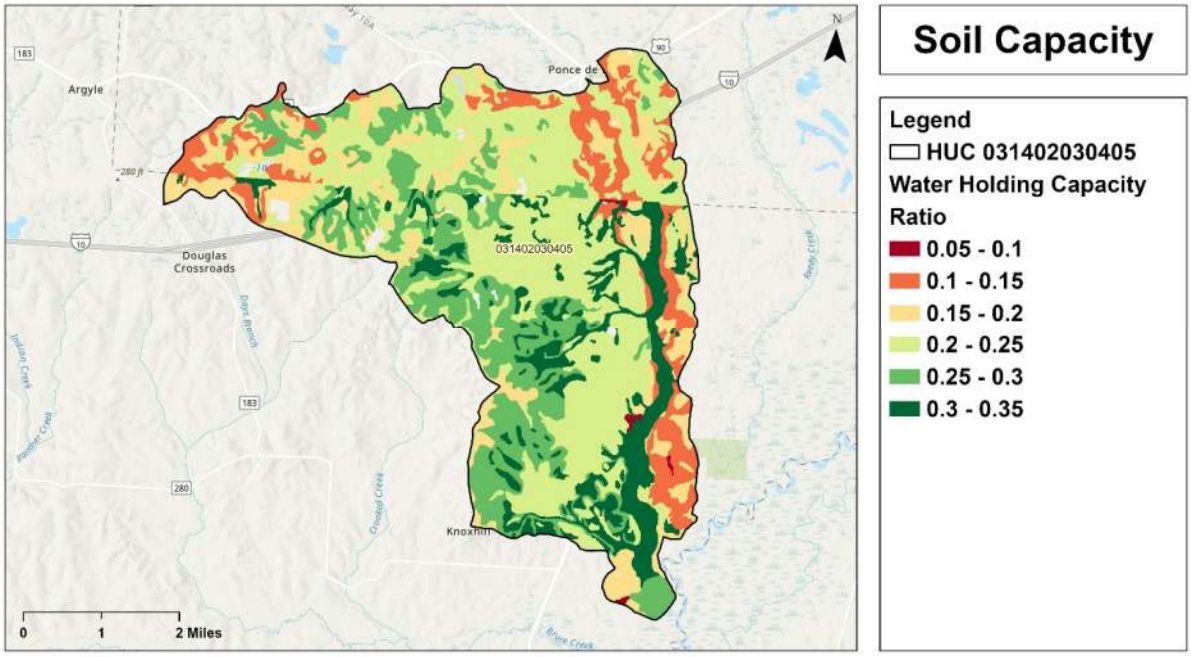

Figure 18. Water Holding Capacity (ratio) for the HUC 031402030405, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

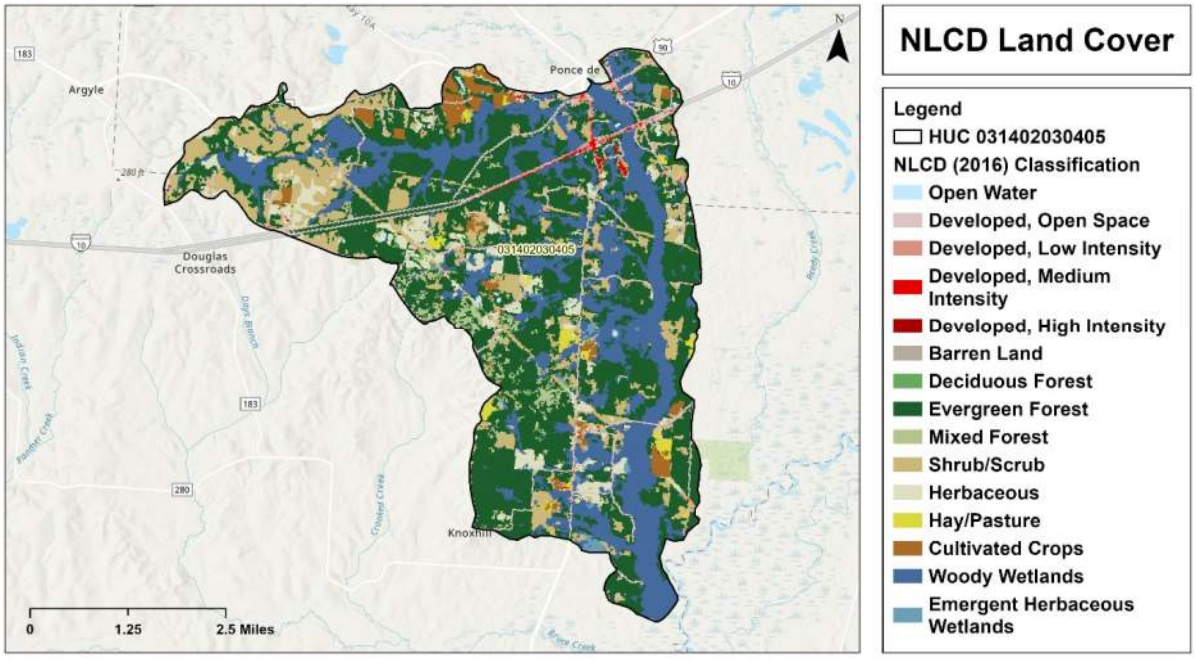

Figure 19. Land use in the HUC (from the 2023 Florida Geographic Data Library (FGDL) database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

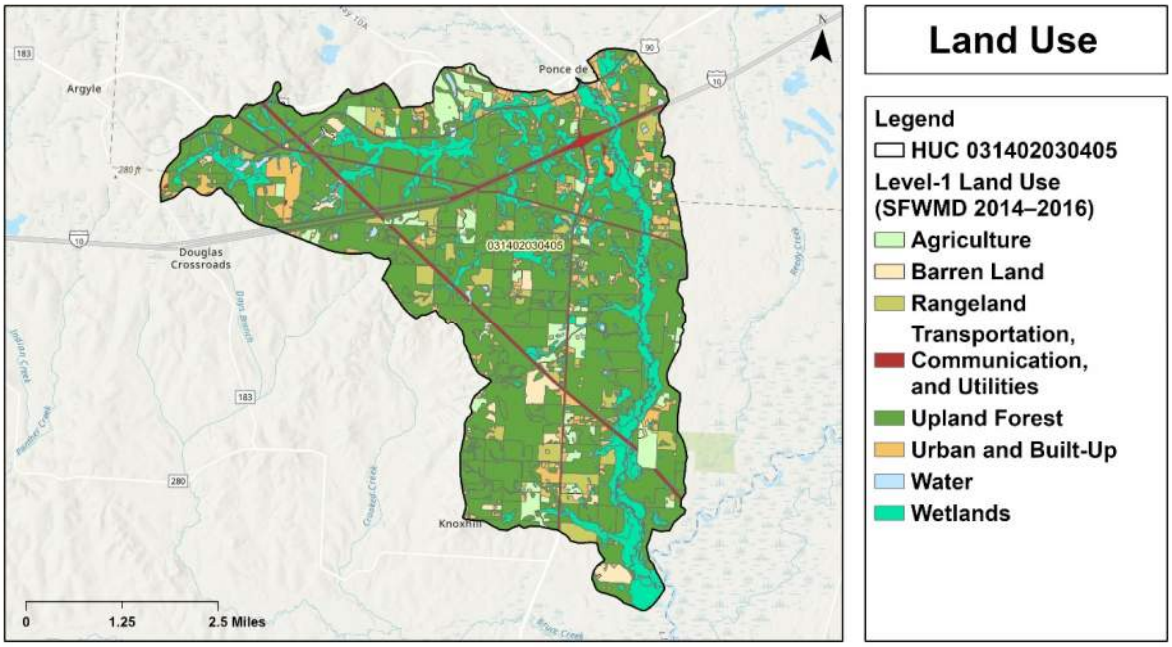

Figure 20. Land use in the HUC 031402030405 (from the 2023 Florida Geographic Data Library (FGDL) database)), processed by FAU.

In the HUC 031402030405 sub-watershed, the predominant land cover is upland forest, accounting for 51.06% of the area. Wetlands comes in second at 12.47%, followed by Transportation, Communication, and Utilities at 12.02%, and water at 11.42%. Developed land constitutes a minor portion, with only 3.87% categorized as urban and built-up, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031402030405 subwatershed.

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	1056.38	3.98%
Barren Land	326.07	1.23%
Rangeland	1054.53	3.97%
Transportation, Communication, and Utilities	3193.51	12.02%
Upland Forest	13567.97	51.06%
Urban and Built-Up	1029.02	3.87%
Water	3034.34	11.42%
Wetlands	3313.24	12.47%
Grand Total:	**26575.06**	**100.00%**

(Source Data: 2023 Florida Geographic Data Library (FGDL) database))

Table 4. Roughness and CN Values for Each Land Use Code

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

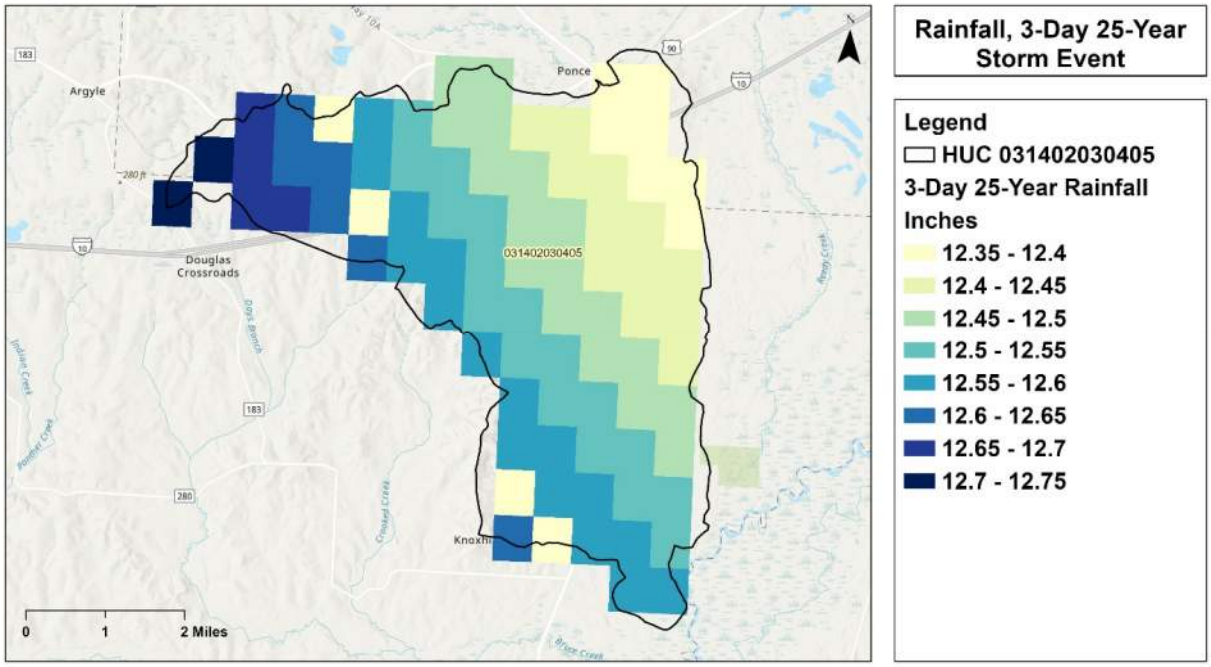

Figure 21. Rainfall distribution map across HUC 031402030405 sub-watershed, for 3-day 25-year storm event, processed by FAU.

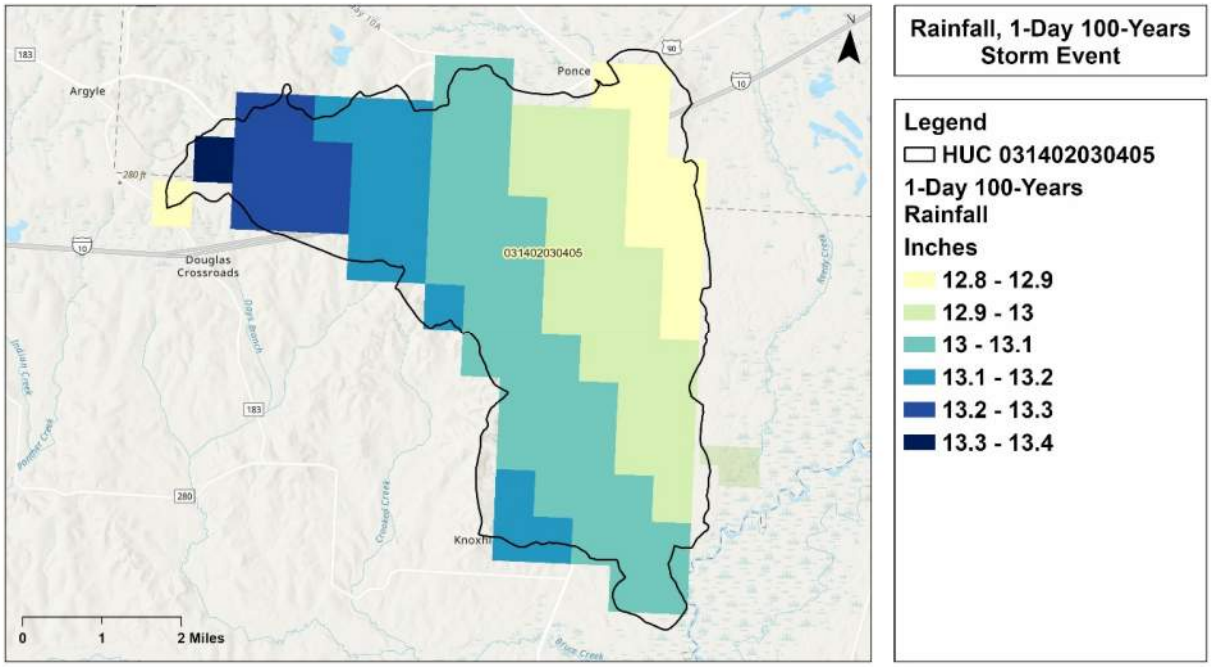

Figure 22. Rainfall distribution map across HUC 031402030405 sub-watershed, for 1-day 100-year storm event, processed by FAU.

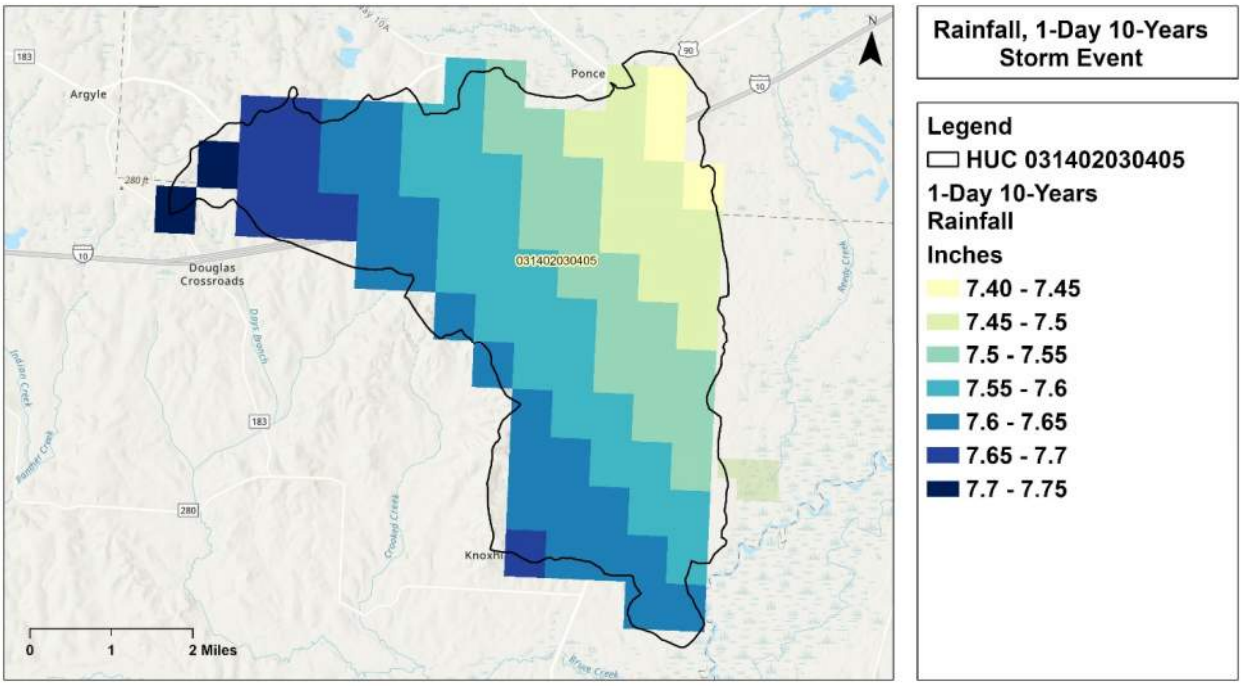

Figure 23. Rainfall distribution map across HUC 031402030405 sub-watershed, for 1-day 10-year storm event, processed by FAU.

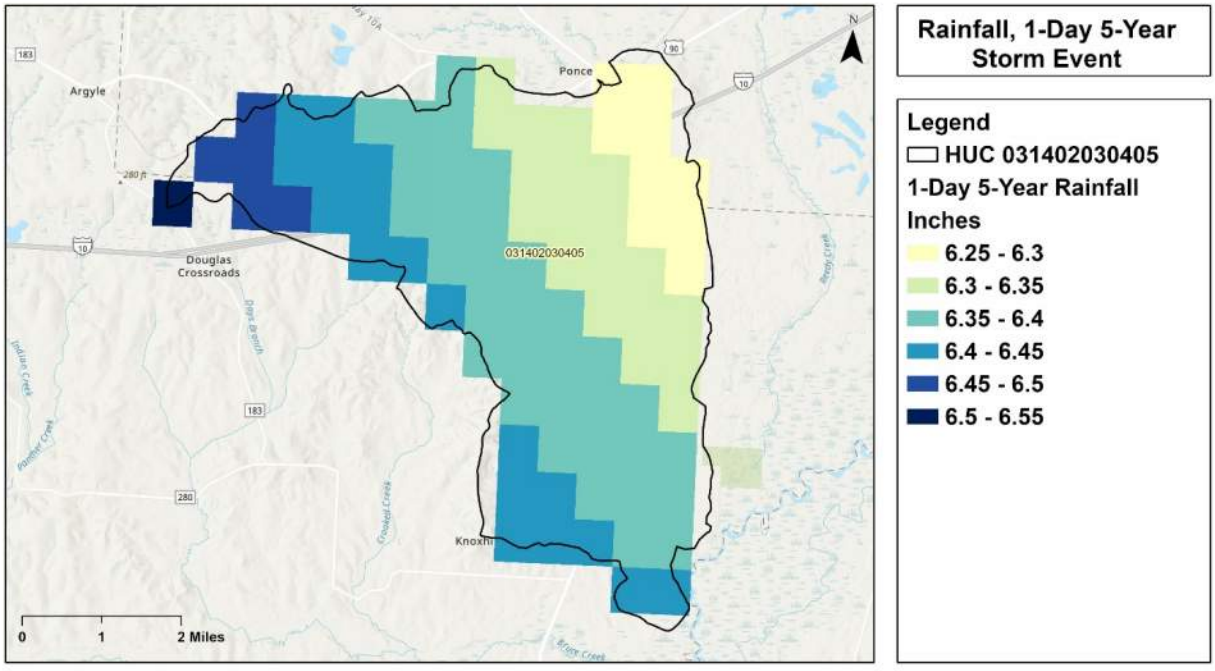

Figure 24. Rainfall distribution map across HUC 031402030405 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

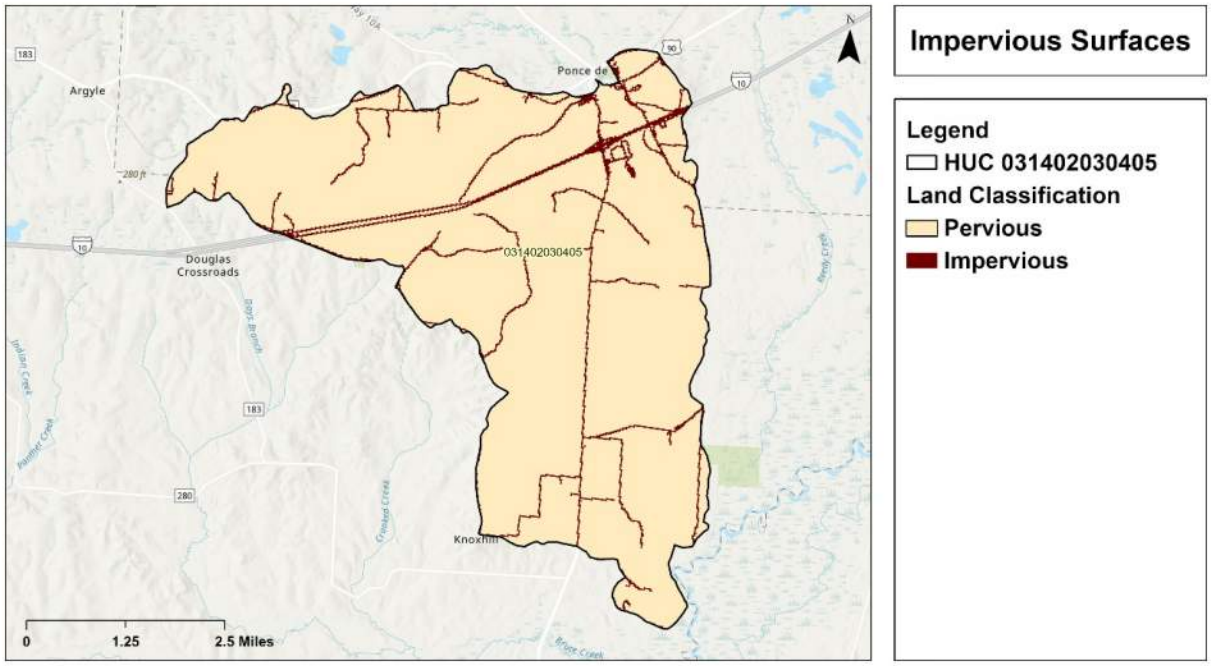

Figure 25. Impervious area map for the HUC 031402030405 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

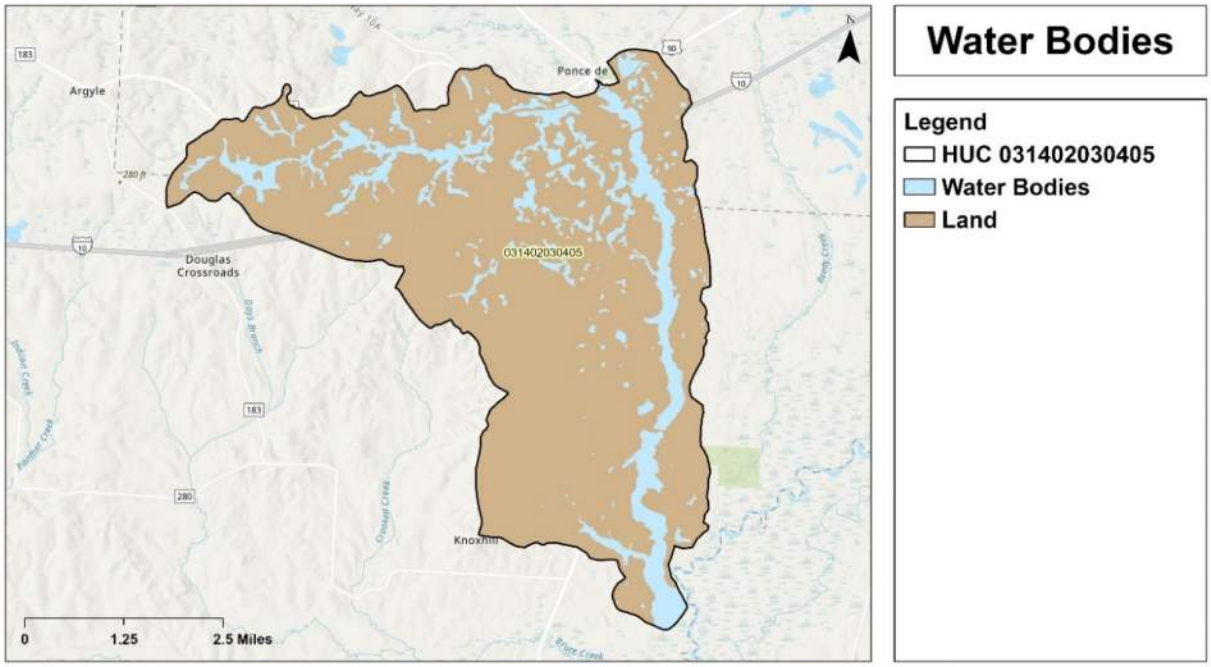

Figure 26. Water bodies map for the HUC 031402030405 sub-watershed, processed by FAU.

1.10. Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

(Source: US Census Bureau 2020, and Zip-codes.com)

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.

- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

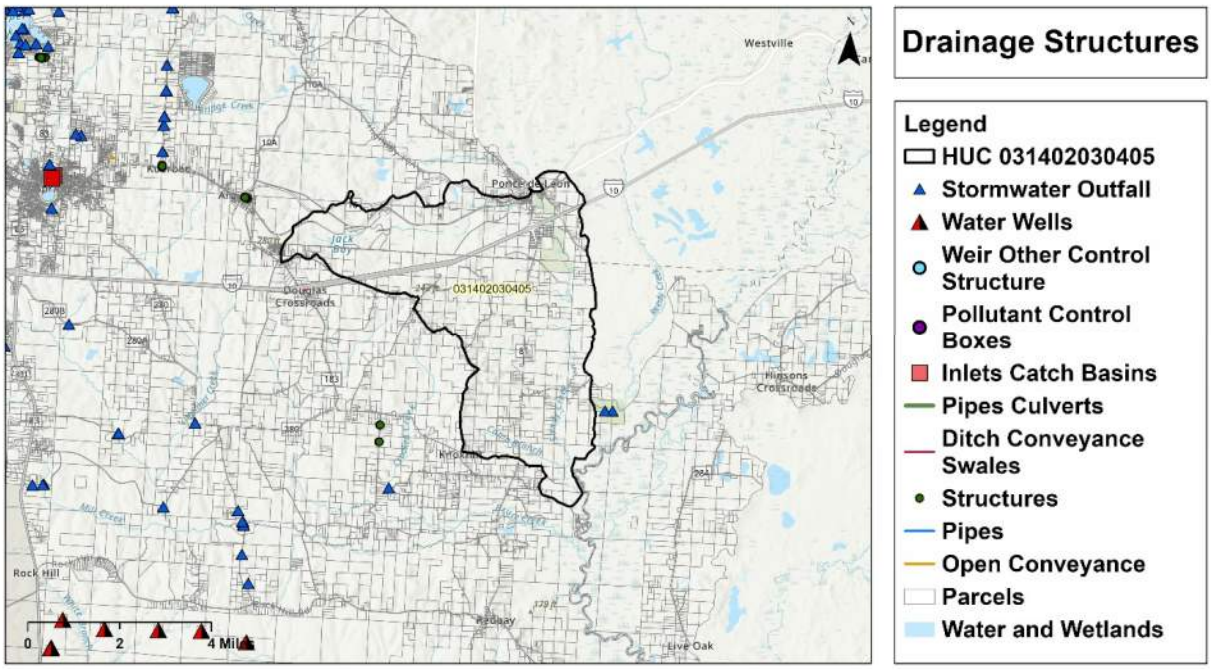

Figure 27. Stormwater Infrastructure for the HUC 031402030405. Processed by FAU.

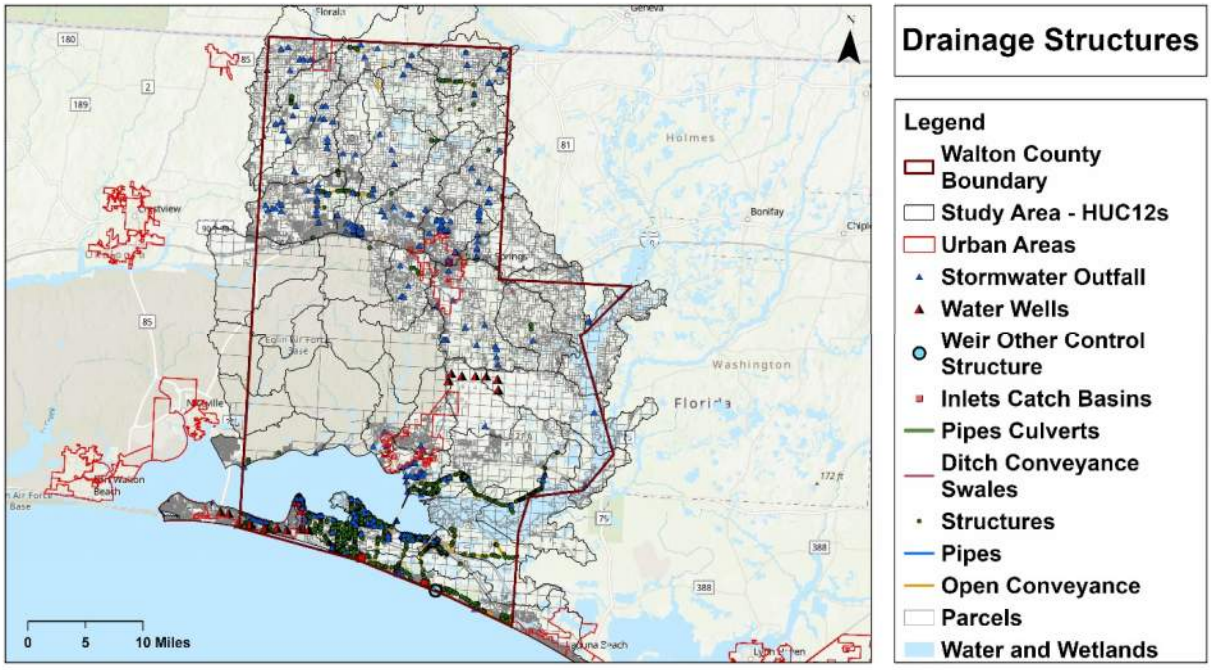

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020)

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1, analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031402030405 sub-watershed flood response to a series of rainfall events (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.3.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the

coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD DBHYDRO website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

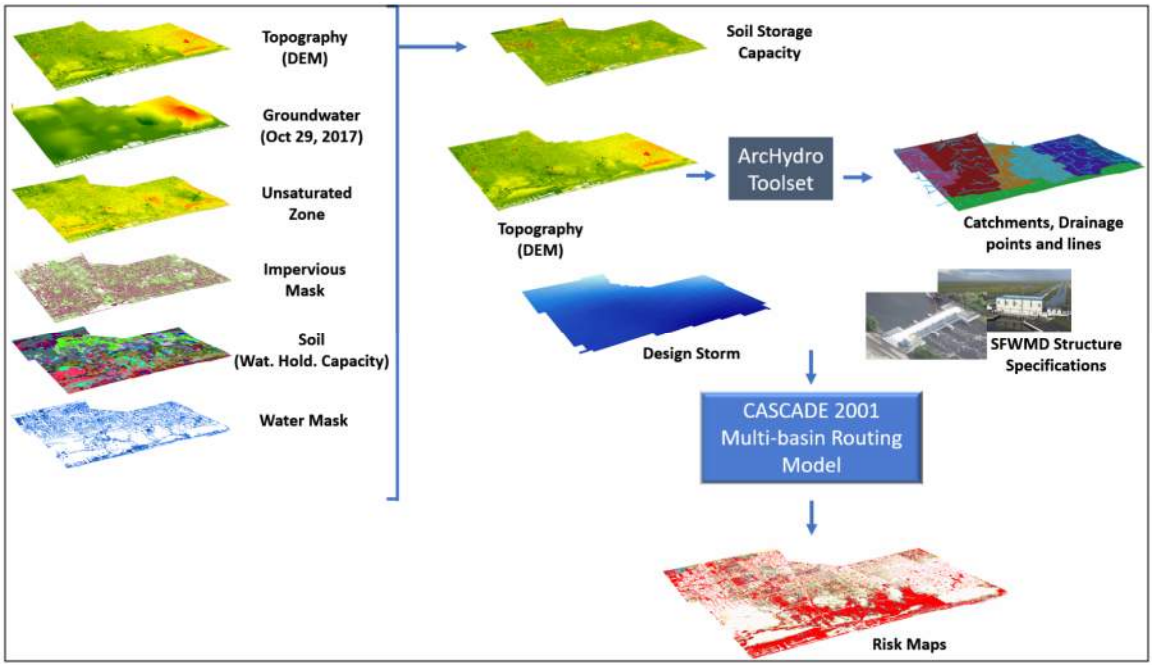

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the

investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

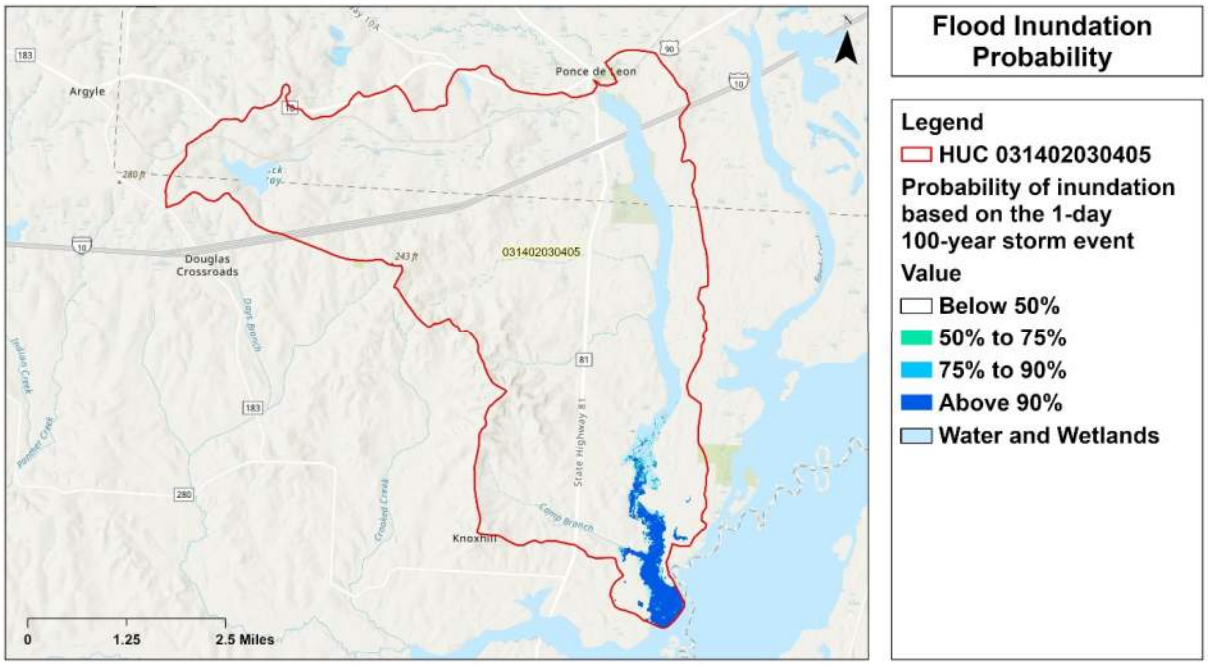

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031402030405, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes

and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 2.4 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in

the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a moderate amount of flooding is noted at the creek entrance to the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, the HUC is expected to remain unaffected by sea level rise, therefore SLR scenarios were not computed.

The design storm simulation determined that approximately 2.3% of the HUC total area or 0.55 mi^2 has a probability of inundation above 50% for all four design storm scenarios, indicating a high expectancy to be inundated in all four scenarios. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031402030405 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	23.52	0.55	97.7%	2.3%
1-day 100-year	23.52	0.55	97.7%	2.3%
1-day 10-year	23.52	0.55	97.7%	2.3%
1-day 5-year	23.52	0.55	97.7%	2.3%

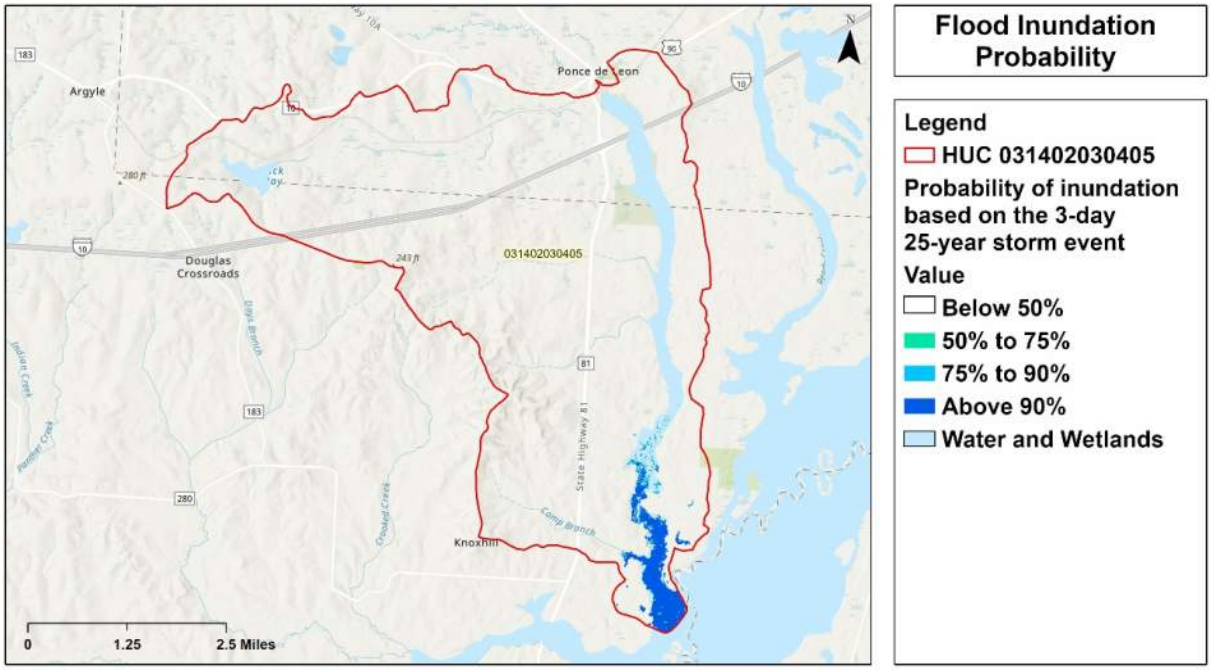

Figure 31. 3-day 25-year storm event for HUC 031402030405 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

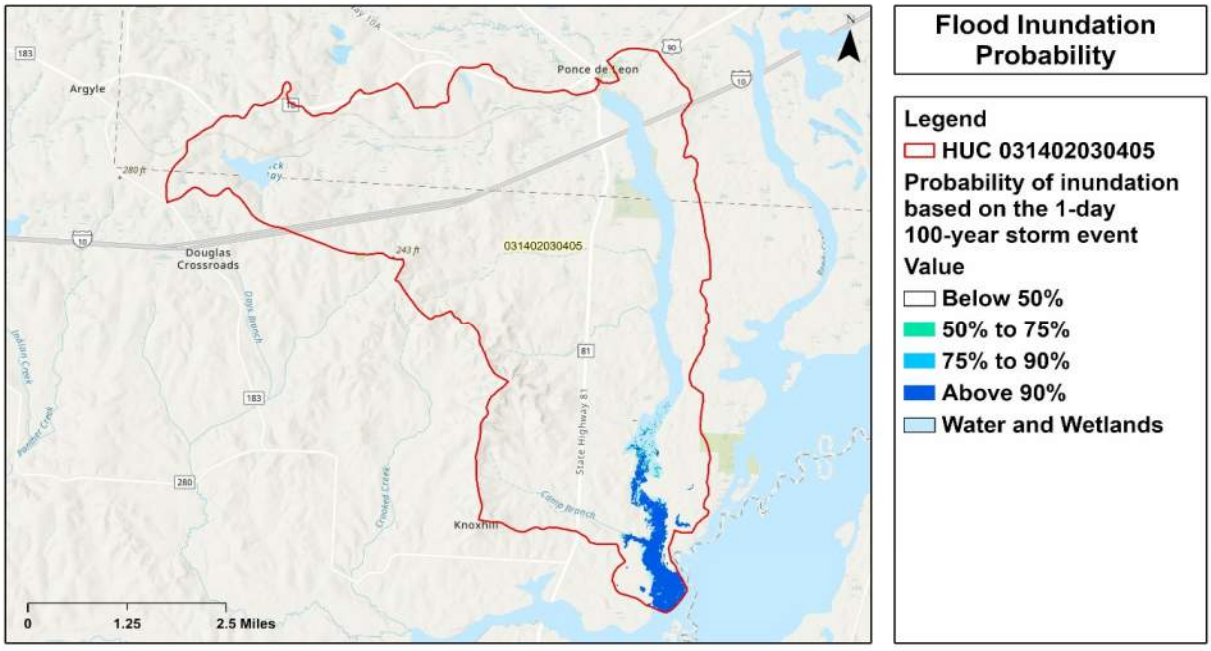

Figure 32. 1-day 100-year storm event for HUC 031402030405 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

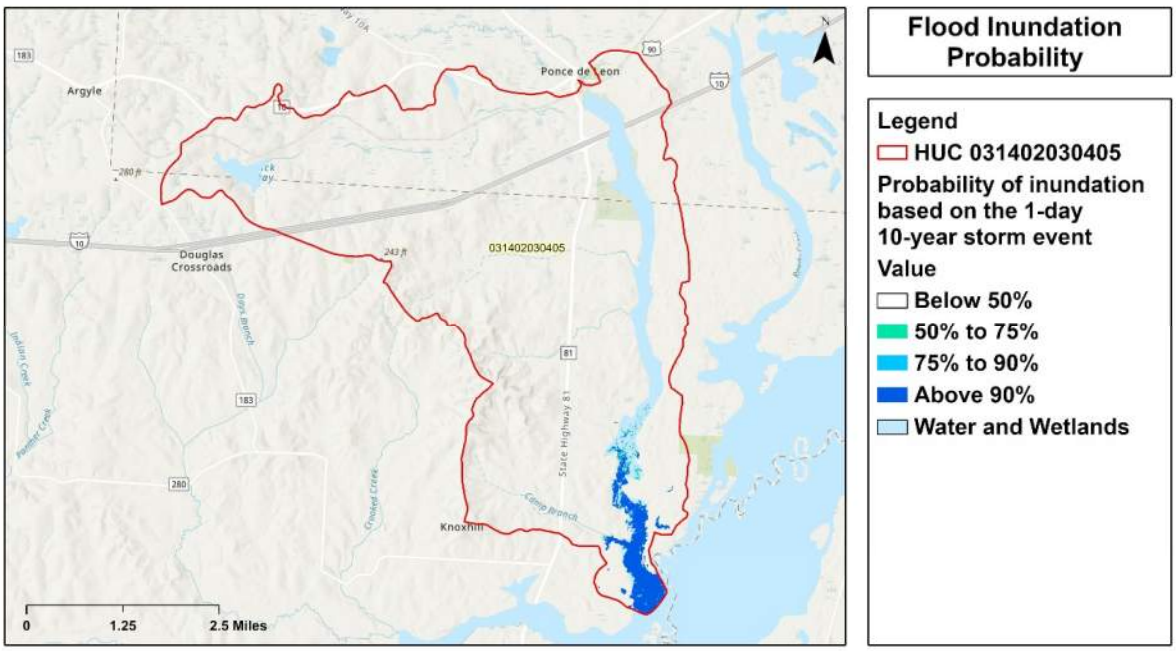

Figure 33. 1-day 10-year storm event for HUC 031402030405 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

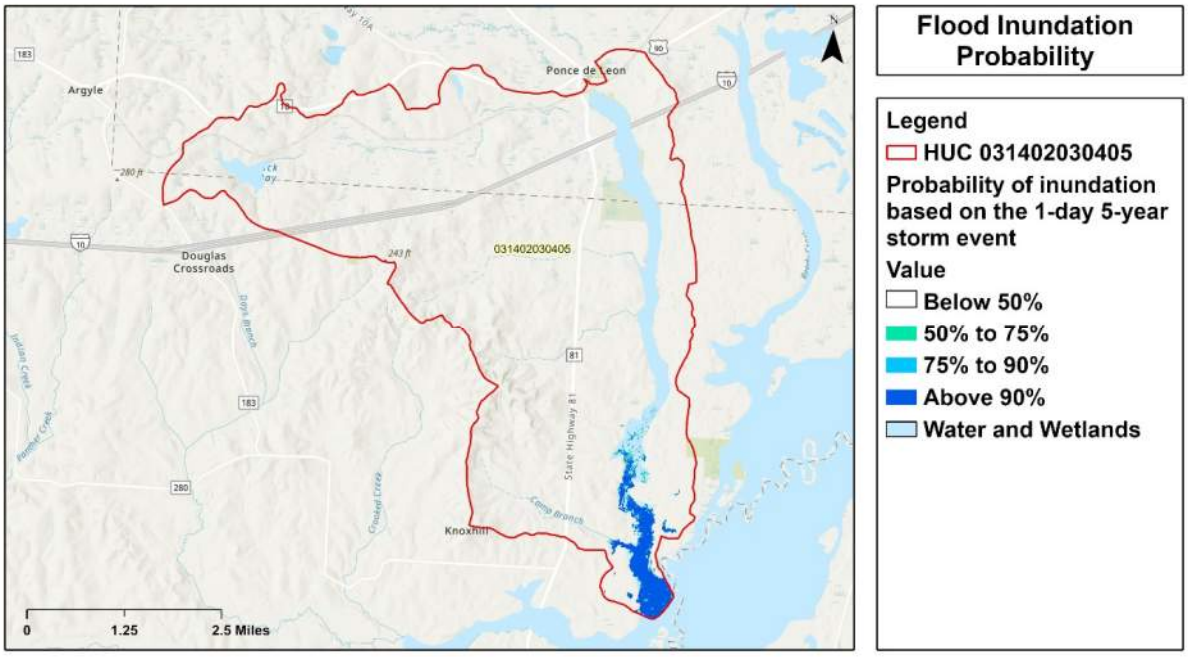

Figure 34. 1-day 5-year storm event for HUC 031402030405 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6

11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3

45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
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54	Timberland - Site Index 90 and Above	6
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67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6

82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031402030405 sub-watershed priority of land uses showing the critical facilities that should receive priority The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.**is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.**illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

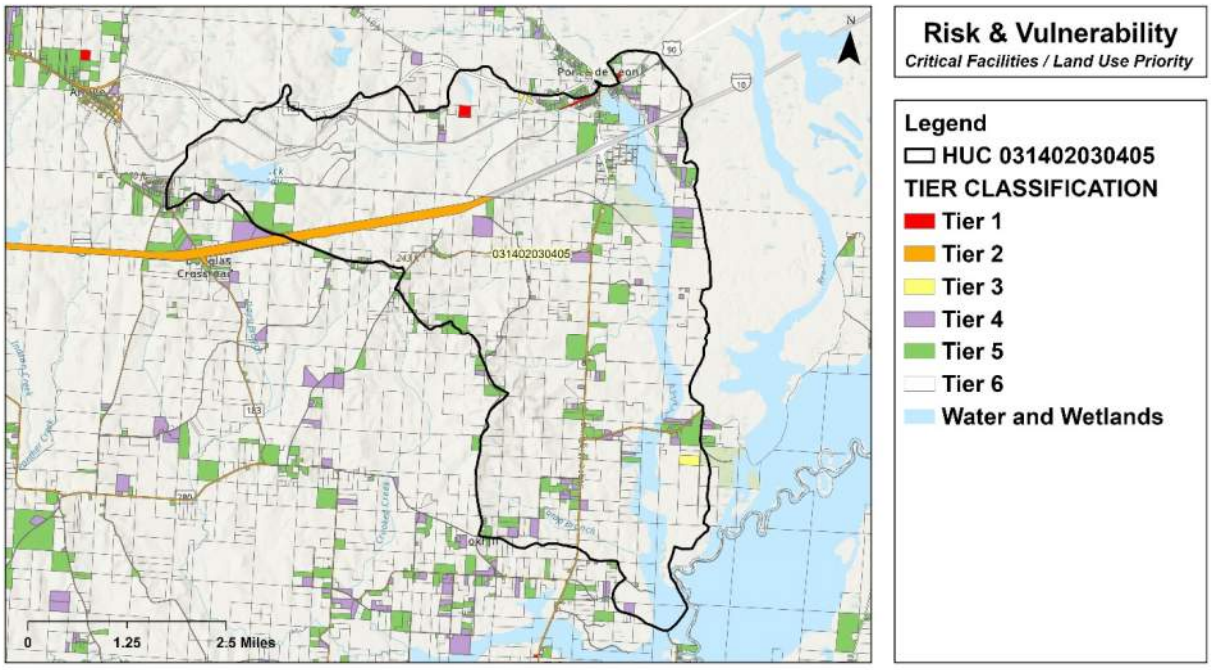

Figure 35. HUC 031402030405 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

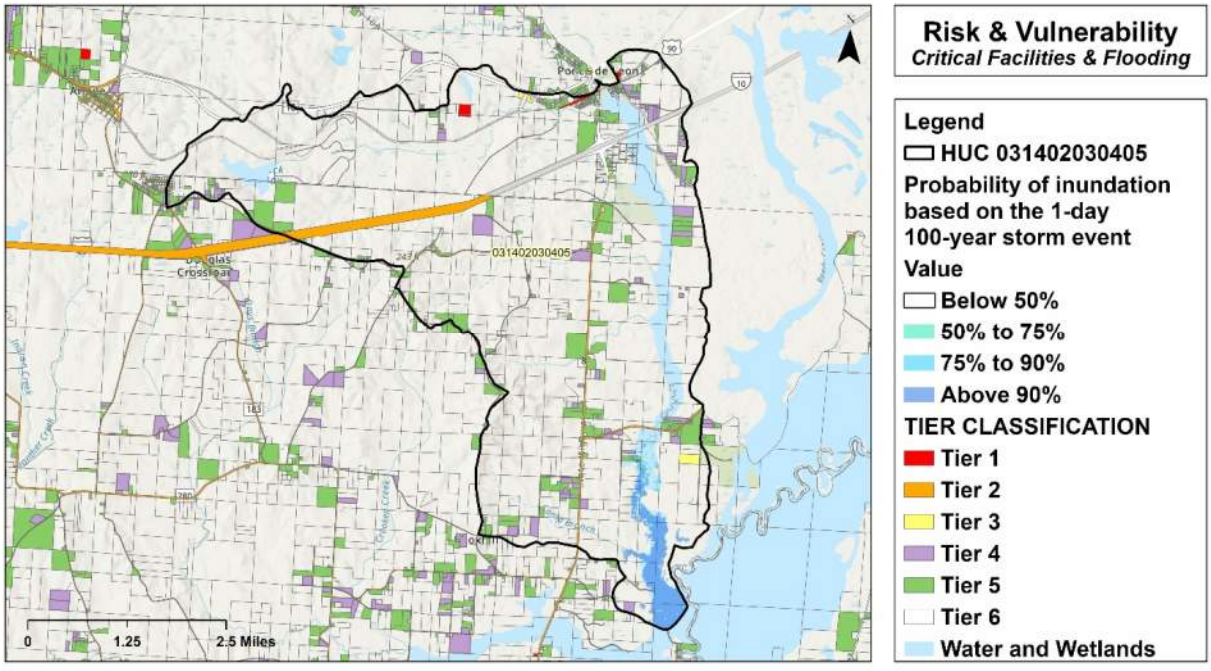

Figure 36. HUC 031402030405 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

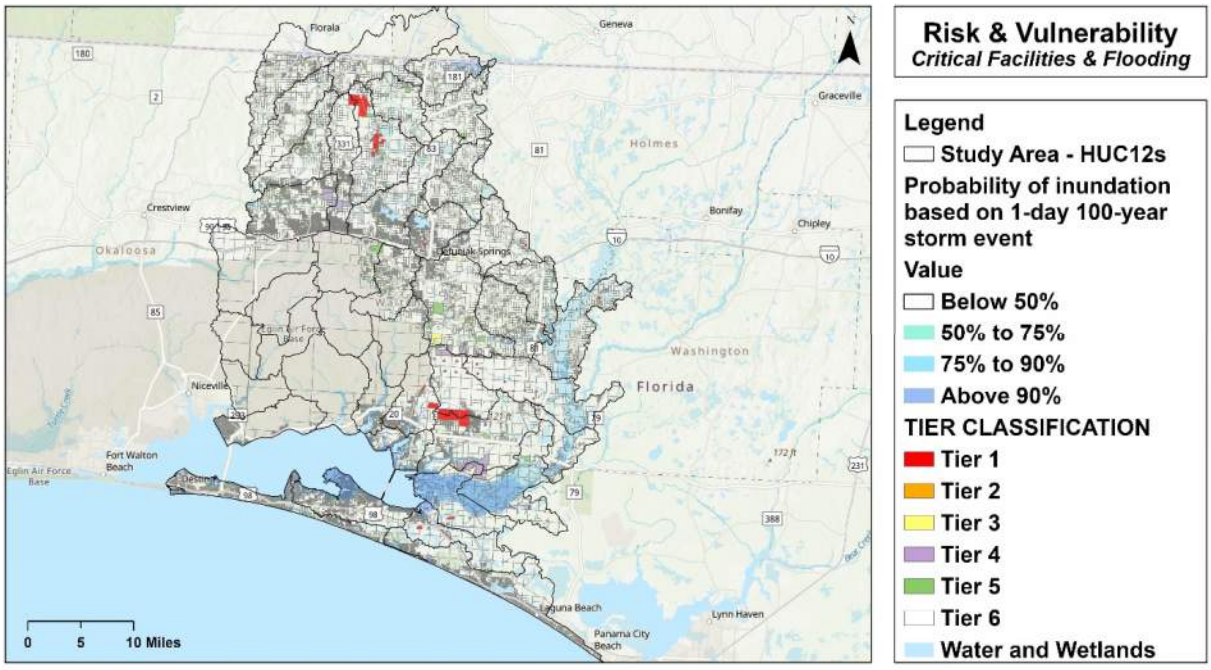

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

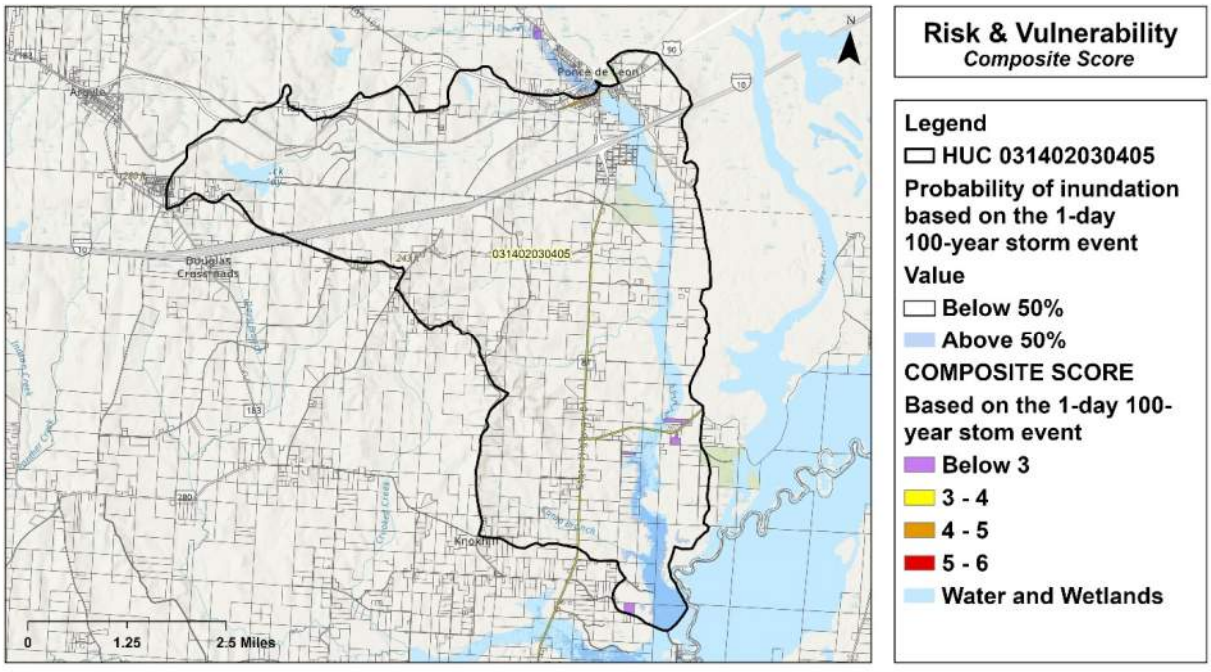

Figure 38. HUC 031402030405 sub-watershed Composite Score Risk map, with calculation based on 1-day 100-year storm event. Processed by FAU.

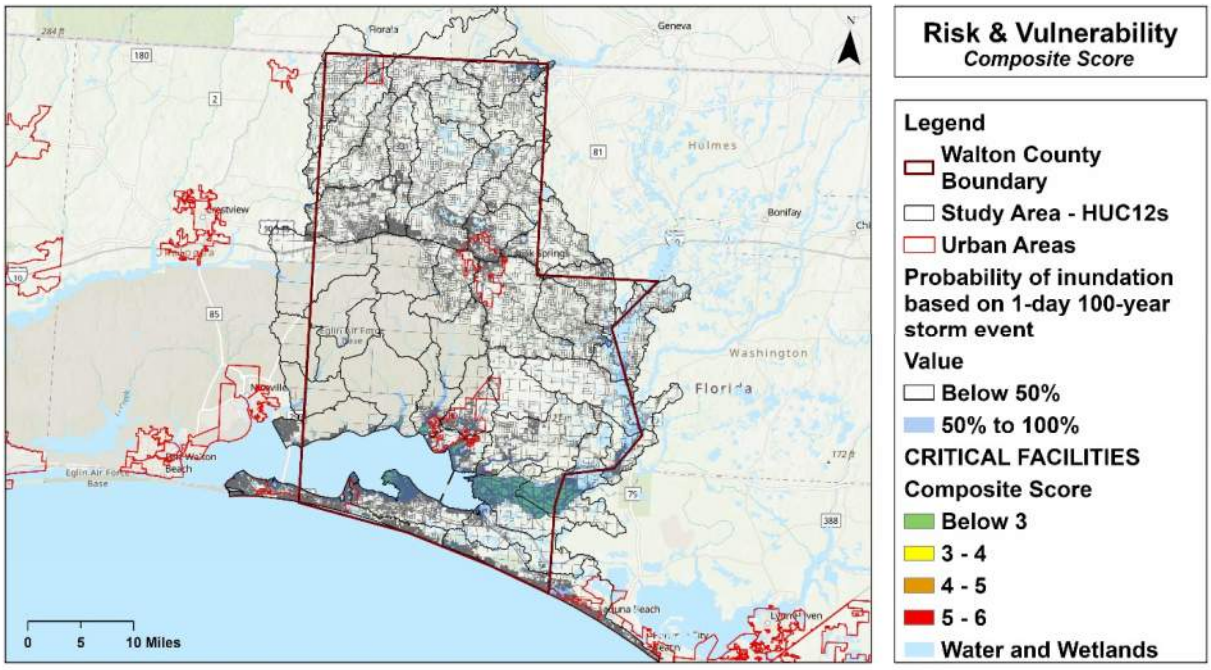

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.
Please note that due to the scale of the map, the composite score layer is not properly visible in this map.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031402030405. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031402030405. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031402030405	15410.98
All of the 1-day 100-year storm event inundation	**355.06**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	0.00
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	5.47
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	355.06
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	349.58

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

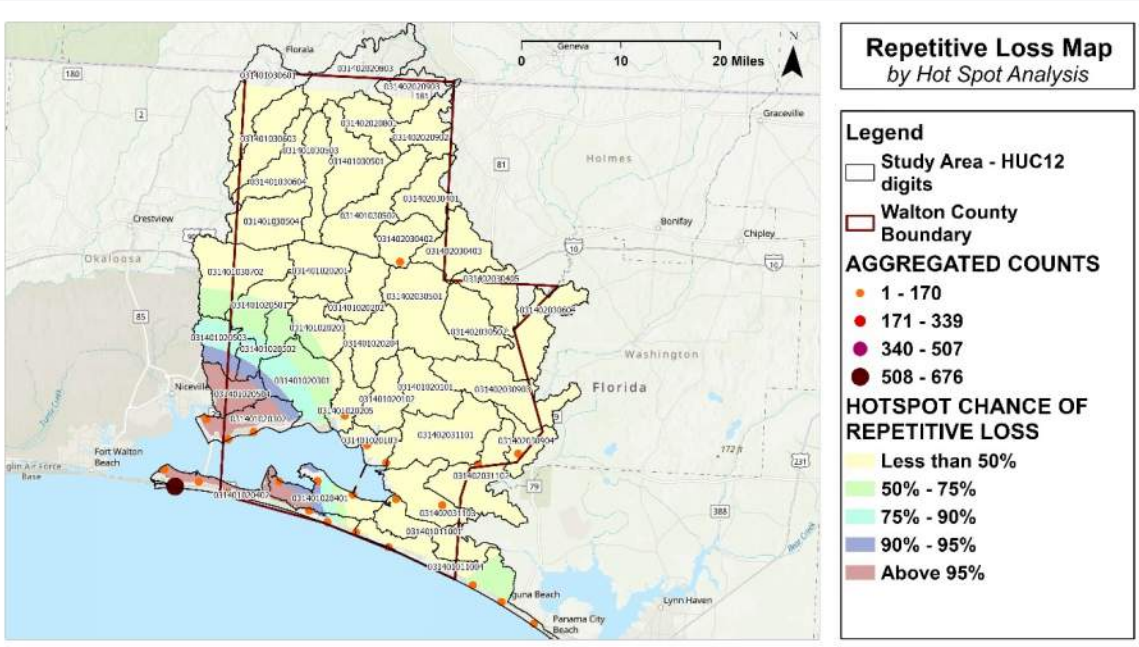

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5 Priority Projects

Although there are a good amount of parcels falling within tiers classification 1 to 5 priority of land uses, only a few of them are within the flooding zone, once flooding in the area is relatively minor and not alarming. Consequently, when considering the composite score, it is notable that most of the results are null. There are only nine exceptions within the basin: a utility parcel within score 4-5, four roads (Sandy Creek Landing Road, Highway 81, River Rd, and Highway 181) within score 3-4, and four mobile home parcels, all of them with scores below 3.

APPENDIX AL

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031402030501

UPPER BRUCE CREEK

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Research Assistant: Leticia Sabio

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031402030501) is highlighted among all the HUCs to help identifying its location.

The city of DeFuniak Springs shares a portion of its boundary with the basin. Demographics data and other considerations of DeFuniak Springs, along with other cities in Walton County, will be discussed later.

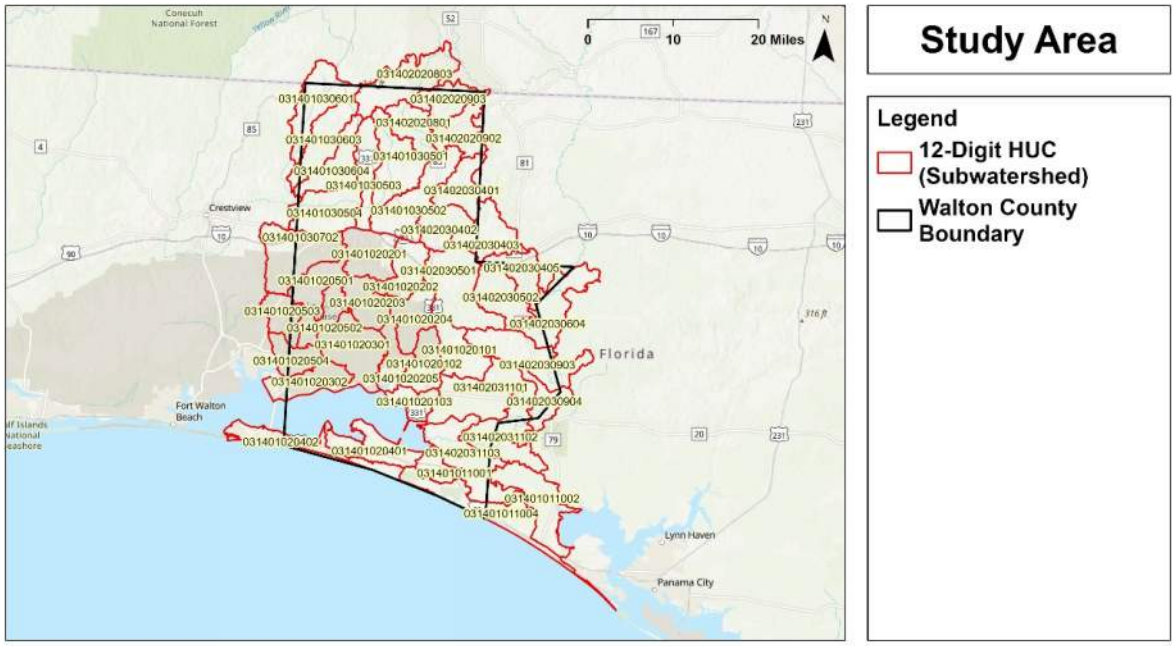

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

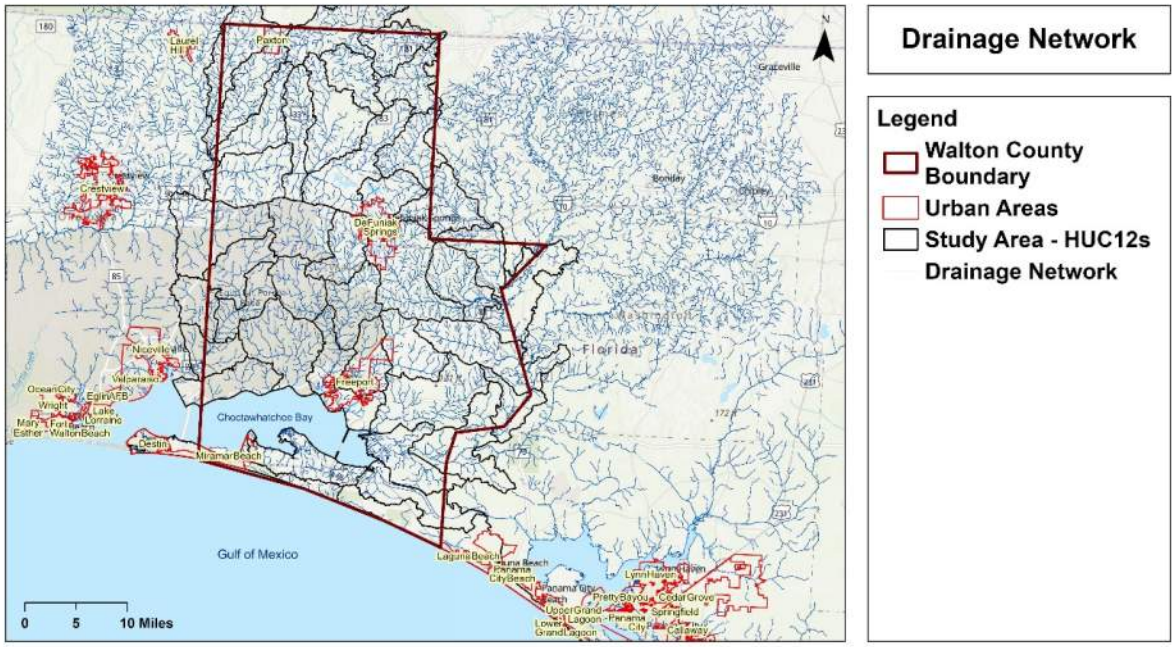

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

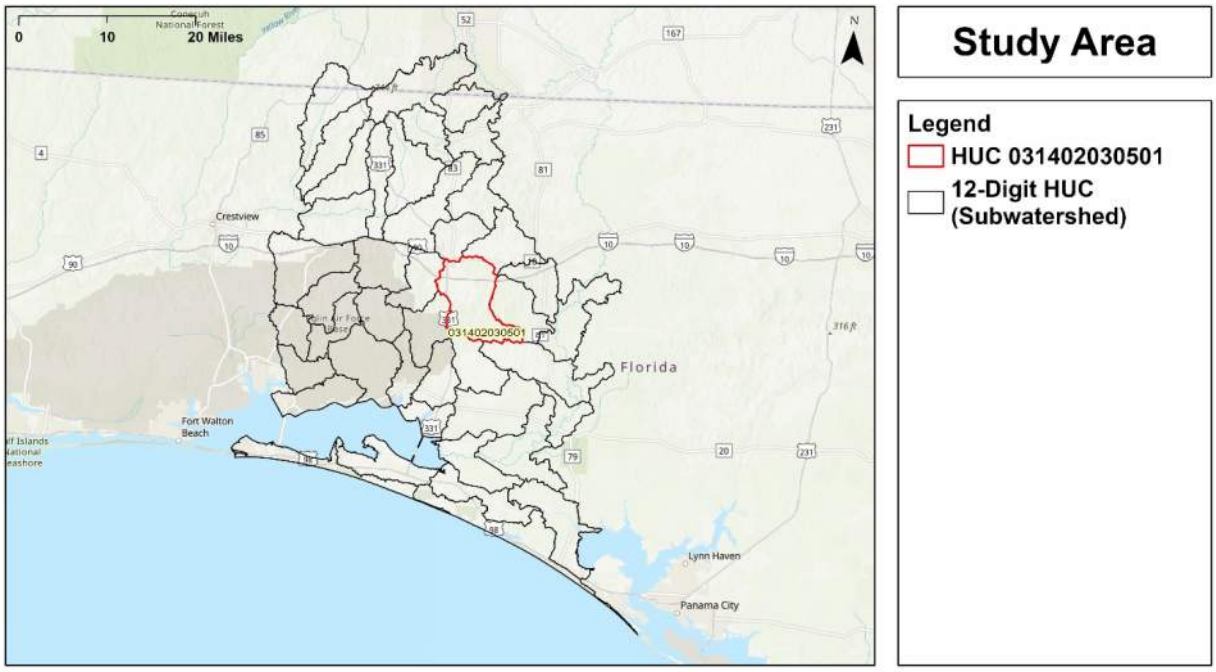

Figure 3. HUC 031402030501 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Based on the the Level 1 land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to

understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

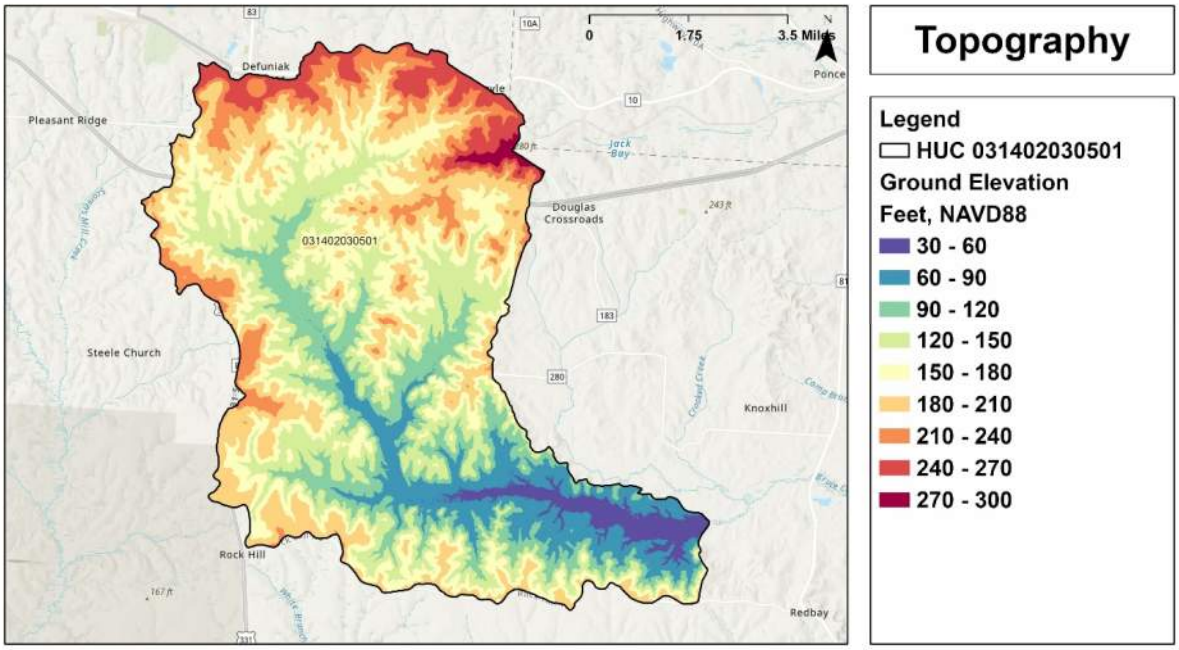

Figure 4. Topographic map of the HUC 031402030501 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of

wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031402030501 sub-watershed is shown in **Error! Reference source not found.**.

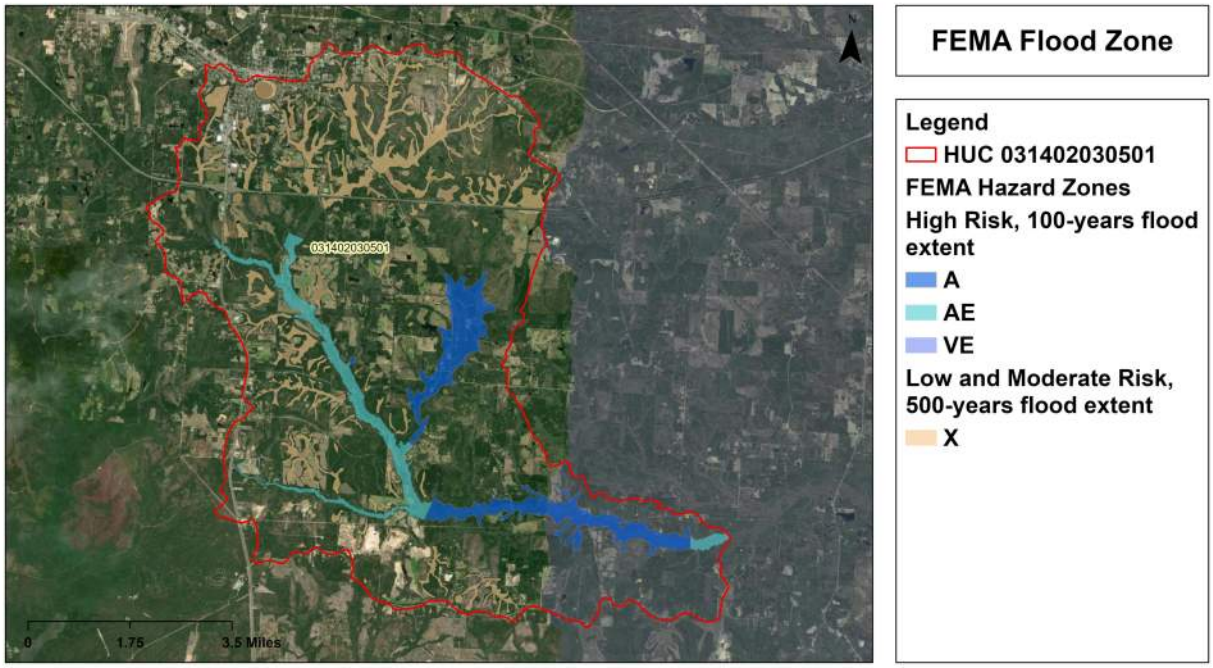

Figure 5. FEMA Flood Zone map (2020) for HUC 031402030501 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes,

including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031402030501 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

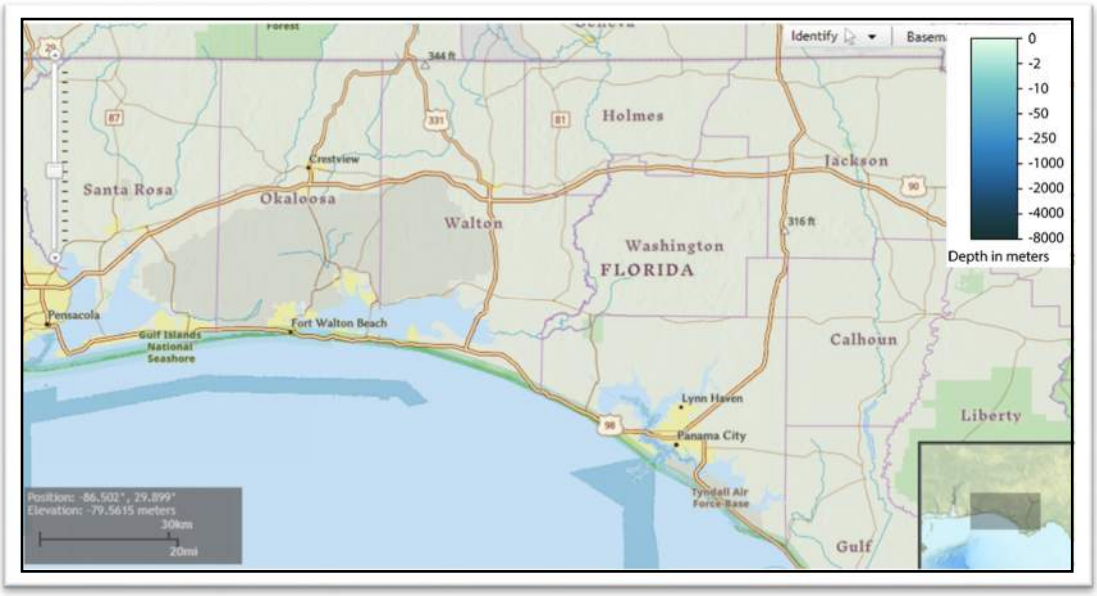

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle. Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological

conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

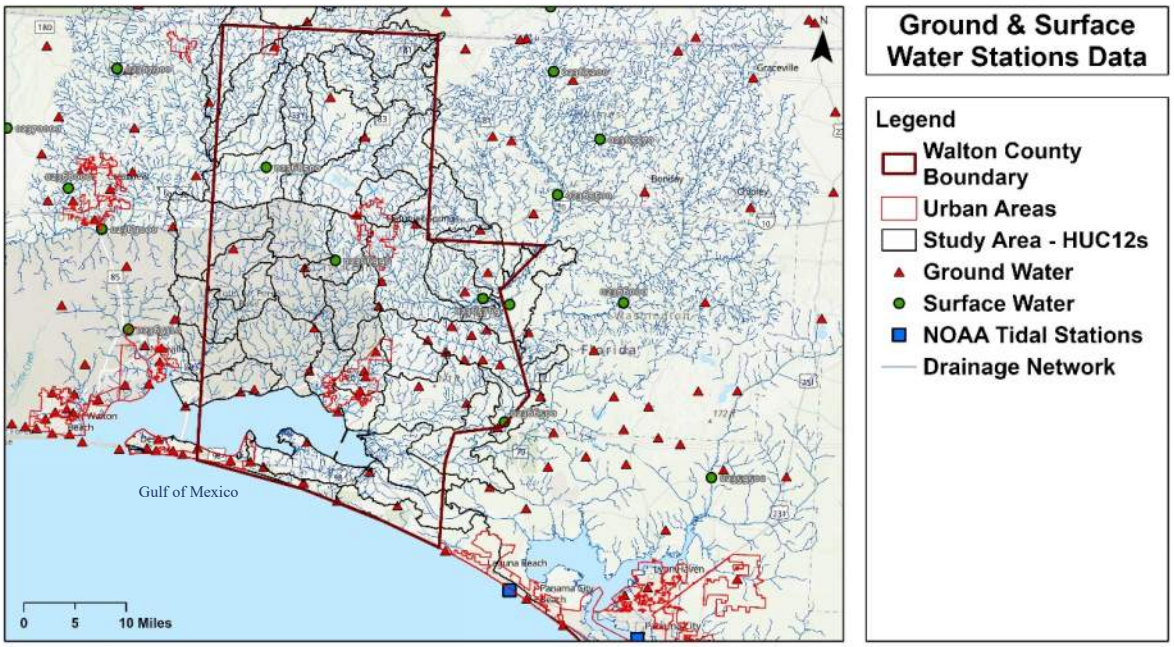

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031402030501 has no major rivers and canals, but creeks and branches, include:

- Bruce Creek
- Mill Creek
- McCallum Branch
- Ward Branch
- Black Branch
- Panther Creek
- Indian Creek
- Bay Branch

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366996. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031402030501, which is USGS 02366996 Alaqua Creek Near Pleasant Ridge, FL.

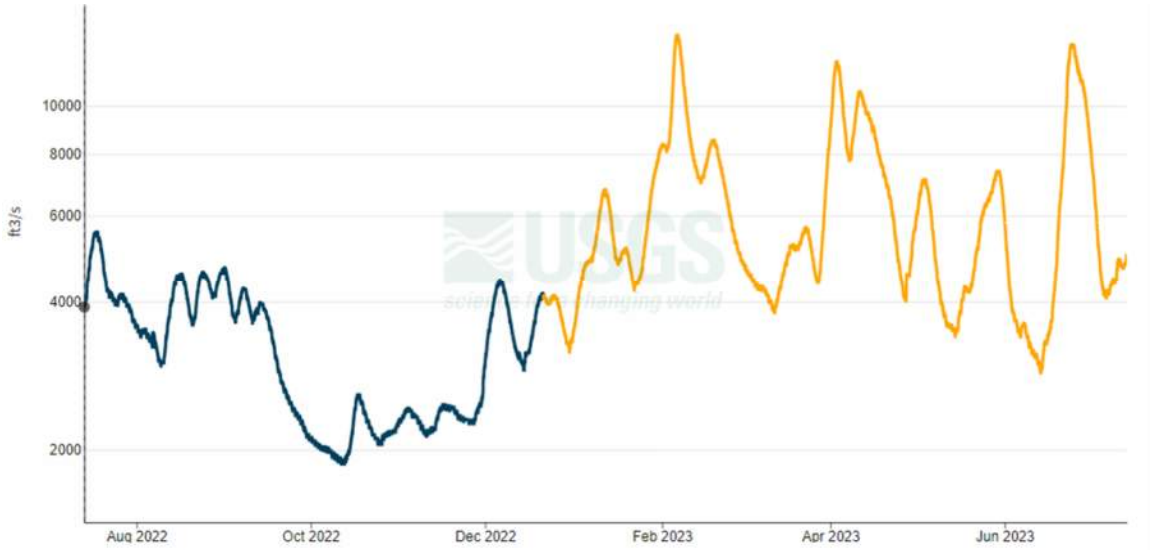

Figure 8. Average streamflow for Alaqua Creek Near Pleasant Ridge, FL (USGS 02366996 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02366996/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish

a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031402030501 and points out the location of the ground water station in the surroundings. A groundwater-surface layer for the HUC 031402030501 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

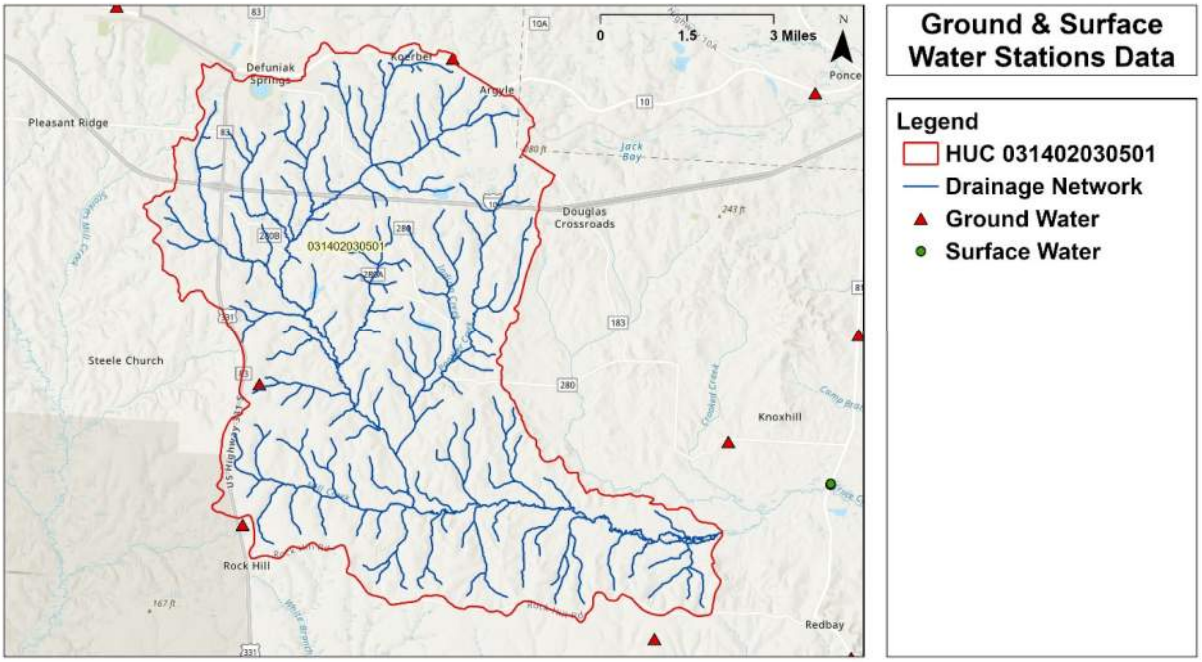

Figure 9. Ground and Surface Water Stations in the HUC 031402030501 sub-watershed, processed by FAU.

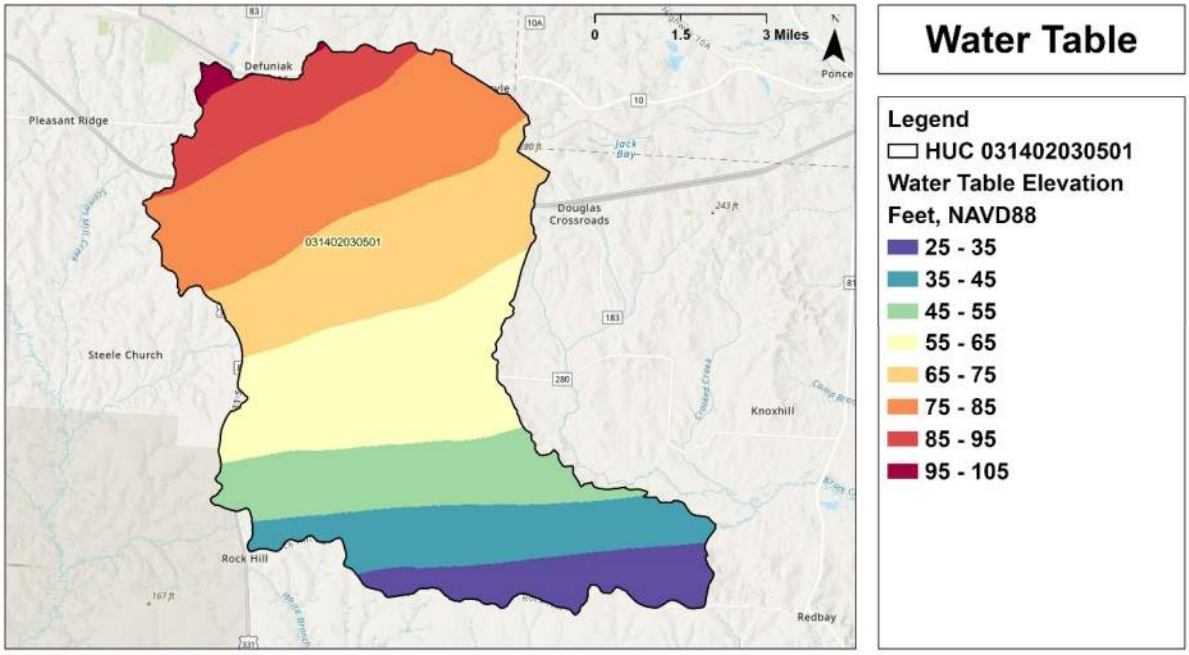

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031402030501 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

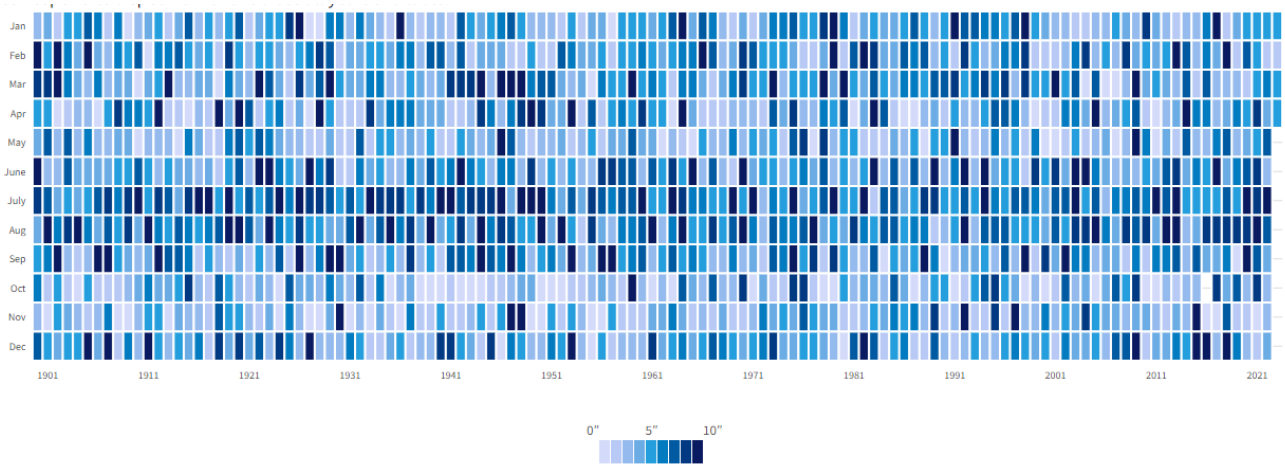

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/).

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

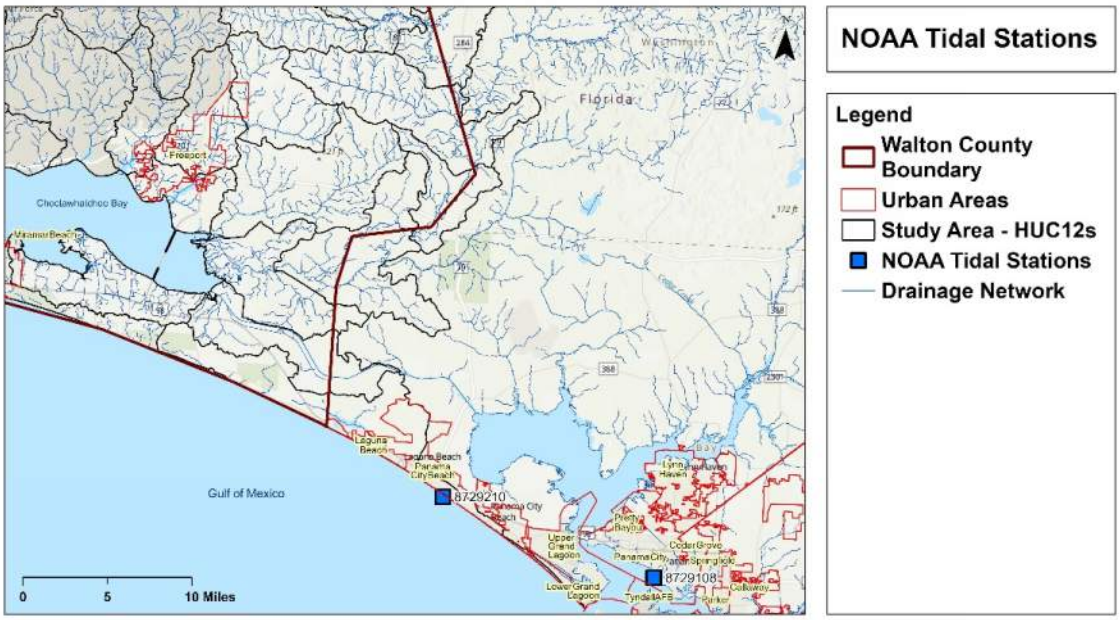

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

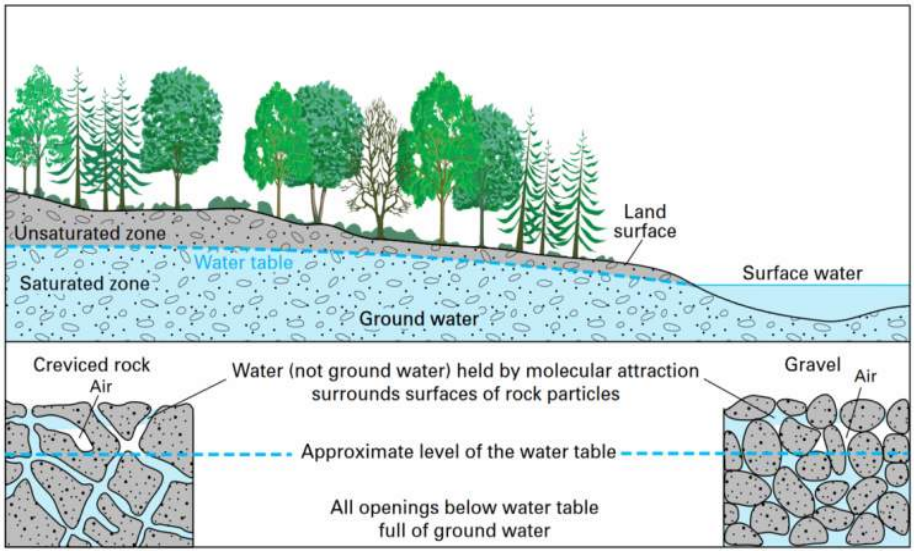

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

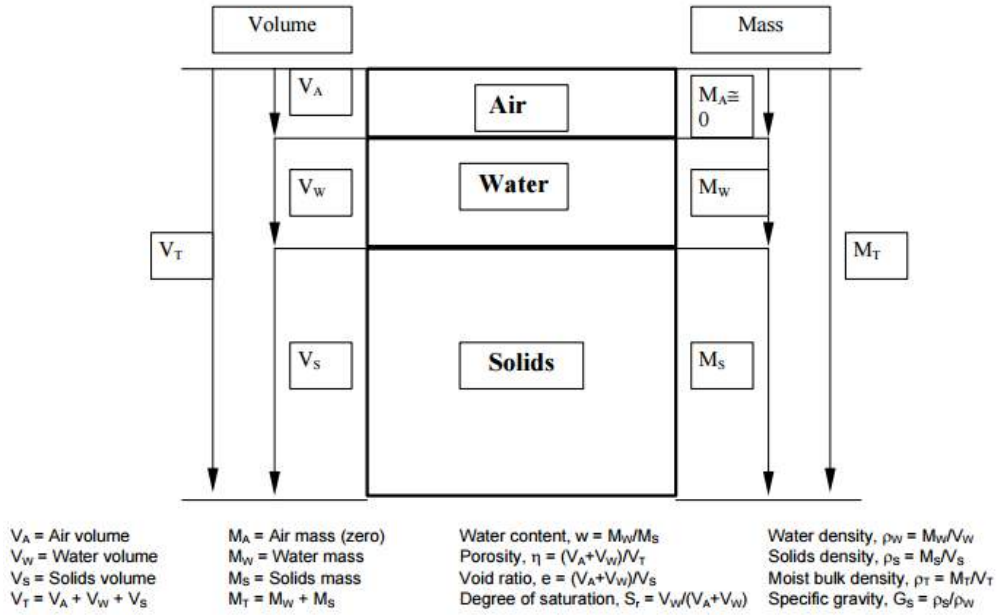

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). Figure 15 shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

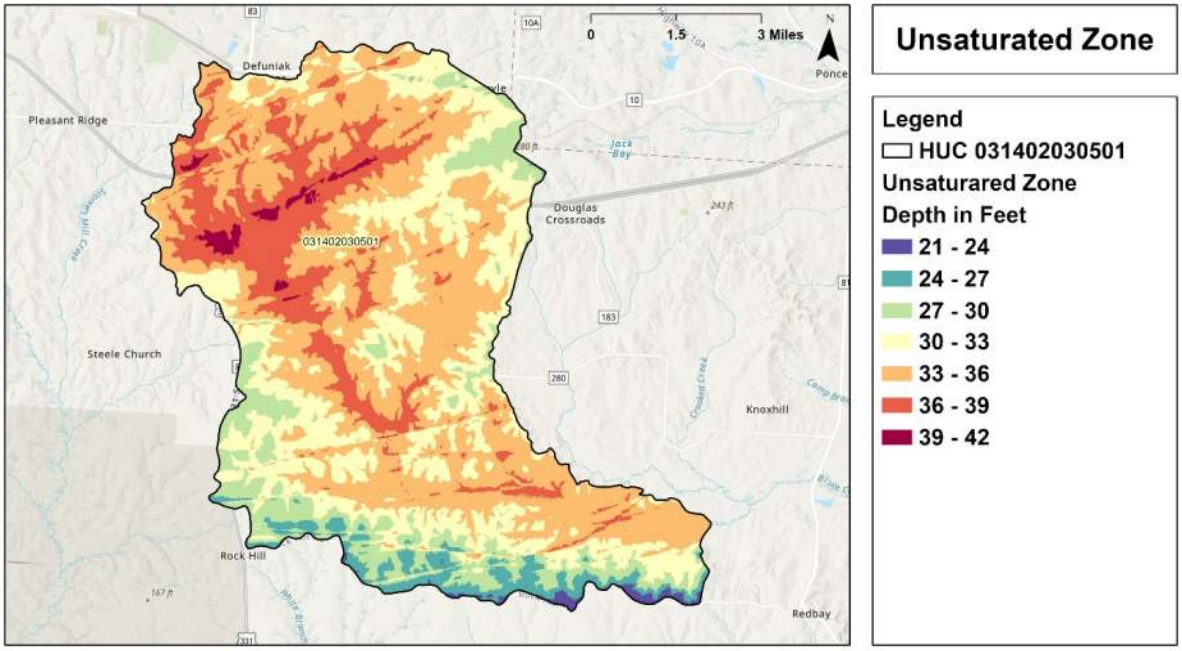

Figure 15. Unsaturated zone map for HUC 031402030501, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately favorable soil storage capacity, falling within the range of 27 to 39 feet of remaining capacity.

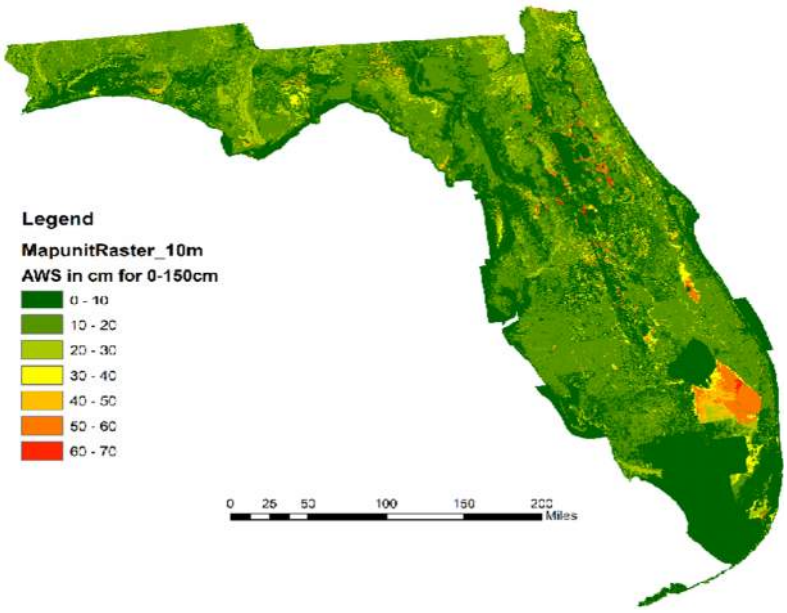

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

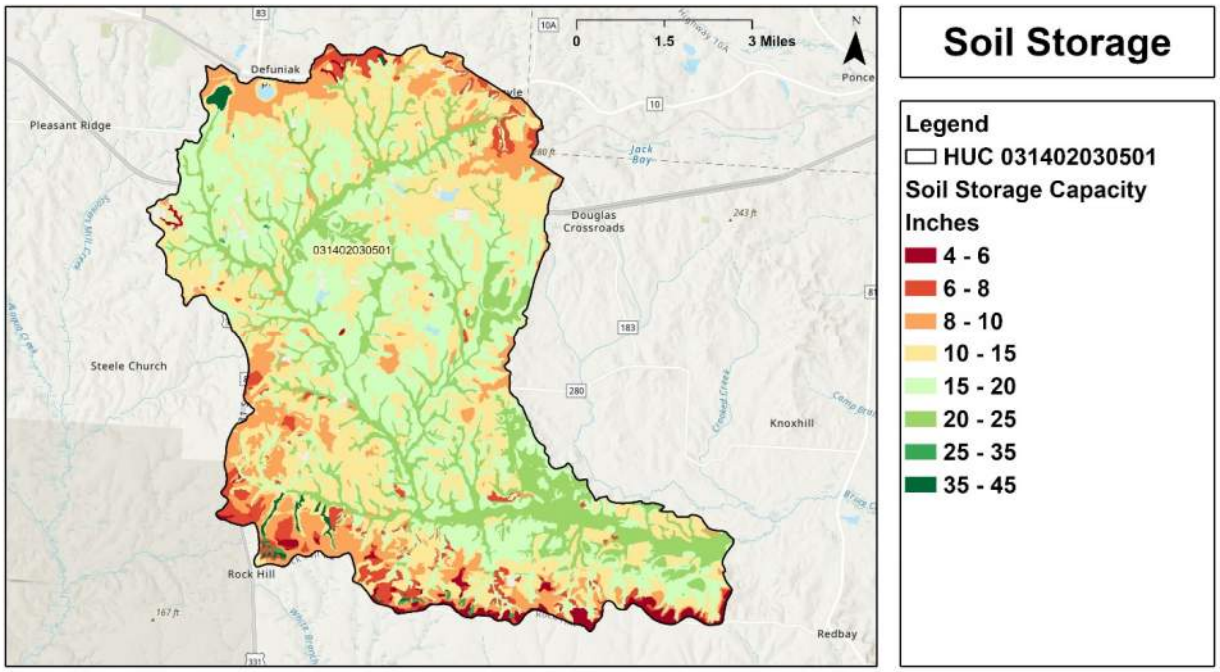

Figure 17. Water storage capacity of soil for the HUC 031402030501, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

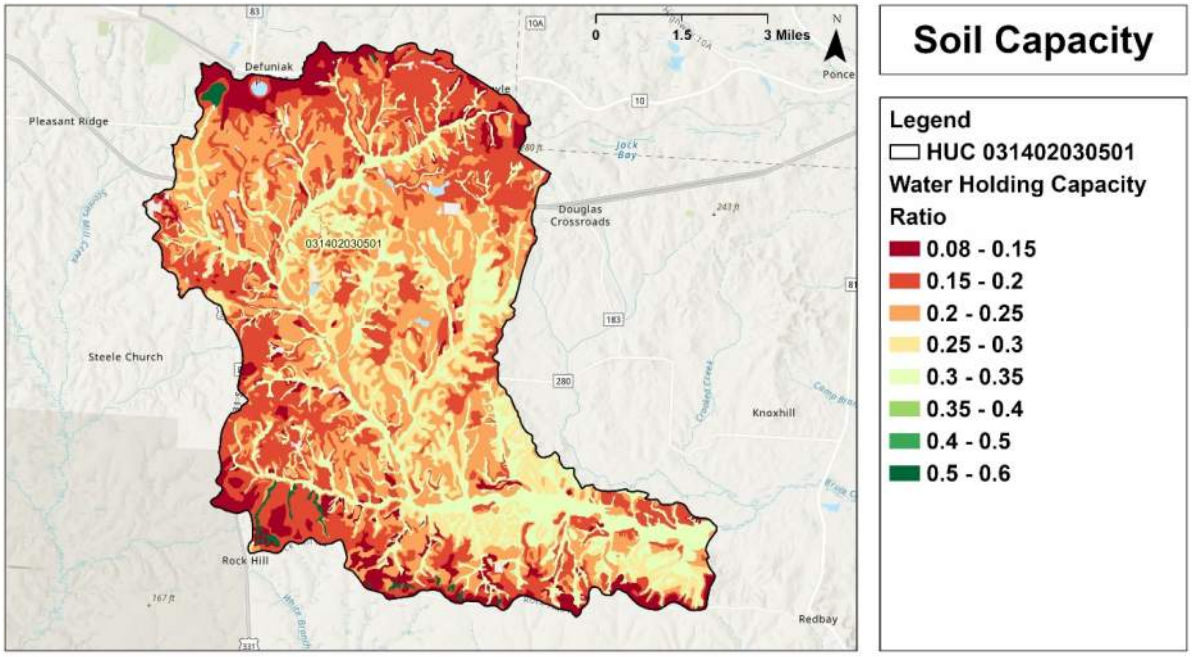

Figure 18. Water Holding Capacity (ratio) for the HUC 031402030501, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

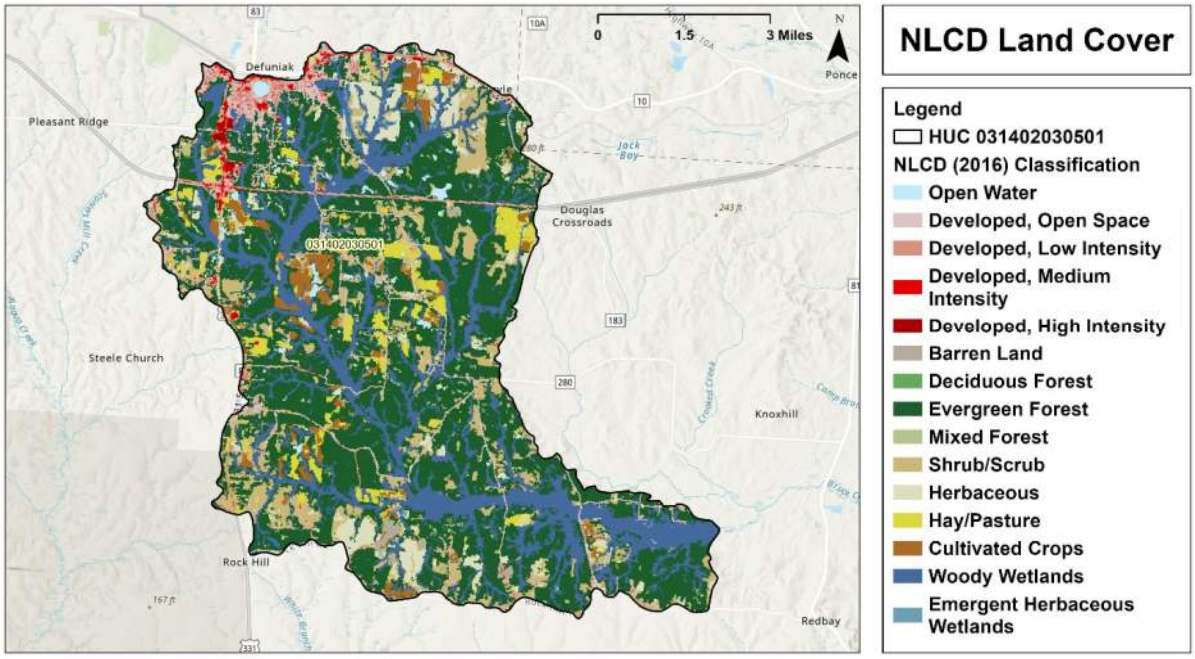

Figure 19. Land use in the HUC 031402030501 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

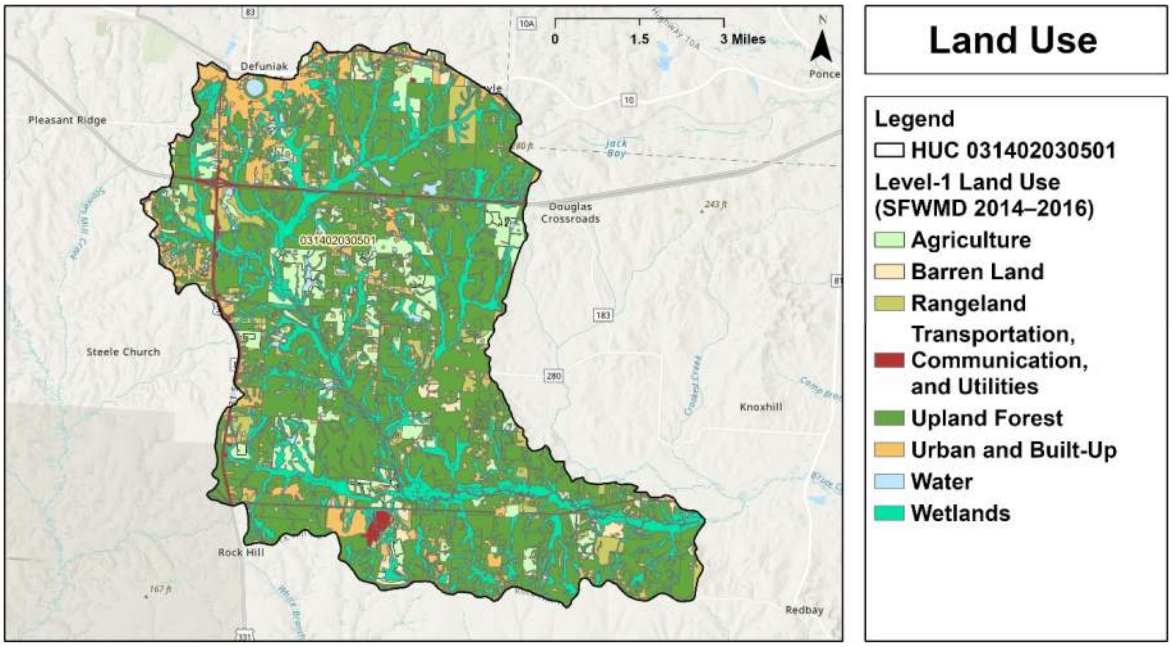

Figure 20. Land use in the HUC 031402030501 (from the 2023 Florida Geographic Data Library (FGDL)), processed by FAU.

In the HUC 031402030501 sub-watershed, the predominant land cover is upland forest, accounting for 52.64% of the area. Wetlands comes in second at 16.53%, followed by Urban and Built-Up at 8.11%, and Agriculture at 7.92%. Unlike most HUCs in the County, the basis presents a moderate portion of developed land once the basin takes a small portion of the city DeFuniak Springs. The percentage of area by land use type is as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031402030501 subwatershed (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	3468.64	7.92%
Barren Land	479.98	1.10%
Rangeland	2022.03	4.62%
Transportation, Communication, and Utilities	3389.03	7.74%
Upland Forest	23045.26	52.64%
Urban and Built-Up	3551.06	8.11%
Water	587.23	1.34%
Wetlands	7234.34	16.53%
Grand Total:	**43777.58**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). Figure 21 shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

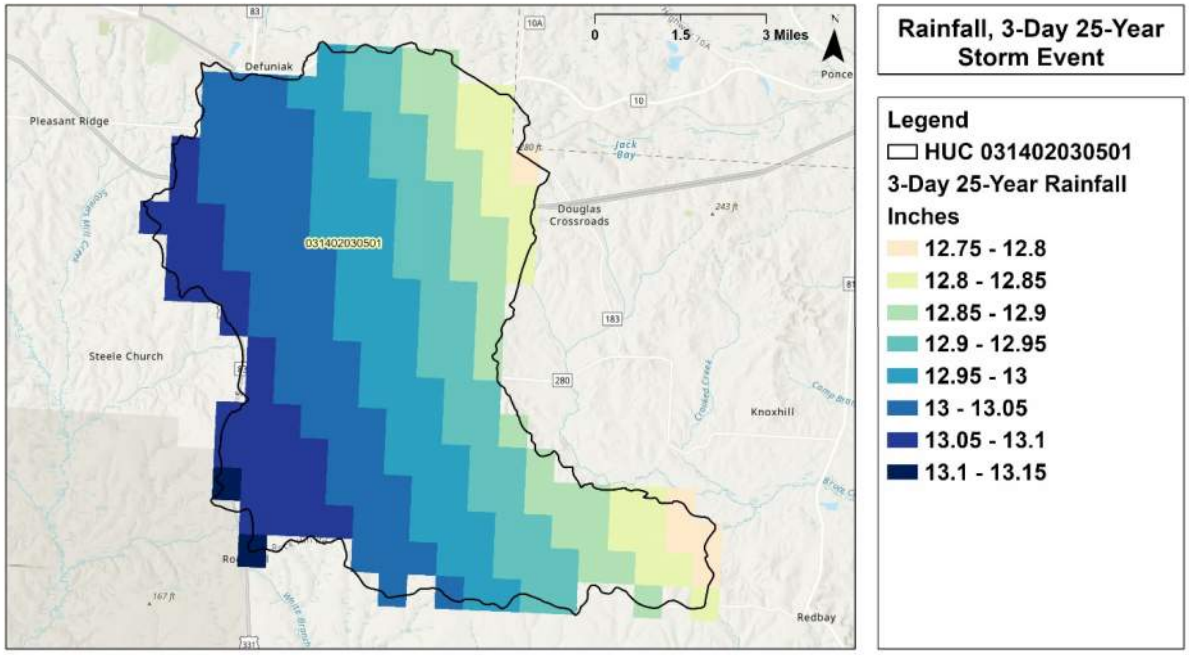

Figure 21. Rainfall distribution map across HUC 031402030501 sub-watershed, for 3-day 25-year storm event, processed by FAU.

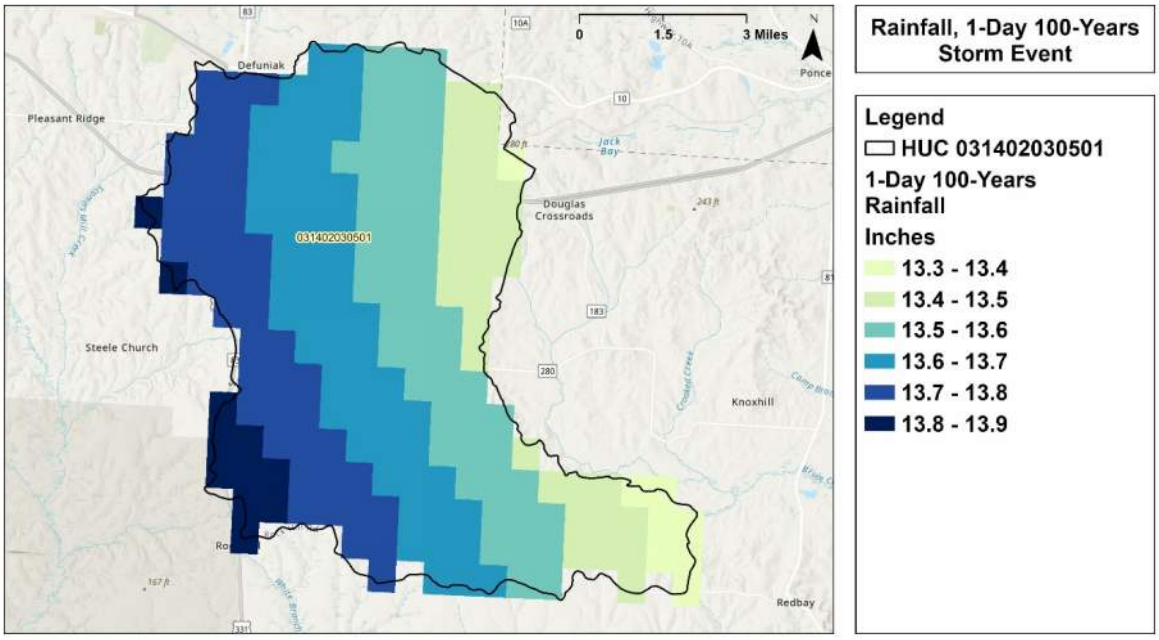

Figure 22. Rainfall distribution map across HUC 031402030501 sub-watershed, for 1-day 100-year storm event, processed by FAU.

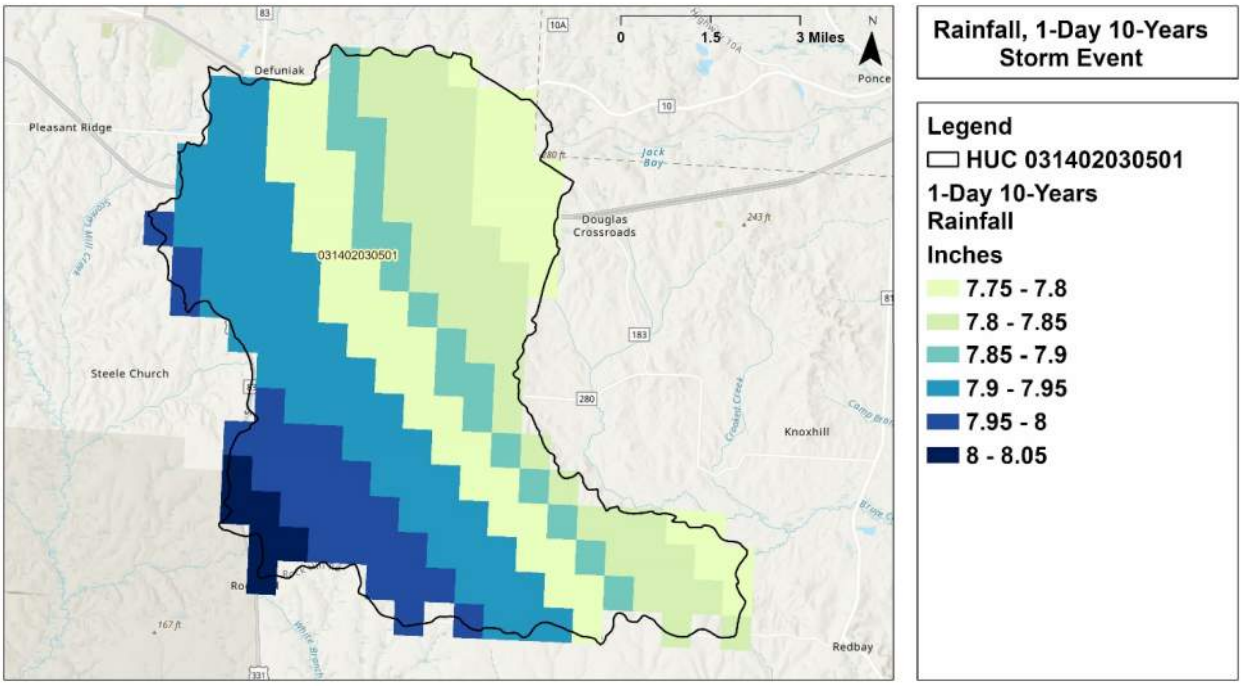

Figure 23. Rainfall distribution map across HUC 031402030501 sub-watershed, for 1-day 10-year storm event, processed by FAU.

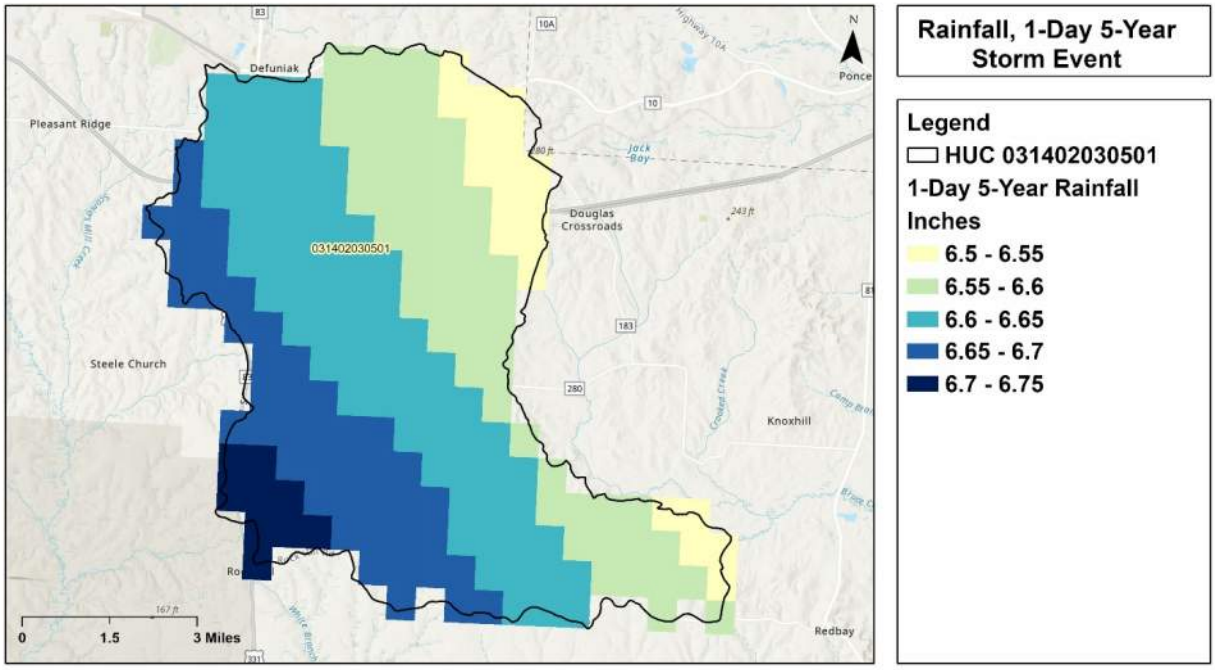

Figure 24. Rainfall distribution map across HUC 031402030501 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 2.5). Added to this will be the water bodies discussed in Section 2.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically

aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

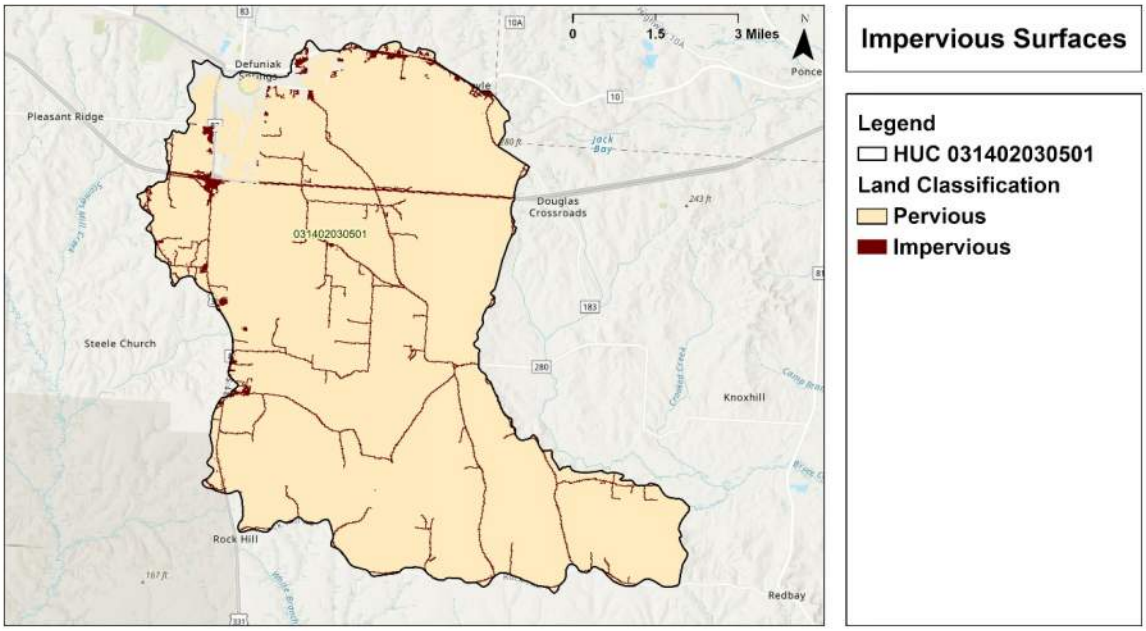

Figure 25. Impervious area map for the HUC 031402030501 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 2.4.

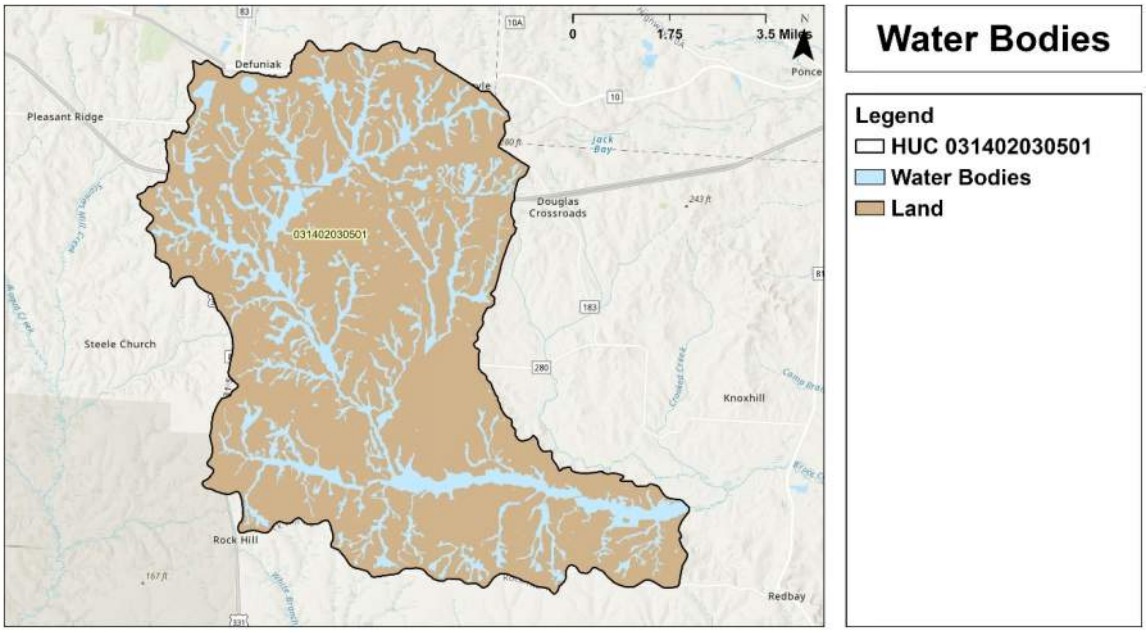

Figure 26. Water bodies map for the HUC 031402030501 sub-watershed, processed by FAU.

1.10. Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place.

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other

waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant

control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

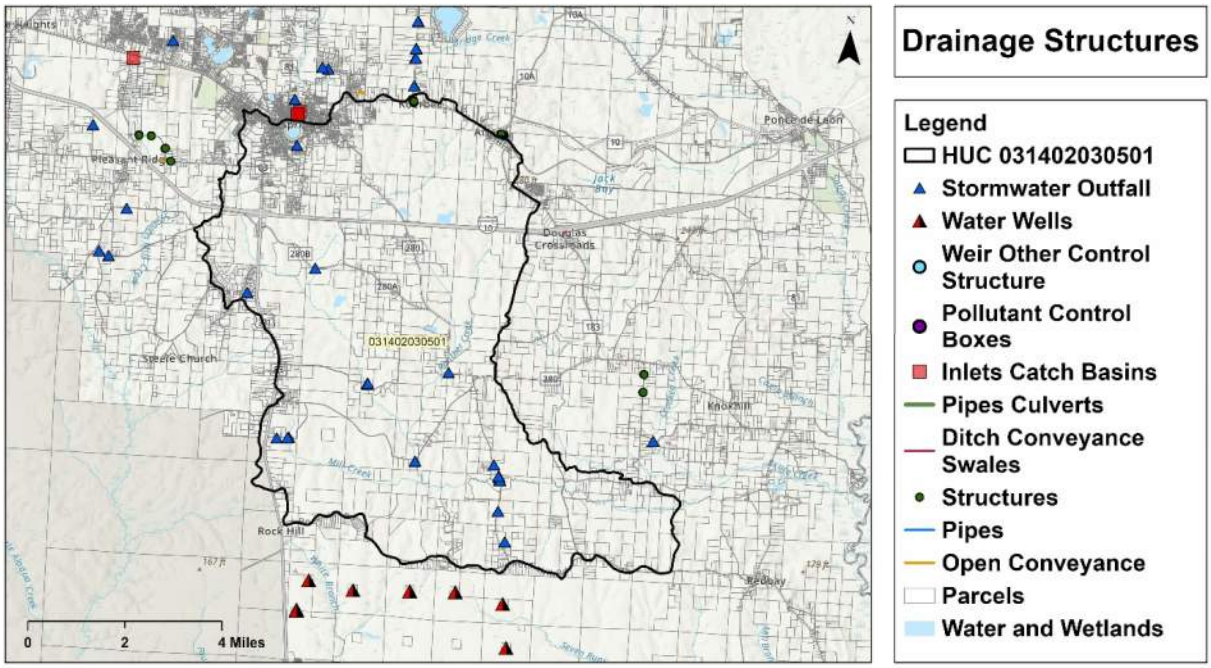

Figure 27. Stormwater Infrastructure for the HUC 031402030501. Processed by FAU.

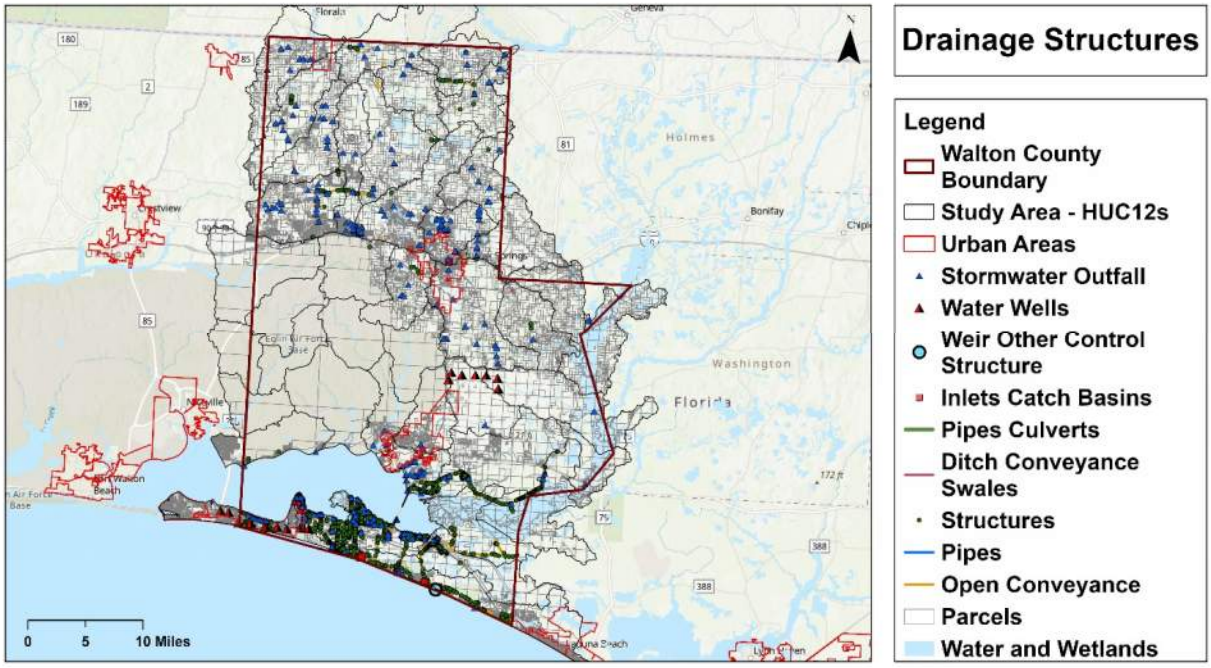

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020)

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031401030501 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. Figure 29 shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

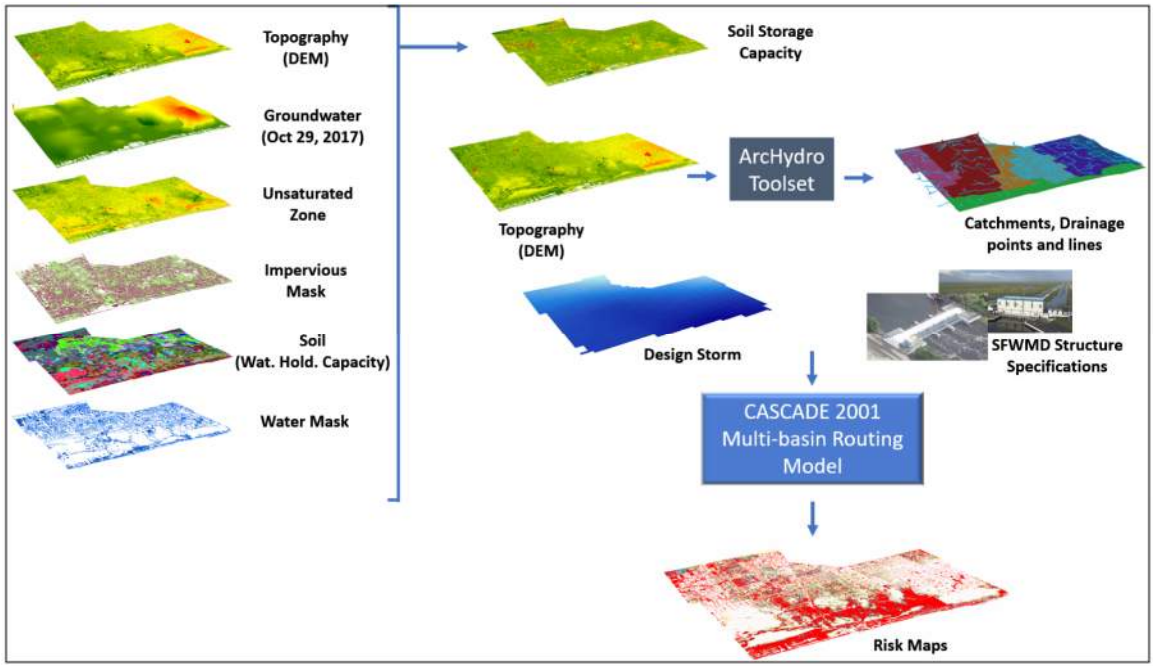

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)

= 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

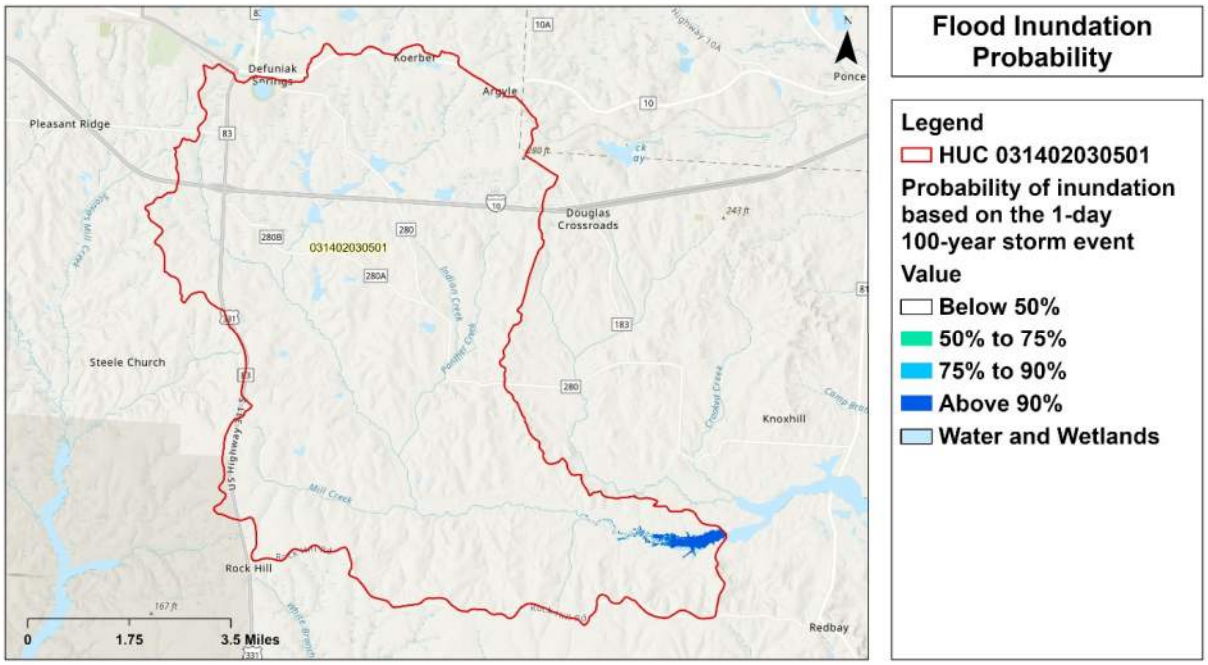

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031402030501, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data

to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.4 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a small portion of flooding is noted at the creek entrance to the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, the HUC is expected to remain unaffected by sea level rise, therefore SLR scenarios were not computed.

The design storm simulation determined that approximately 0.74% of the HUC total area or 0.41 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 0.51% of the HUC's total area, or 0.28 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 0.47% of the HUC's total area, or 0.26 mi^2, would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 0.39% of the HUC's total area, or 0.22 mi^2, would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031402030501 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	54.94	0.41	99.26%	0.74%
1-day 100-year	55.07	0.28	99.49%	0.51%
1-day 10-year	55.09	0.26	99.53%	0.47%
1-day 5-year	55.14	0.22	99.61%	0.39%

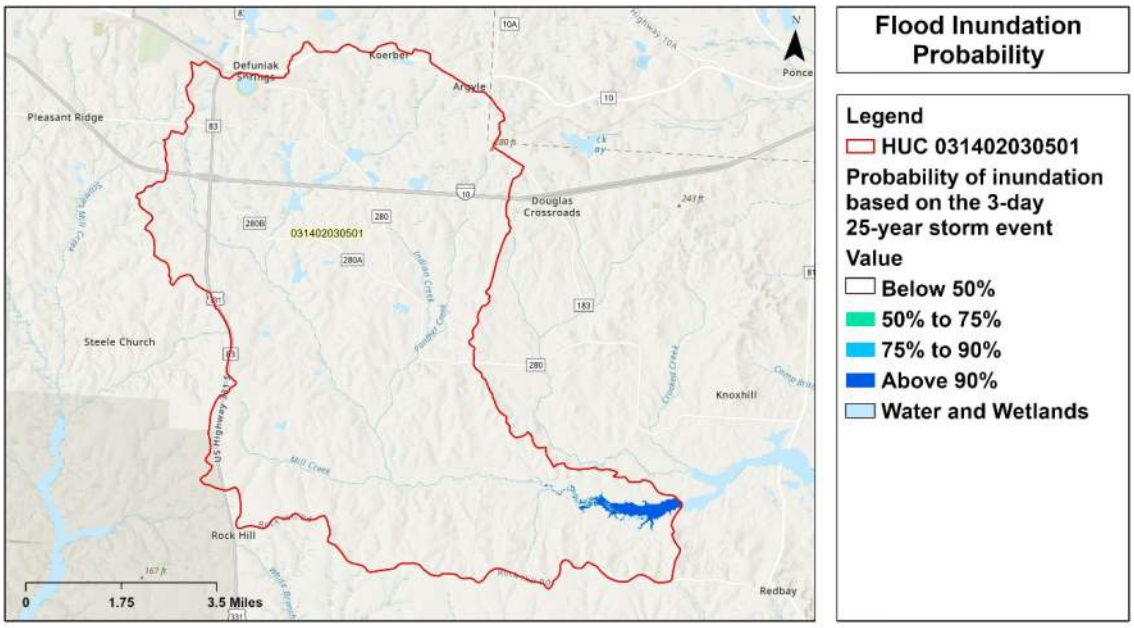

Figure 31. 3-day 25-year storm event for HUC 031402030501 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

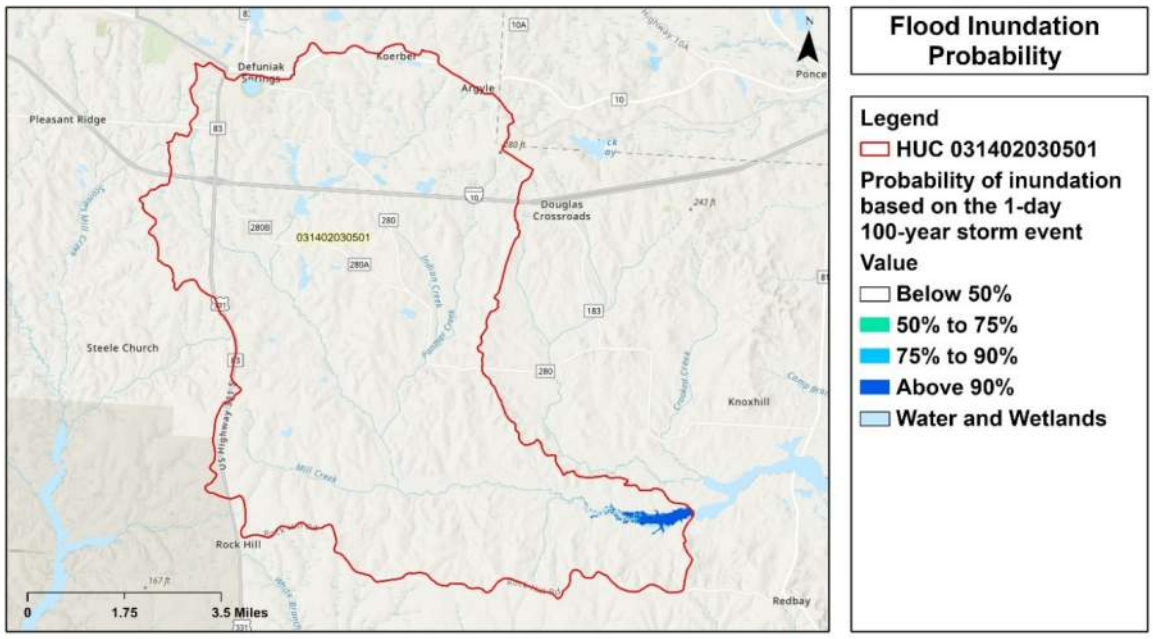

Figure 32. 1-day 100-year storm event for HUC 031402030501 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

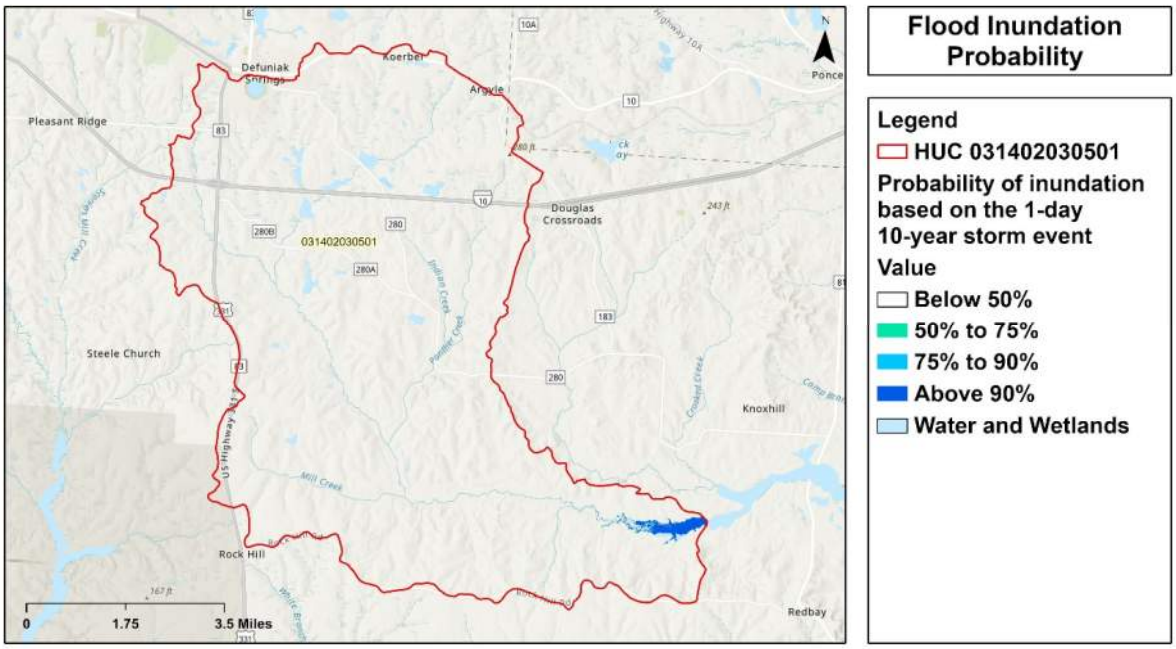

Figure 33. 1-day 10-year storm event for HUC 031402030501 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

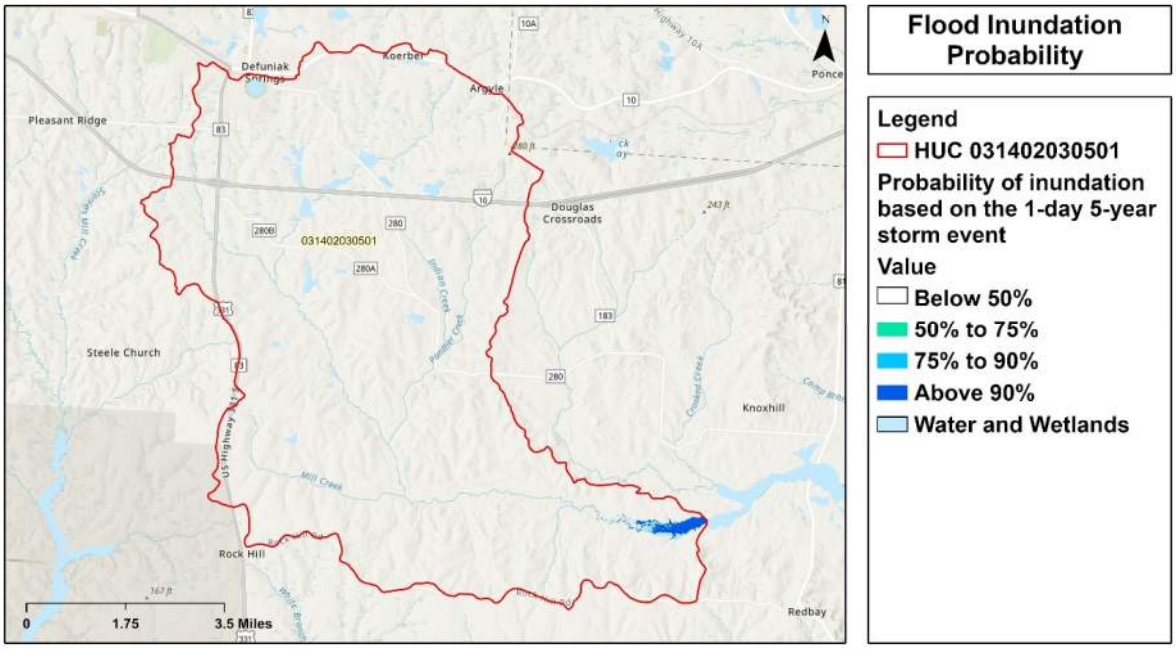

Figure 34. 1-day 5-year storm event for HUC 031402030501 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

2.5 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have

lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3

26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6

53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6

87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is

converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.5.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031402030501 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.**is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.**illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

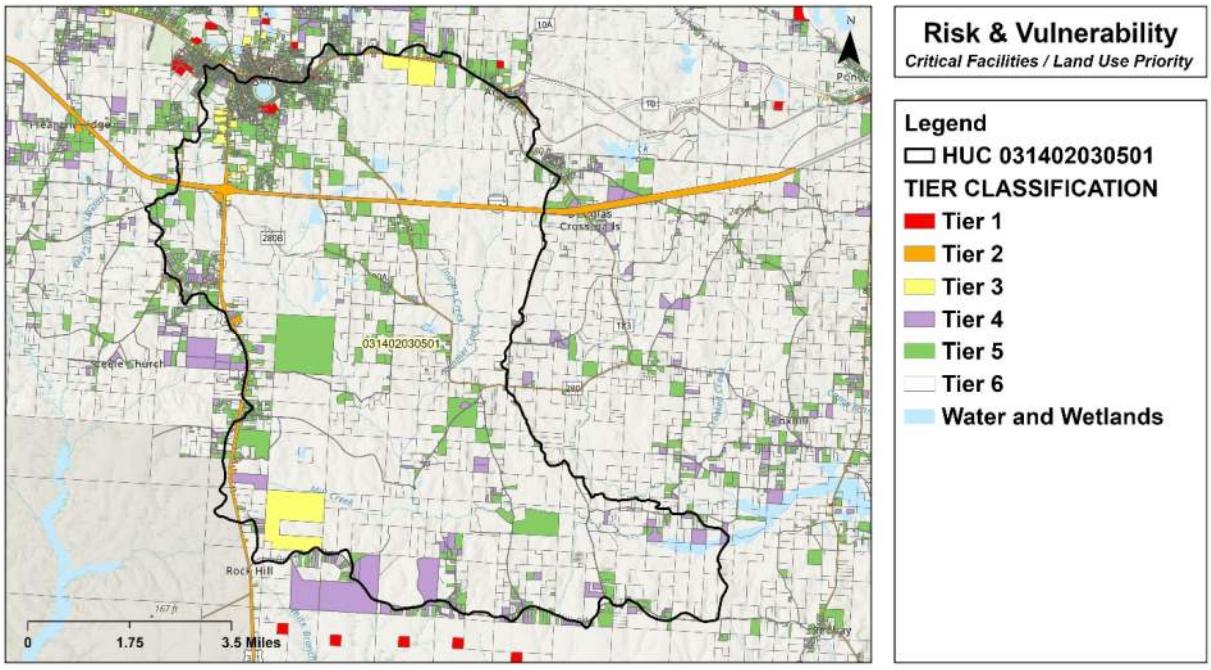

Figure 35. HUC 031402030501 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

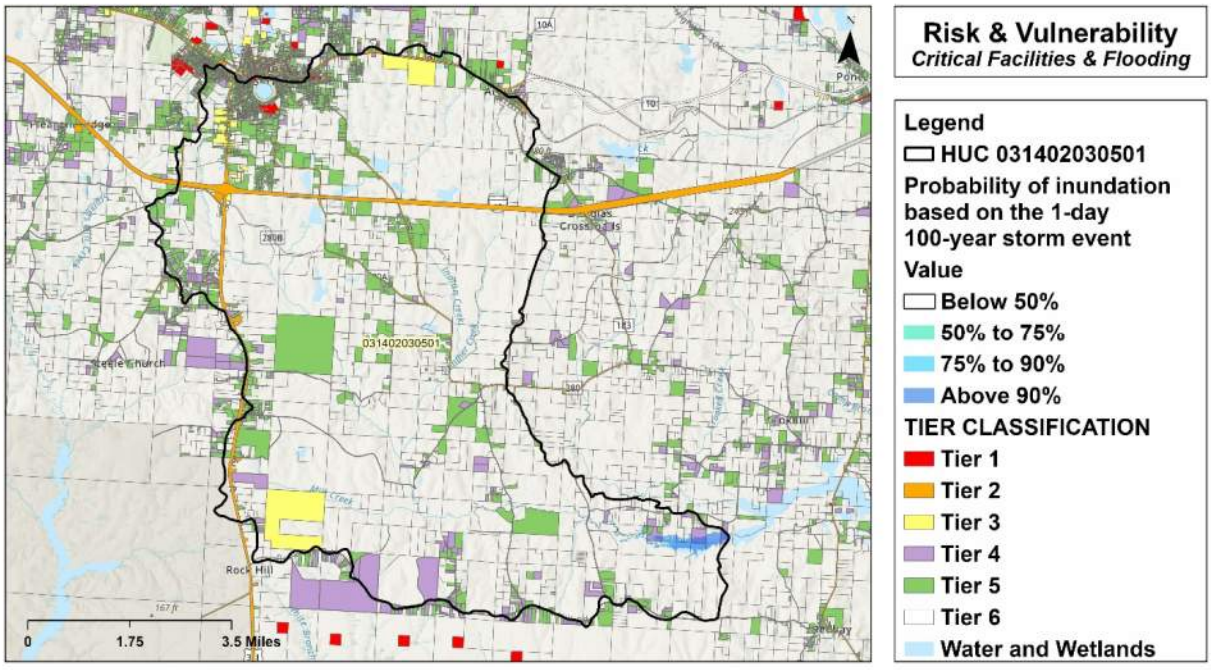

Figure 36. HUC 031402030501 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

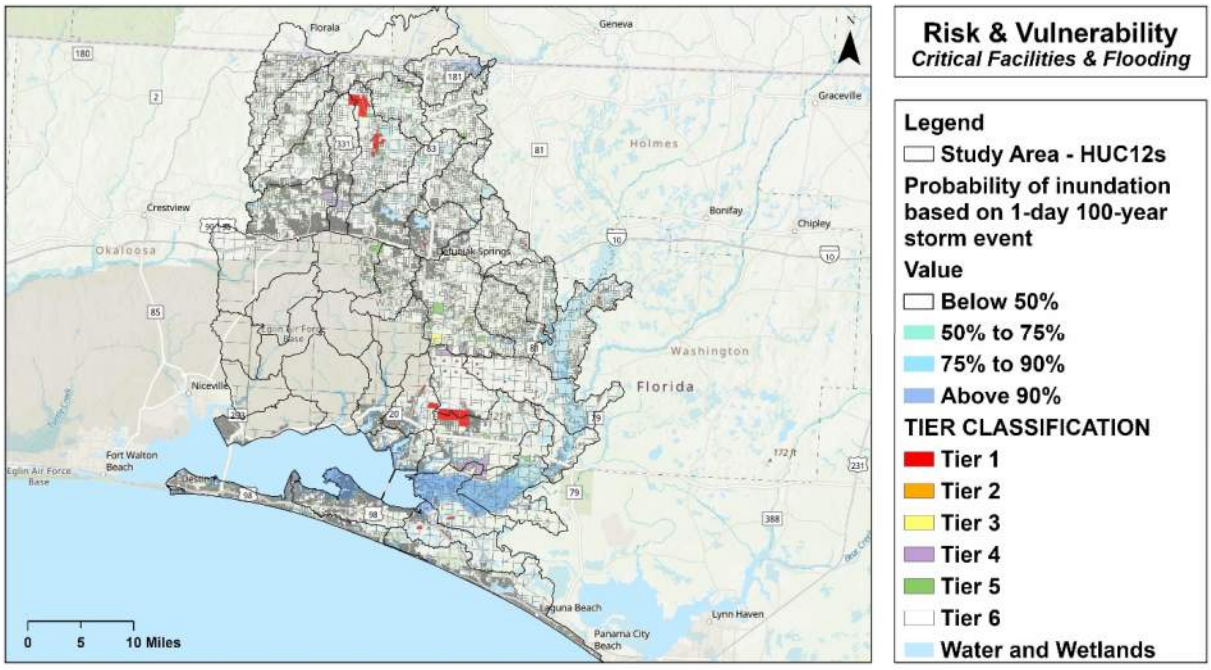

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

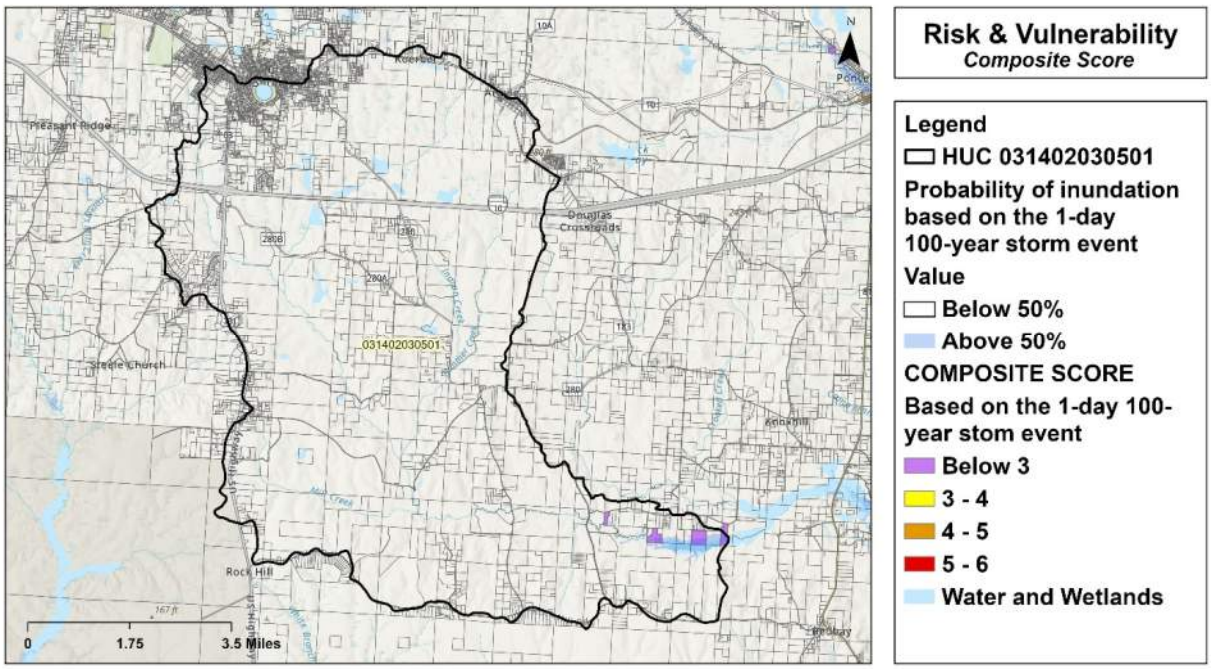

Figure 38. HUC 031402030501 sub-watershed Composite Score Risk map, with calculation based on 1-day 100-year storm event. Processed by FAU.

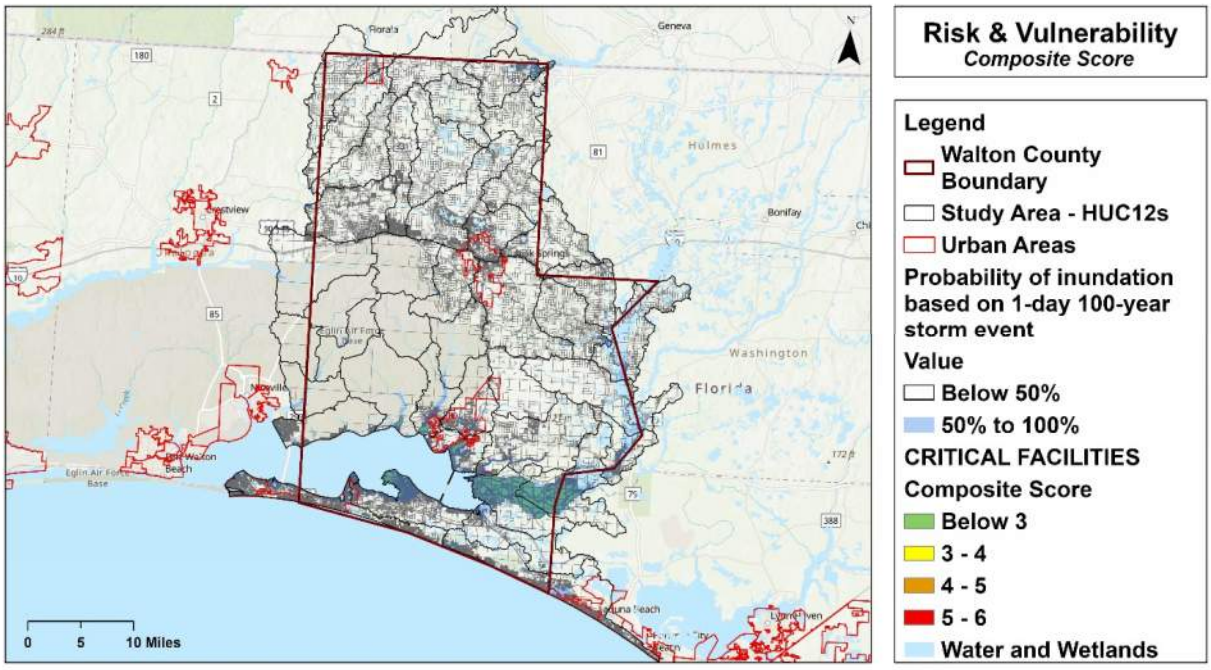

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.
Please note that due to the scale of the map, the composite score layer is not properly visible in this map.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

2.4.2 Drill-down – DeFuniak Springs

For enhanced visualization of the urban areas within this HUC 031402030501, **Error! Reference source not found.** to **Error! Reference source not found.** illustrate the same results for critical facilities (land use priorities) and composite scores, but on a reduced scale, which better facilitates the examination of finer details within the urban area (DeFuniak Springs). These maps cover both the 1-day 100-year scenario and the 1-day 100-year + 5 feet SLR scenario, although the results for Sea Level Rise is null due to distance of the basin to the coast and its high elevation.

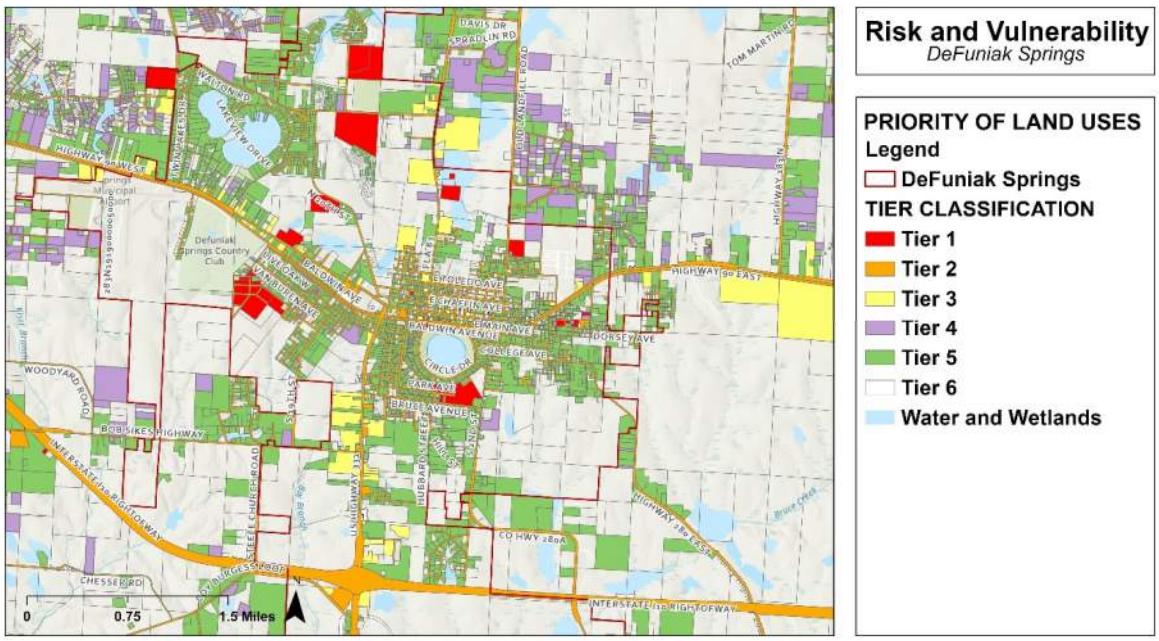

Figure 40. Critical Facilities (priority of land uses) map for DeFuniak Springs. Processed by FAU.

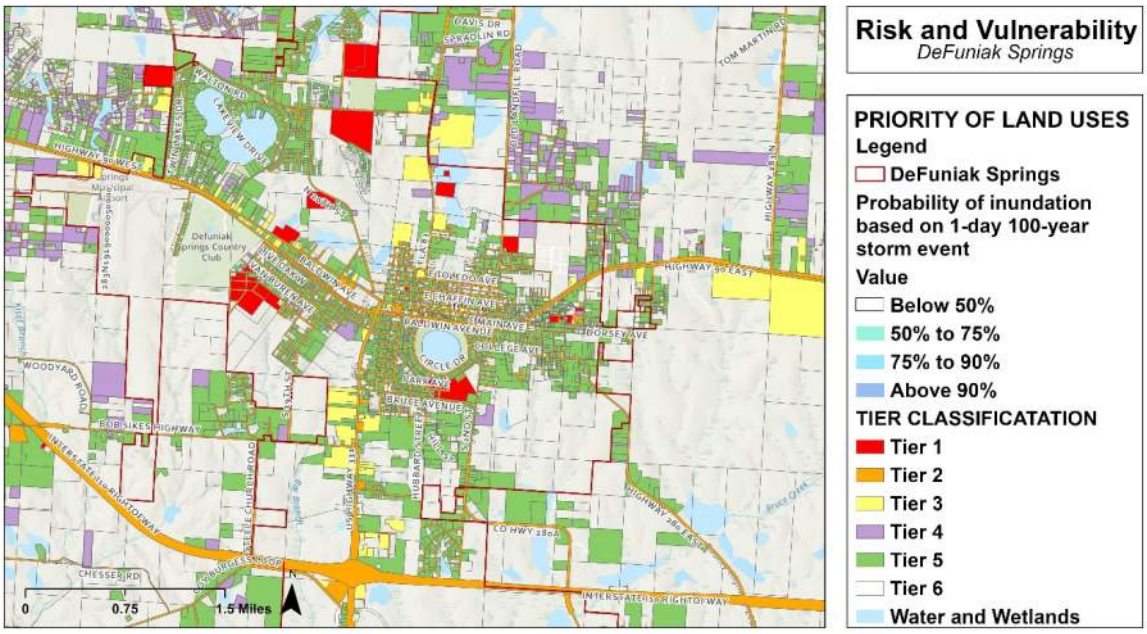

Figure 41. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event for DeFuniak Springs. Processed by FAU.

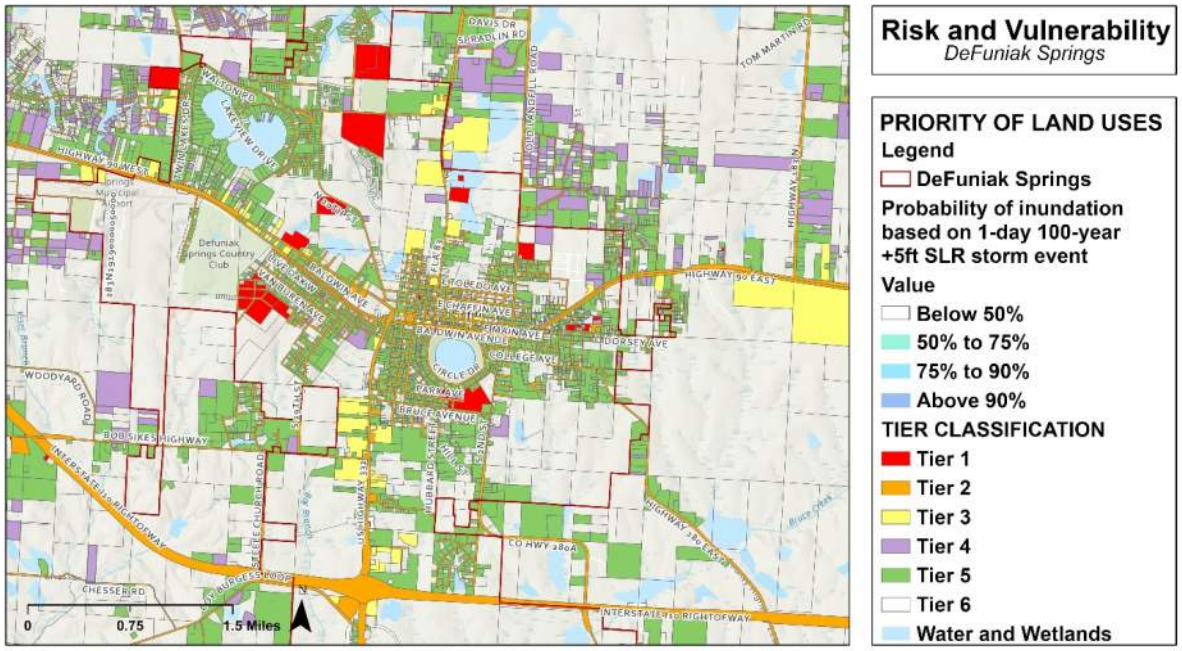

Figure 42. Critical Facilities (priority of land uses) map overlaid in the 1-day 100-year storm event + 5ft SLR for DeFuniak Springs. Processed by FAU.

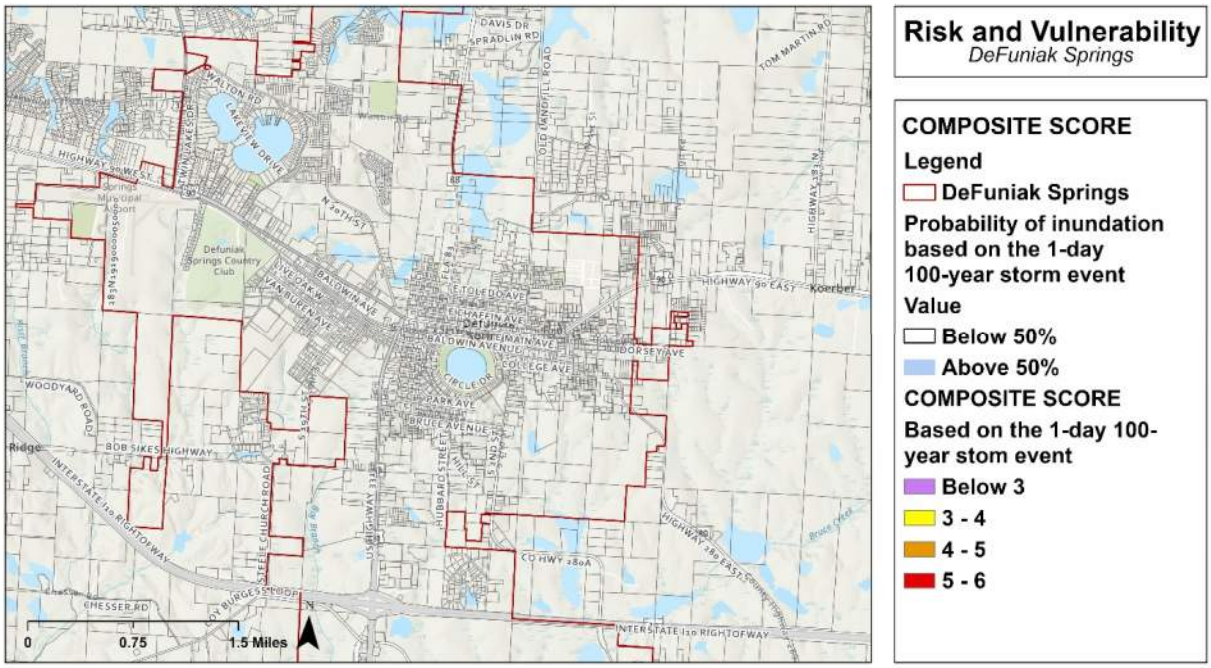

Figure 43. Composite Score map based on 1-day 100-year storm event, overlaid in flooding layer for DeFuniak Springs. Processed by FAU.

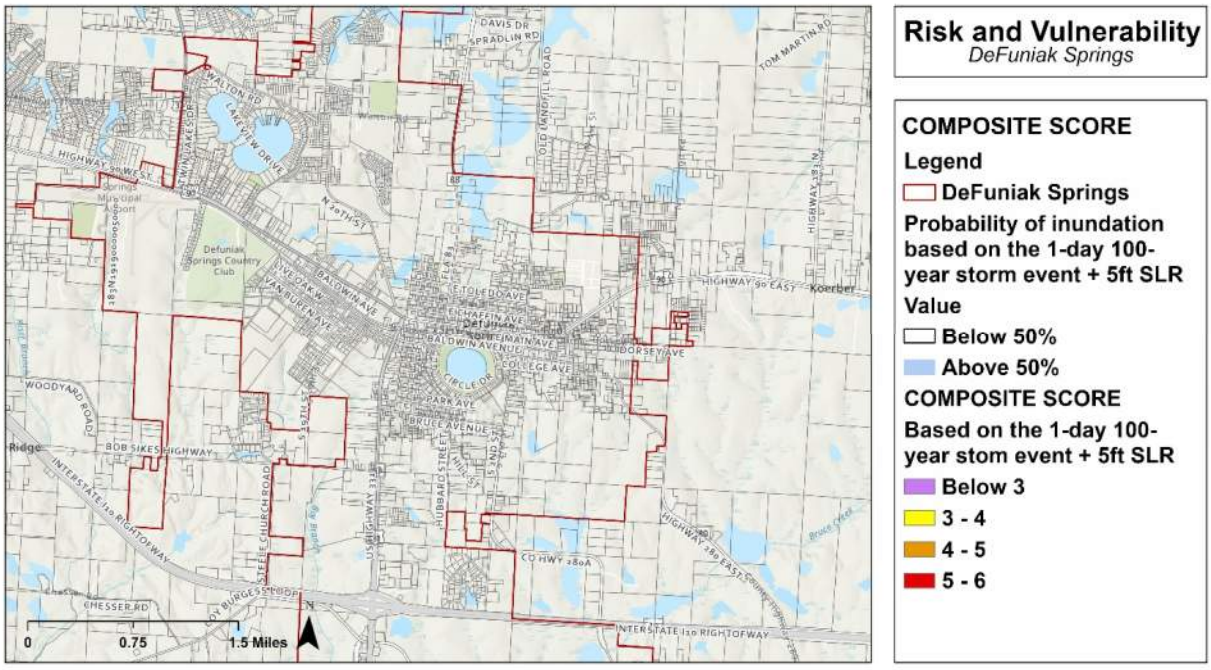

Figure 44. Composite Score map based on 1-day 100-year storm event + 5 feet SLR, overlaid in flooding layer for DeFuniak Springs. Processed by FAU.

The composite score results for this location are null, as the city of DeFuniak Springs shows no indication of flooding in both the 1-day 100-year and 1-day 100-year + 5ft SLR flooding scenarios.

2.5.3 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031402030501. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**.. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.5.4 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It is important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands: This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands: In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031402030501. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031402030501	35426.35
All of the 1-day 100-year storm event inundation	**180.41**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	89.61
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	0.00
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	90.81
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	90.81

2.5.5 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. Figure 45 indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

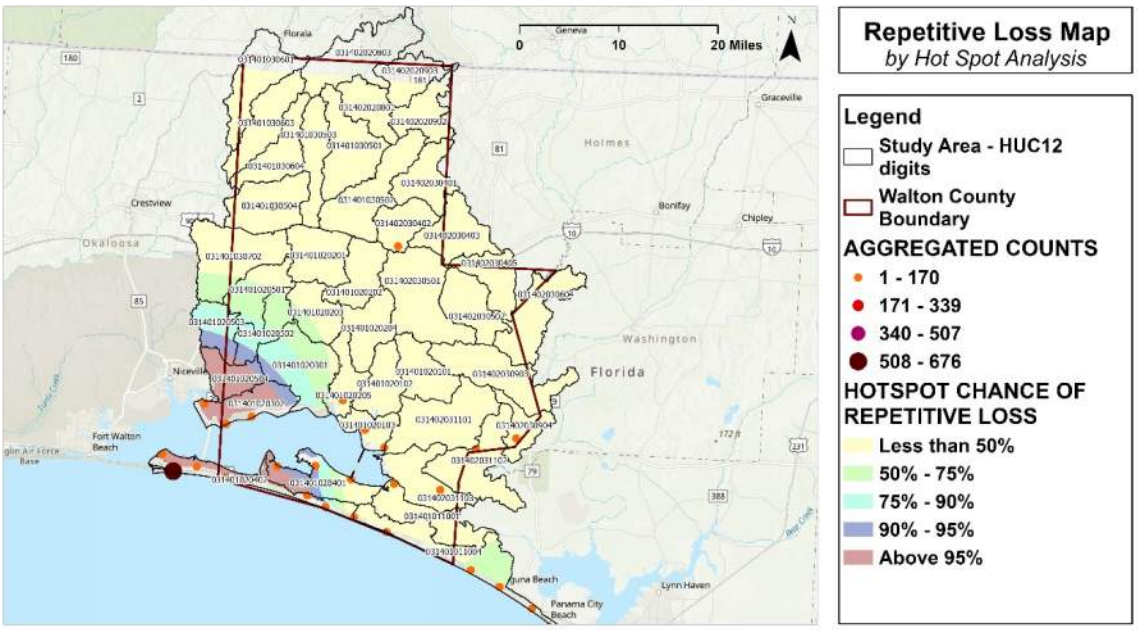

Figure 45. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.5.6 Priority Projects

Although the basin features a significant amount of developed land, including a portion of the city of DeFuniak Springs, only a few of them are within the flooding zone, once flooding in the area is relatively minor and not alarming. Consequently, when considering the composite score, it is notable that most of the results are null. There are only five exceptions within the basin: one road (Walton Bridge Rd) within score 3-4, and four mobile homes, with score below 3.

APPENDIX AJ

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031402030502

LOWER BRUCE CREEK]

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031402030502) is highlighted among all the HUCs to help identifying its location. (Figure 3).

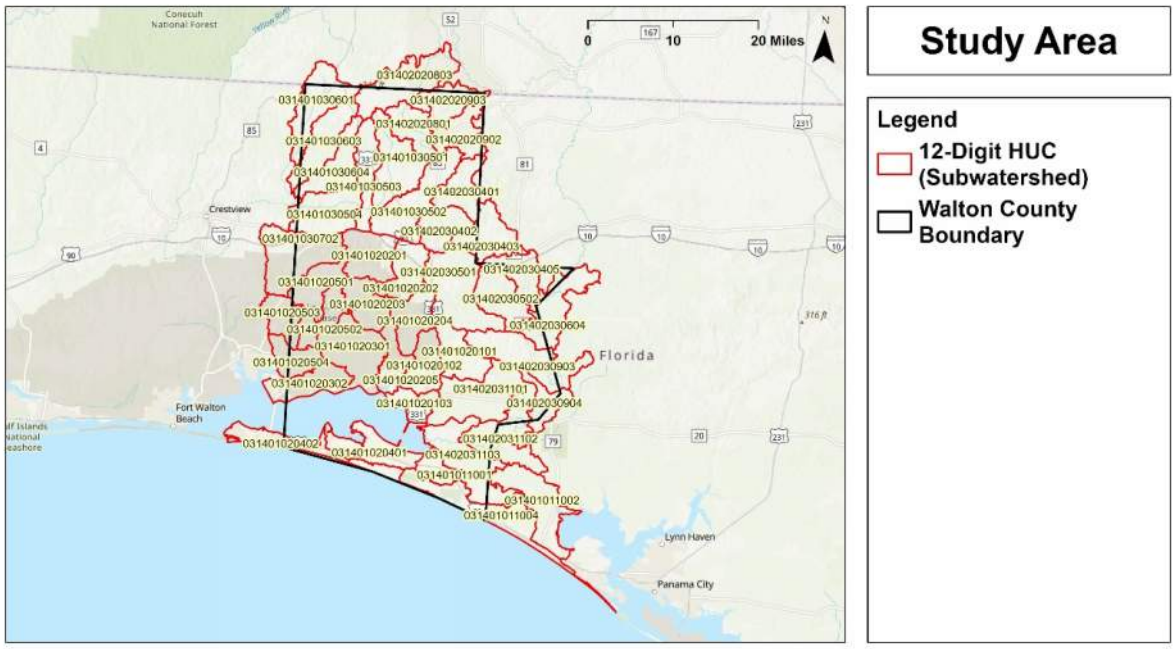

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

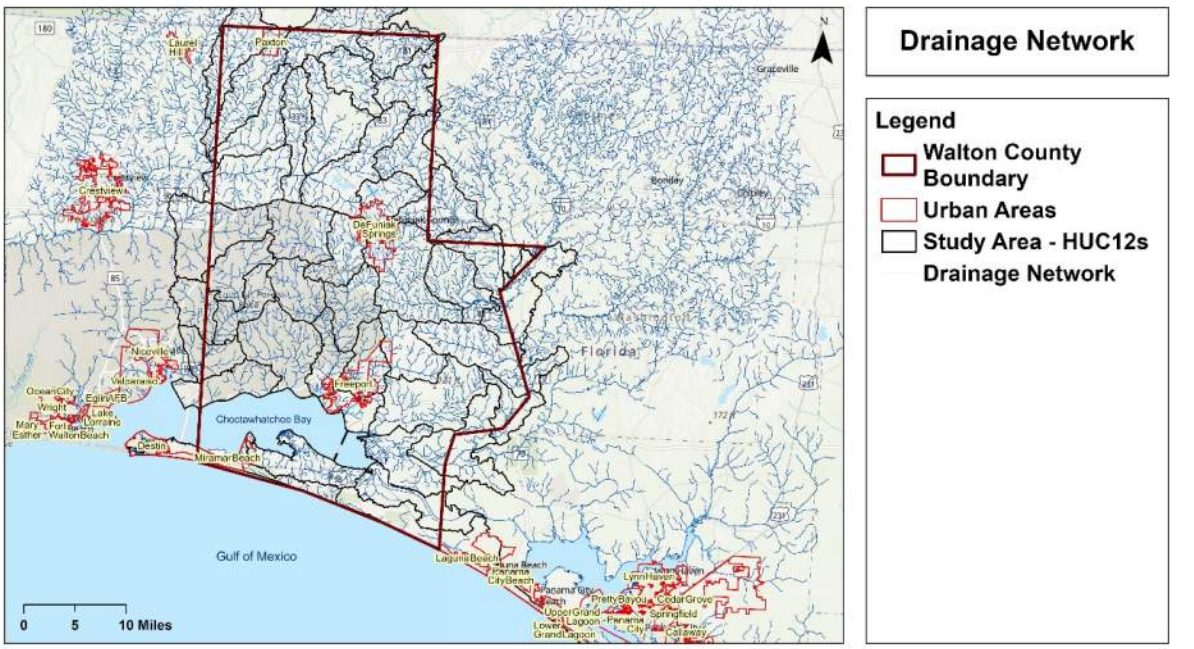

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

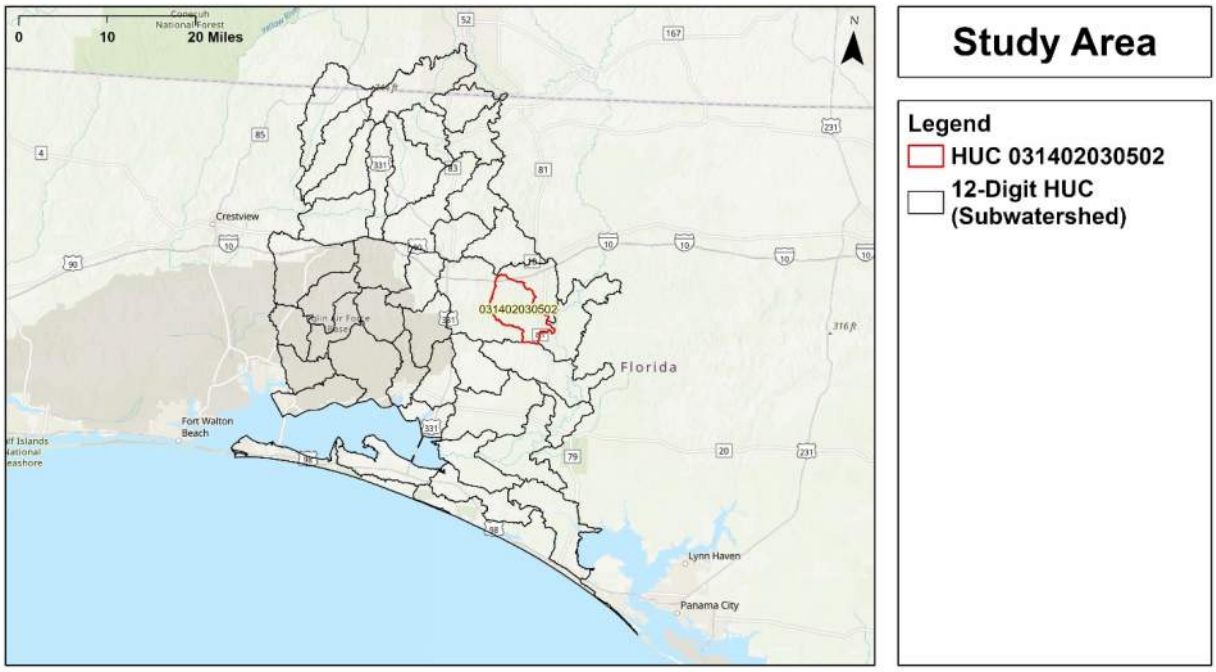

Figure 3. HUC 031402030502 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Based on the future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to

understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

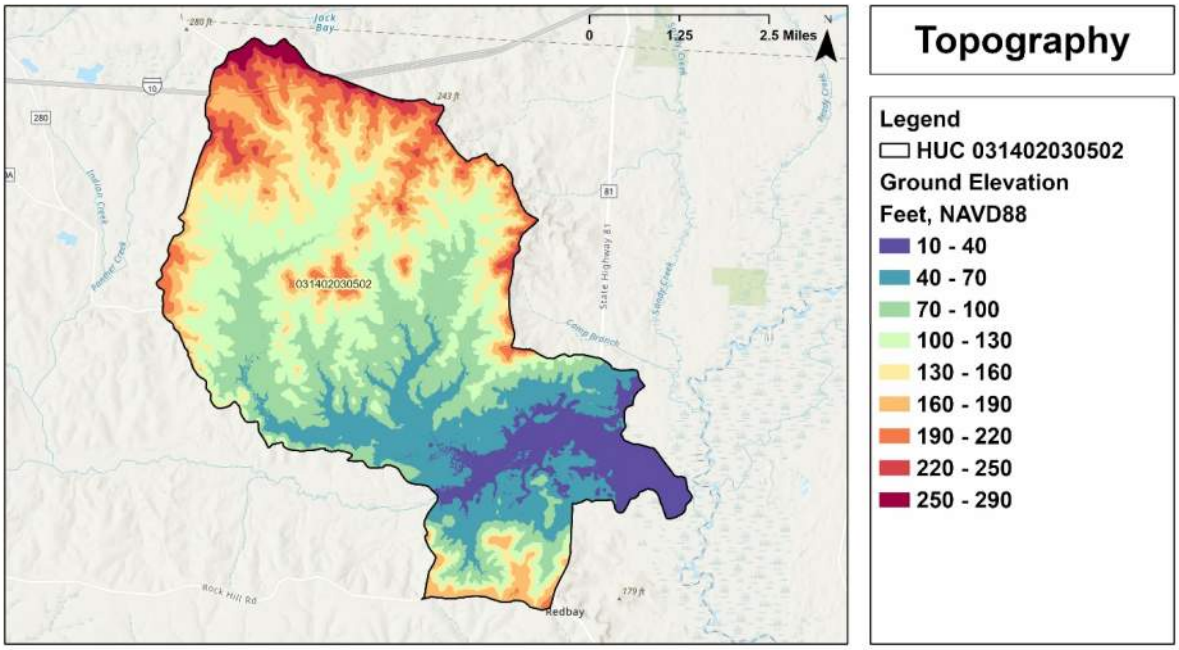

Figure 4. Topographic map of the HUC 031402030502 sub-watershed, processed by FAU.

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of

wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031402030502 sub-watershed is shown in **Error! Reference source not found.**.

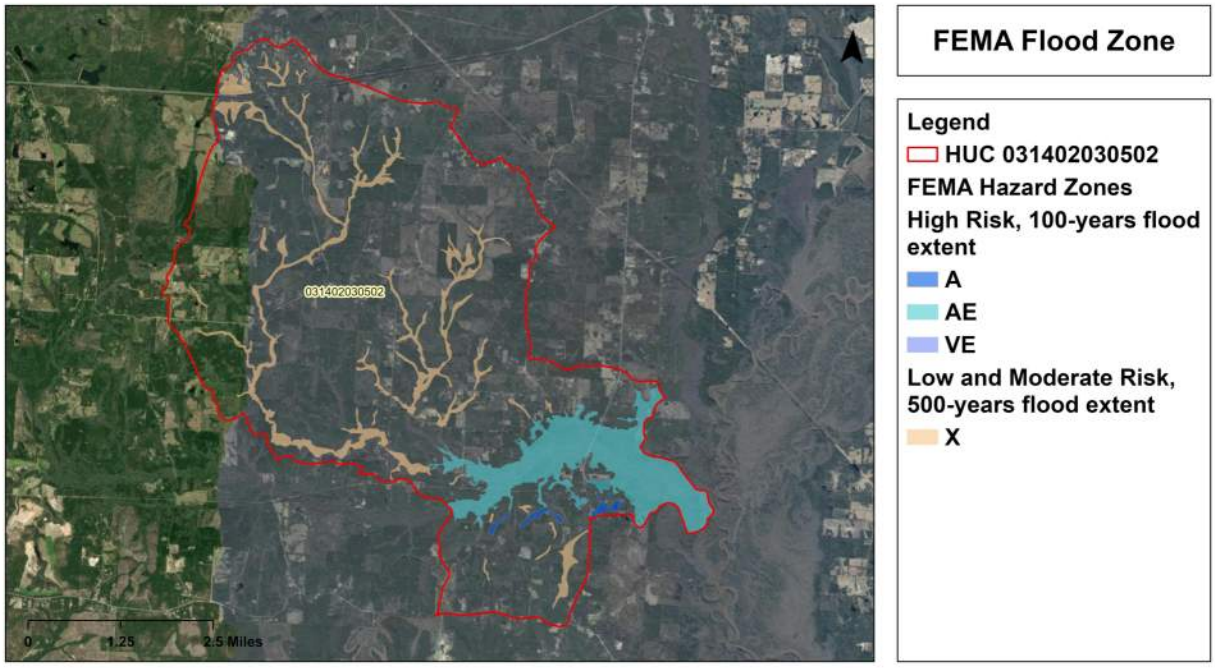

Figure 5. FEMA Flood Zone map (2020) for HUC 031402030502 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination

between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031402030502 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

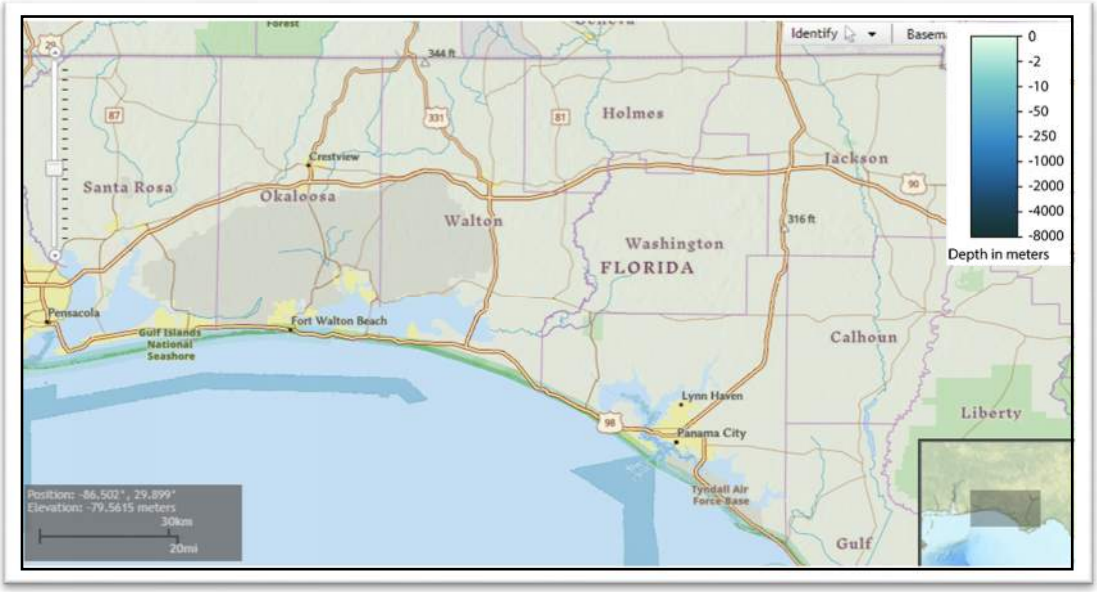

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle. Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological

conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

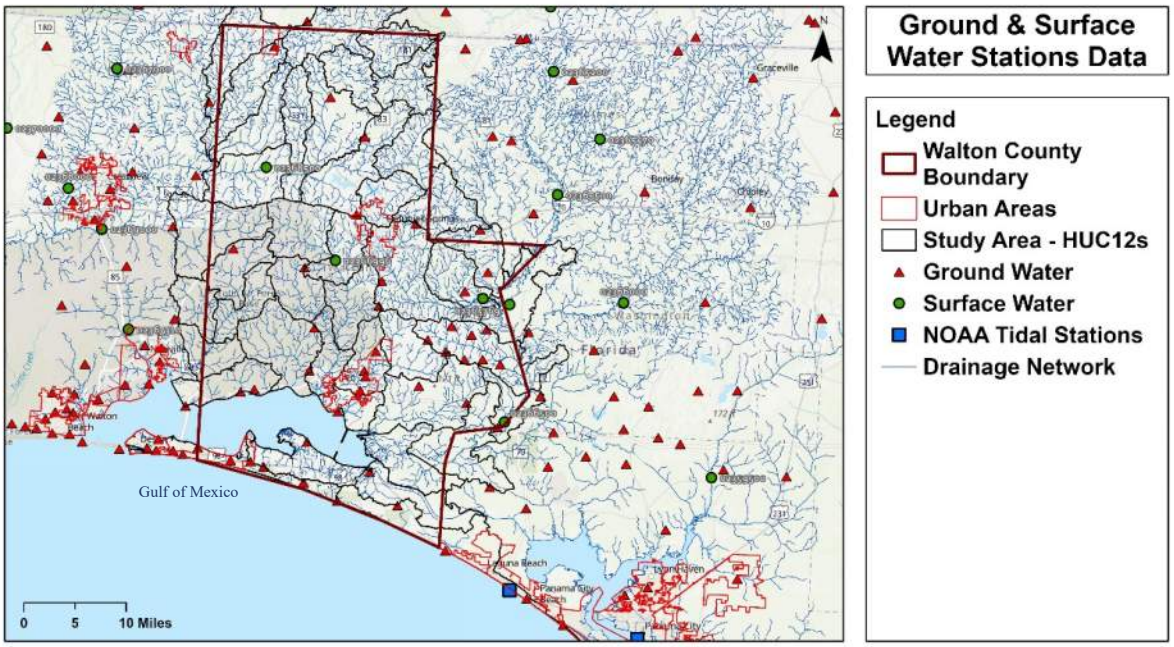

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The HUC 031402030502 has no major rivers and canals, but creeks and branches, include:

- Bruce Creek
- White Creek

- Crooked Creek
- Spears Branch
- Days Branch
- Otter Branch
- Folks Creek
- Goose Branch
- Days Branch
- Spears Branch
- Hunter Branch
- McKinnon Branch

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02365769 - Bruce Creek at SH 81 NR Redbay, FL, located inside the basin 031402030502 limits.

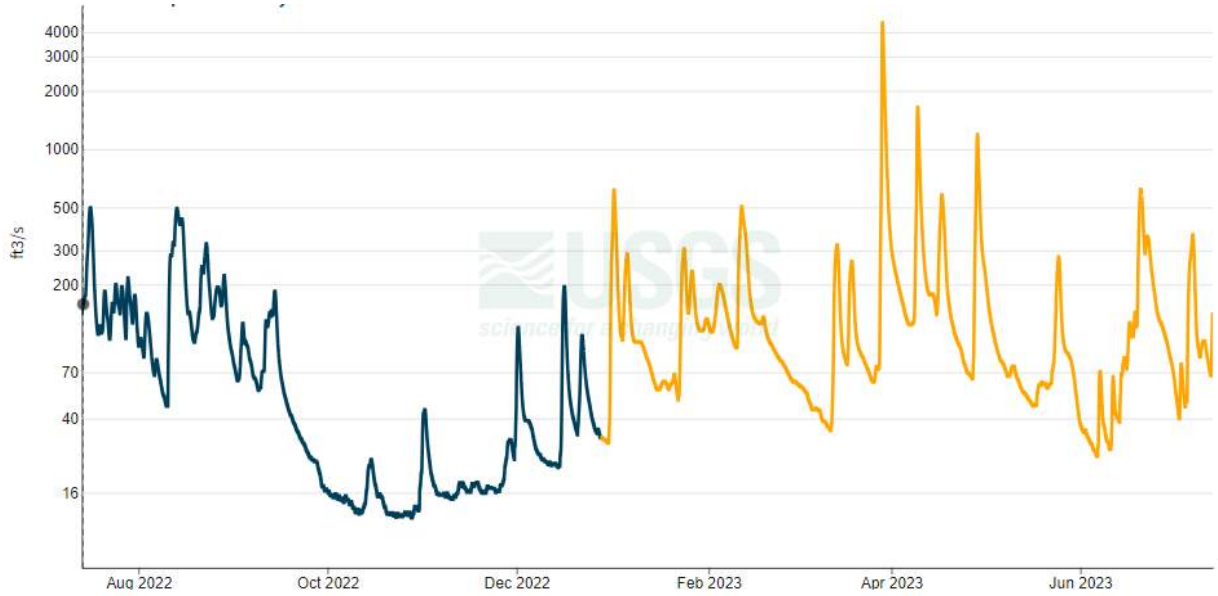

Figure 8. Average streamflow for Bruce Creek at SH 81 NR Redbay, FL (USGS 02365769 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02365769/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure

detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031402030502 and points out the location of the ground water station in the surroundings. A groundwater-surface layer for the HUC 031402030502 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

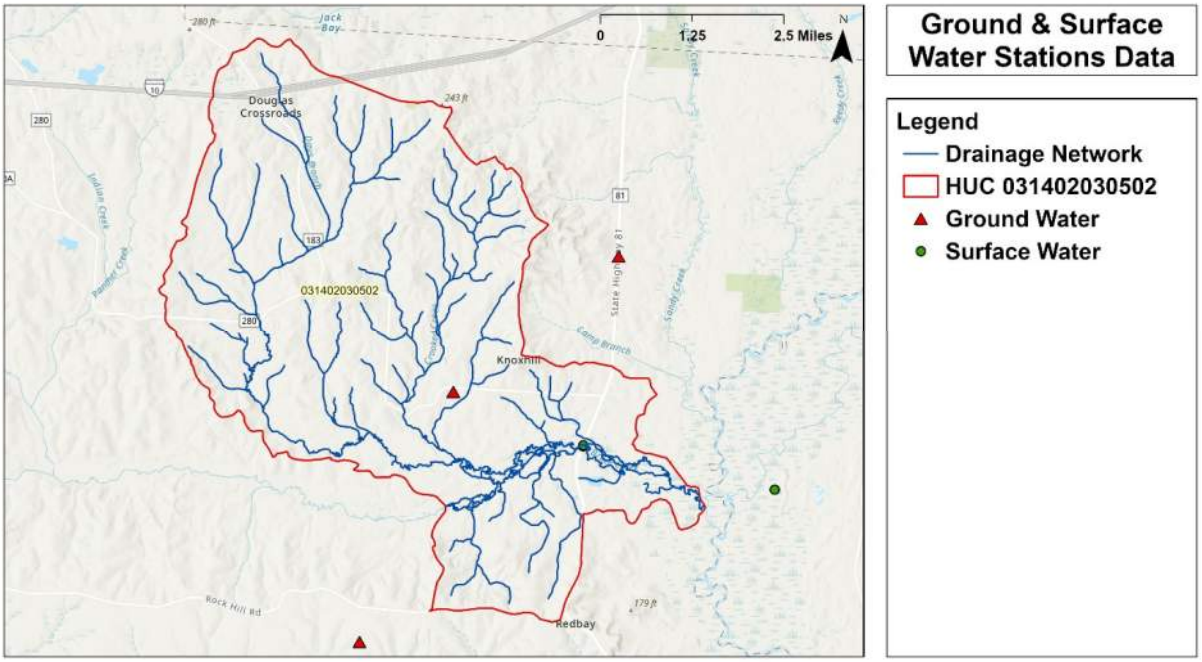

Figure 9. Ground and Surface Water Stations in the HUC 031402030502 sub-watershed, processed by FAU.

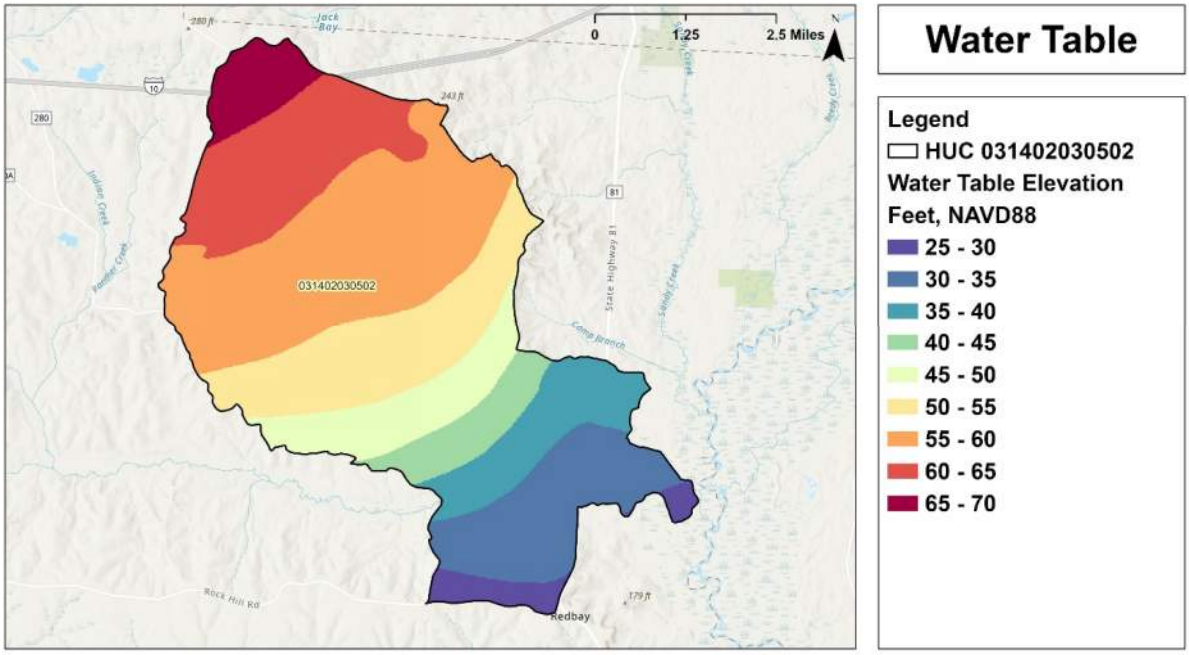

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031402030502 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

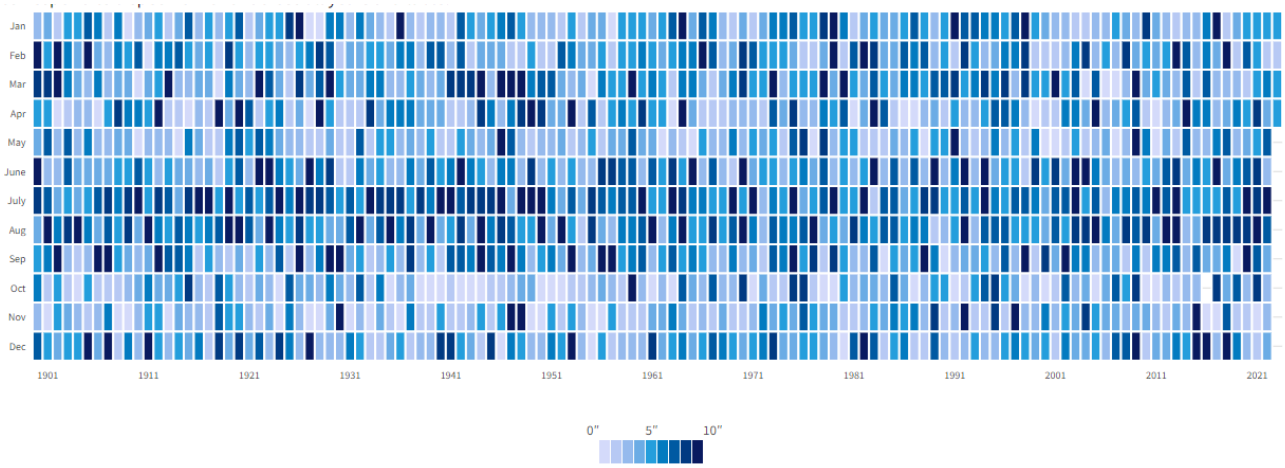

Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/).

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

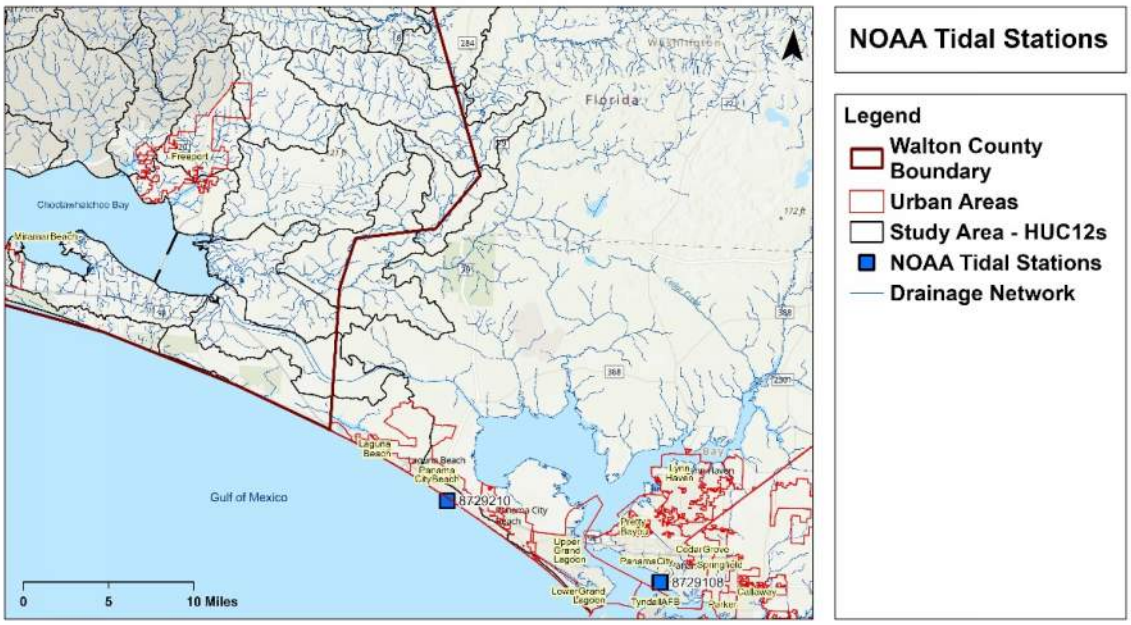

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

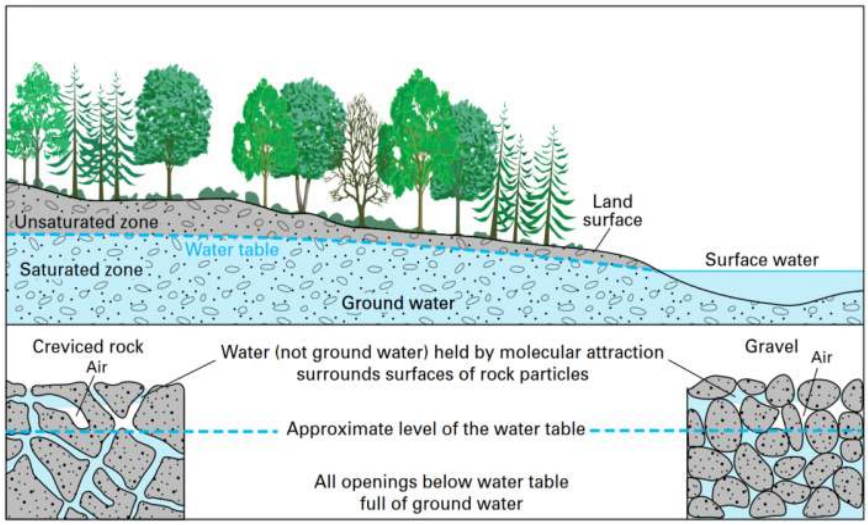

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

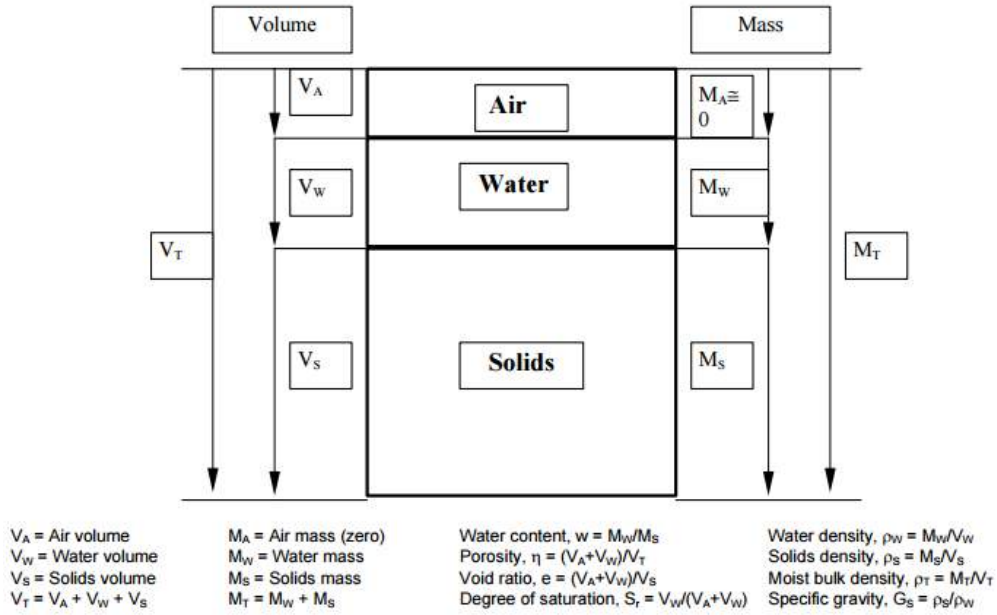

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

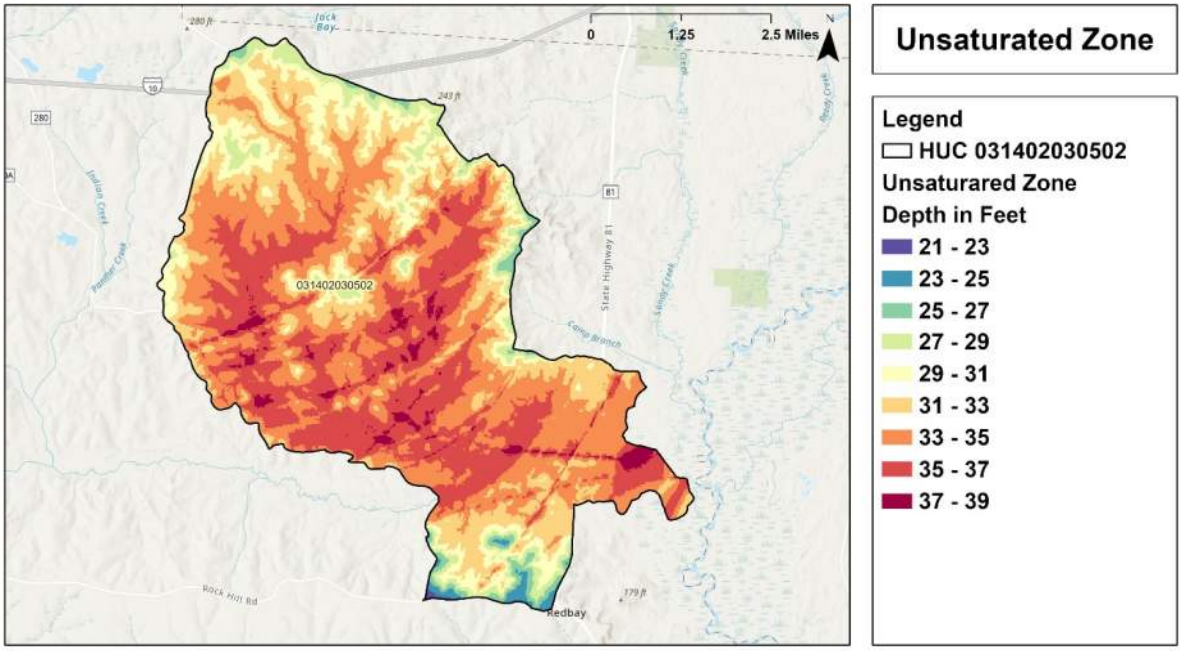

Figure 15. Unsaturated zone map for HUC 031402030502, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately favorable soil storage capacity, falling within the range of 29 to 37 feet of remaining capacity.

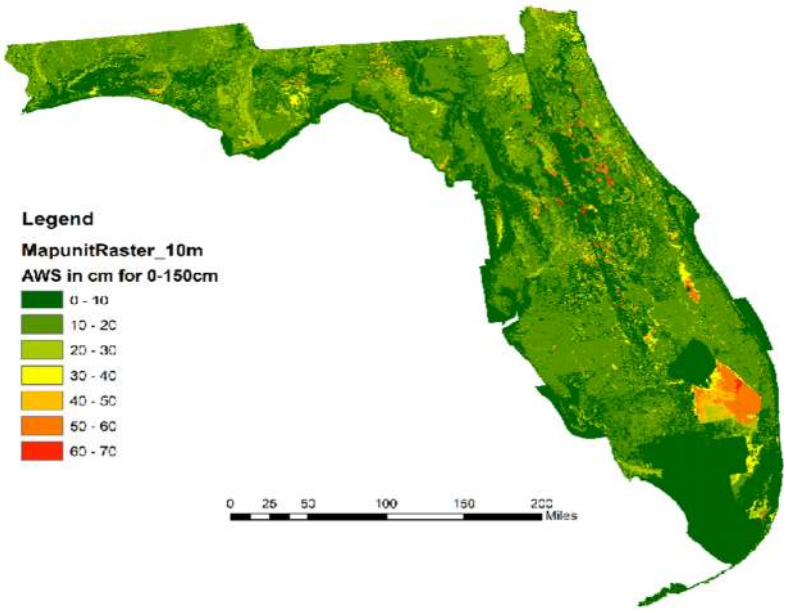

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

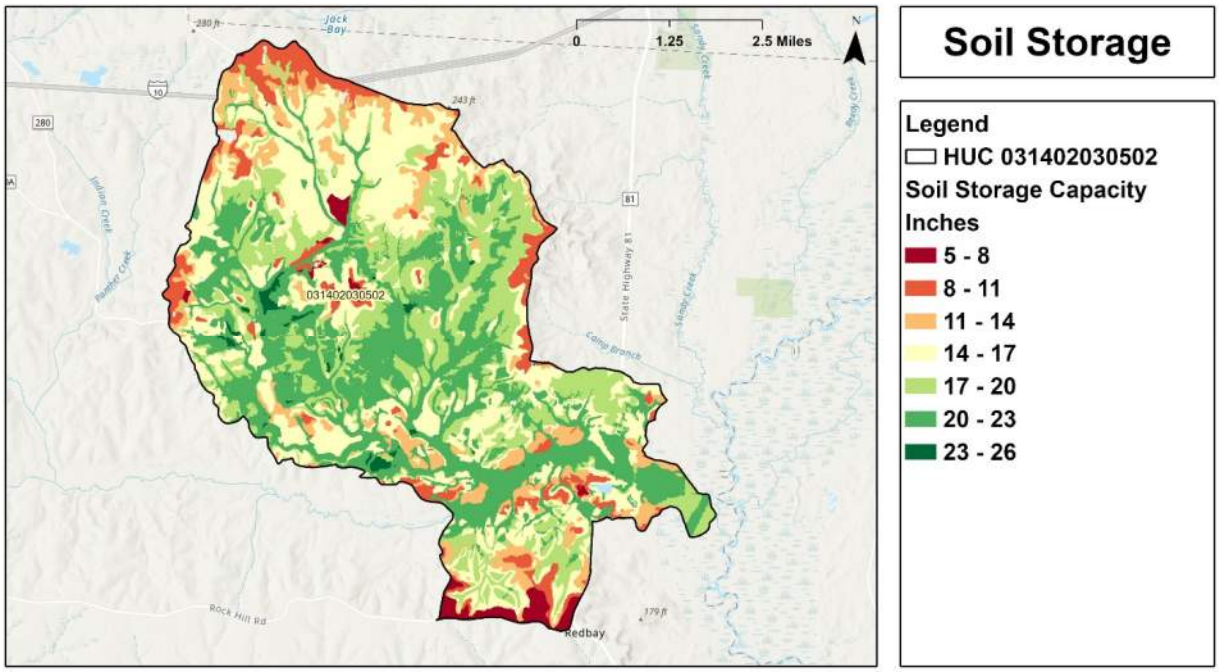

Figure 17. Water storage capacity of soil for the HUC 031402030502, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

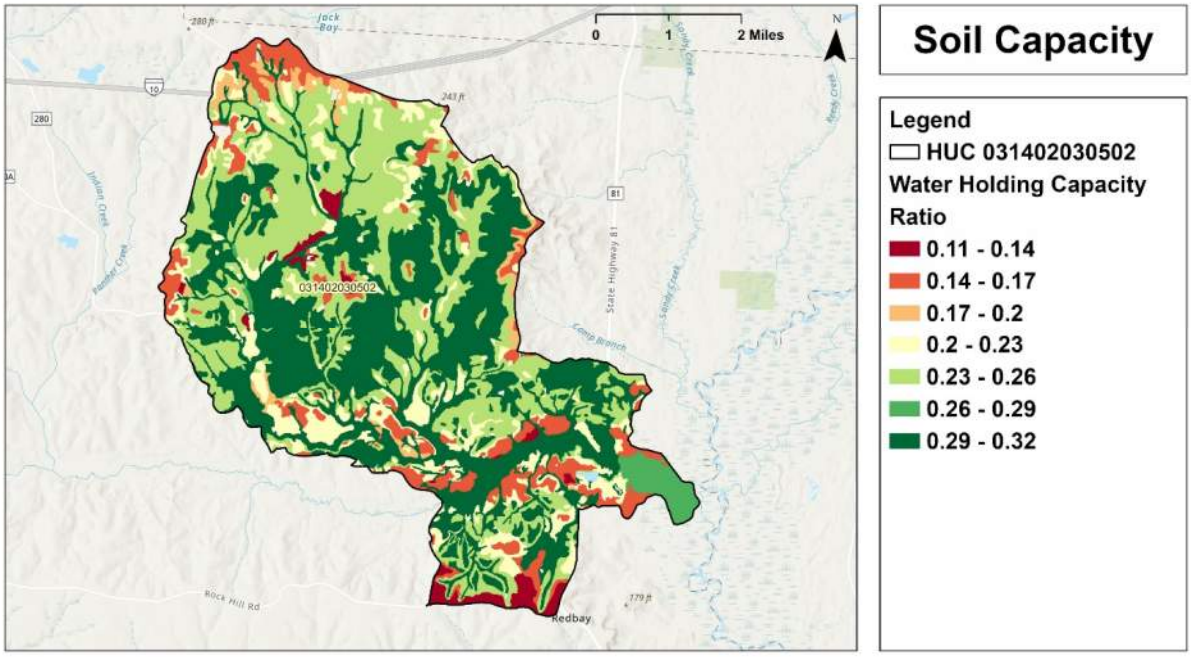

Figure 18: Water Holding Capacity (ratio) for the HUC 031402030502, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

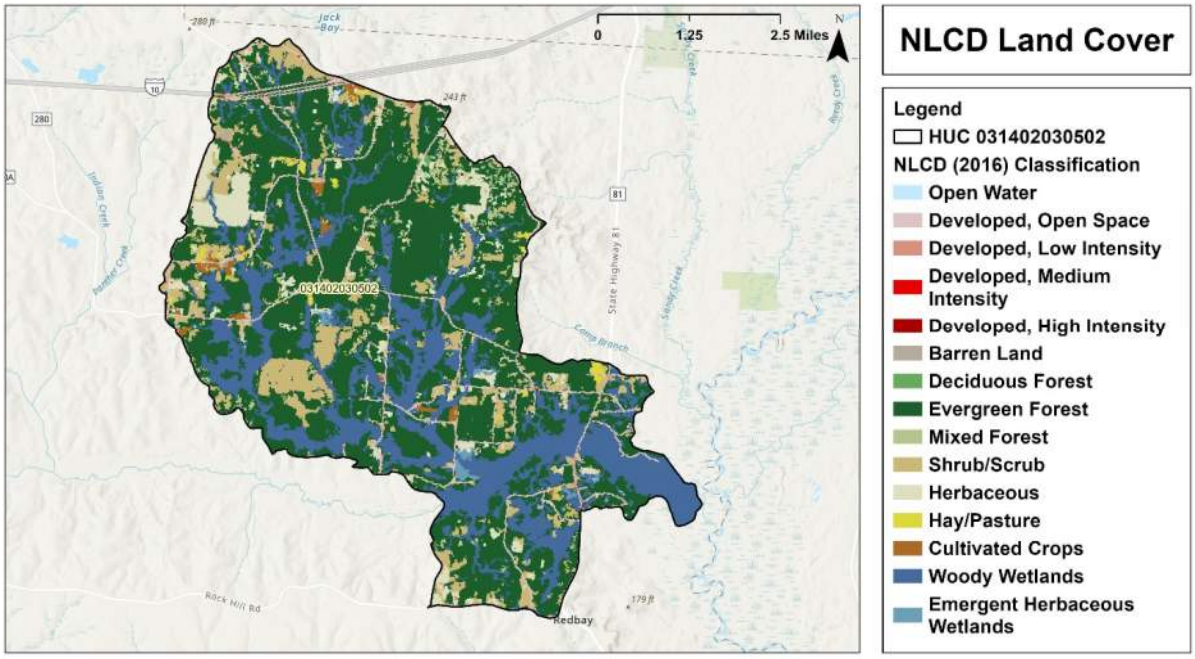

Figure 19. Land use in the HUC 031402030502 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

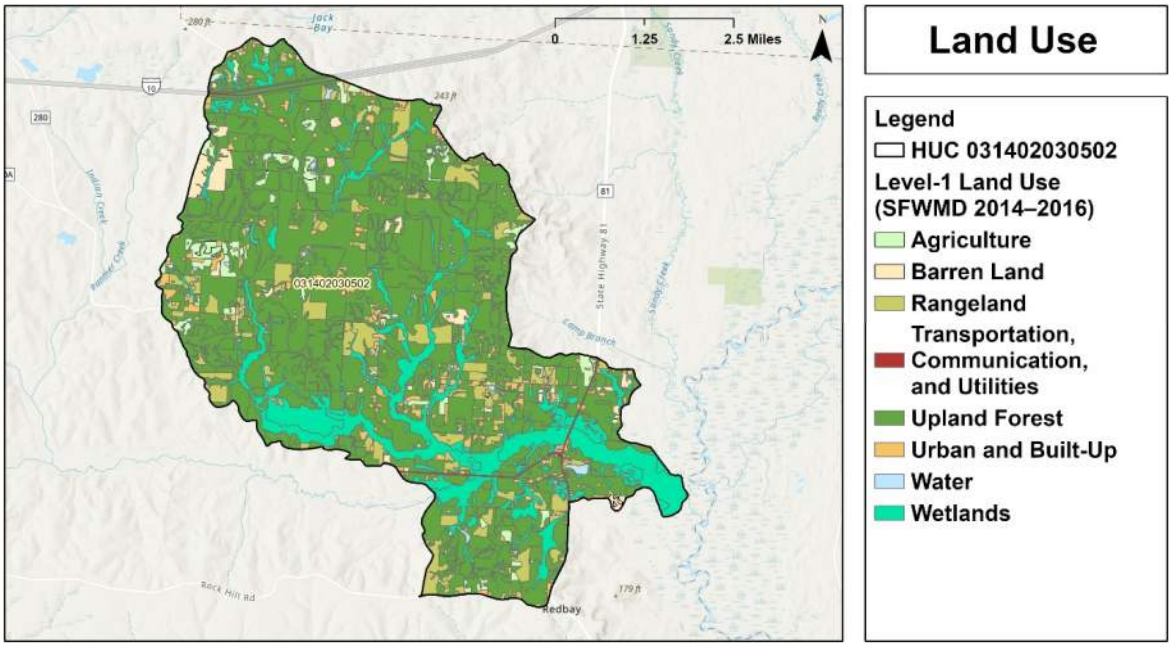

Figure 20. Land use in the HUC 031402030502 (from the 2023 Florida Geographic Data Library (FGDL)), processed by FAU.

In the HUC 031402030502 sub-watershed, the predominant land cover is upland forest, accounting for 55.58% of the area. Wetlands comes in second at 11.79%, followed by water at 9.95%, and Transportation, Communication, and Utilities at 9.25%. Developed land constitutes a minor portion, with only 3.03% categorized as urban and built-up, as indicated in Table 3 below.

Table 3. Land use for HUC 031402030502 subwatershed 2023 Florida Geographic Data Library (FGDL).

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	1002.48	3.29%
Barren Land	463.41	1.52%
Rangeland	1704.65	5.59%
Transportation, Communication, and Utilities	2821.95	9.25%
Upland Forest	16947.87	55.58%
Urban and Built-Up	922.76	3.03%
Water	3033.80	9.95%
Wetlands	3595.27	11.79%
Grand Total:	**30492.20**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

2.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

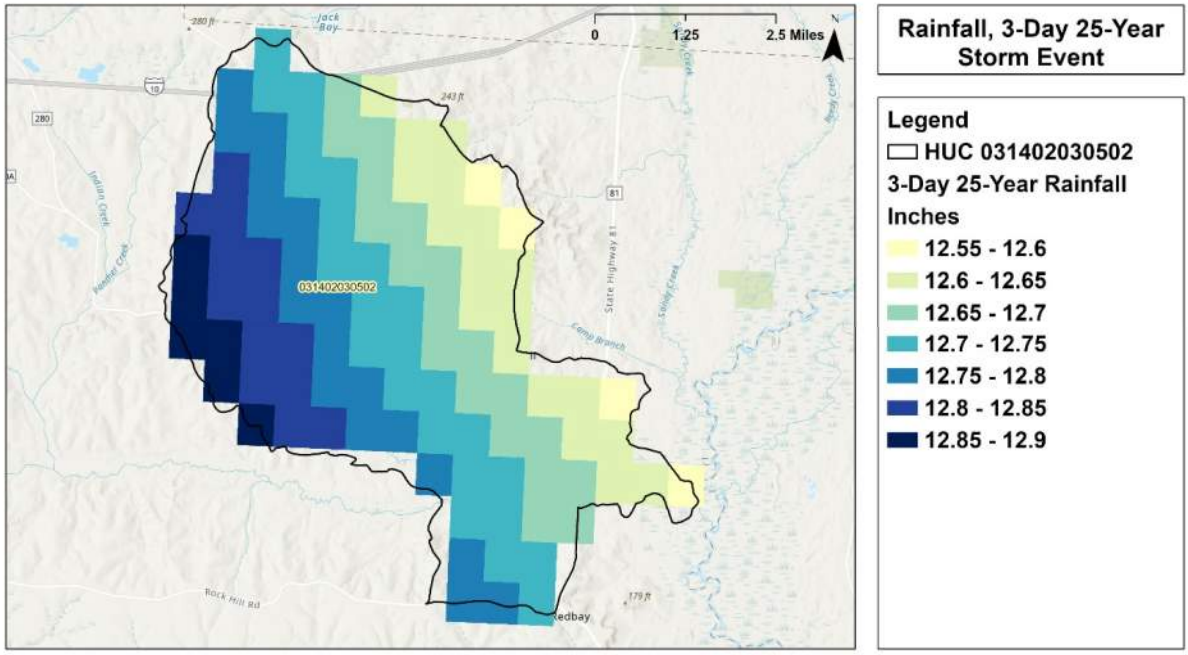

Figure 21. Rainfall distribution map across HUC 031402030502 sub-watershed, for 3-day 25-year storm event, processed by FAU.

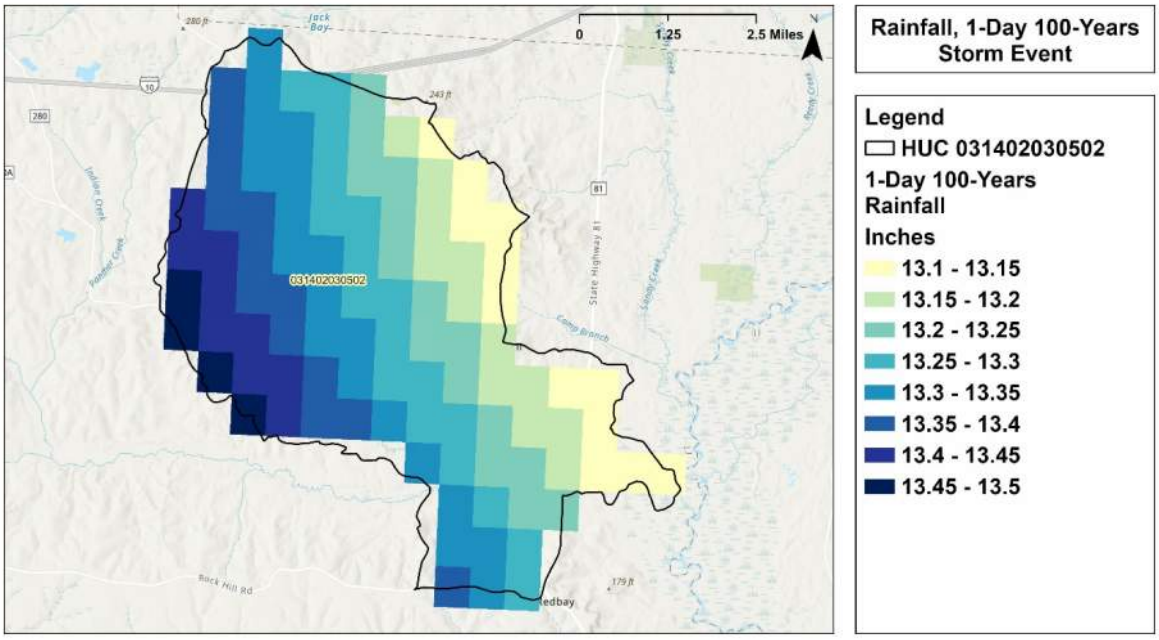

Figure 22. Rainfall distribution map across HUC 031402030502 sub-watershed, for 1-day 100-year storm event, processed by FAU.

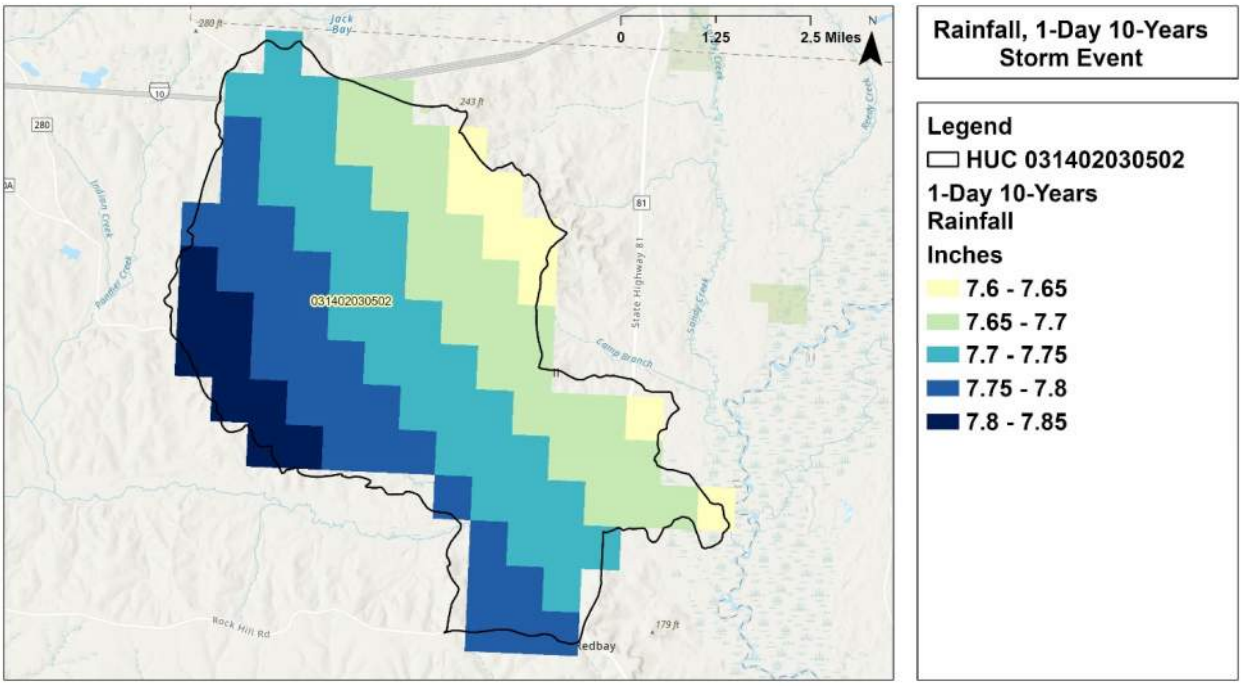

Figure 23. Rainfall distribution map across HUC 031402030502 sub-watershed, for 1-day 10-year storm event, processed by FAU.

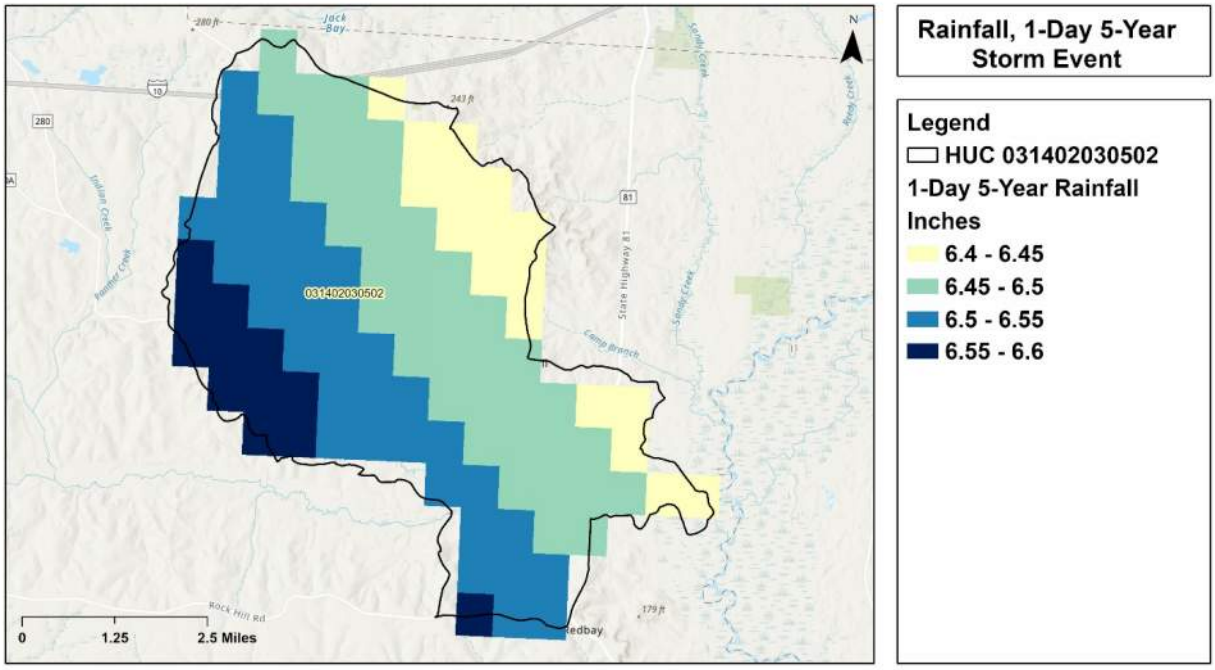

Figure 24. Rainfall distribution map across HUC 031402030502 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 2.5). Added to this will be the water bodies discussed in Section 2.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically

aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

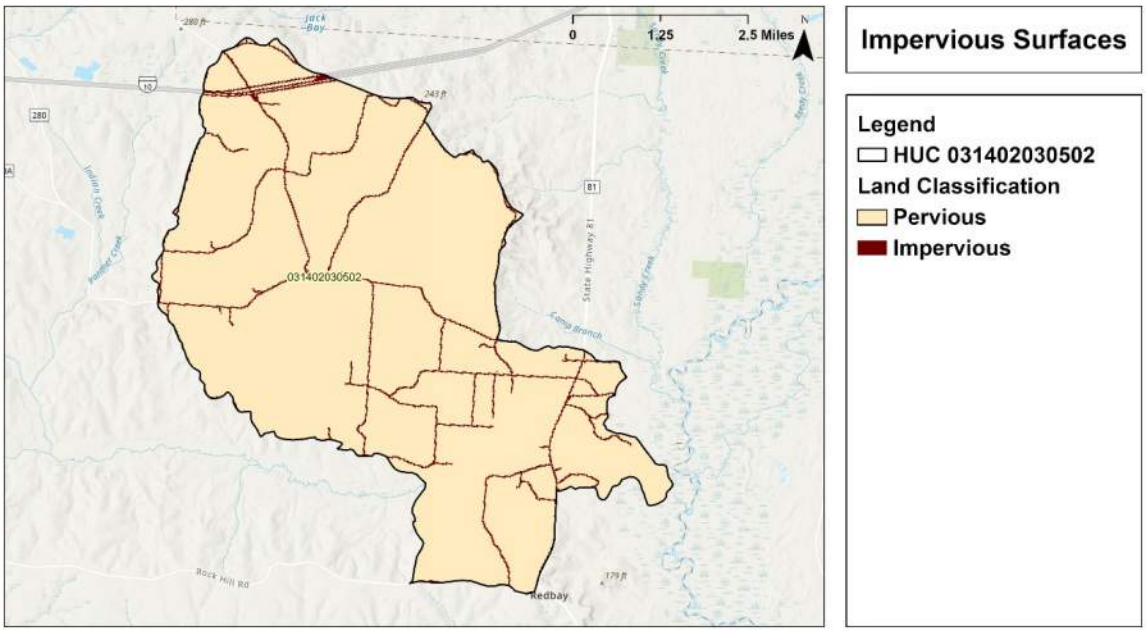

Figure 25. Impervious area map for the HUC 031402030502 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

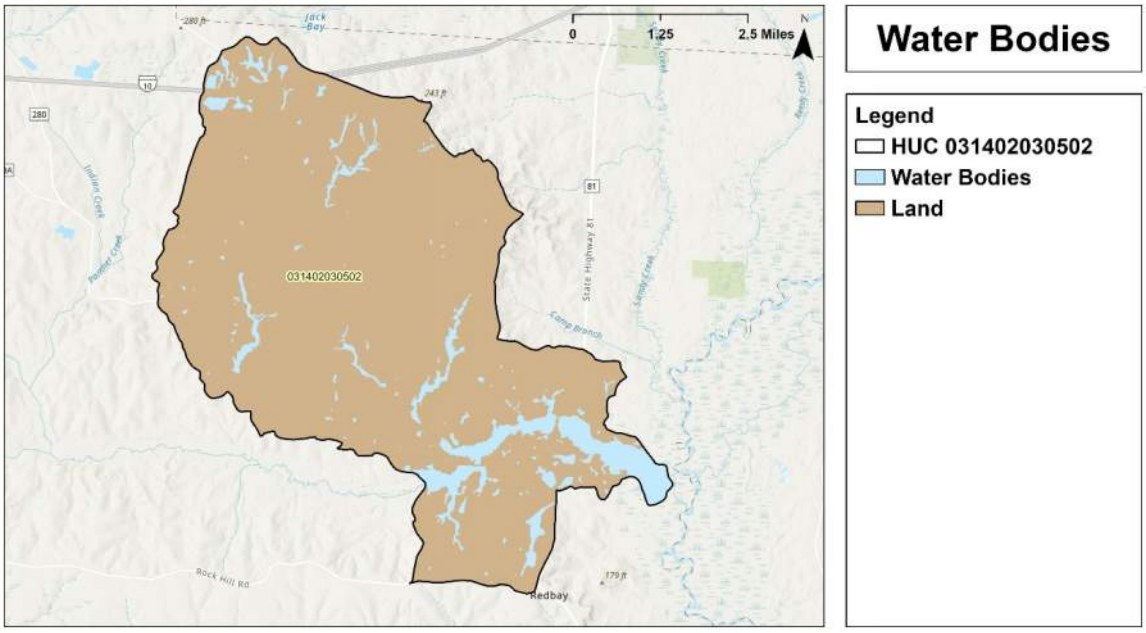

Figure 26. Water bodies map for the HUC 031402030502 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place.

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.

- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

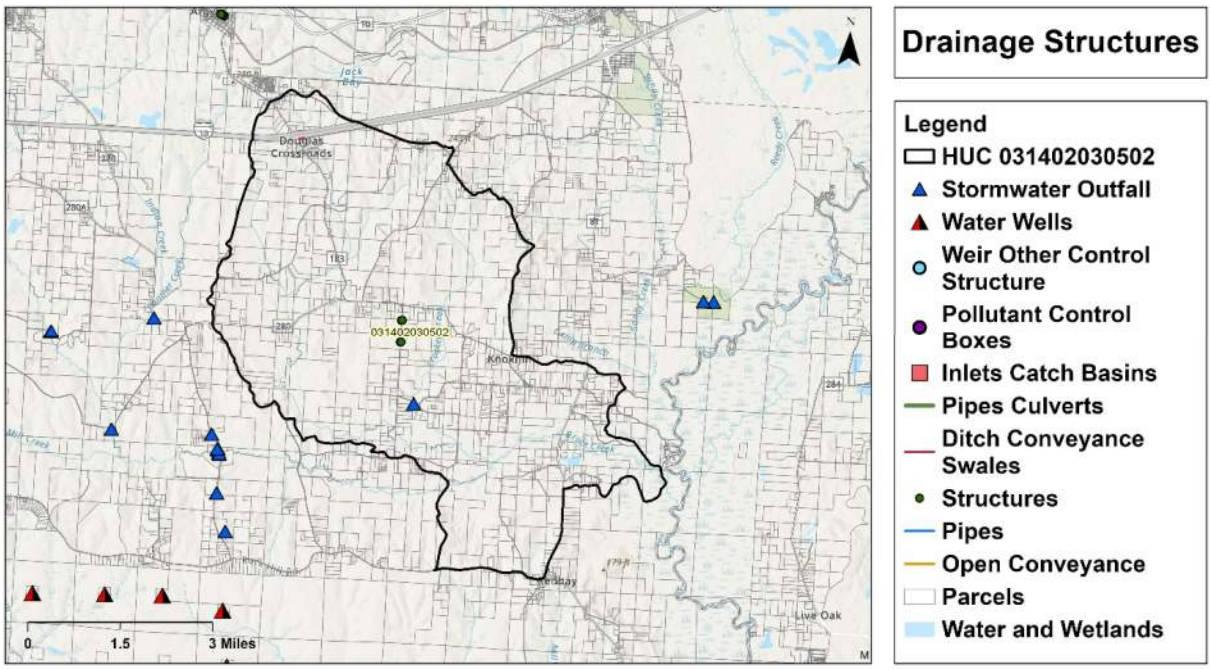

Figure 27. Stormwater Infrastructure for the HUC 031402030502. Processed by FAU.

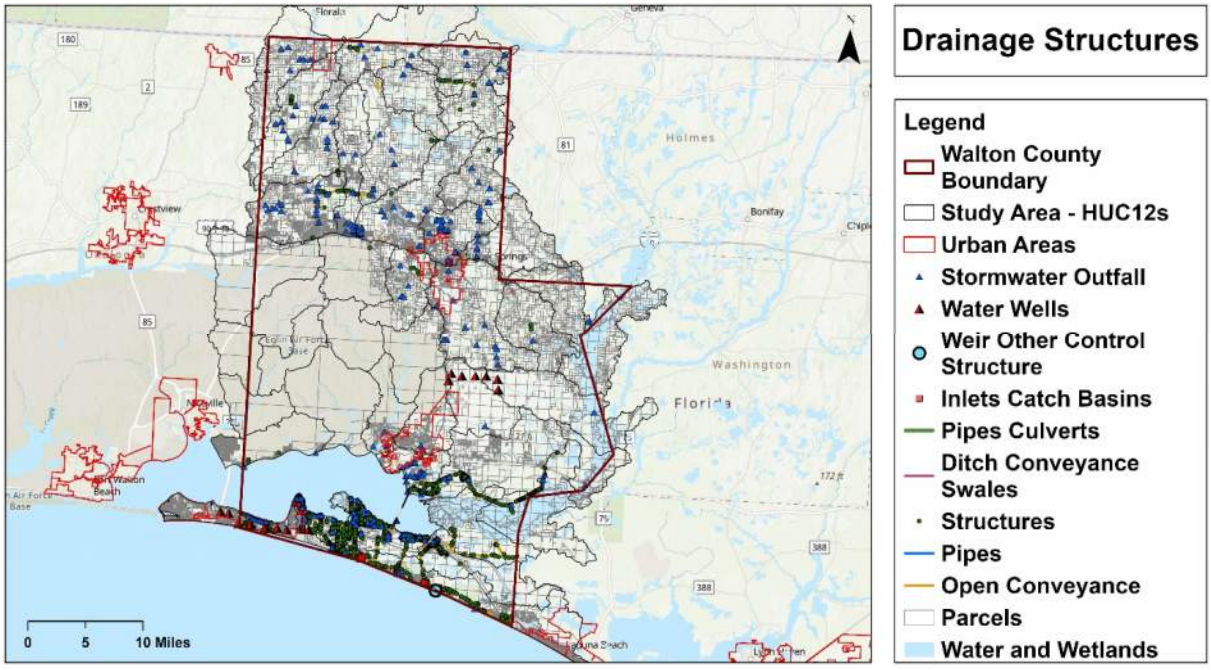

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020)

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031402030502 sub-watershed flood response to a series of rainfall events (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the

coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

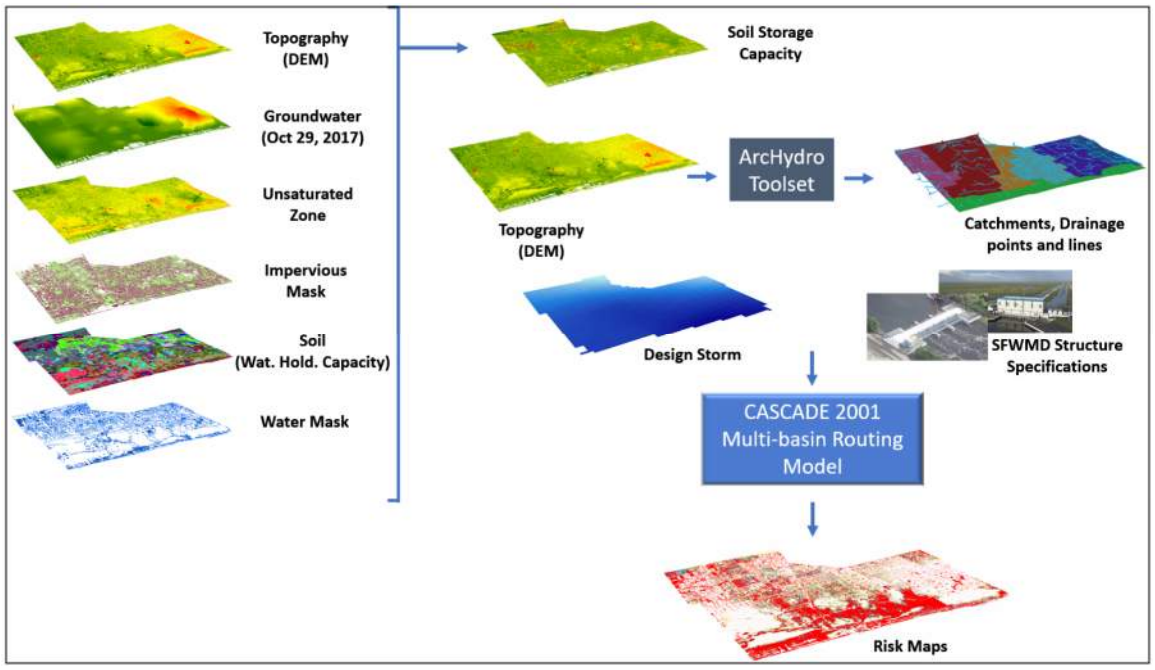

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are

critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

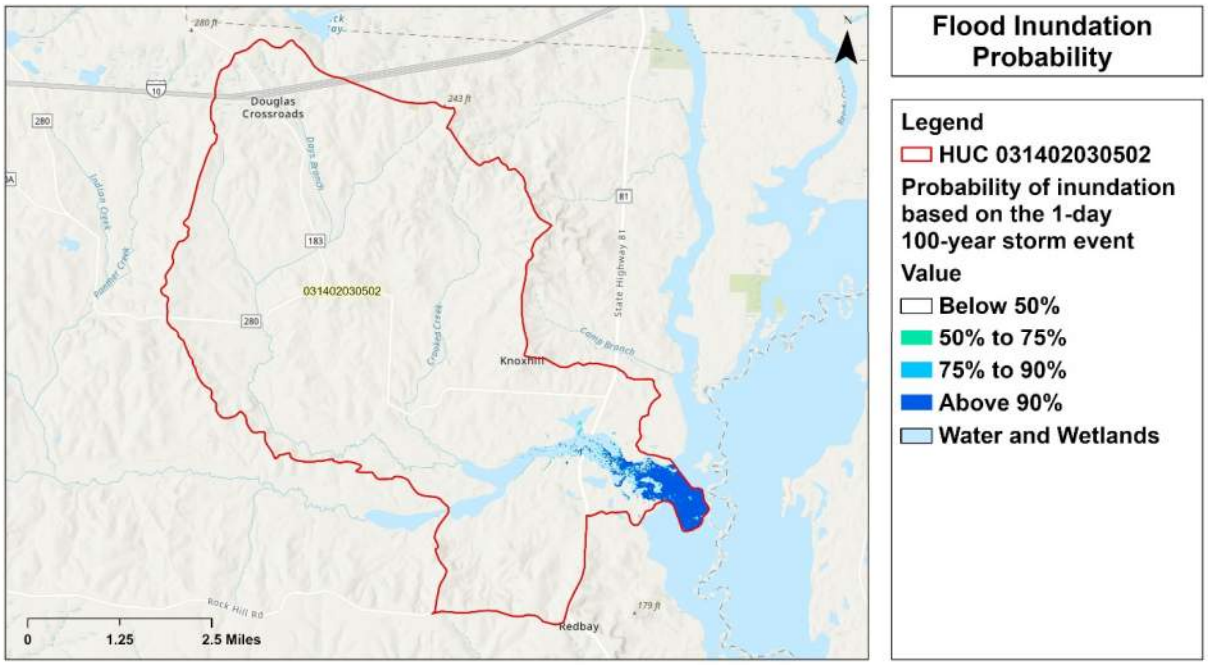

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031402030502, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate

the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not

eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. 3-day 25-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
2. 1-day 100-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
3. 1-day 10-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)
4. 1-day 5-year storm event. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (**Error! Reference source not found.**)

In all storm event scenarios, a moderate amount of flooding is noted at the creek entrance to the HUC. As this basin is not connected to the ocean and its altitude is above 20 feet, the HUC is expected to remain unaffected by sea level rise, therefore SLR scenarios were not computed.

The design storm simulation determined that approximately 1.88% of the HUC total area or 0.56 mi² has a probability of inundation above 50% for all four design storms. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031402030502 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	28.94	0.56	98.12%	1.88%
1-day 100-year	28.94	0.56	98.12%	1.88%
1-day 10-year	28.94	0.56	98.12%	1.88%
1-day 5-year	28.94	0.56	98.12%	1.88%

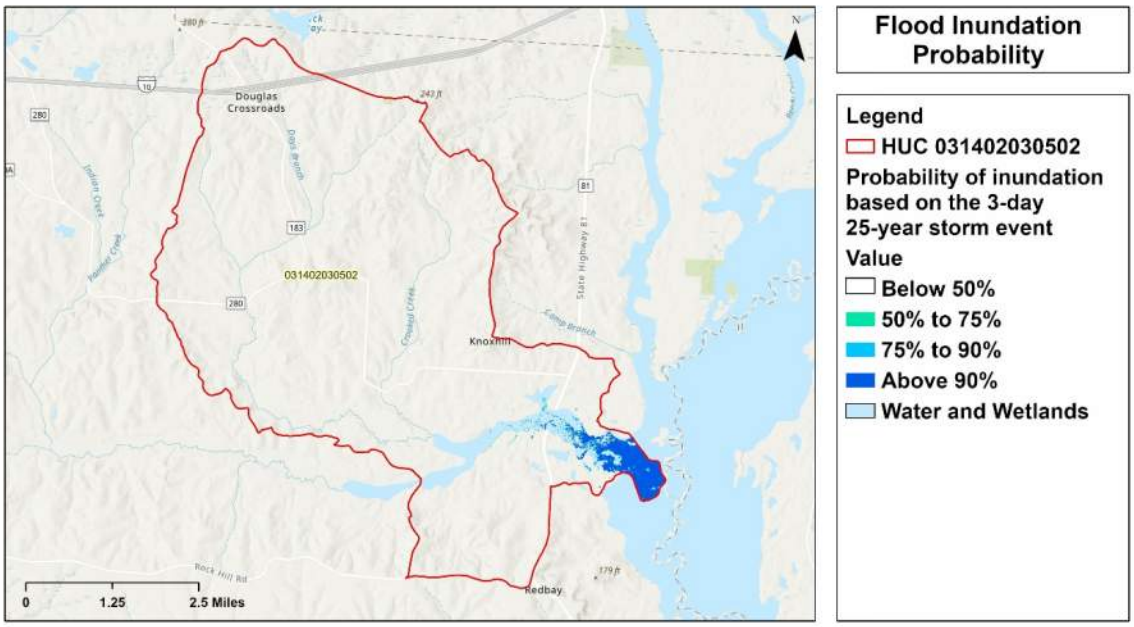

Figure 31. 3-day 25-year storm event for HUC 031402030502 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

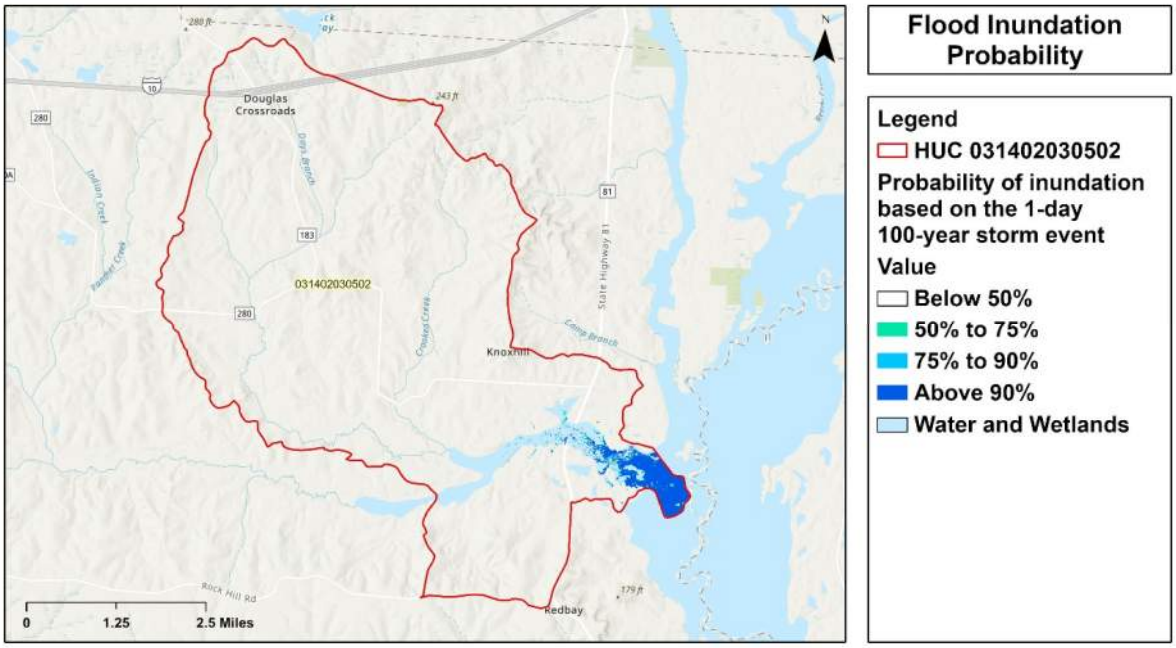

Figure 32. 1-day 100-year storm event for HUC 031402030502 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

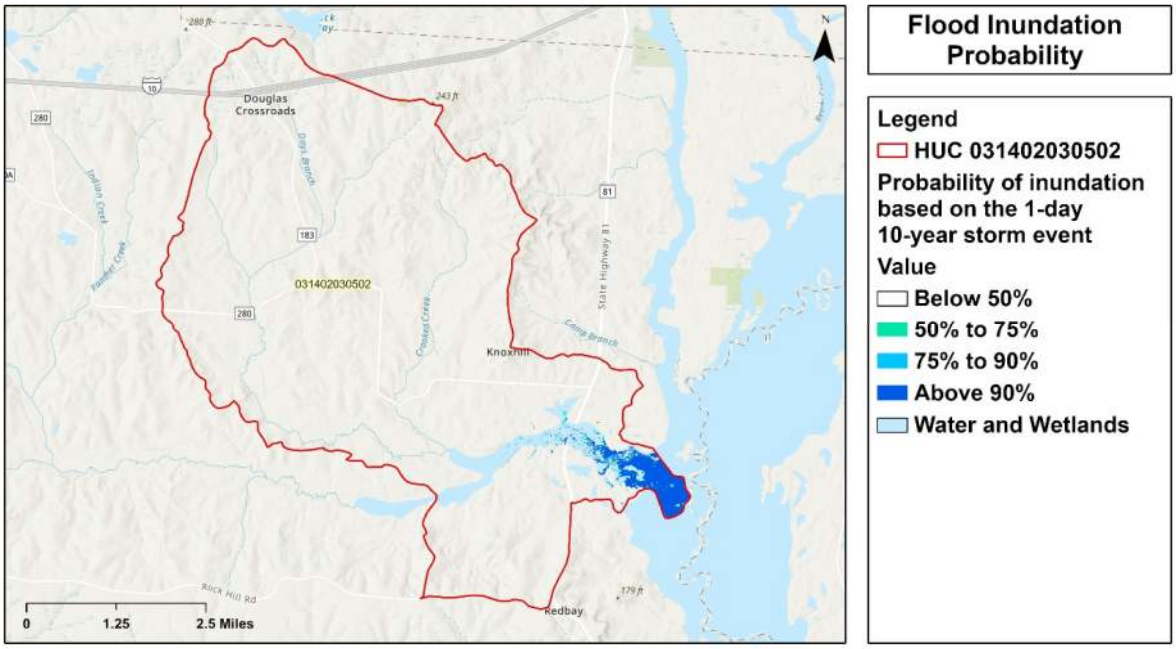

Figure 33. 1-day 10-year storm event for HUC 031402030502 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

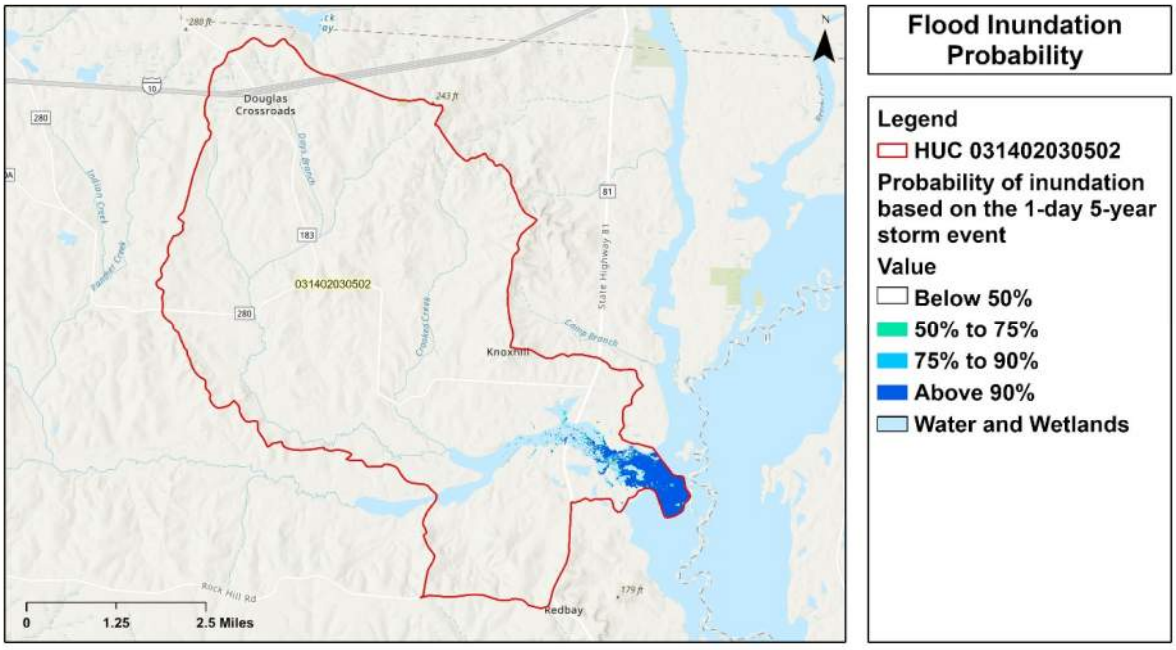

Figure 34. 1-day 5-year storm event for HUC 031402030502 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

2.4 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6

11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6

41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6

69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6

99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.4.1 Results

Error! Reference source not found. and **Error! Reference source not found.** depict the HUC 031402030502 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (**Error! Reference source not found.**) overlays critical facilities onto the 1-day 100-year storm event scenario. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** illustrates the composite score based on 1-day 100-year storm event for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. Lastly, **Error! Reference source not found.** is a mosaic showing the results for composite score overlaid in the 1-day 100-year storm event for the coastal area of Walton County. As the subwatershed is not coastal, the results based on 5 ft. SLR + 1-day 100-year storm event were not computed for the basin.

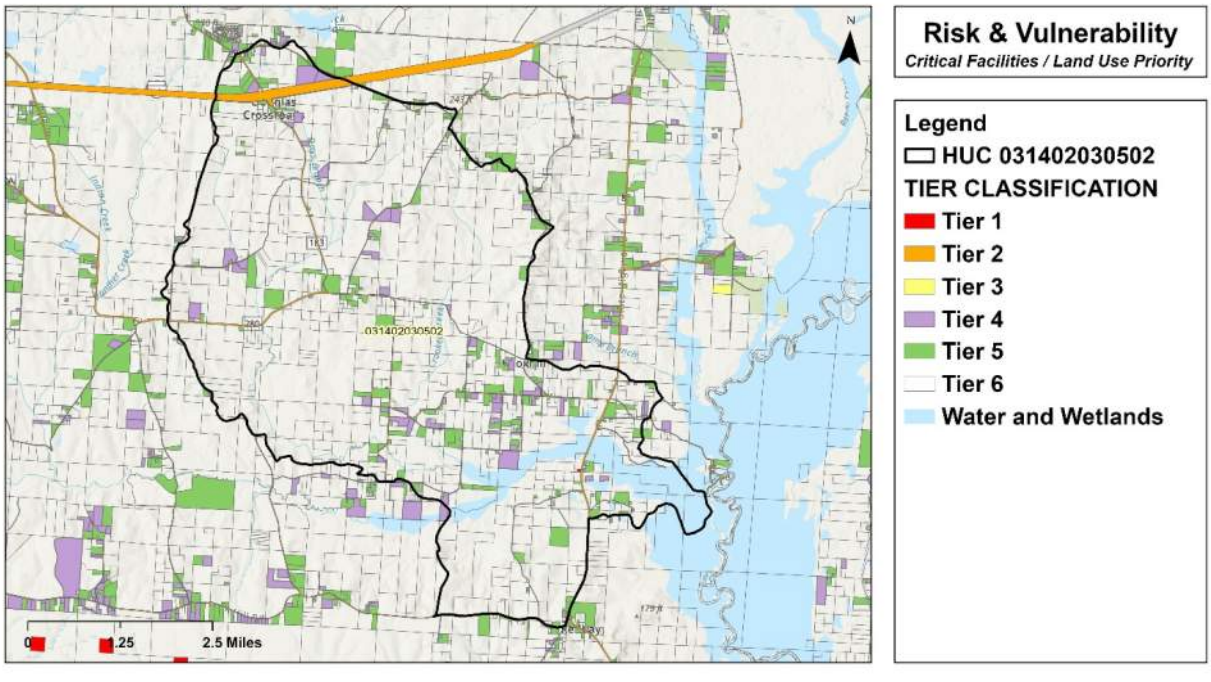

Figure 35. HUC 031402030502 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

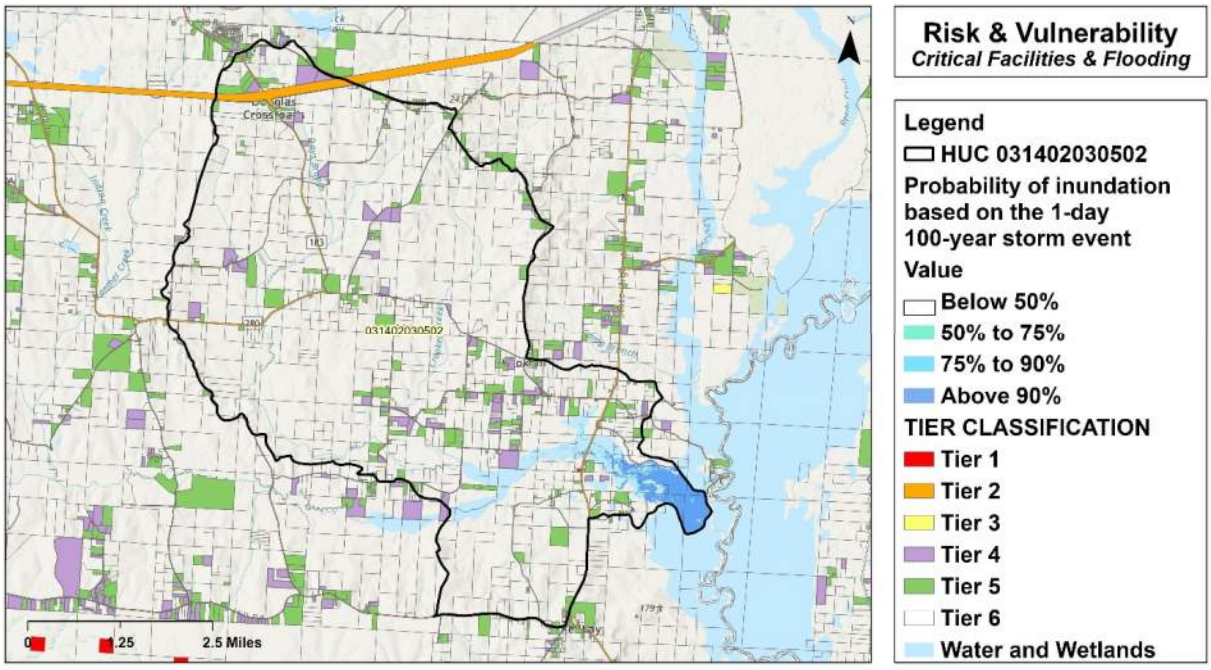

Figure 36. HUC 031402030502 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

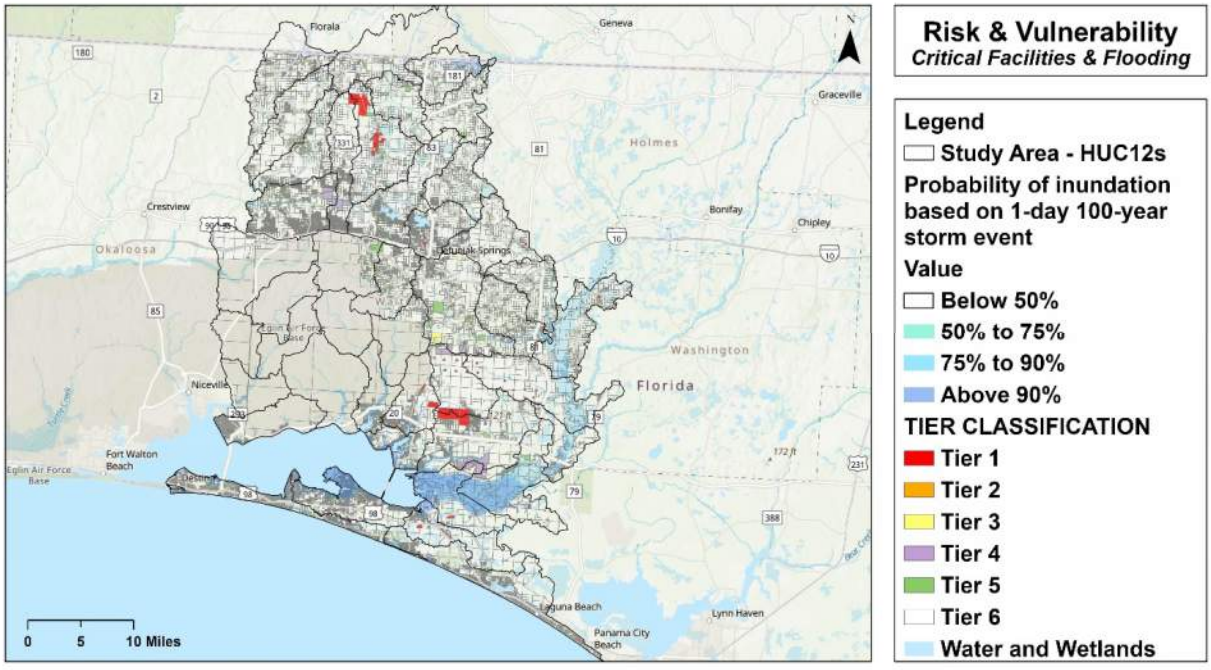

Figure 37. Walton County (mosaic) - Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation for Walton County. Processed by FAU.

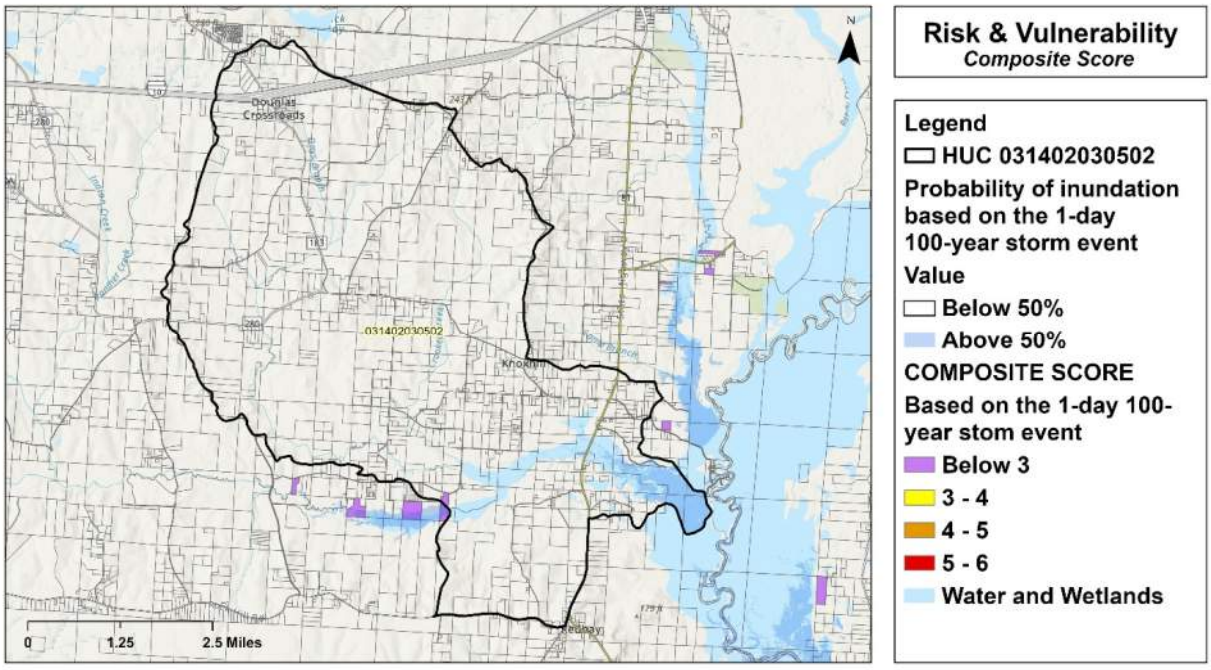

Figure 38. HUC 031402030502 sub-watershed Composite Score Risk map, with calculation based on 1-day 100-year storm event. Processed by FAU.

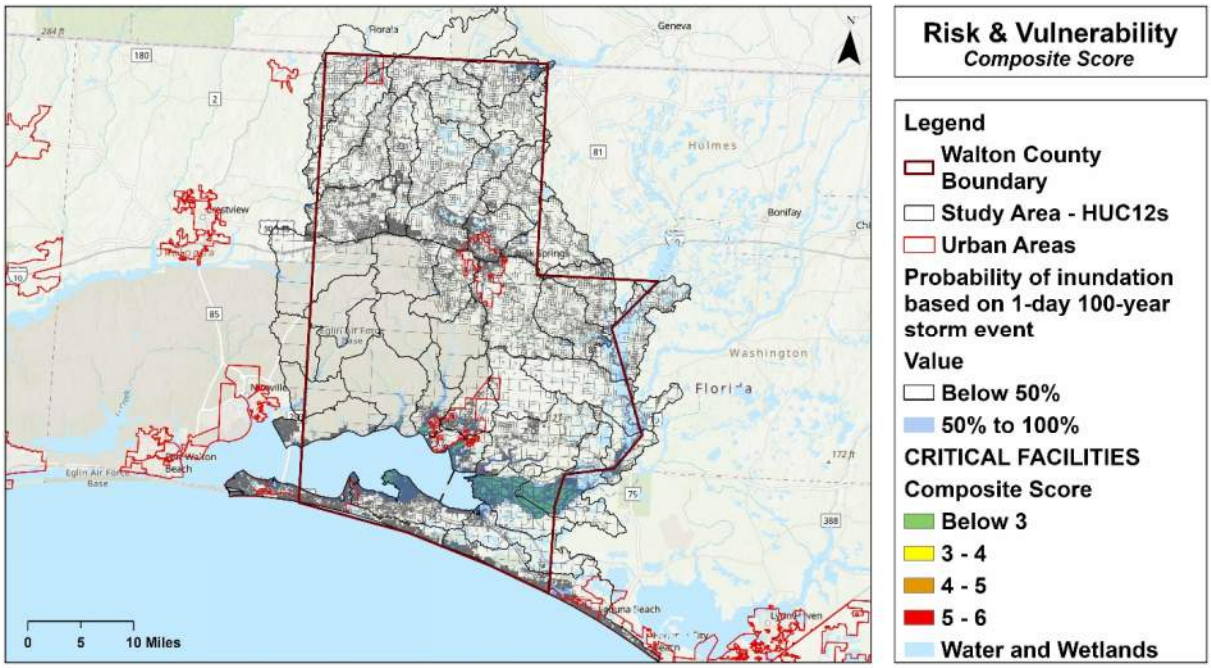

Figure 39. Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

Please note that due to the scale of the map, the composite score layer is not properly visible in this map.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

2.4.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031402030502. A summary of these flood mitigation strategies is listed in table 9. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.4.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space – see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031402030502. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031402030502	18879.32
All of the 1-day 100-year storm event inundation	**355.77**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	335.50
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	14.55
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	0.00
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	20.27
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	5.72

2.4.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

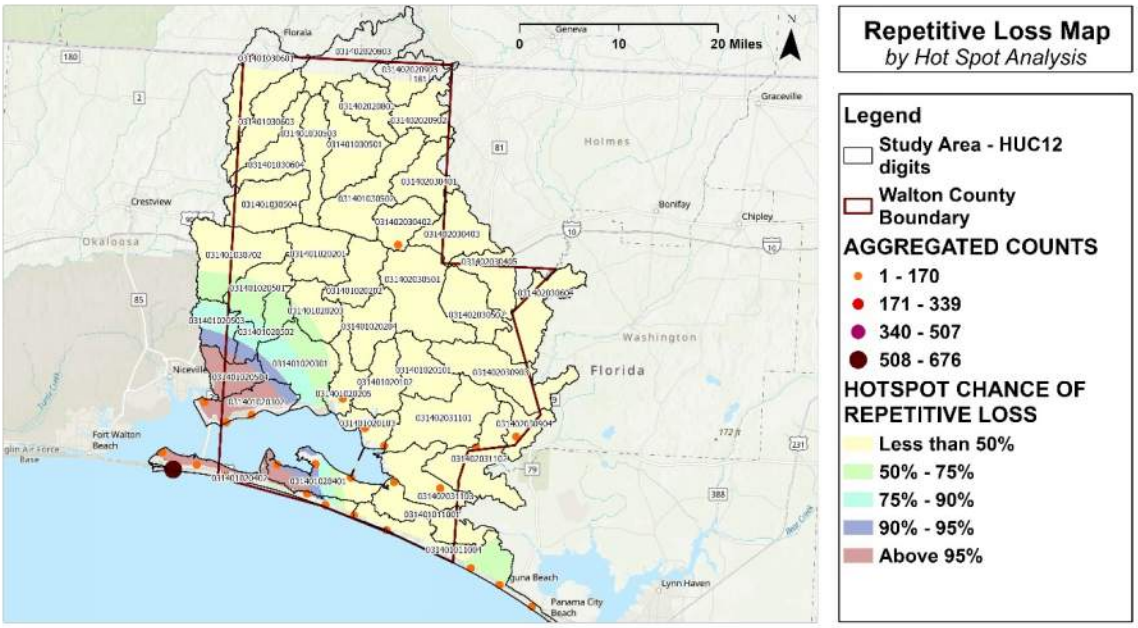

Figure 40. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.4.5 Priority Projects

Although there are a good amount of parcels falling within tiers classification 1 to 5 priority of land uses, only a few of them are within the flooding zone, once flooding in the area is relatively minor and not alarming. Consequently, when considering the composite score, it is notable that most of the results are null. There are only six exceptions within the basin: five roads (Walton Bridge Rd, Sandy Creek Landing Road, Highway 81, River Rd, and Camp House Landing Rd) within score 3-4, and one mobile home, with score below 3.

APPENDIX AK

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031402030604

CARLISLE LAKE

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 sub-watershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031402030604) is highlighted among all the HUCs to help identifying its location. (Figure 3).

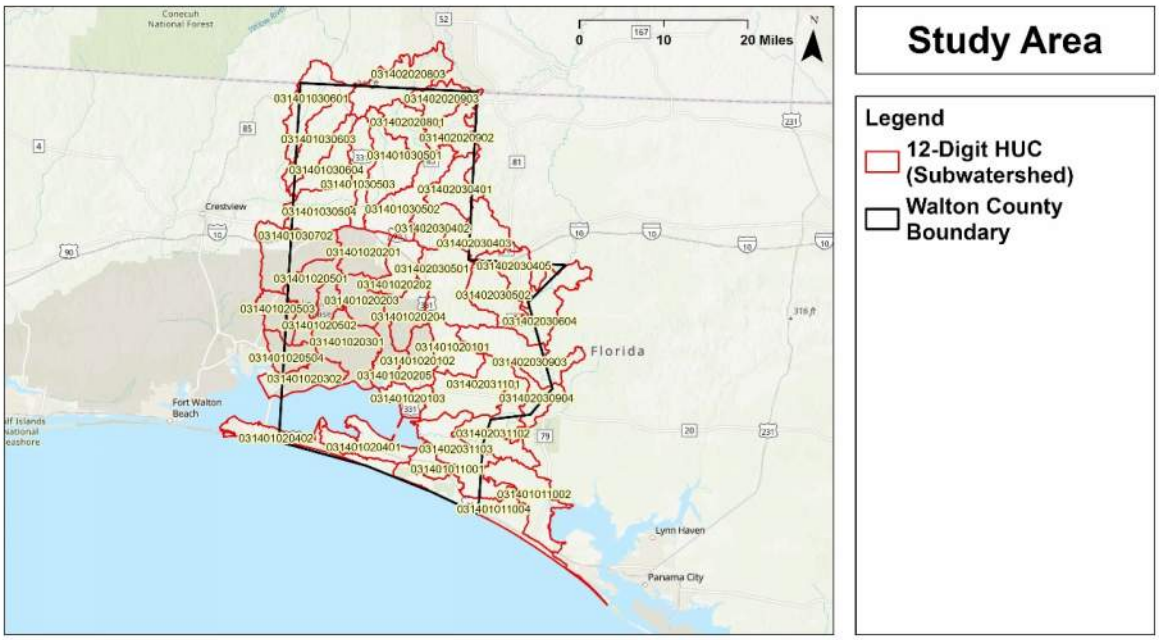


Figure 1. Walton County and all HUCs 12-digit sub-watershed, processed by FAU.

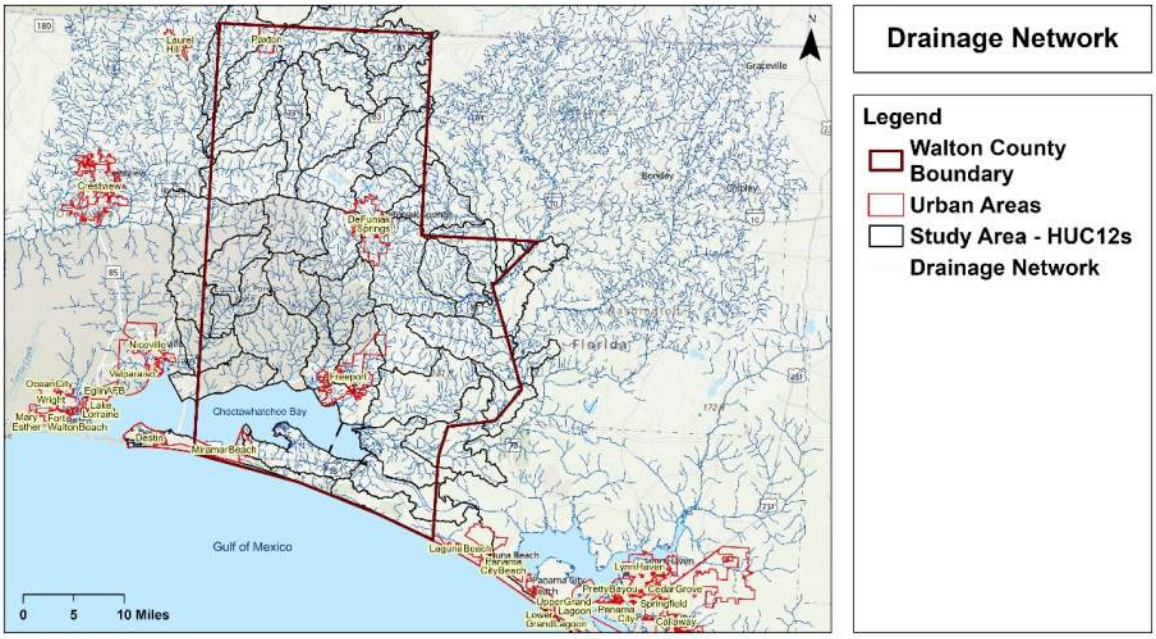


Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

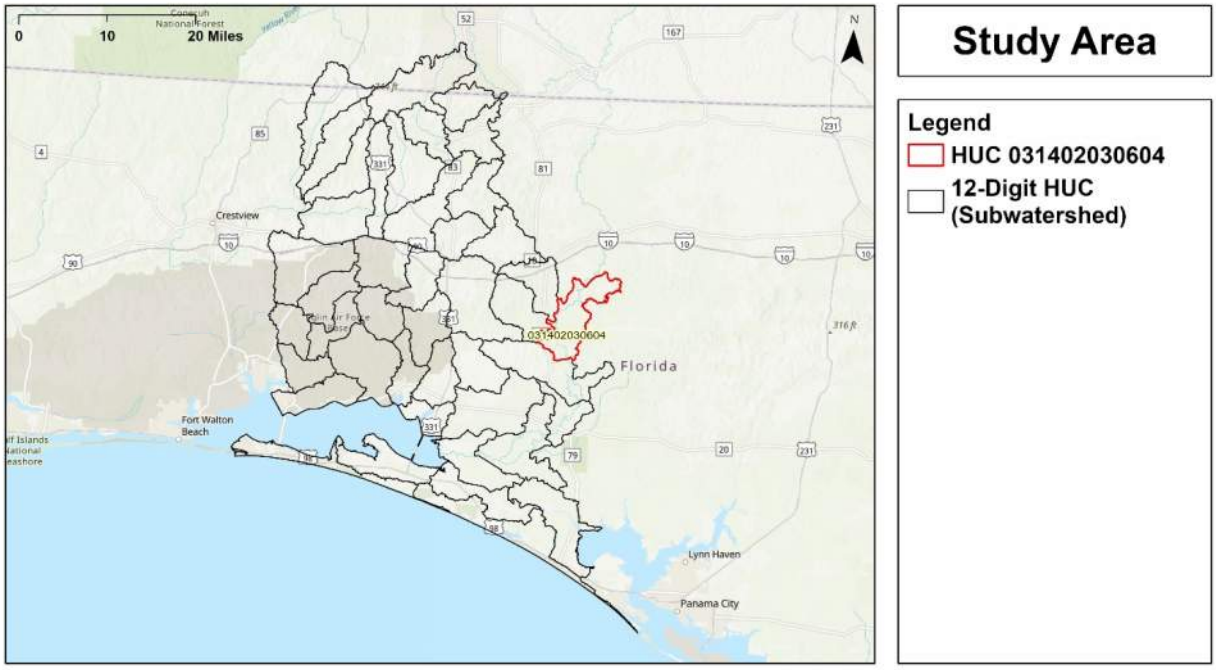


Figure 3. HUC 031402030604 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering

diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	Community Name	CRS Class Rating	Premium Discount for SFHA	% Discount for Non- SFHA	Status
120317	Walton County	6	20%	10	Cycle

Based on the future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land use table for Walton County (2023 Florida Geographic Data Library (FGDL)).

Level 1 Land Use-Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 2.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to

understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

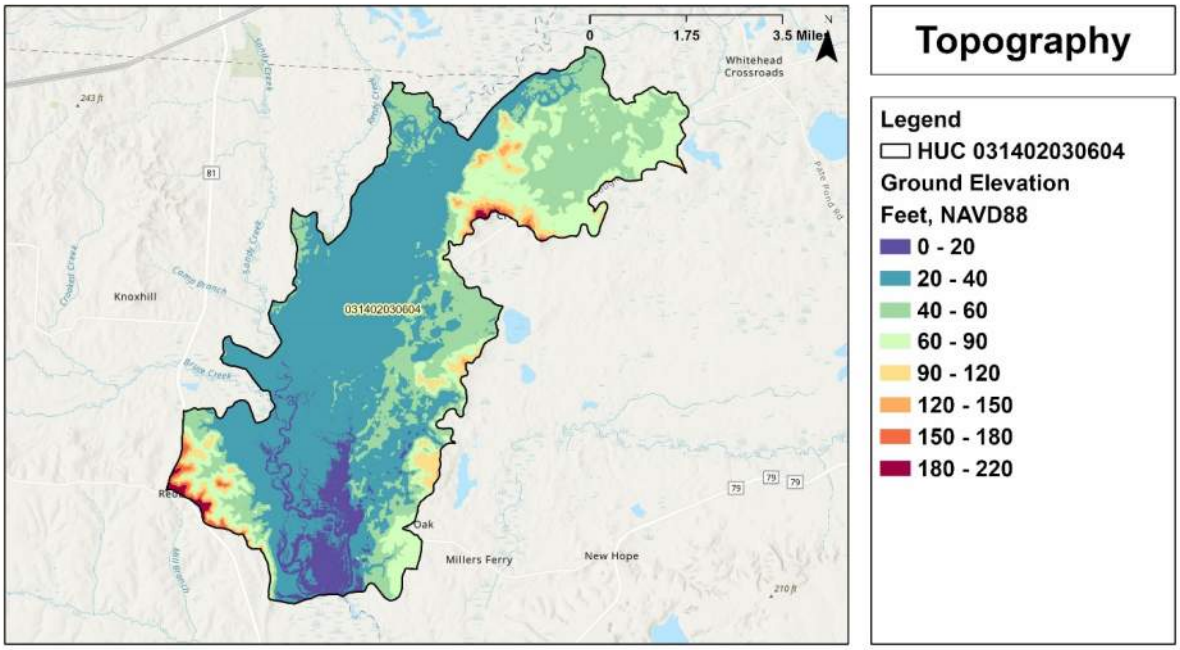


Figure 4. Topographic map of the HUC 031402030604 sub-watershed, processed by FAU

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology.

Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031402030604 sub-watershed is shown in **Error! Reference source not found.**.

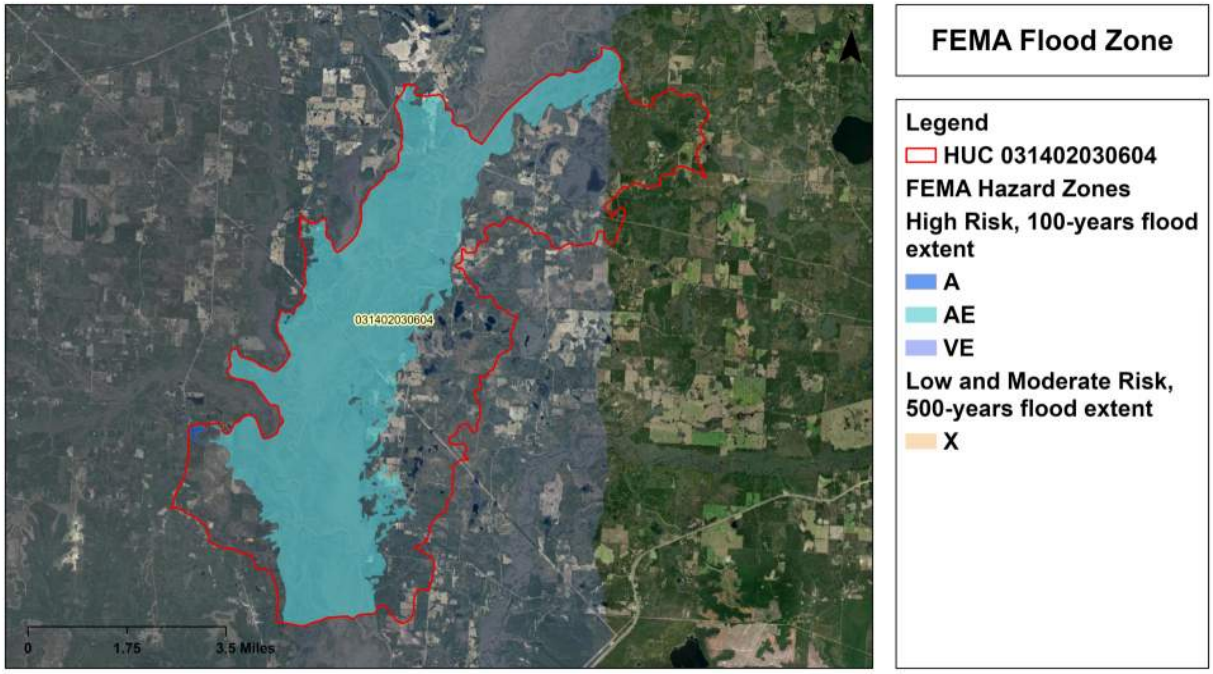


Figure 5. FEMA Flood Zone map (2020) for HUC 031402030604 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal

area, including the sub-watershed 031402030604 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

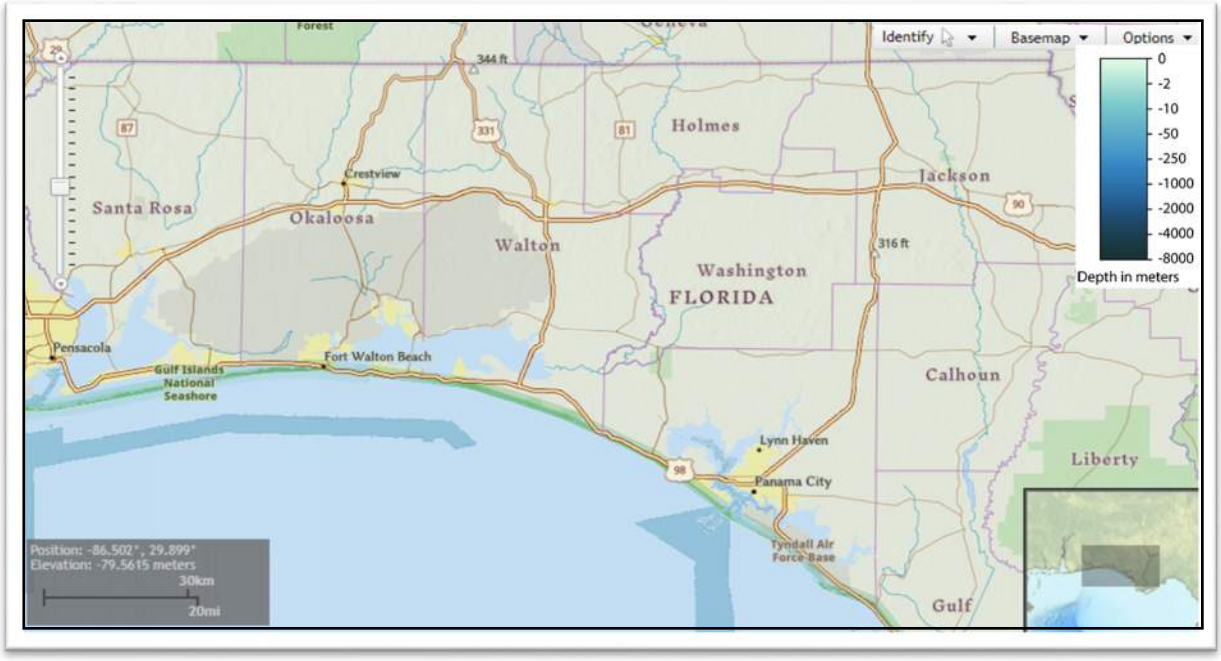


Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

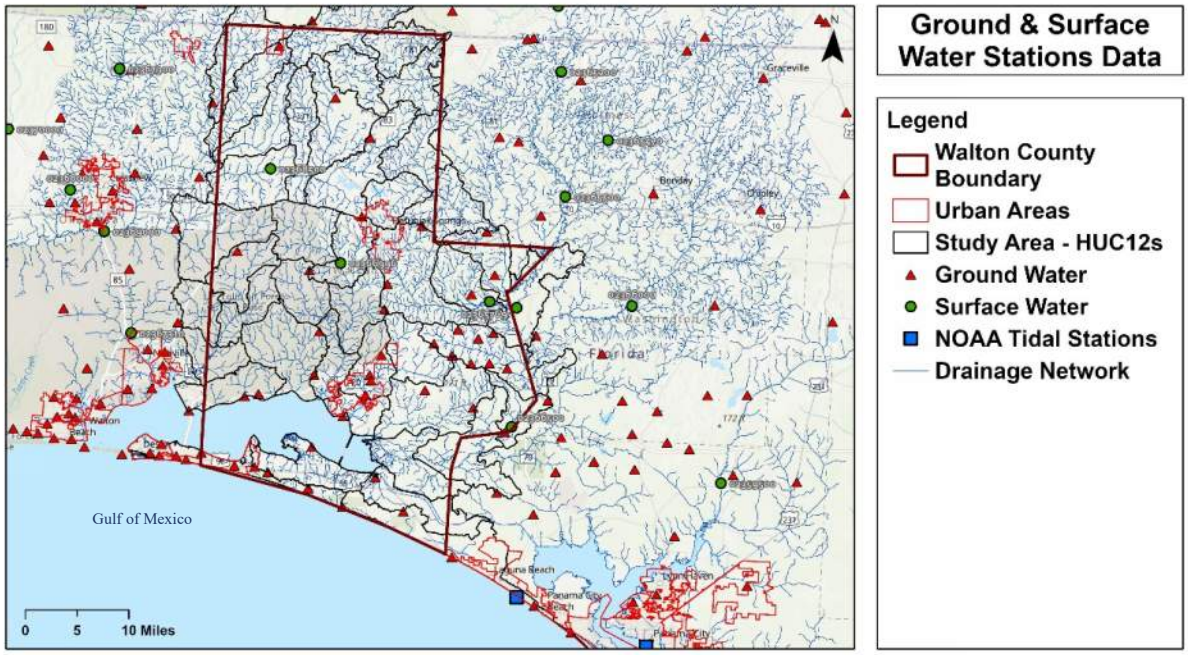


Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The major water bodies in the HUC 031402030604 sub-watershed include:

- Choctawhatchee River
- Mill Creek
- Hughes Ditch
- Carlisle Lake
- Yates Mill Creek

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02365769. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031402030604, which is USGS 02365769 Bruce Creek at SH 81 NR Redbay, FL.

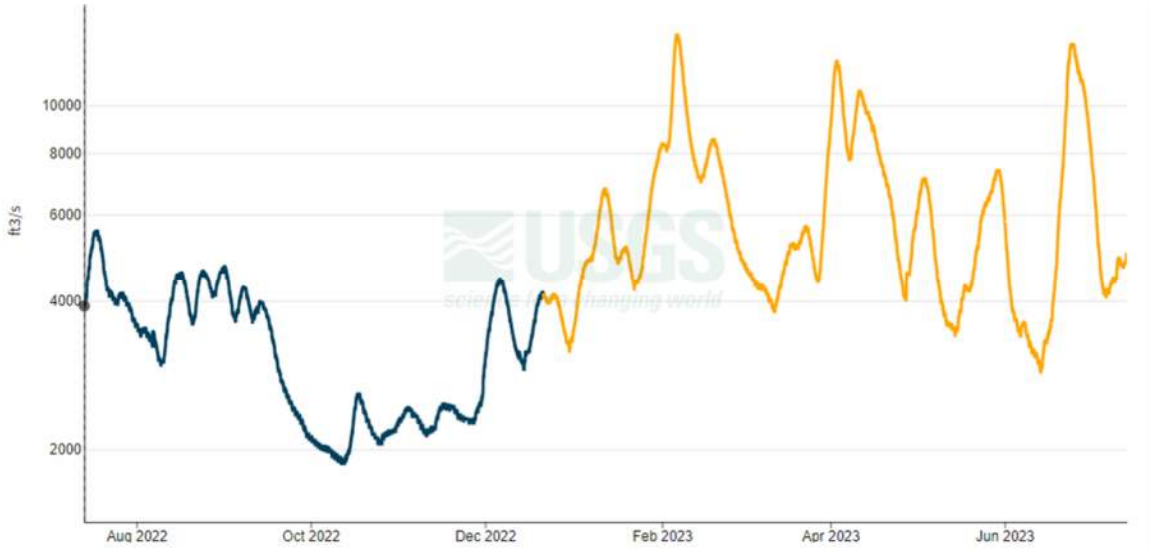


Figure 8. Average streamflow for Bruce Creek at SH 81 NR Redbay, FL (USGS 02365769 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (https://waterdata.usgs.gov/monitoring-location/02365769/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the

database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the rivers and streams to establish points for a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The topography and points where streams join form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031402030604 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031402030604 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

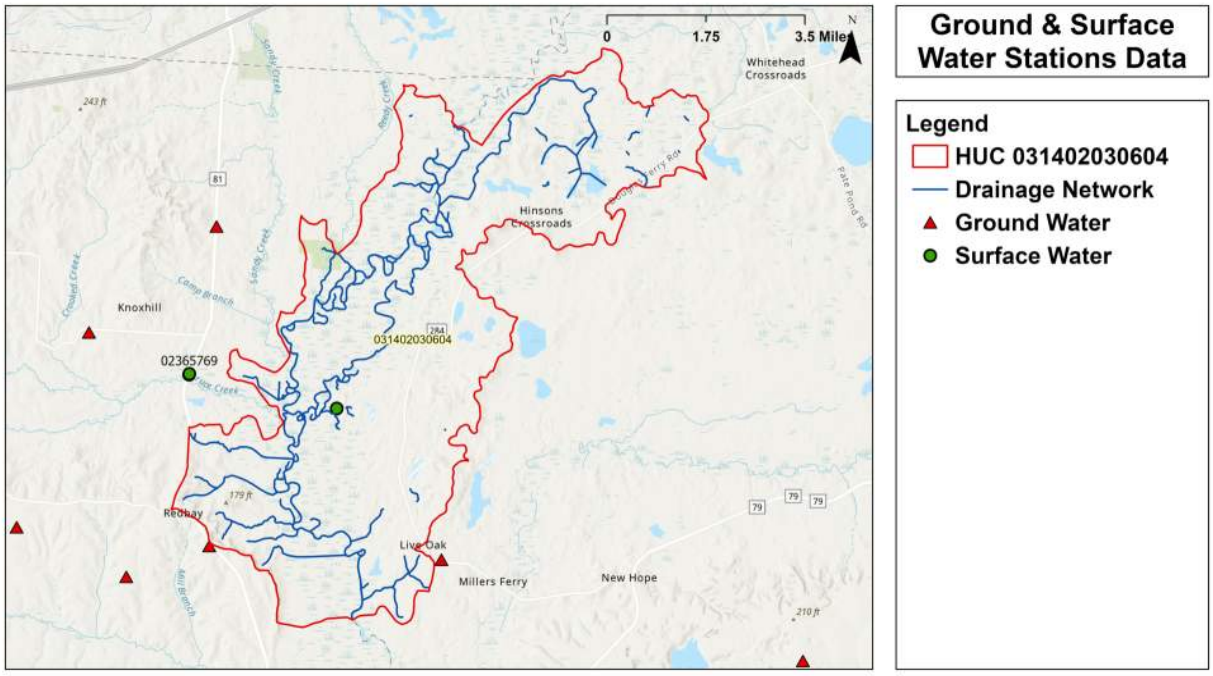


Figure 9. Ground and Surface Water Stations in the HUC 031402030604 sub-watershed, processed by FAU.

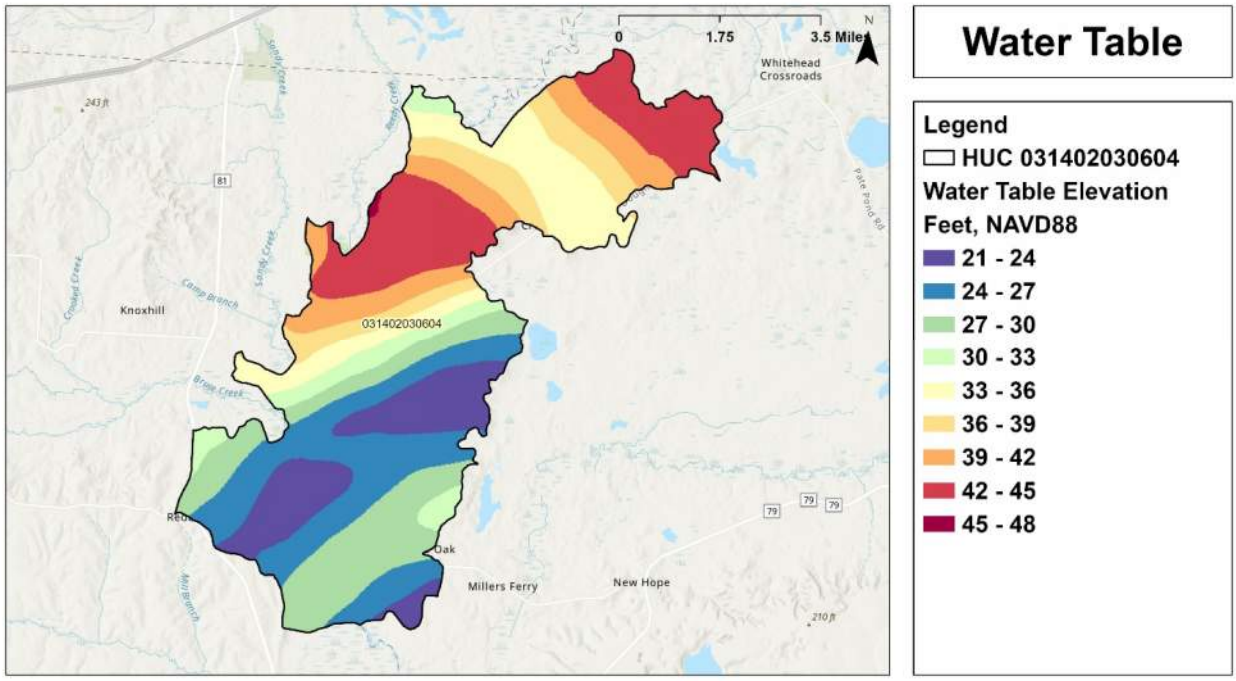


Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031402030604 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the observed rainfall over Walton County for every month between 1900 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches, for the entire county.

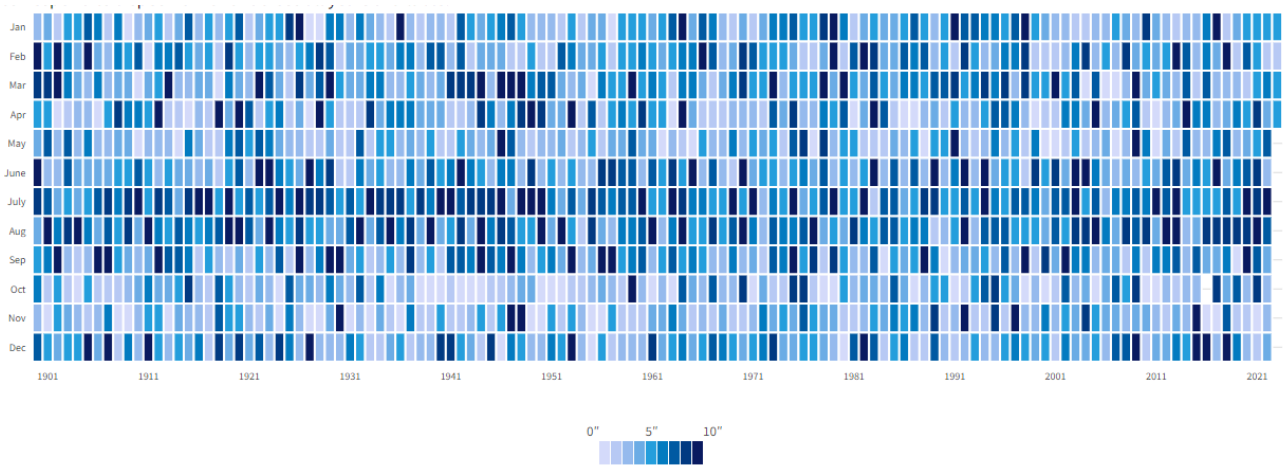


Figure 11. Monthly precipitation in Walton County, FL.
Source: National Centers for Environmental Information
(https://usafacts.org/issues/climate/state/florida/county/walton-county/#precipitation/).

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

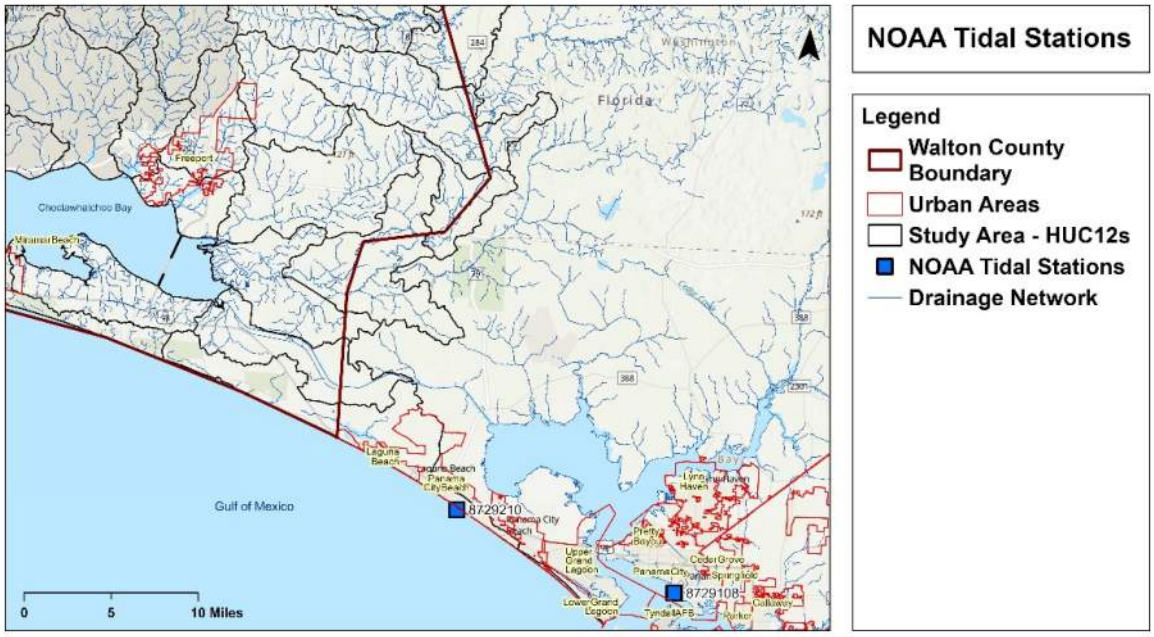


Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

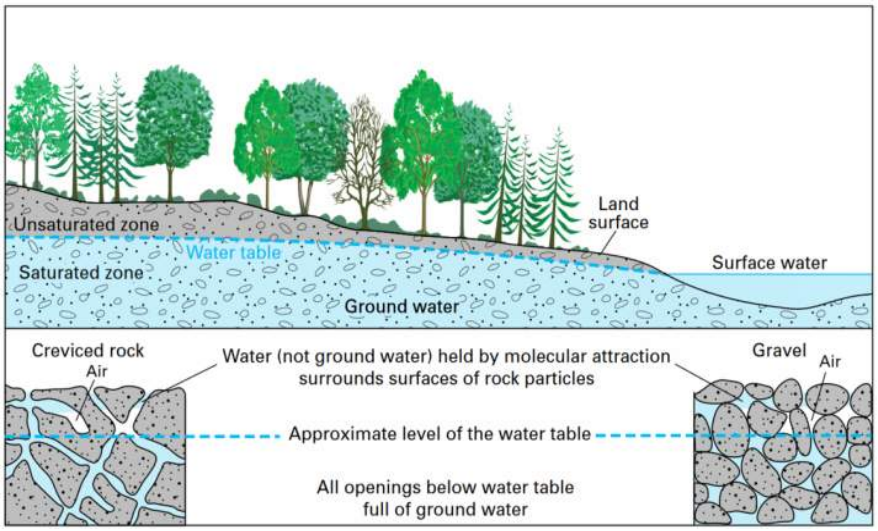


Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**.. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

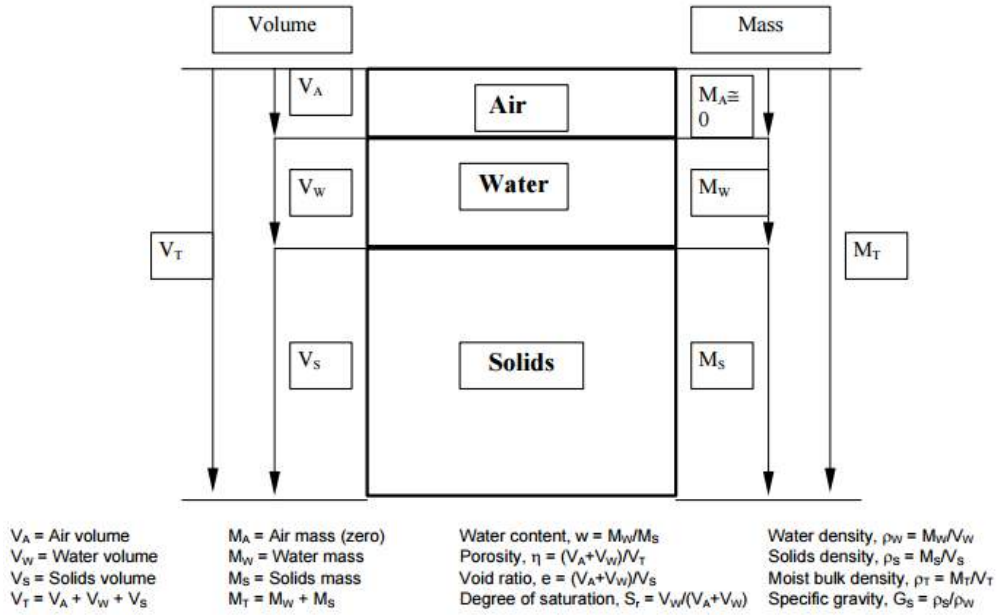


Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

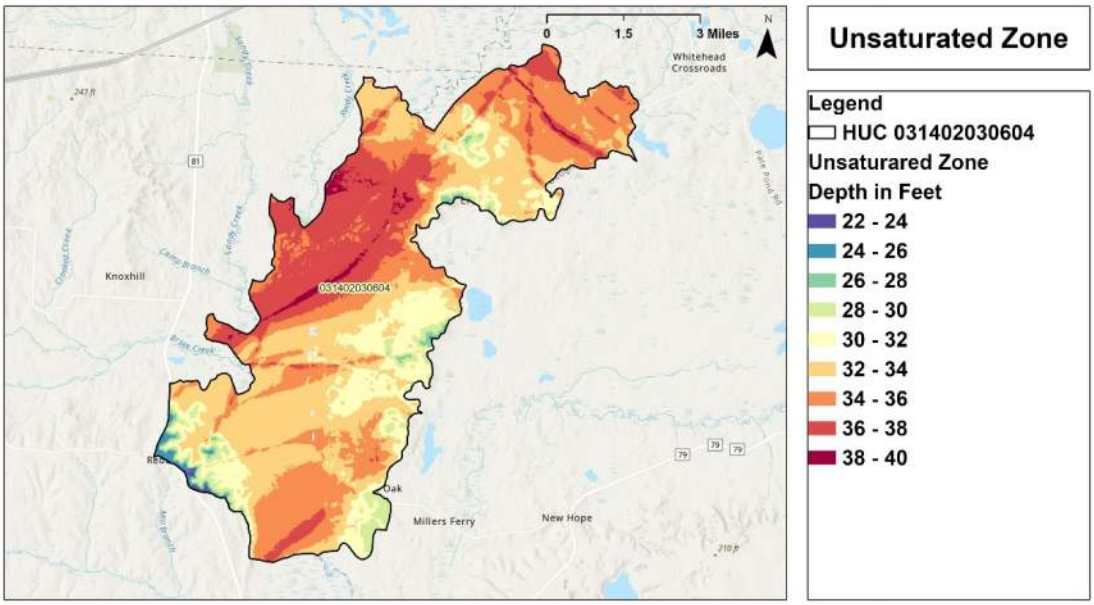


Figure 15. Unsaturated zone map for HUC 031402030604, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in Figure 16, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (Figure 17), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately favorable soil storage capacity, falling within the range of 28 to 38 feet of remaining capacity.

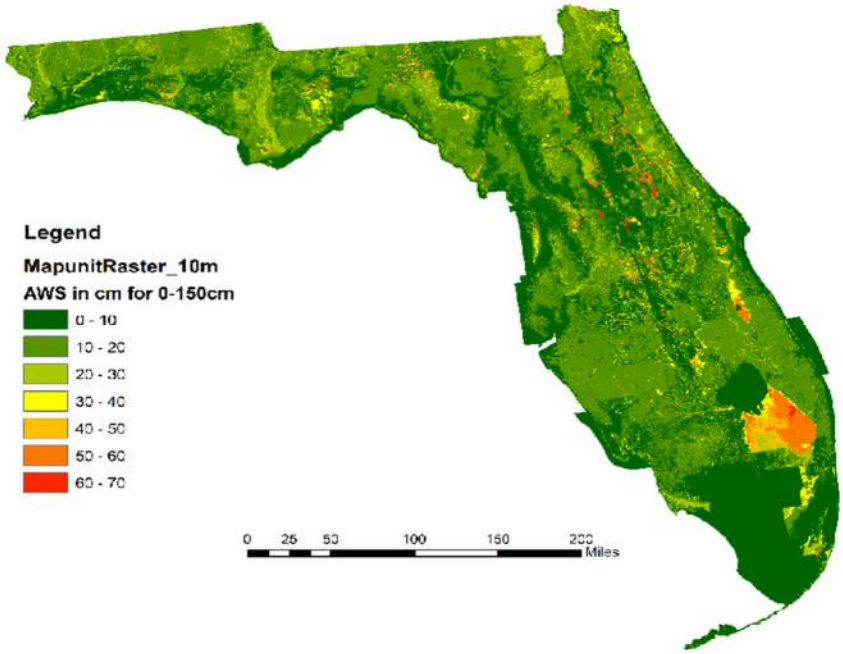


Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.

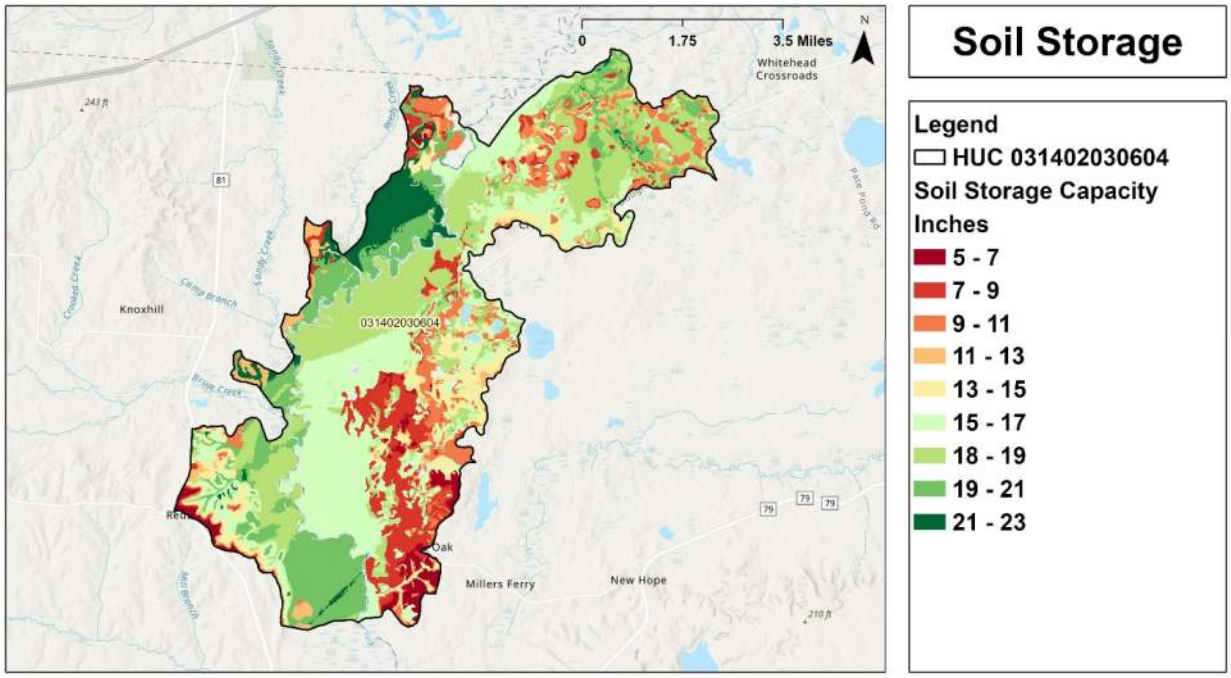


Figure 17. Water storage capacity of soil for the HUC 031402030604, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

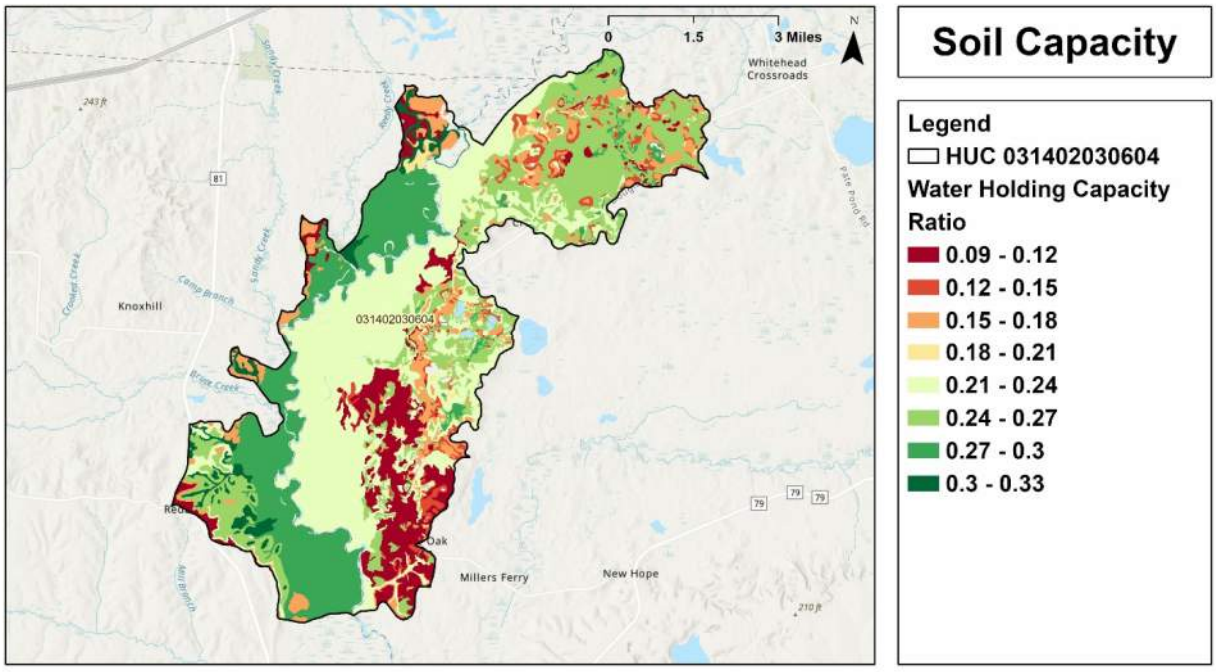


Figure 18. Water Holding Capacity (ratio) for the HUC 031402030604, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

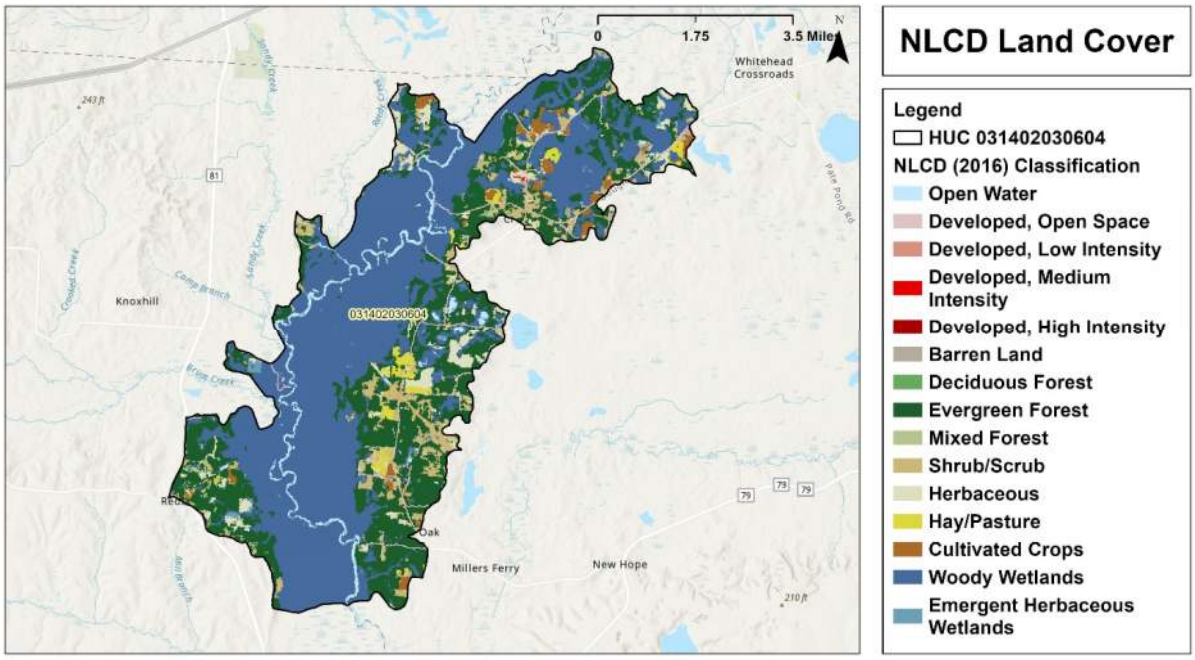


Figure 19. Land use in the HUC 031402030604 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

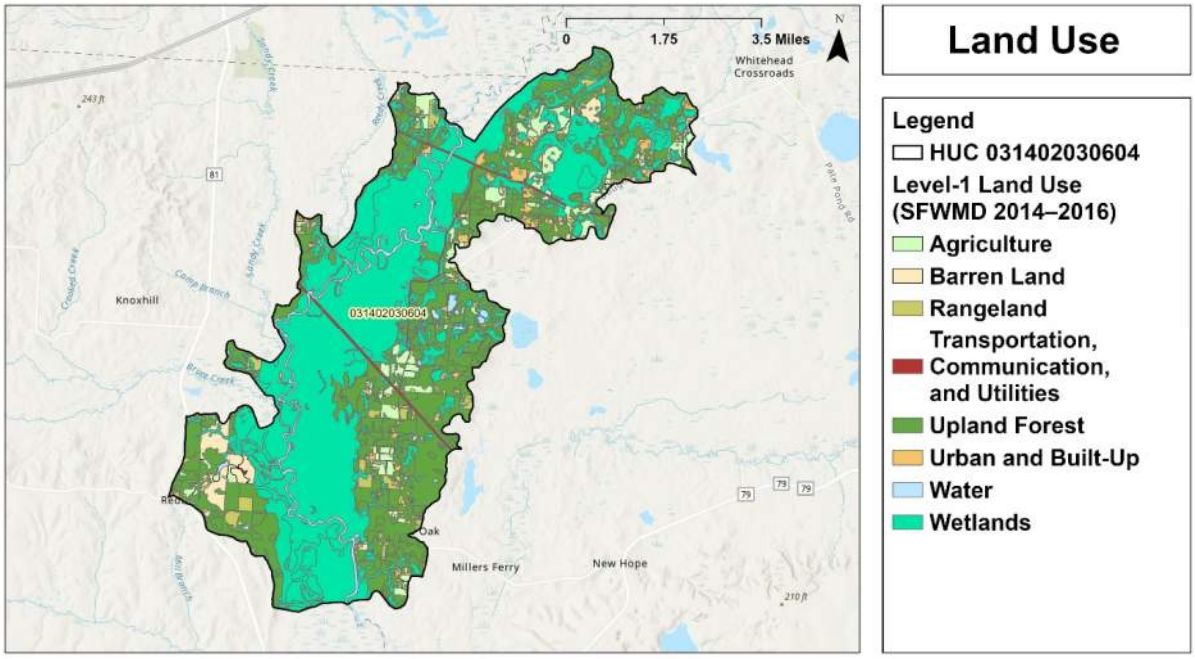


Figure 20. Land use in the HUC 031402030604 (from the 2023 Florida Geographic Data Library (FGDL), processed by FAU.

In the HUC 031402030604 sub-watershed, the predominant land cover is wetlands, accounting for 41.88% of the area. Upland forest comes in second at 30.77%, followed by water at 9.43%, and Transportation, Communication, and Utilities at 9.12%. Developed land constitutes a minor portion, with only 1.88% categorized as urban and built-up, as indicated in Table 3 below.

Table 3. Land use for HUC 031402030604 sub-watershed (2023 Florida Geographic Data Library (FGDL).

Level 1 Land Use Land Cover Type	Area (Acres)	Percentage of Total
Agriculture	1232.50	3.71%
Barren Land	476.09	1.43%
Rangeland	584.87	1.76%
Transportation, Communication, and Utilities	3027.36	9.12%
Upland Forest	10210.45	30.77%
Urban and Built-Up	623.67	1.88%
Water	3127.96	9.43%
Wetlands	13895.01	41.88%
Grand Total:	**33177.90**	**100.00%**

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

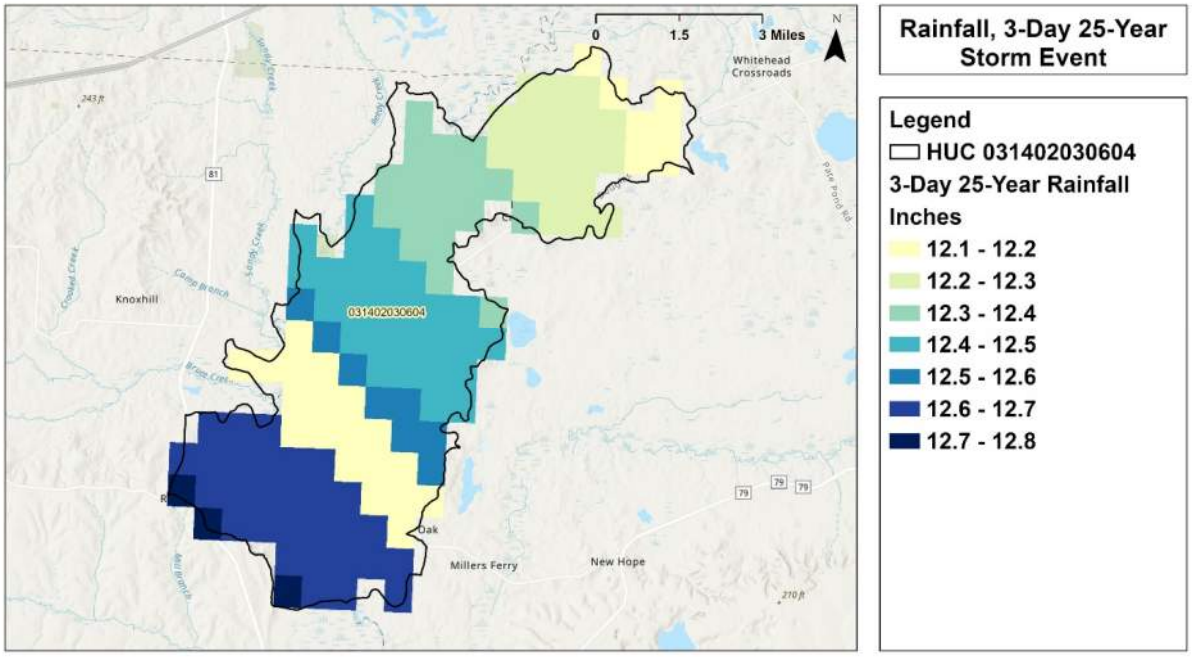


Figure 21. Rainfall distribution map across HUC 031402030604 sub-watershed, for 3-day 25-year storm event, processed by FAU.

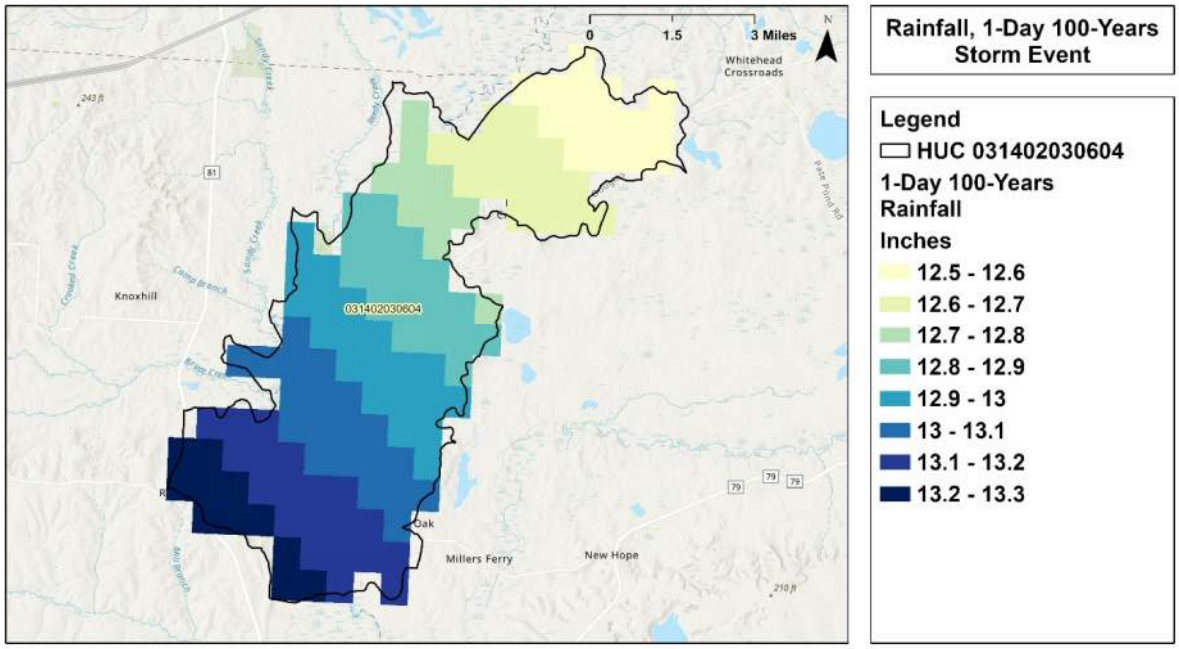


Figure 22. Rainfall distribution map across HUC 031402030604 sub-watershed, for 1-day 100-year storm event, processed by FAU.

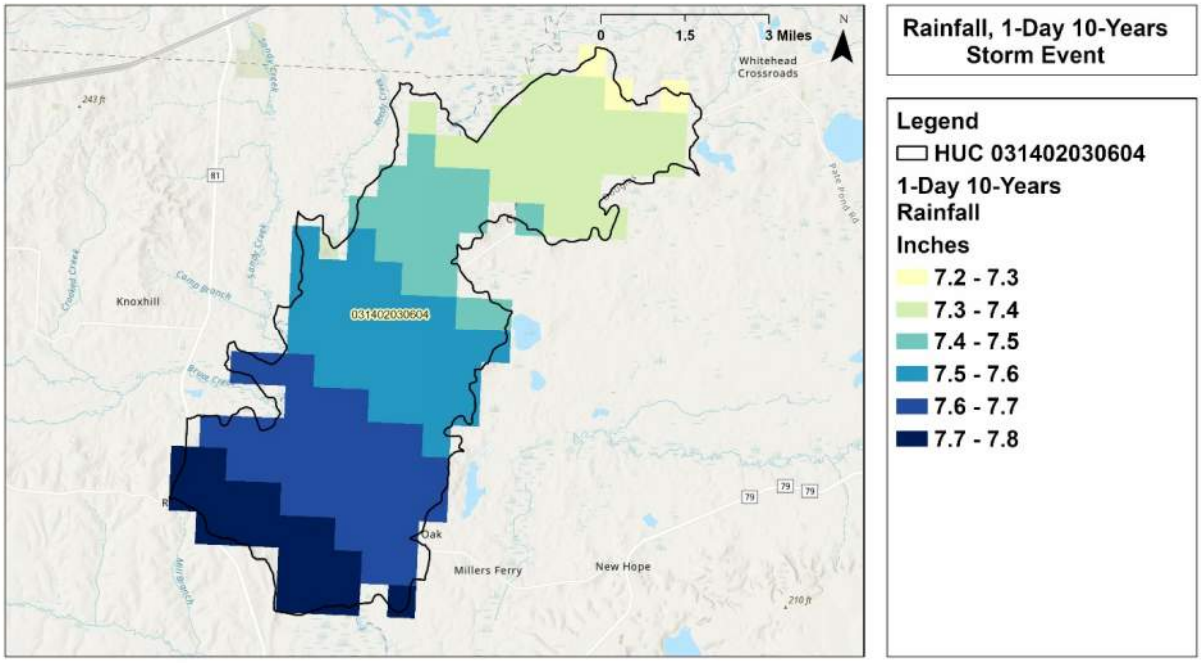


Figure 23. Rainfall distribution map across HUC 031402030604 sub-watershed, for 1-day 10-year storm event, processed by FAU.

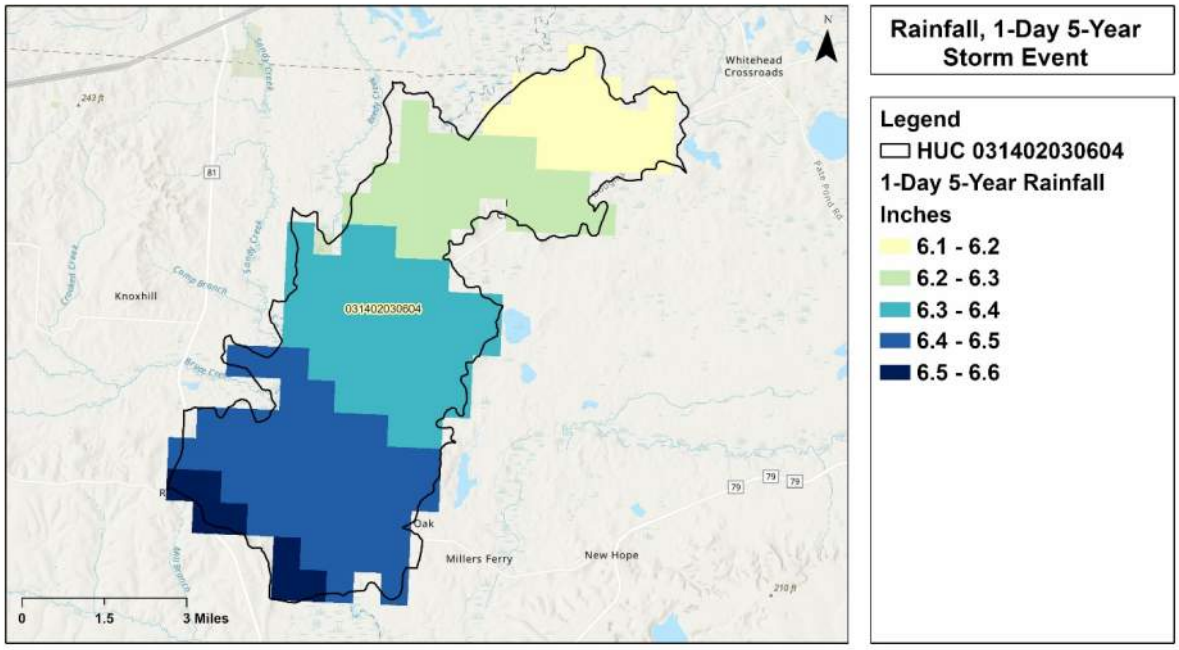


Figure 24. Rainfall distribution map across HUC 031402030604 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 2.5). Added to this will be the water bodies discussed in Section 2.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land

cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

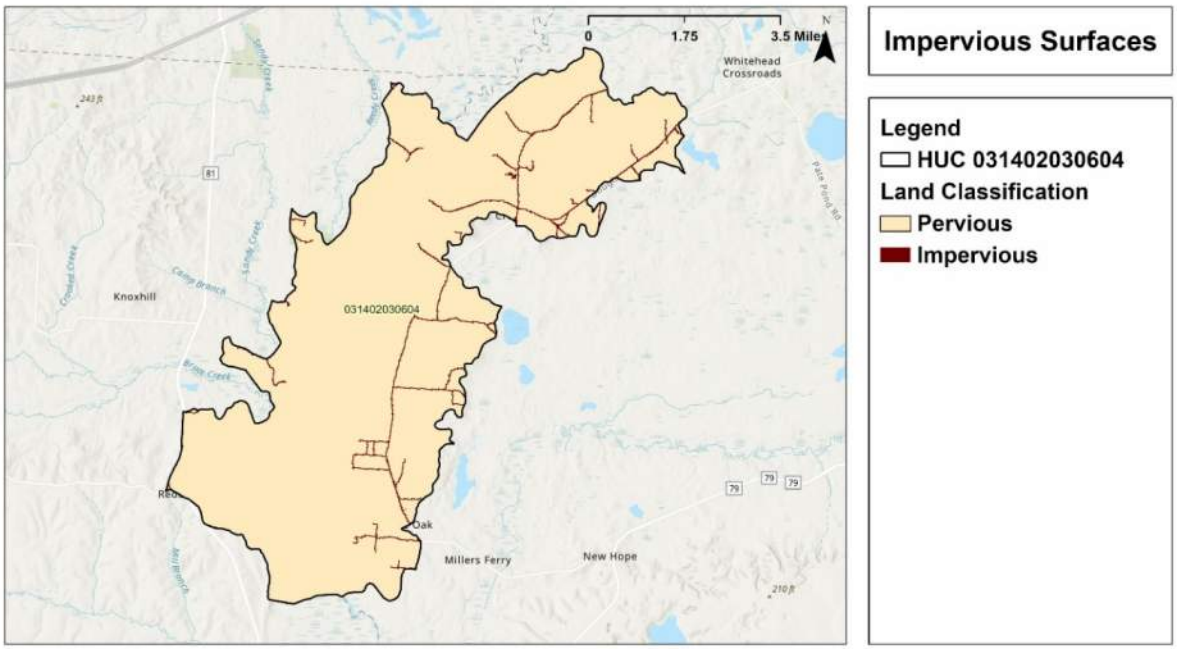


Figure 25. Impervious area map for the HUC 031402030604 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

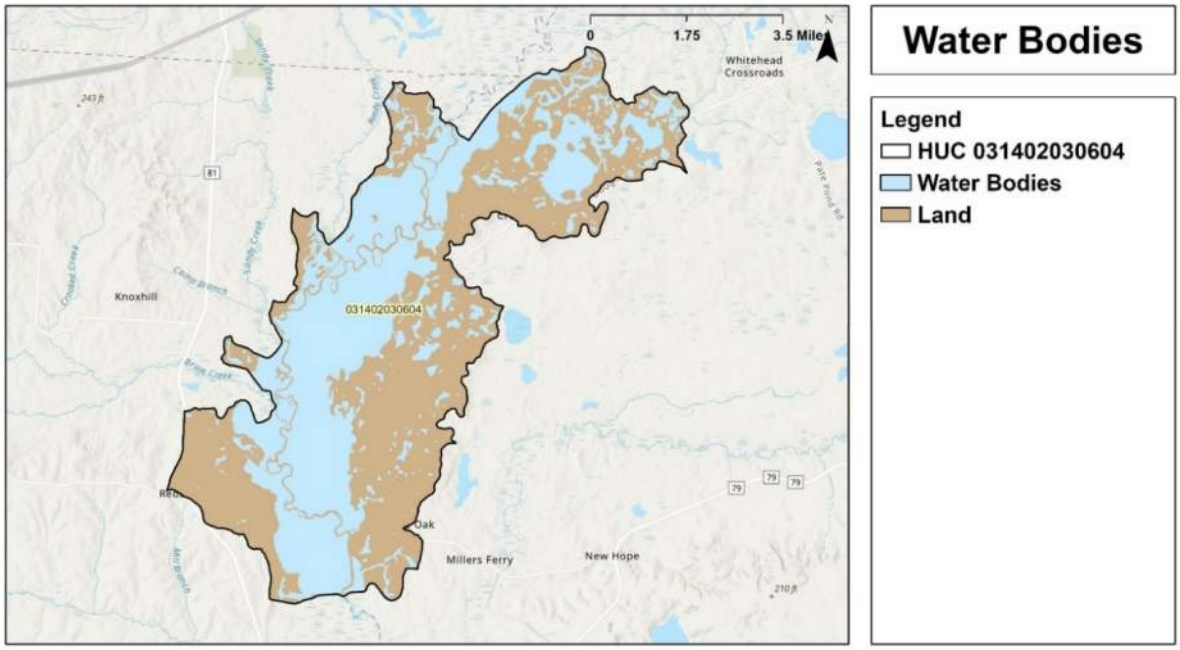


Figure 26. Water bodies map for the HUC 031402030604 sub-watershed, processed by FAU.

1.10. Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract

level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

Source: US Census Bureau 2020 and Zip-codes.com

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.

- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

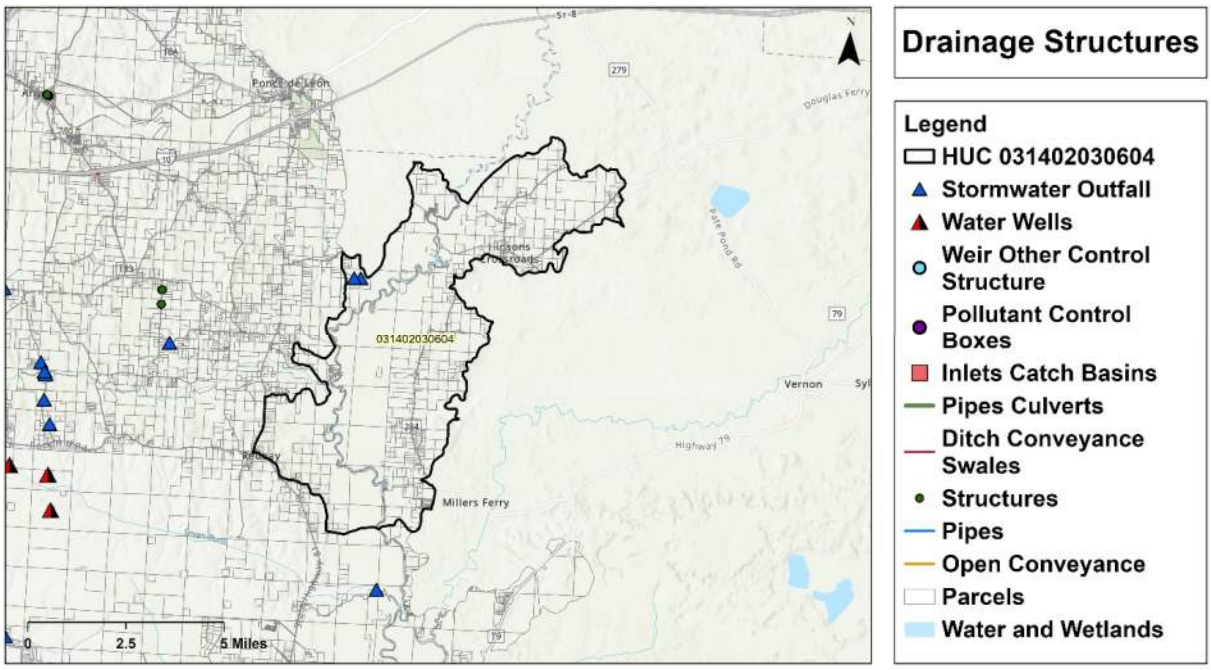


Figure 27. Stormwater Infrastructure for the HUC 031402030604. Processed by FAU.

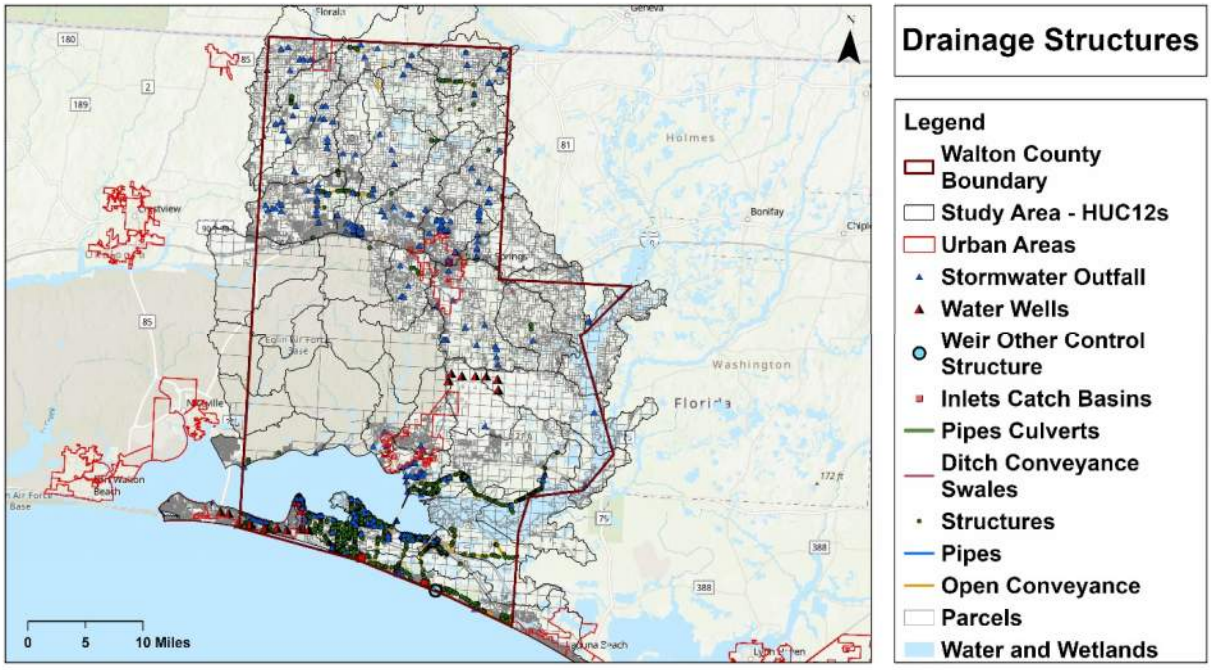


Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1 and 2, and comparing to data in Chapter 3, vulnerability can be identified.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031402030604 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

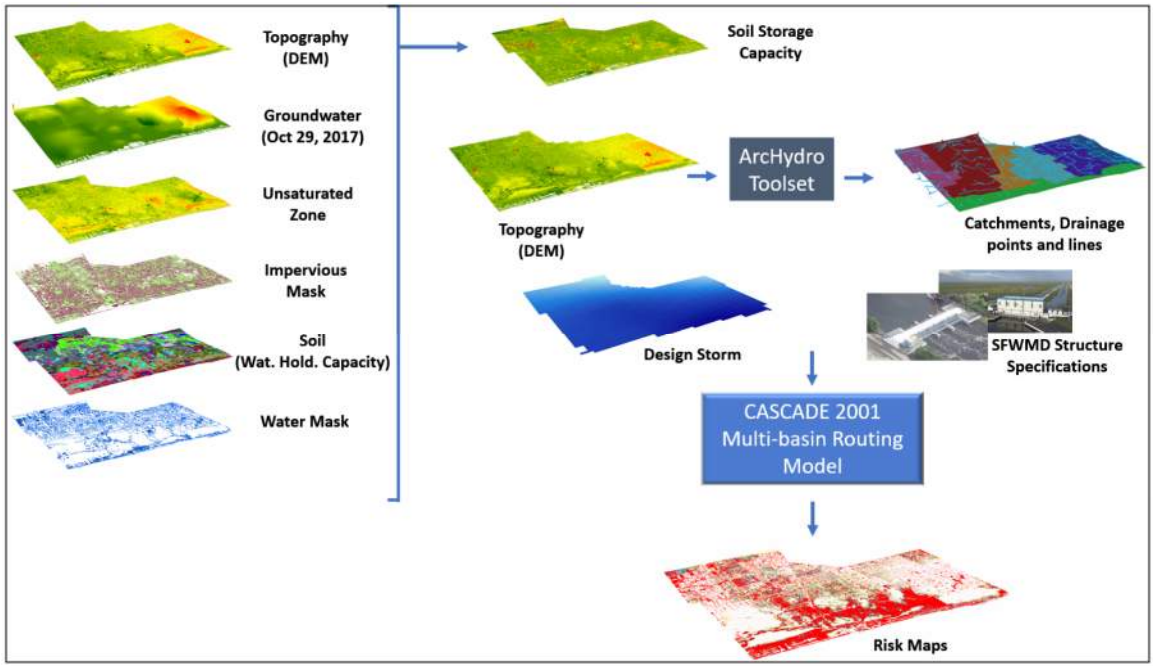


Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)

= 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

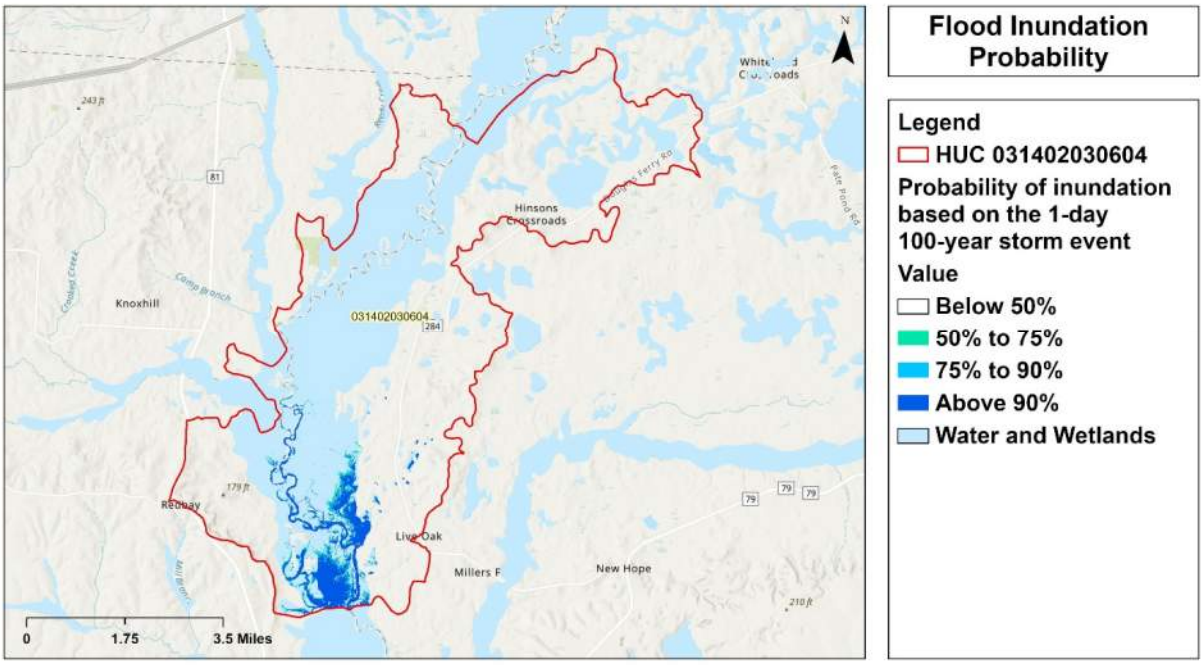


Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031402030604, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation

and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 5.2 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations,

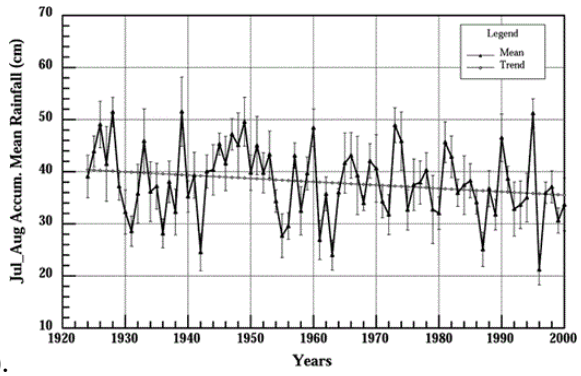
Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Future Challenges of Sea Level Rise and Climate Change

Global observations from satellites and long-term data collection have made it possible to document and analyze patterns in the Earth's climate. Scientific analysis of the impact of these changes has helped to improve the understanding of future flood hazard driving forces and long-term impacts on human activities and watershed master planning (http://www.research.noaa.gov/climate/t_observing.html). Examples of impacts are rising global average air and ocean temperatures, increased and earlier snow and ice melt, shorter subtropical rainy seasons, shifted seasons, sea level rise and greater variations in temperature and precipitation (IPCC, 2013; Freas et al., 2008; Marshall et al., 2004; Bloetscher et al., 2010). Marshall et al. (2004) specifically focused on the Florida peninsula to predict changes in rainfall and warmer temperatures but interspersed lower low temperatures due to the potential loss of wetlands.

Future changes in climate will add to the existing impacts, at a time when the population of the state is expected to nearly double by 2030. Additional research and high-resolution climate modeling for the Florida peninsula and local jurisdictions is needed to help guide long-term plans like WMPs. Rainfall appears to be decreasing and temperatures rising (see **Error! Reference**

source not found.).



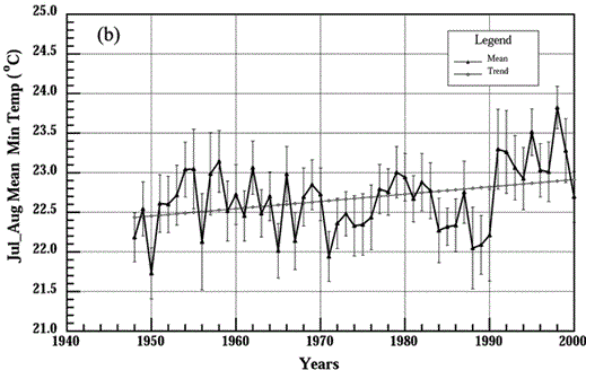


Figure 31. Change in average rainfall and change in average temp 1924 to 2000. Note the reversed trend, which means groundwater input variability is lessened. Source: Marshall et al., 2004.

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3 feet. Accompanying these drivers are potential changes in storm frequency and intensity, desertification, population migration, ocean acidification and coastal flooding (IPCC, 2007), exacerbated by the land cover and land use changes, which are substantially impacted by the fluxes, timing and quality of precipitation (Adrians et al., 2003; Scanlon et al., 2005; Marshall et al., 2004; Salmun and Molod, 2006), and leading to changes in the timing of peak flows and volumes (Richey and Costa-Cabral, 2006).

The results of these climatic changes are likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly An outcome of these climatic patterns is that during the past 140 years, an increase in sea levels has been observed (Bloetscher, 2012), a worrying pattern since sea level rise is a permanent phenomenon, that can be catastrophic to low lying areas in the long-term. The question is how much and how soon? Various studies (Bindoff et al., 2007; Domingues et al., 2008; Edwards, 2007; Gregory, 2008; Vermeer and Rahmstorf, 2009; Jevrejeva, Moore and Grinsted, 2010; Bloetscher, 2010, 2011; IPCC, 2007; Heimlich et al., 2009) indicate large uncertainty in projections of sea level rise by 2100. Gregory et al. (2012) note that during the last two decades, the global rate of sea level rise has been larger than the 20th-century time-mean, and Church et al. (2011) suggested that the cause was increased rates of thermal expansion, glacier mass loss, and ice discharge from icesheets. Gregory et al. (2012) suggested that there may also be increasing contributions to global sea level rise from the effects of groundwater depletion, reservoir impoundment, and loss of storage capacity in surface waters due to siltation. Measurements of Florida's east coast (Maul, 2008) show an average rate of sea level rise of 2.27 ± 0.04 mm per year from 1915 to 1992 based on tide gauge readings. Analyzing the tidal gauge readings for Florida shows that:

1. Florida average sea level rise is 2.10 ± 0.49 mm/yr
2. All but one location is within the 95% confidence limit range (the exception is Panama City where there is evidence of submergence and other land-based issues)
3. None of the Florida sea level rise rates differ statistically
4. Average global sea level rise for 1920-2000 was 2.0 mm/yr – within 95% confidence limit for Florida locations

From 1929 to 1992, over eight inches of sea, with another 6 inches added since 1992, which is already having significant impacts on coastal communities where population growth has increased the need for improved flood management strategies (Bloetscher, 2008; Parkinson, 2010; Zhang et al., 2011, 2011a; NFIP, 2011; Schmidt et al., 2011; Warner et al., 2012).

As a result, the SFRCCC (2015) adopted USACE's methodology to derive scenarios of sea level change intermediate to high rates of sea level rise for years 2030 (3" to 7") and 2060 (9" to 24") as the consensus projection to guide future planning. The path keeps increasing – now 14 inches

since 1929 (**Error! Reference source not found.**) caused by thermal expansion of the ocean and melting ice caps (Jevrejeva et al., 2010; Vermeer and Rahmstorf, 2009). Sea level rise is a major concern in Florida, including Walton County, since the majority of the state's population live on the coast, involving most major commercial, residential, and economic enterprises. **Error! Reference source not found.** demonstrate the estimated sea level change for Panama City, considering the predictions of NOAA 2017. For NOAA high scenario SLR change scenario, the estimated level change is higher than 8 ft., while for the intermediate and low scenarios are about 3.9 feet and 1.7 feet respectively.

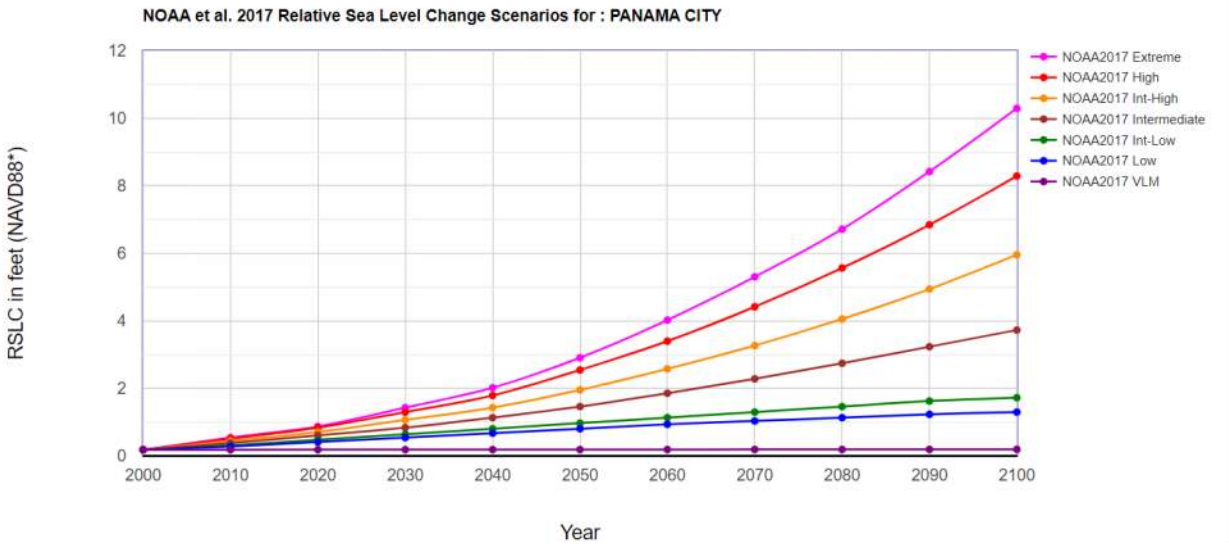


Figure 32. Relative Sea Level Change Scenarios for gauge 8729108, Panama City, FL. Source: NOAA, 2017 (https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html).

NOAA (2017) outlines five scenarios for sea level rise. The NFIP proposes the use of the intermediate high projection, which is 1.2 meters or 4 ft globally from current sea level elevations (**Error! Reference source not found.**).

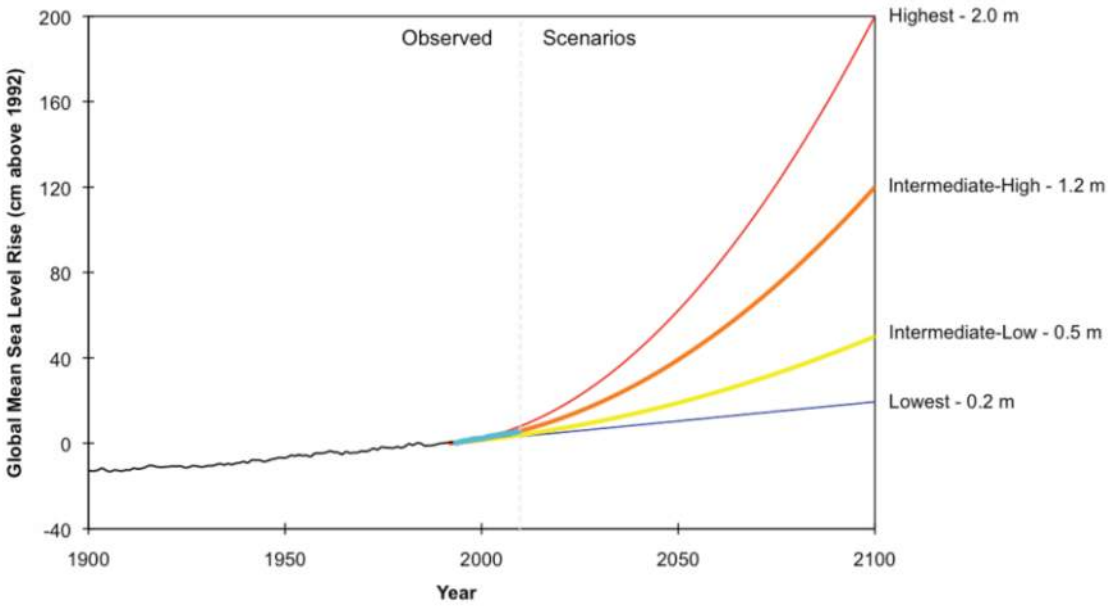


Figure 33. Graphic of global sea level rise projections from NOAA (2017). Source:https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

As sea level rises, access to roads, bridges, rail, and transit could be at risk of flooding, causing the effects of sea level rise to spread indirectly throughout the entire transportation network, affecting the overall system performance. For example, the flooding of a critical road or facility access can cause a shifting of traffic flow causing congested conditions in other roadways that are not actually flooded. Since the roadway network would be unable to carry the traffic demand, the system would experience operational failure; as a result, causing travel times and delays. Moreover, the inundation of a critical access could cause transportation connectivity problems to essential infrastructure like ports or airports. Transportation infrastructure relies on the effectiveness of flood control and stormwater drainage systems for the transportation corridors. Road integrity relies on adequate drainage. The increased risk of severe flooding in Florida's low-lying terrain can adversely affect transportation infrastructure along the coastline; roads can be inundated, and roadway beds can be damaged. Sea level rise will cause increased water table levels (FDOT, 2012), as regional water tables cannot exist naturally below mean high tide (2 feet in Florida). Adding 3 feet of sea level rise on top of groundwater would compound the risk of flooding in low-lying areas. Road bases below 5 feet NVGD would become saturated under this scenario, likely causing premature base failure. As soil storage capacity is diminished due to rising groundwater elevations associated with sea level rise, the potential for more frequently flooded roadways would likely damage pavements (FDOT, 2012). Hence sea level rise must be accounted for in WMPs in coastal areas. To allow flexibility in the analysis due to the range of increases within the different time periods, an approach that uses incremental increases of 1, 2, and 3 feet of sea level rise is suggested for modeling. The increments can work as threshold values in planning

considerations in terms of allowing planners the ability to know ahead of time where the next set of vulnerable areas will be, to allow for a proactive response approach that can be matched to the observed future rates. Sea level rise is a major concern since nearly half the US population lives within 50 miles of the coast, involving most major commercial, residential, and economic enterprises. The effects of 5 ft of sea level rise, King tide, and 1-day 100-year storm event are shown in **Error! Reference source not found.**.

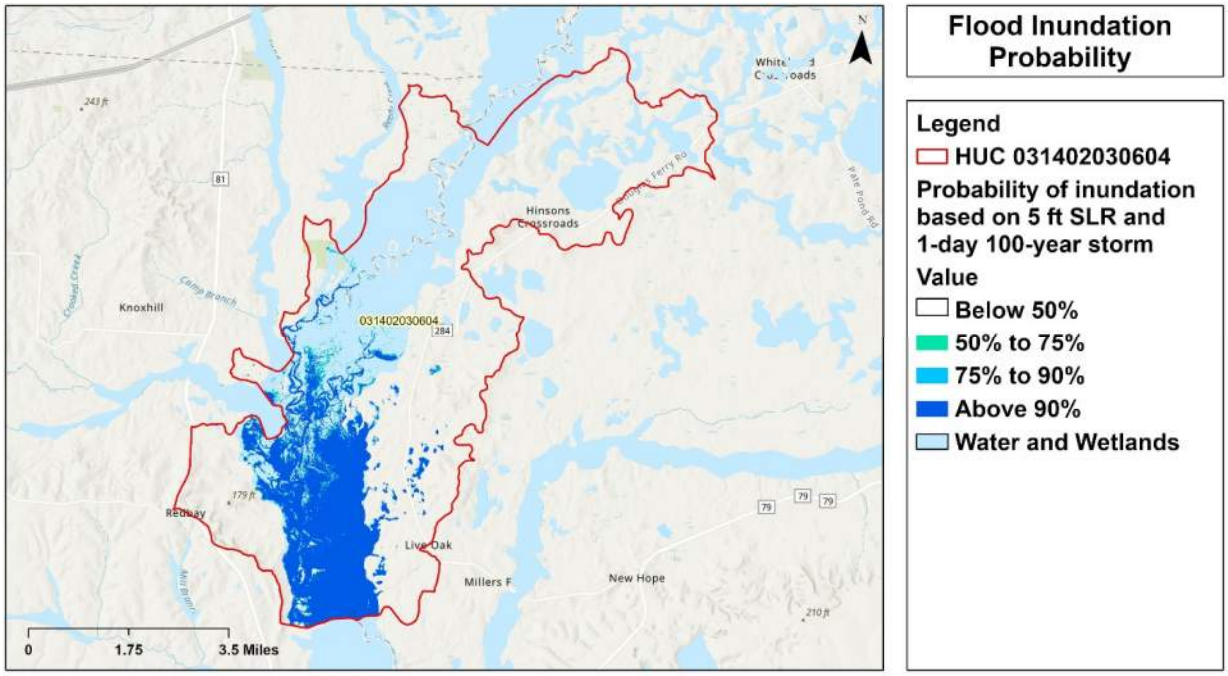


Figure 34. Flood Inundation Probability for a Sea level rise of 5 ft + 1-day 100-year storm event for HUC 031402030604 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Dark blue is area under 5 ft NAVD88 and potentially inundated at the 99th percentile tidal conditions. Processed by FAU.

2.4 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. **3-day 25-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 35)
2. **1-day 100-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 36)

3. **1-day 10-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 37)
4. **1-day 5-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 38)
5. **Sea level rise of 1 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 39)
6. **Sea level rise of 1 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations storm (Figure 40)
7. **Sea level rise of 1 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 41)
8. **Sea level rise of 1 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 42)
9. **Sea level rise of 2 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 43)
10. **Sea level rise of 2 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 44)
11. **Sea level rise of 2 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 45)
12. **Sea level rise of 2 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 46)
13. **Sea level rise of 3 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 47)
14. **Sea level rise of 3 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 48)
15. **Sea level rise of 3 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 49)
16. **Sea level rise of 3 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 50)

17. **Sea level rise of 4 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 51)
18. **Sea level rise of 4 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 52)
19. **Sea level rise of 4 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 53)
20. **Sea level rise of 4 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 54)
21. **Sea level rise of 5 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 55)
22. **Sea level rise of 5 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 56)
23. **Sea level rise of 5 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 57)
24. **Sea level rise of 5 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 58)

In all scenarios, a considerable amount of flooding is noted at the river entrance to the HUC, extending to the wetland areas. As this basin connects to the ocean though Choctawhatchee River, SLR scenarios plays an important hole, implying a considered growth as the projected scenario of rising tides rises.

The design storm simulation determined that approximately 4.7% of the HUC total area or 1.75 mi² has a probability of inundation above 50% for all design storm, indicating that 1.75 mi² of the HUC would be expected to be inundated during all four storm event scenarios, as illustrated in **Error! Reference source not found.**.

Table 7. HUC 031402030604 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	35.65	1.75	95.3%	4.7%

1-day 100-year	35.65	1.75	95.3%	4.7%
1-day 10-year	35.65	1.75	95.3%	4.7%
1-day 5-year	35.65	1.75	95.3%	4.7%

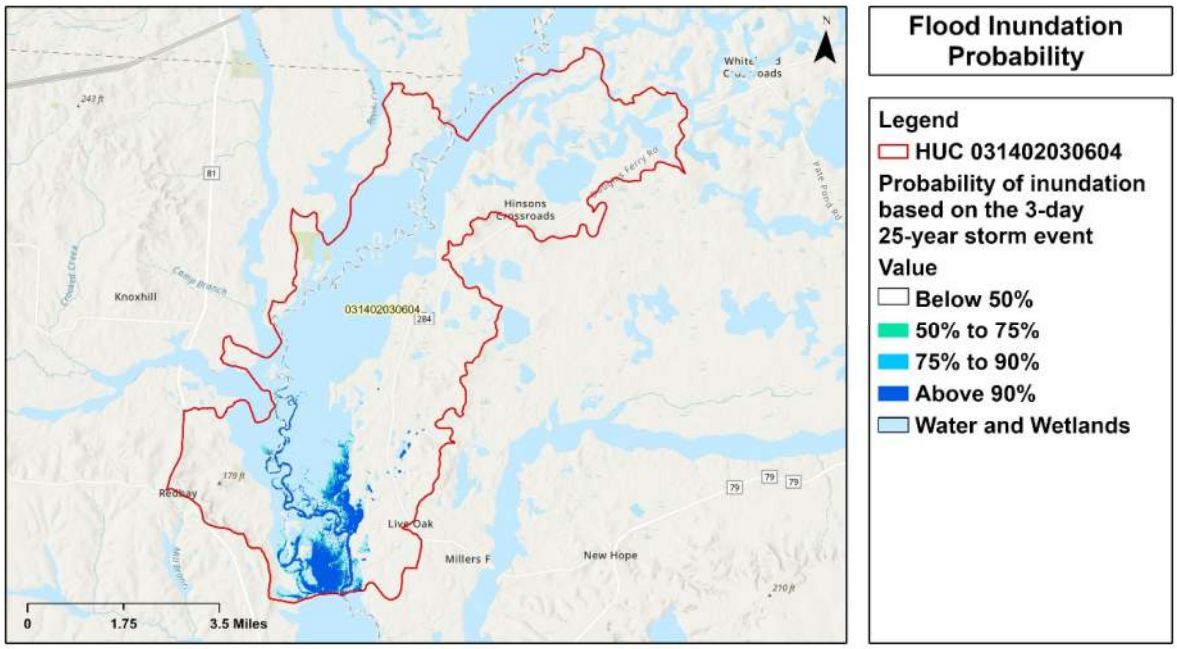


Figure 35. 3-day 25-year storm event for HUC 031402030604 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

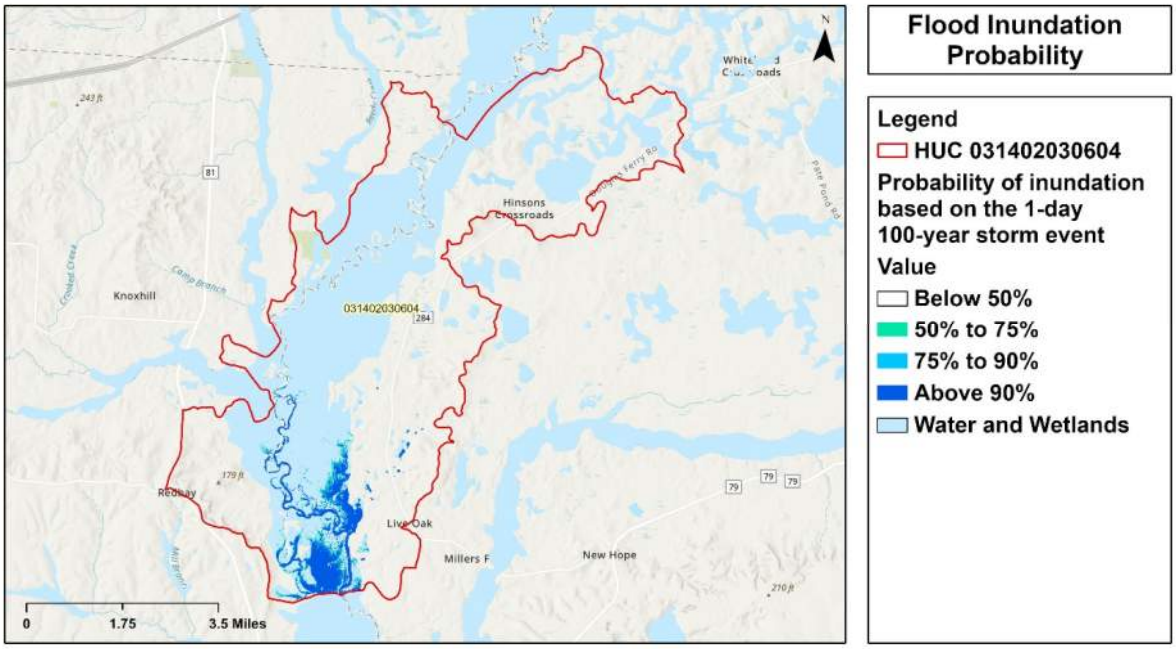


Figure 36. 1-day 100-year storm event for HUC 031402030604 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

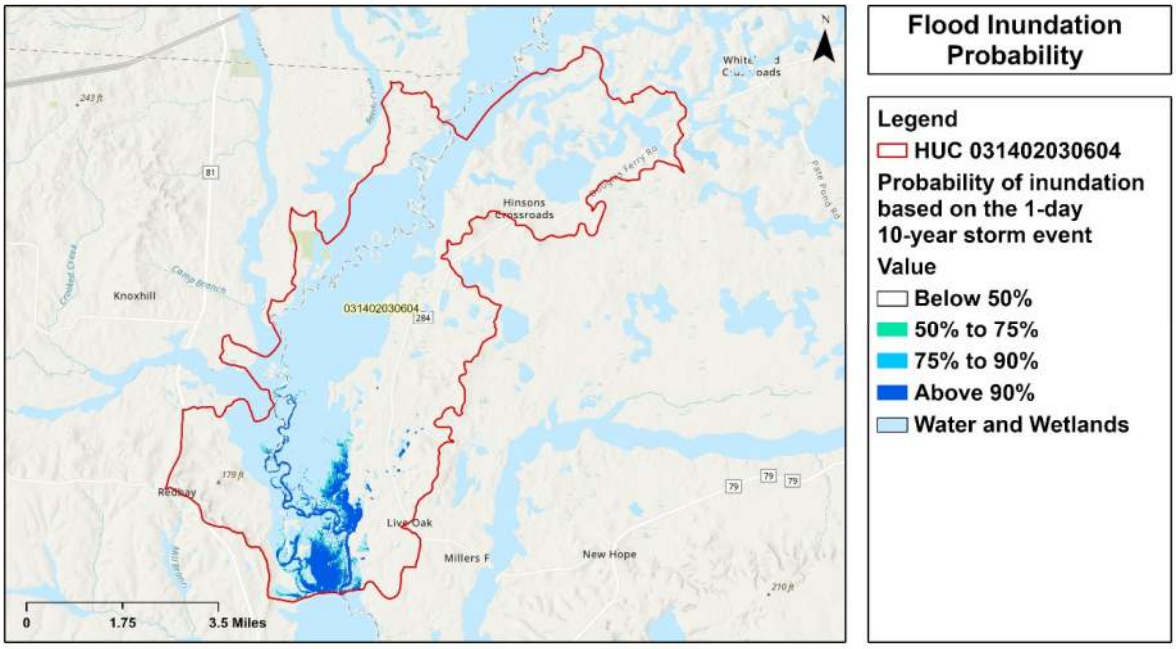


Figure 37. 1-day 10-year storm event for HUC 031402030604 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

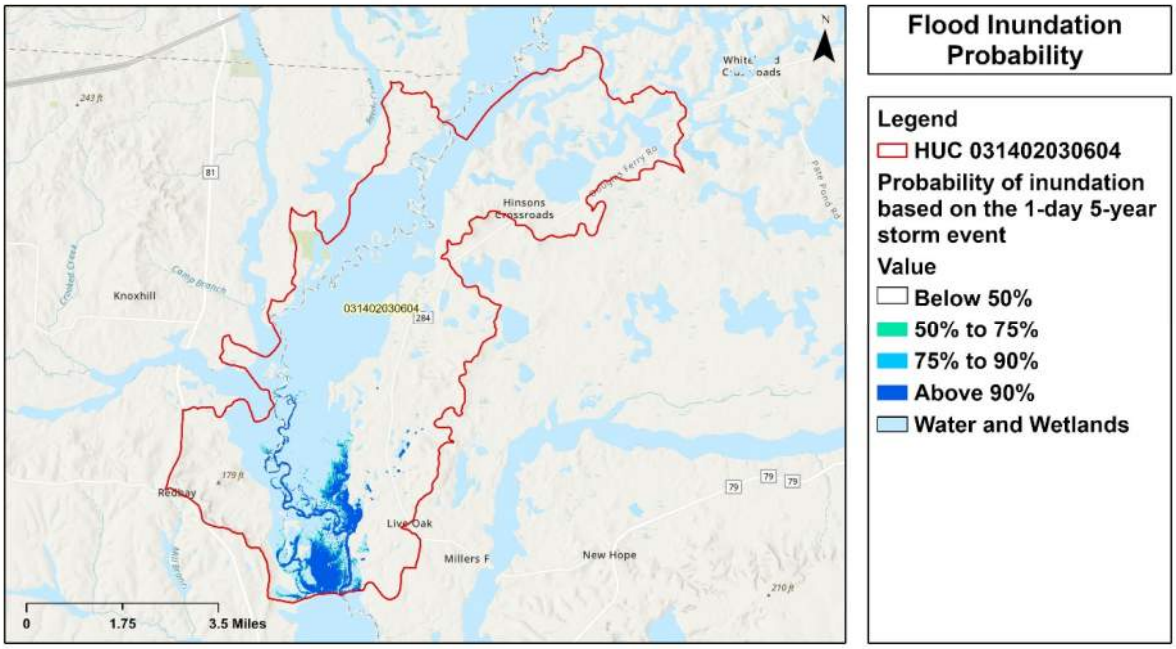


Figure 38. 1-day 5-year storm event for HUC 031402030604 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

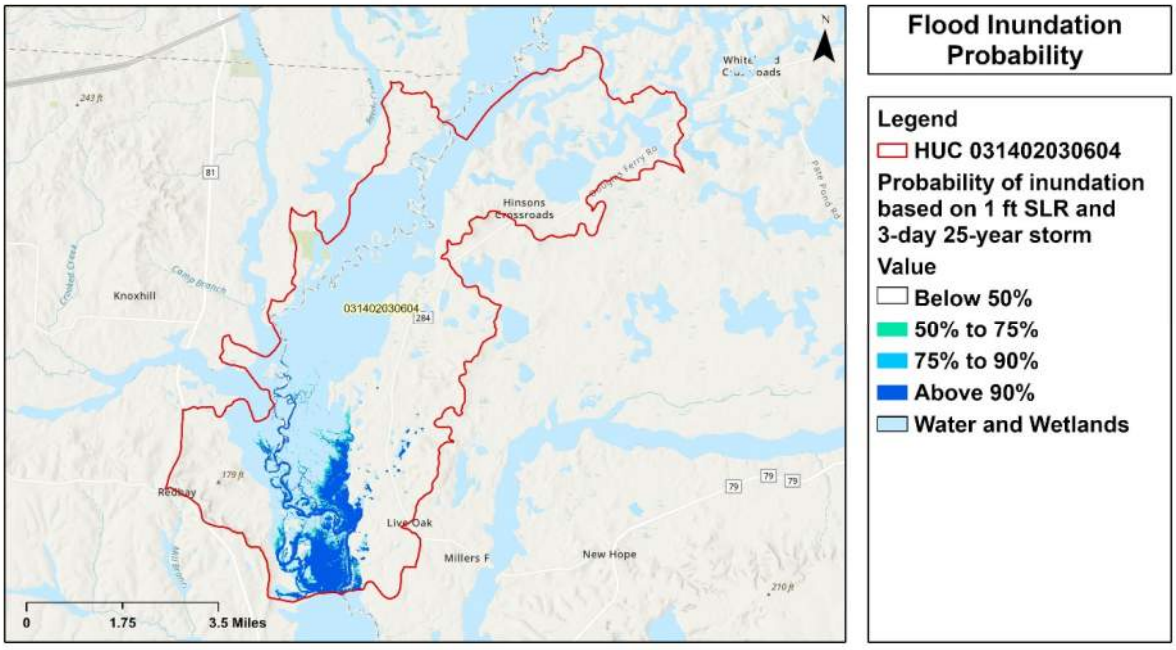


Figure 39. Sea level rise of 1 ft + 3-day 25-year storm for HUC 031402030604 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

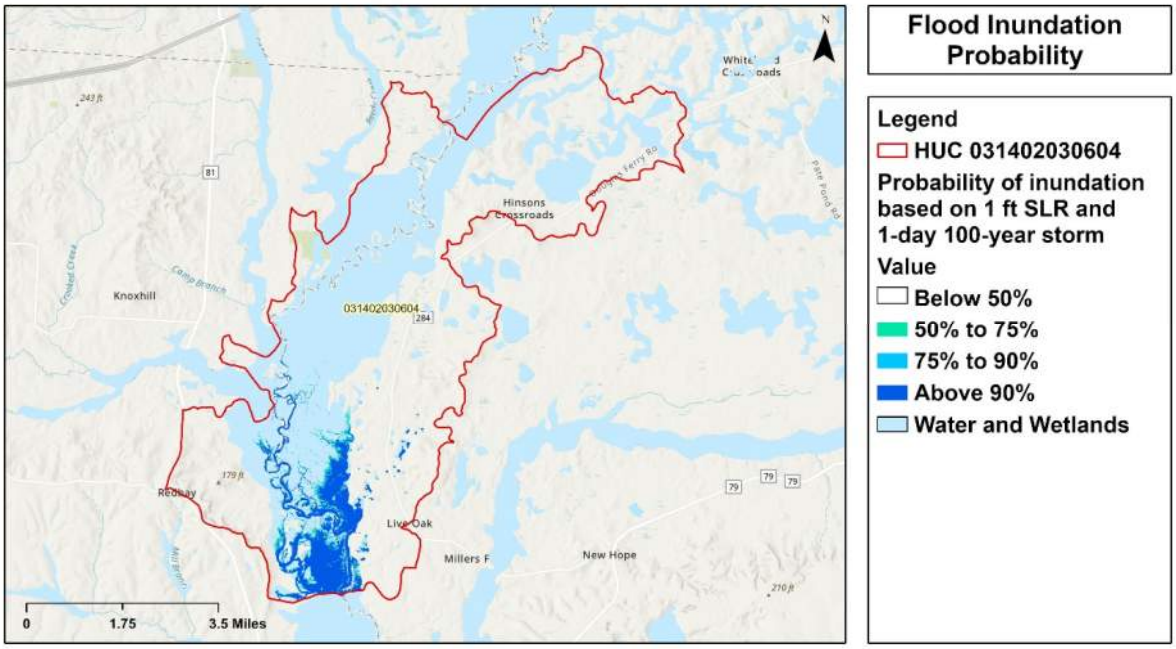


Figure 40. Sea level rise of 1 ft + 1-day 100-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

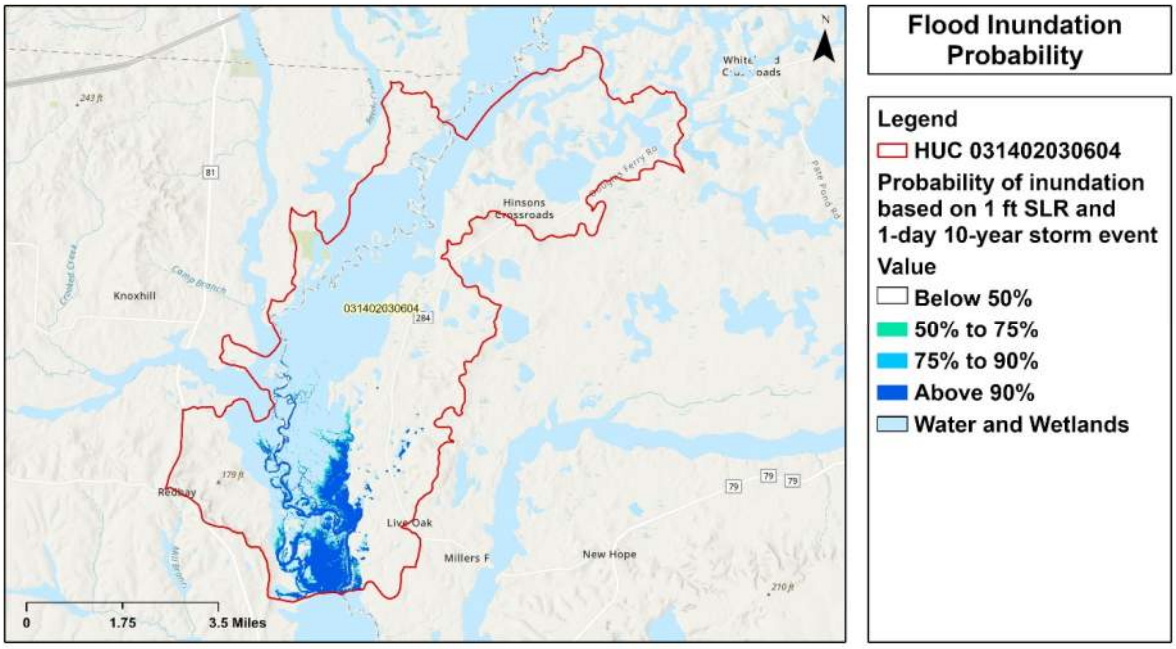


Figure 41. Sea level rise of 1 ft + 1-day 10-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

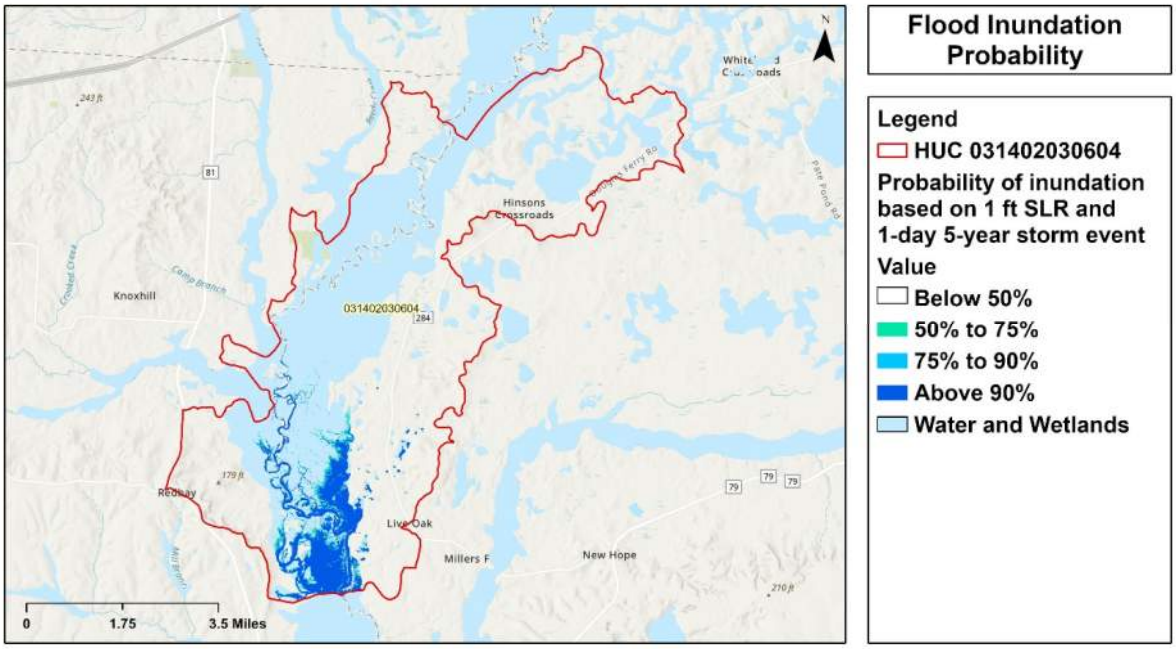


Figure 42. Sea level rise of 1 ft + 1-day 5-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

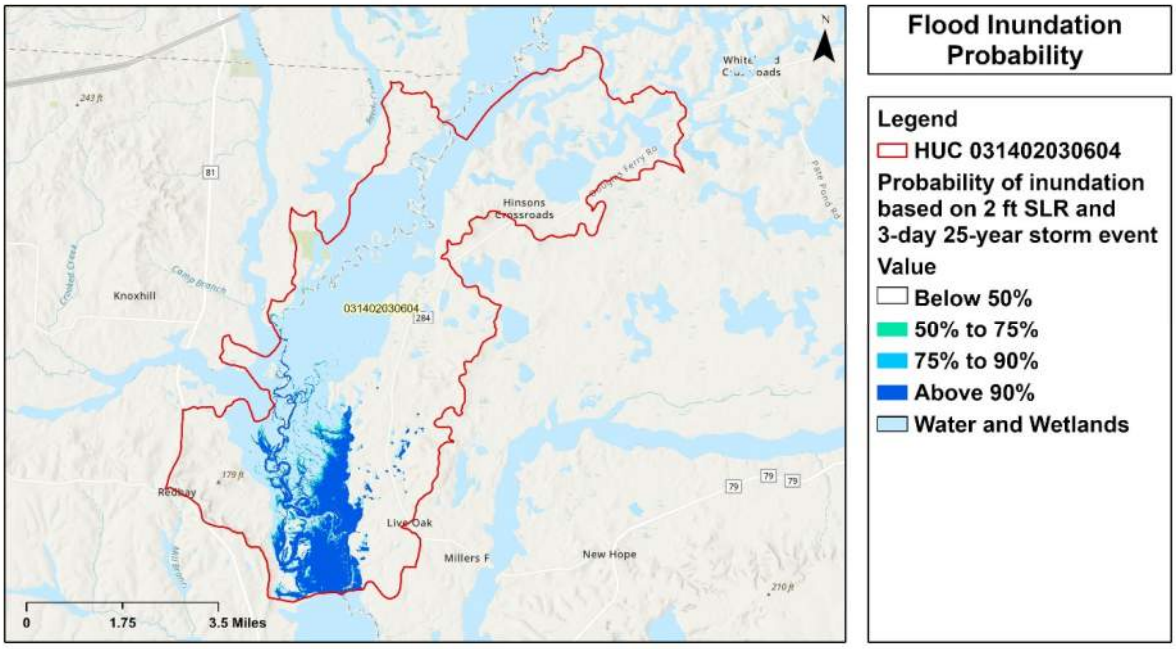


Figure 43. Sea level rise of 2 ft + 3-day 25-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

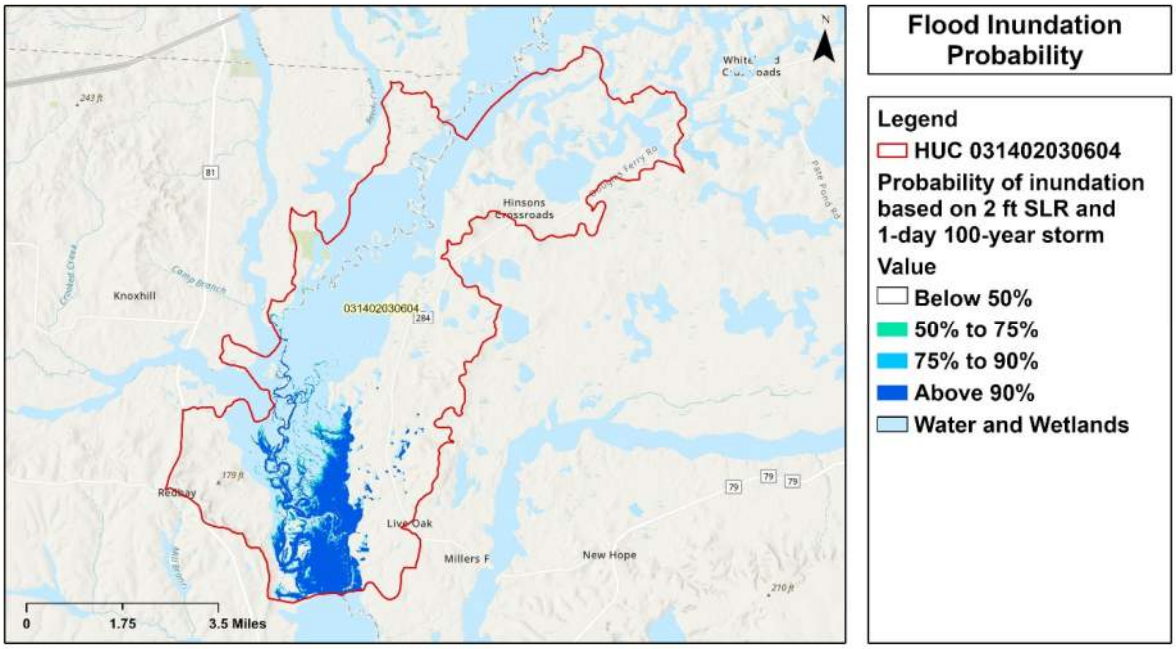


Figure 44. Sea level rise of 2 ft + 1-day 100-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

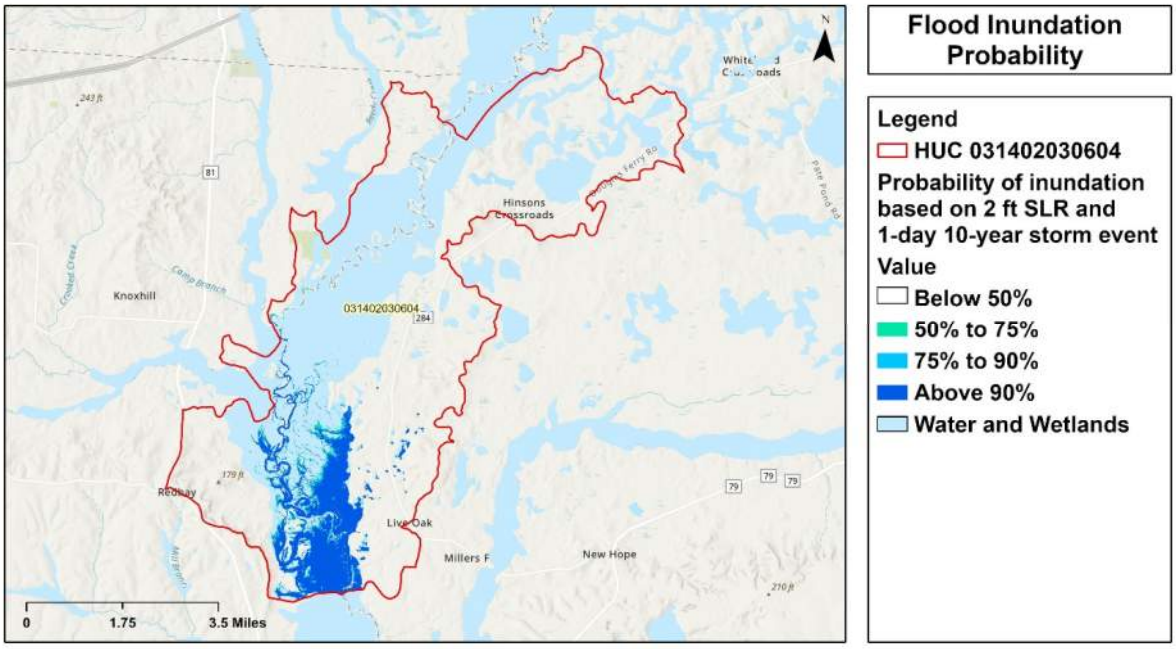


Figure 45. Sea level rise of 2 ft + 1-day 10-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

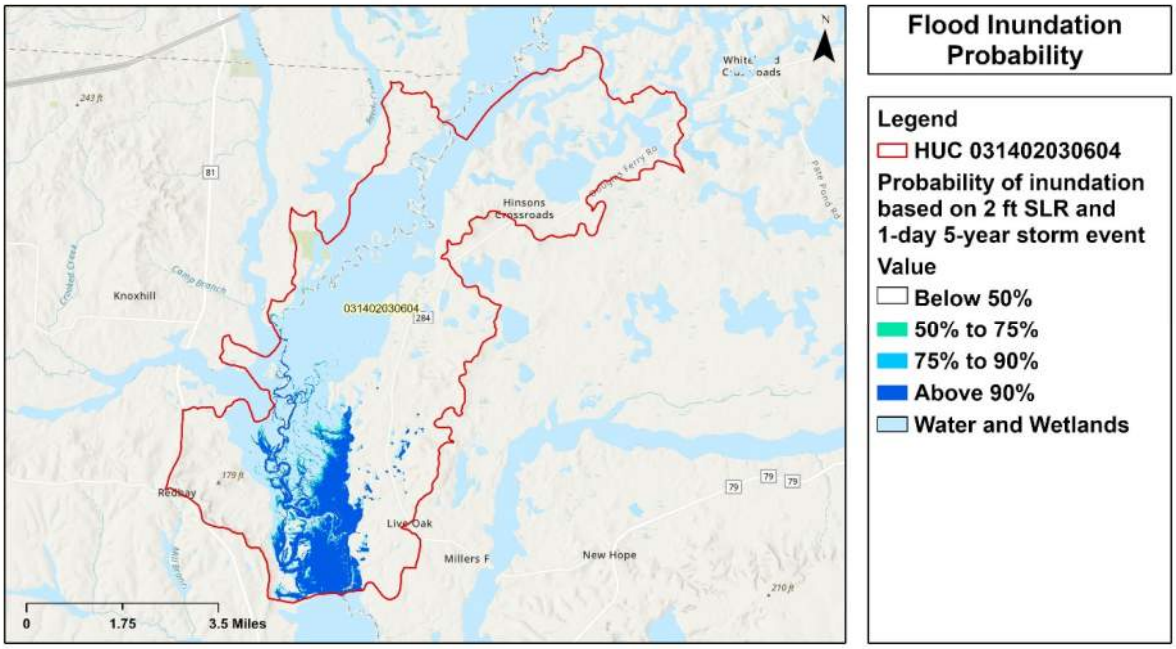


Figure 46. Sea level rise of 2 ft + 1-day 5-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

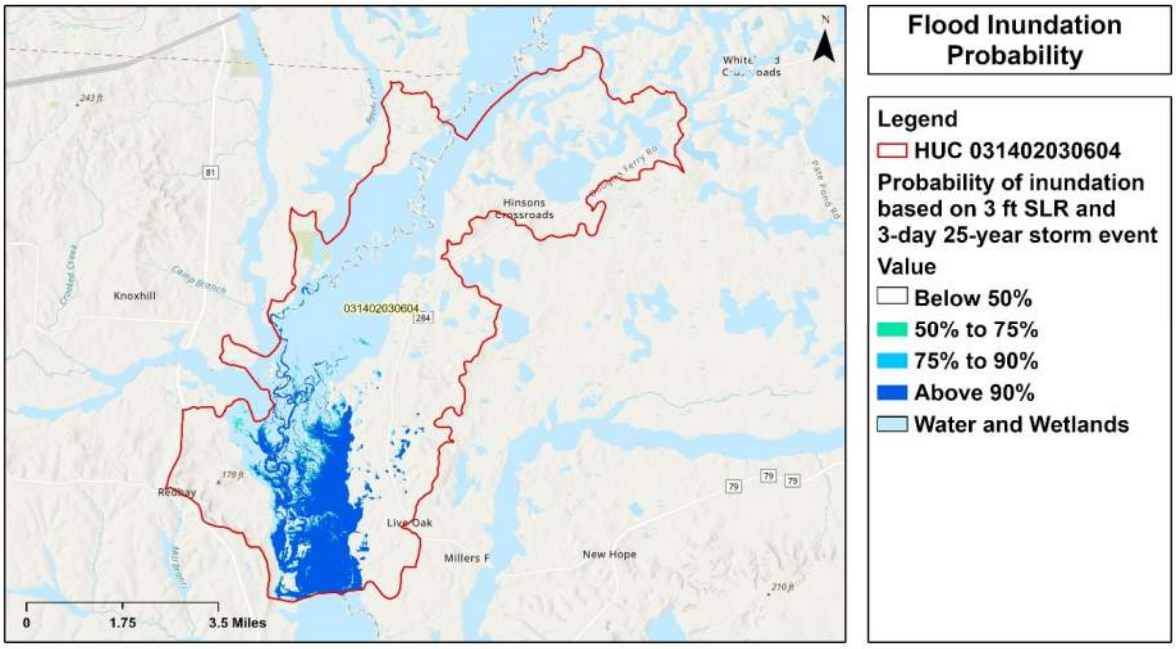


Figure 47. Sea level rise of 3 ft + 3-day 25-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

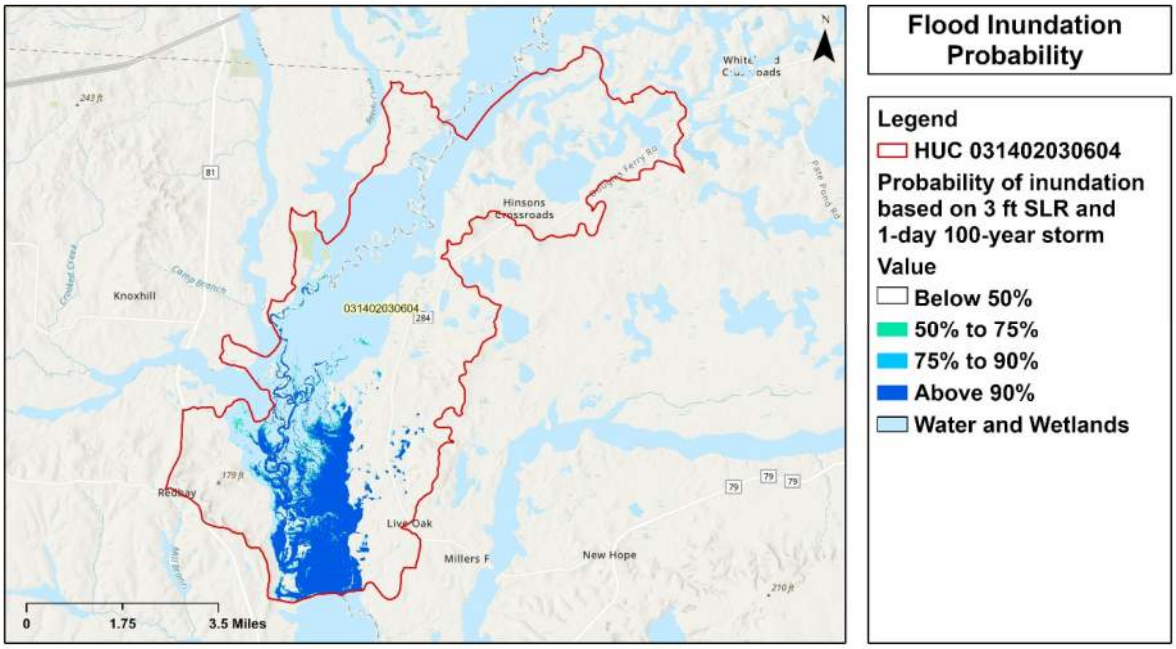


Figure 48. Sea level rise of 3 ft + 1-day 100-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

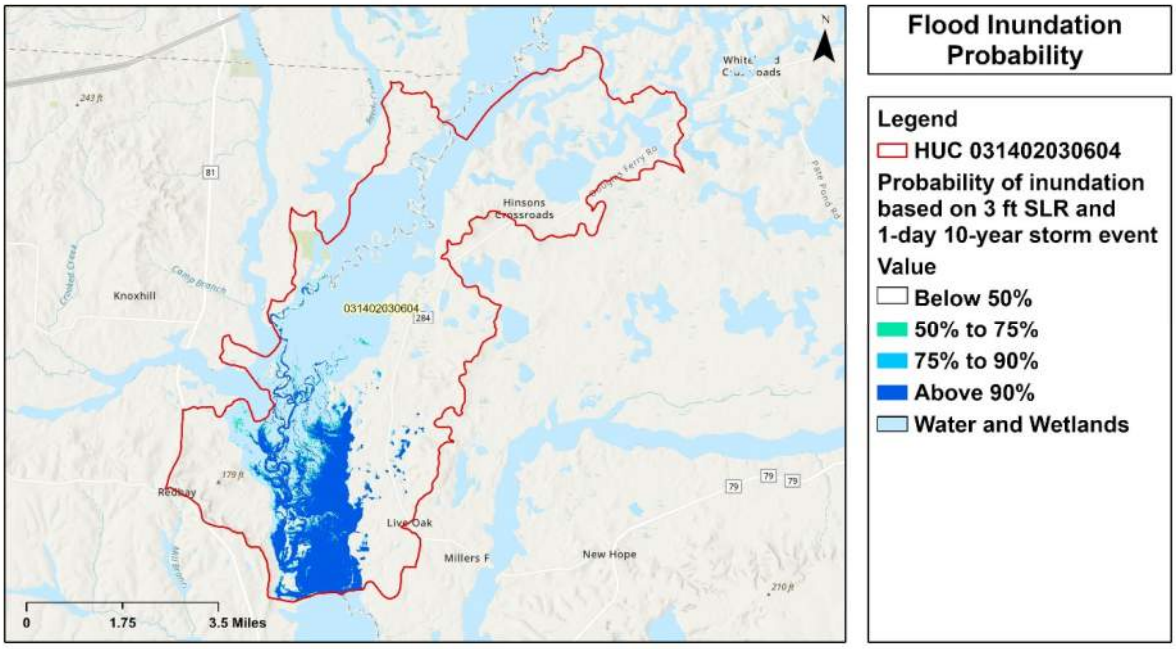


Figure 49. Sea level rise of 3 ft + 1-day 10-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

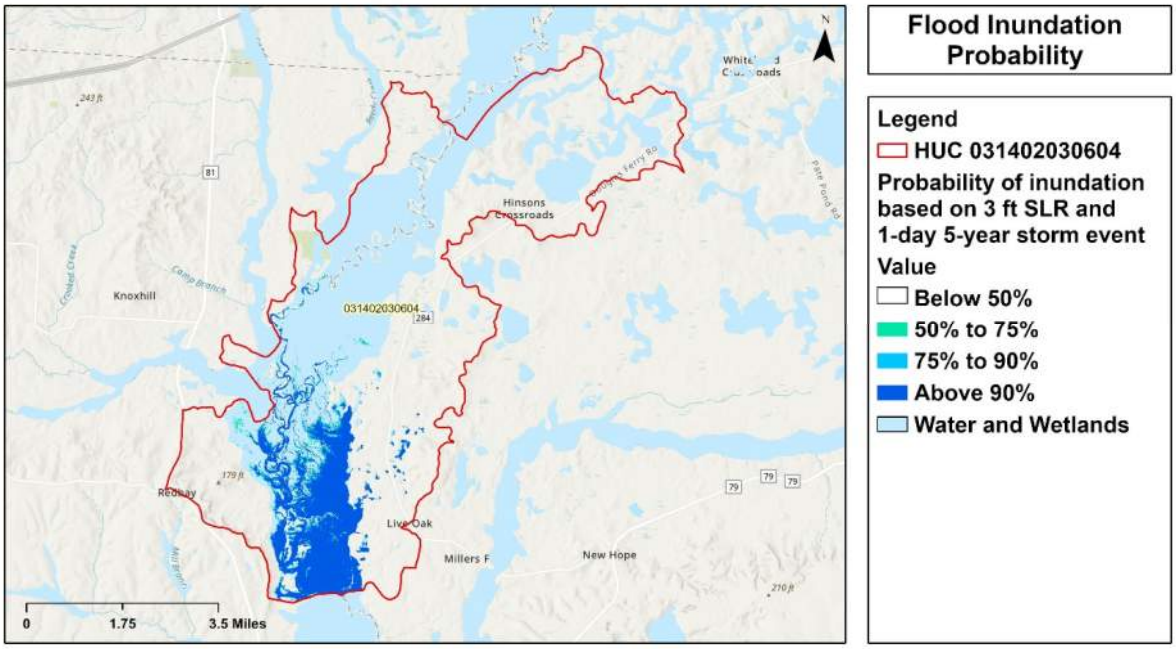


Figure 50. Sea level rise of 3 ft + 1-day 5-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

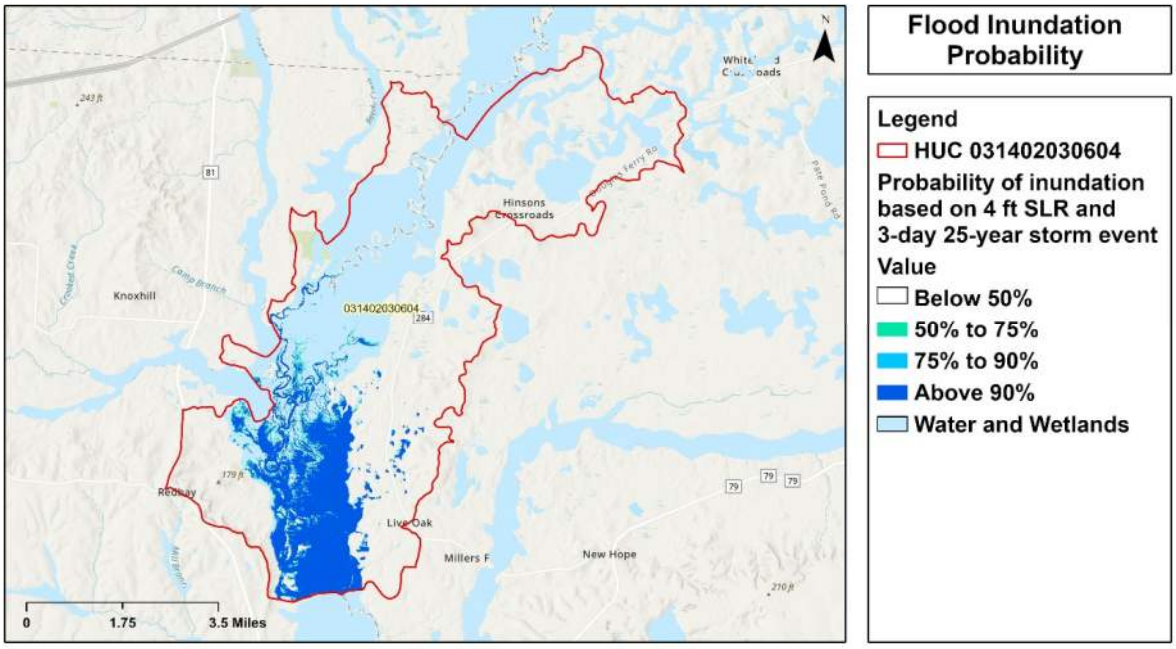


Figure 51. Sea level rise of 4 ft + 3-day 25-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

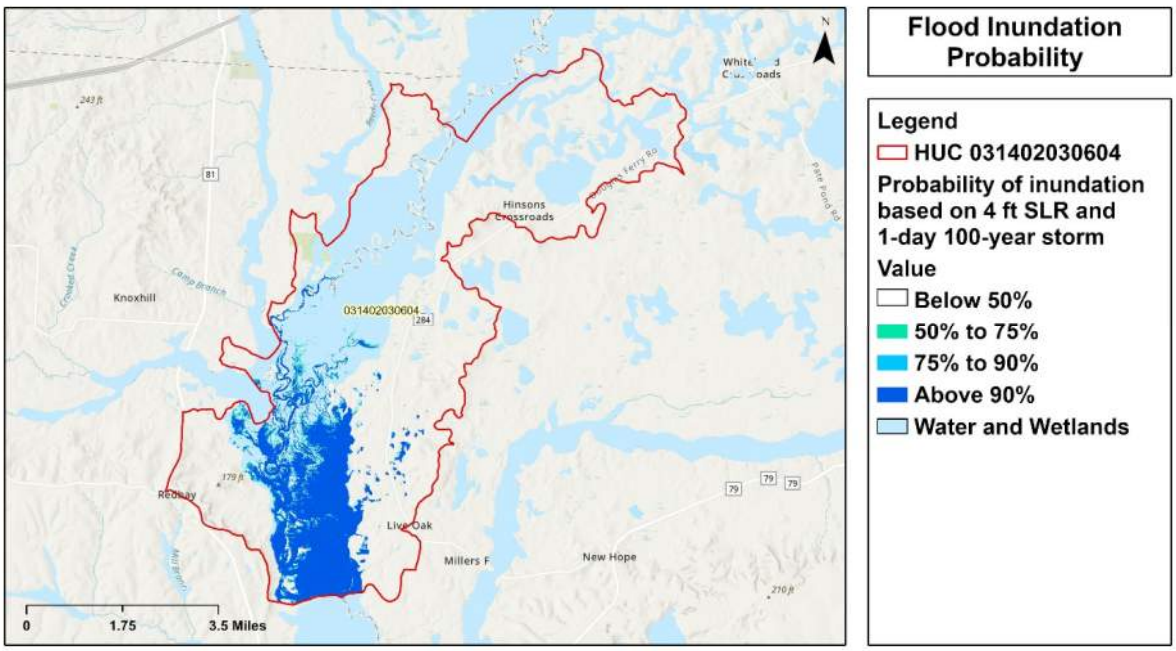


Figure 52. Sea level rise of 4 ft + 1-day 100-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

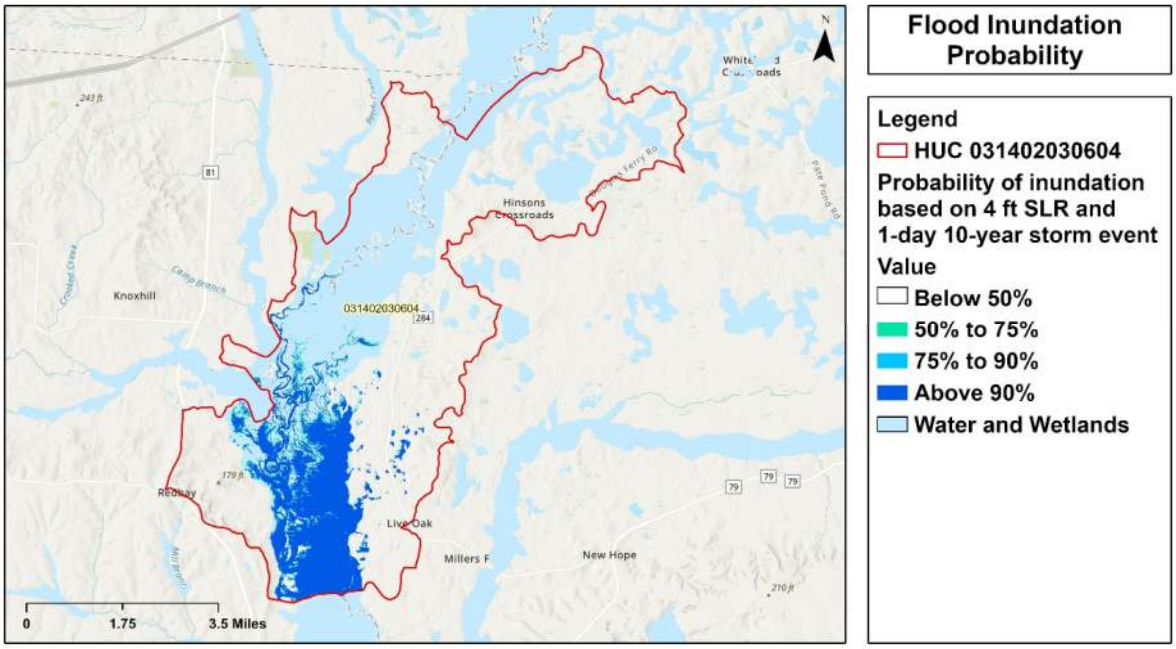


Figure 53. Sea level rise of 4 ft + 1-day 10-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

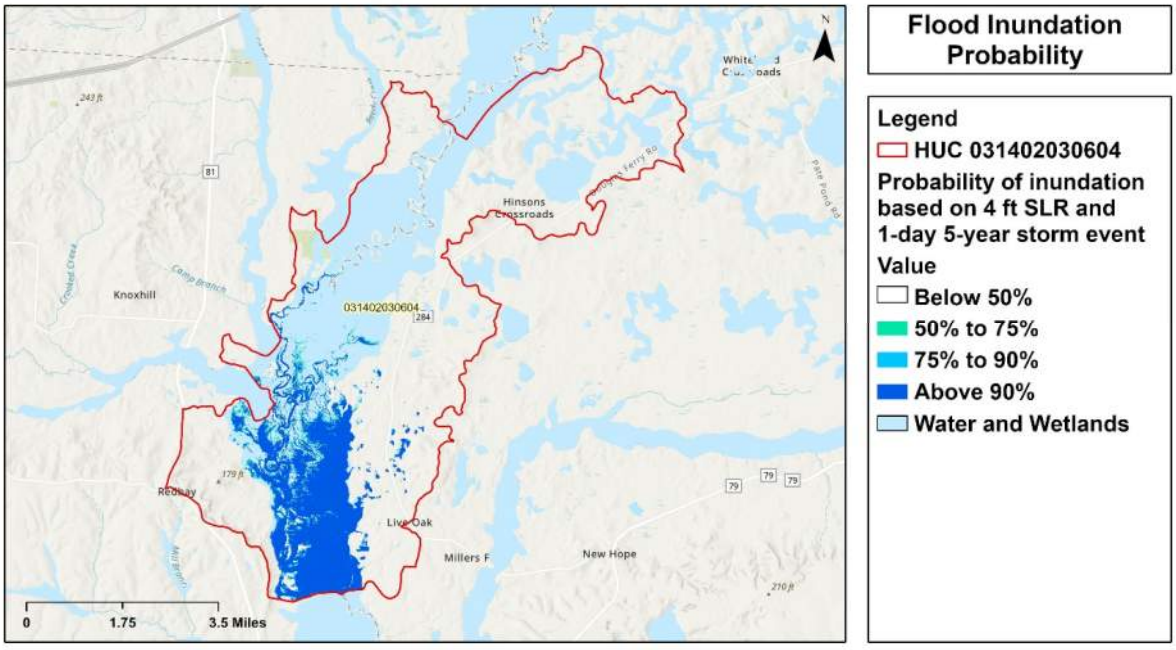


Figure 54. Sea level rise of 4 ft + 1-day 5-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

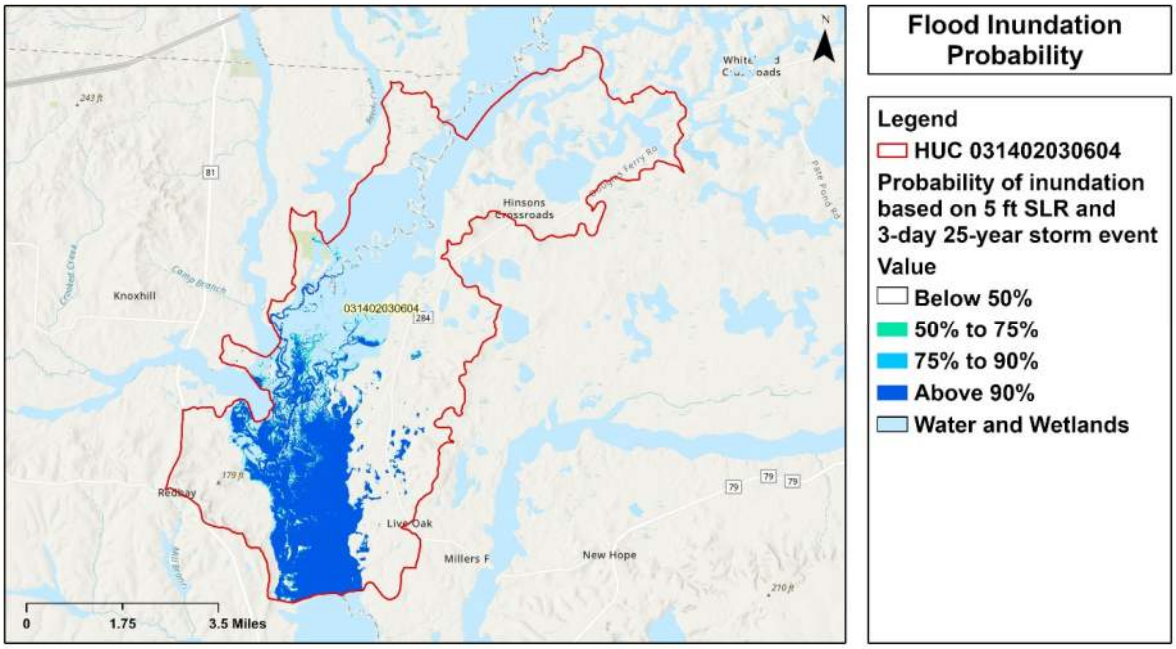


Figure 55. Sea level rise of 5 ft + 3-day 25-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

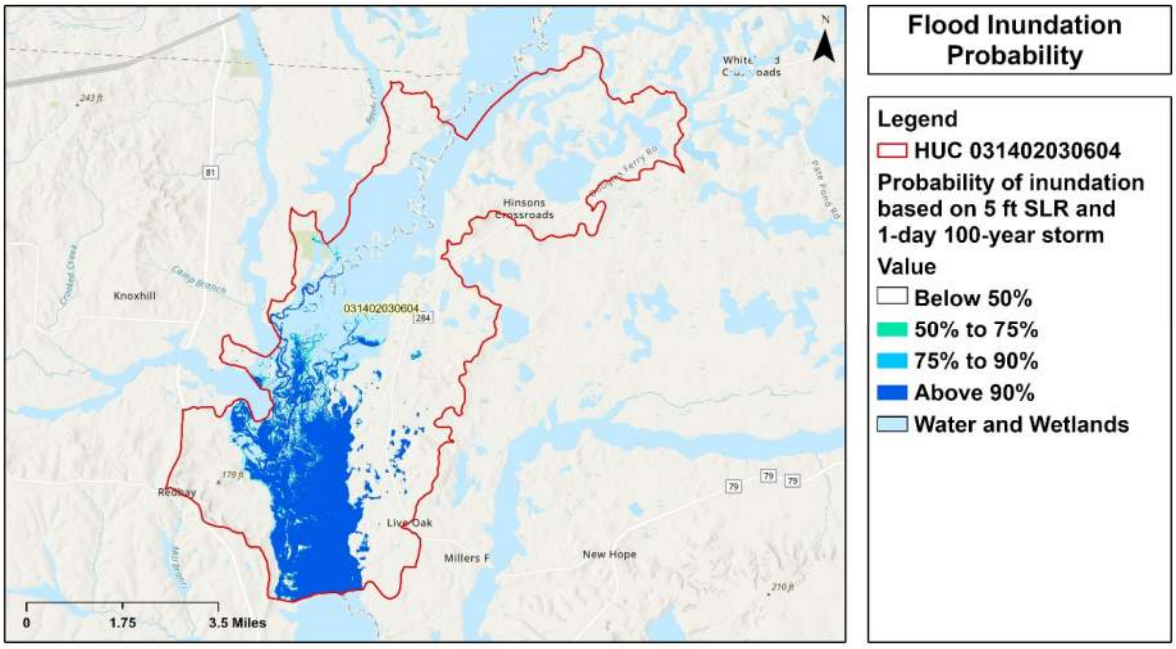


Figure 56. Sea level rise of 5 ft + 1-day 100-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

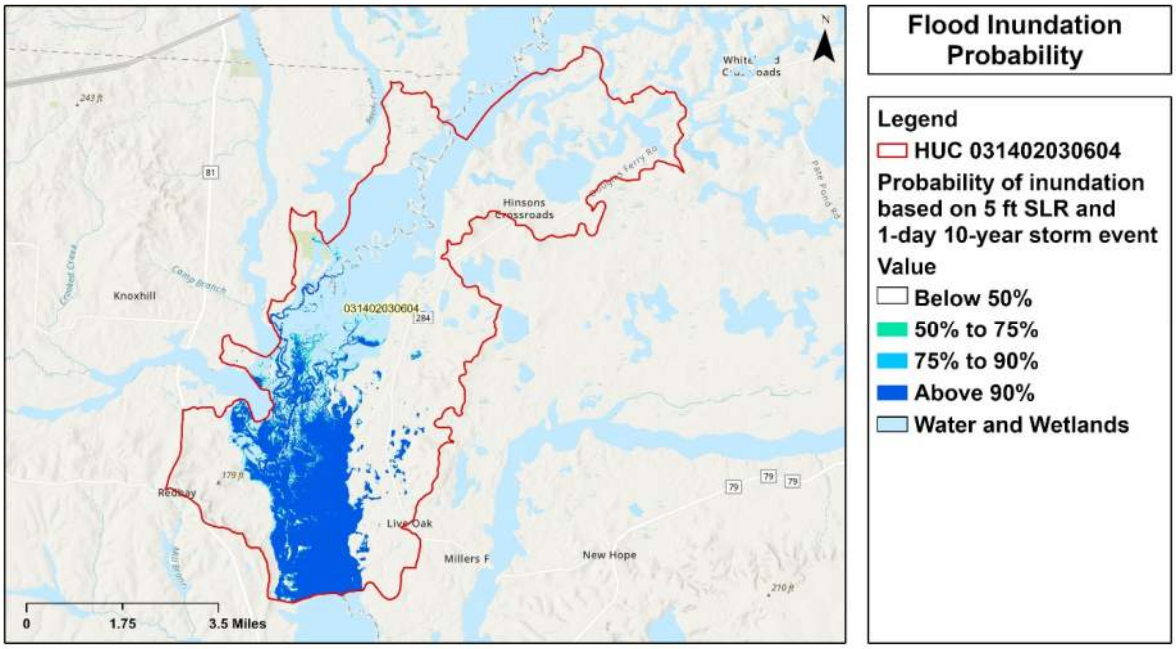


Figure 57. Sea level rise of 5 ft + 1-day 10-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

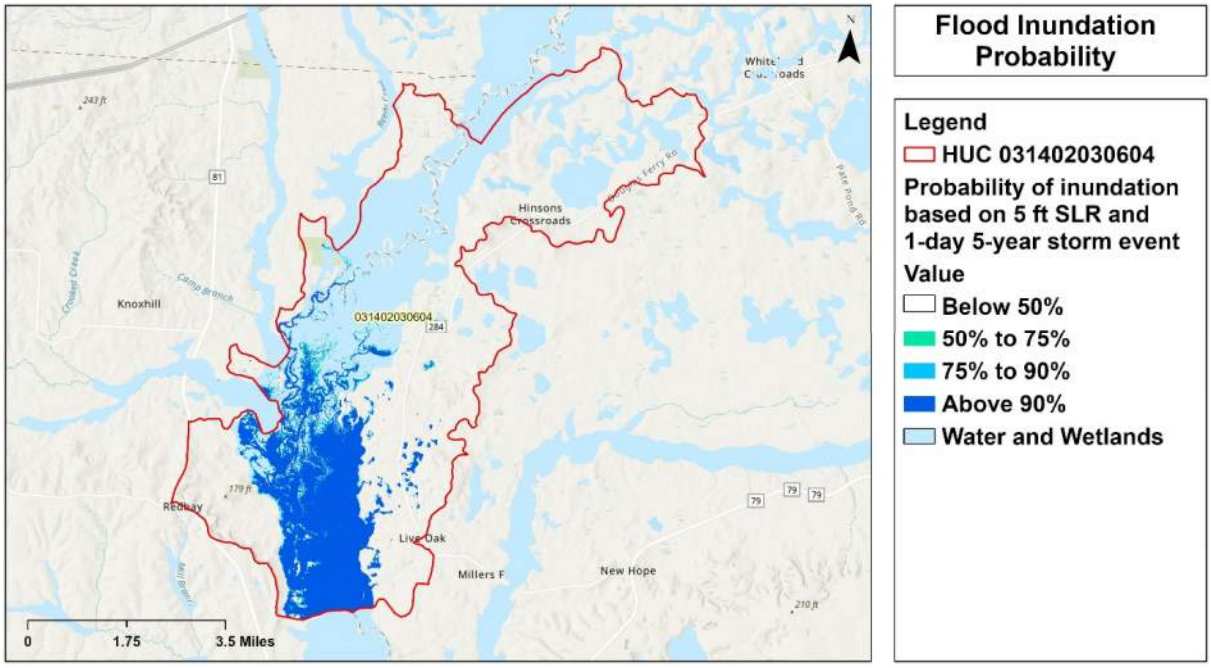


Figure 58. Sea level rise of 5 ft + 1-day 5-year storm for HUC 031402030604 sub-watershed. *Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.* Processed by FAU.

2.5 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6

11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3

43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2

74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.5.1 Results

Error! Reference source not found. to **Error! Reference source not found.** depict the HUC 031402030604 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (Figure 59) exclusively displays critical facility parcels The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 60) overlays critical facilities onto the 1-day 100-year storm event scenario, while the third map (**Error! Reference source not found.**)

represents the same overlay within the context of 5 feet of sea level rise (SLR) combined with the 1-day 100-year storm event. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 5 feet SLR + 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** and **Error! Reference source not found.** illustrate the composite score for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. **Error! Reference source not found.** represents the calculation for composite score based on 1-day 100-year storm event, while **Error! Reference source not found.** shows the calculation for composite score for the same storm event, but including a 5 feet of Sea Level Rise scenario. **Error! Reference source not found.** shows the same area zoomed out.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

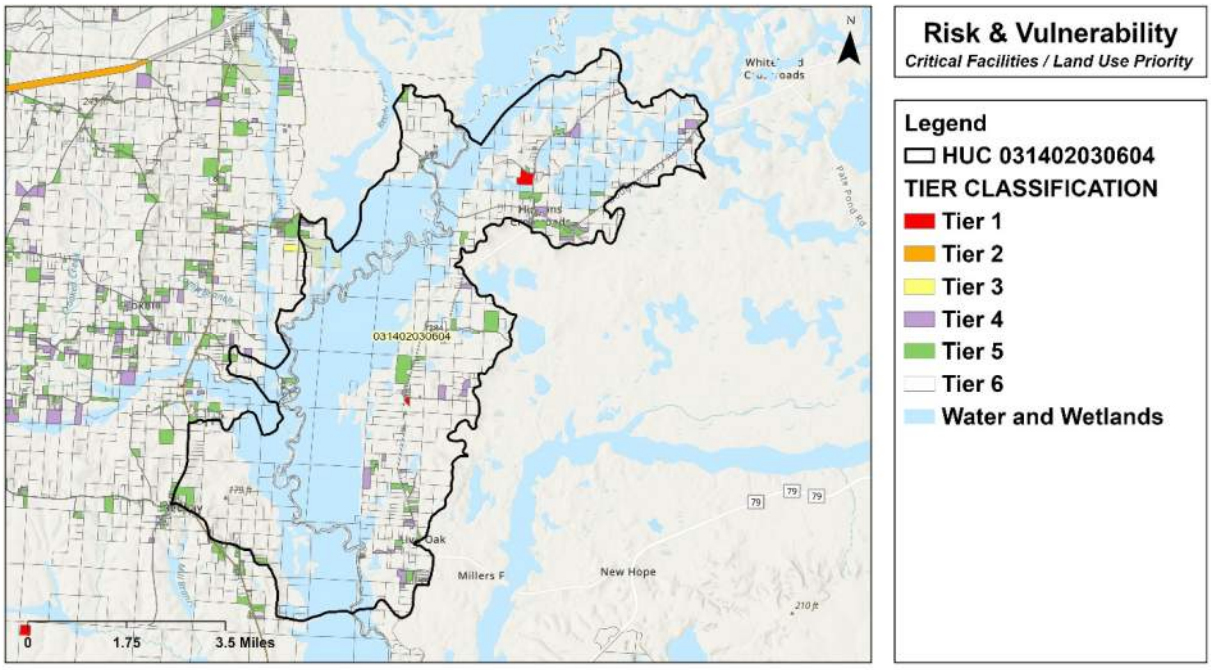


Figure 59. HUC 031402030604 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

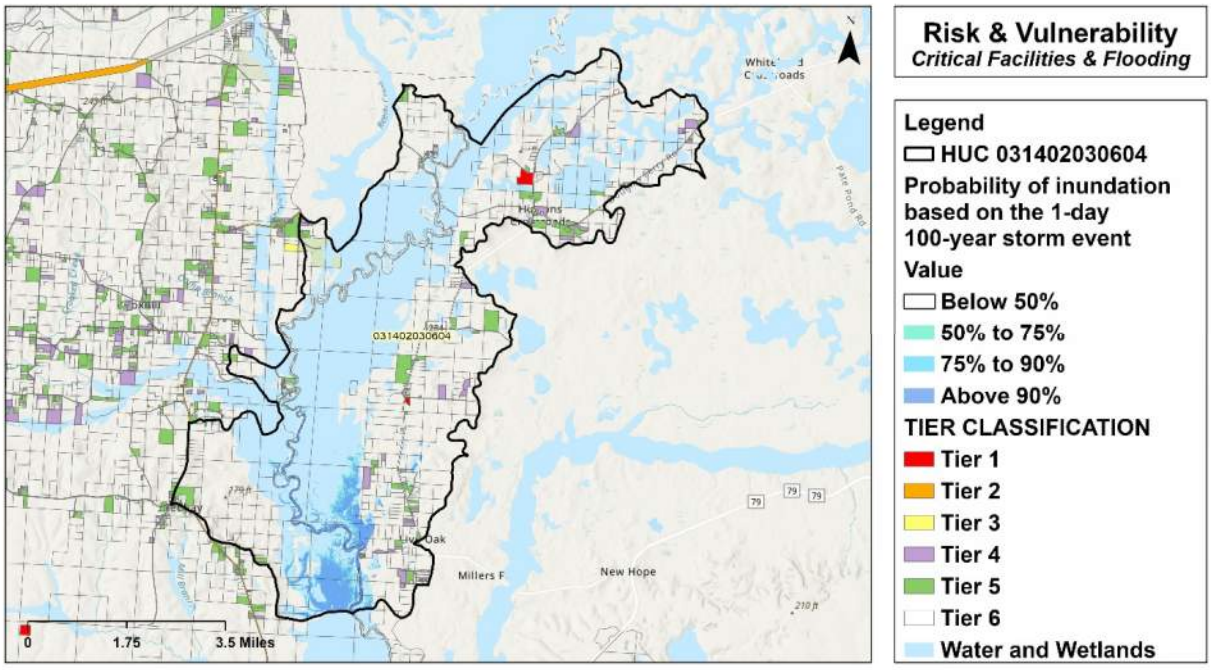


Figure 60. HUC 031402030604 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

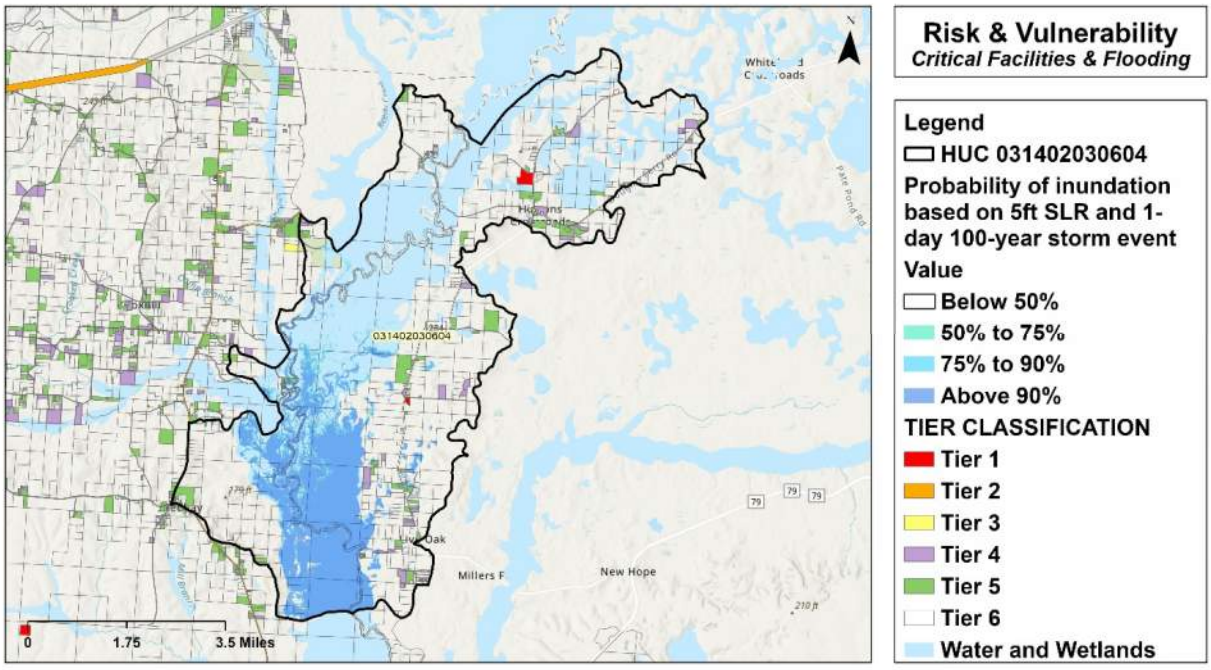


Figure 61. HUC 031402030604 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

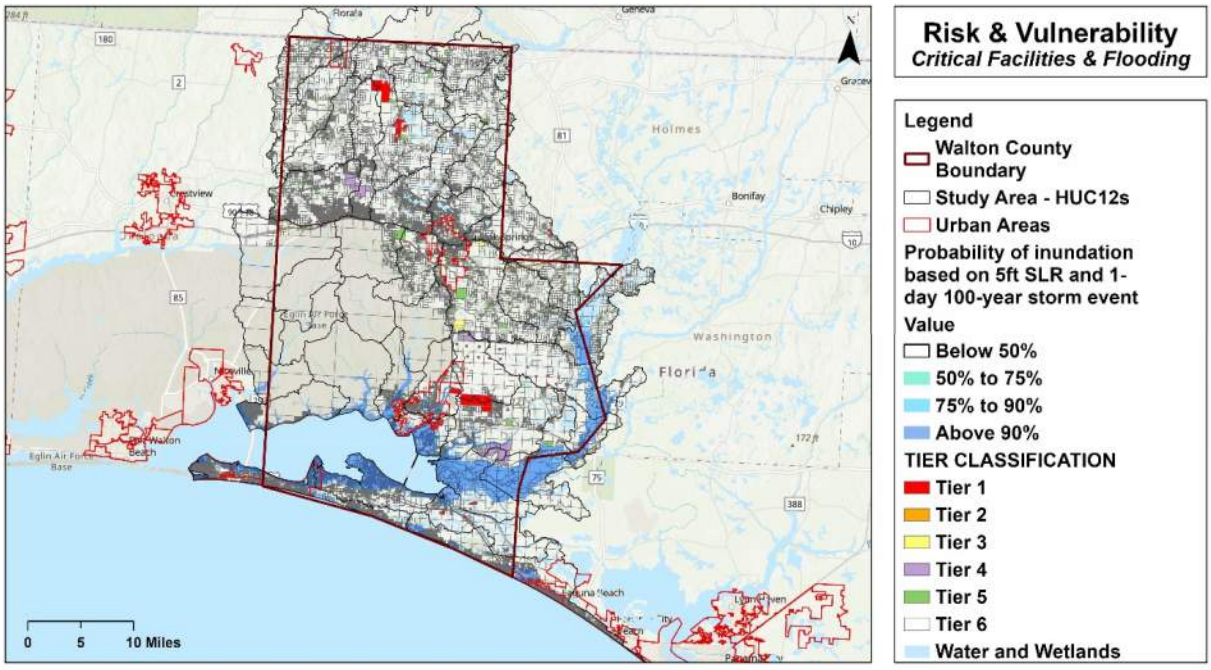


Figure 62. Walton County (mosaic) - Critical Facilities (priority of land uses) map, overlaid on the 1-day 100-year storm event + 5 ft. SLR probability of inundation for Walton County. Processed by FAU.

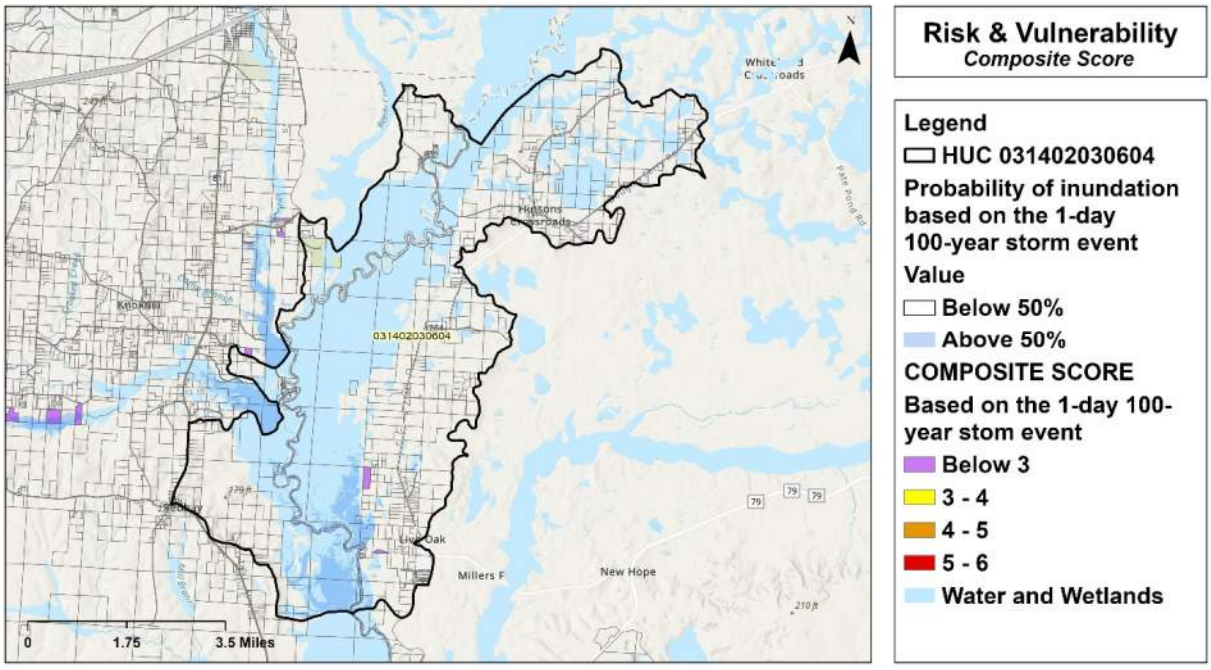


Figure 63. HUC 031402030604 sub-watershed Composite Score Risk map based on the 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation. Processed by FAU.

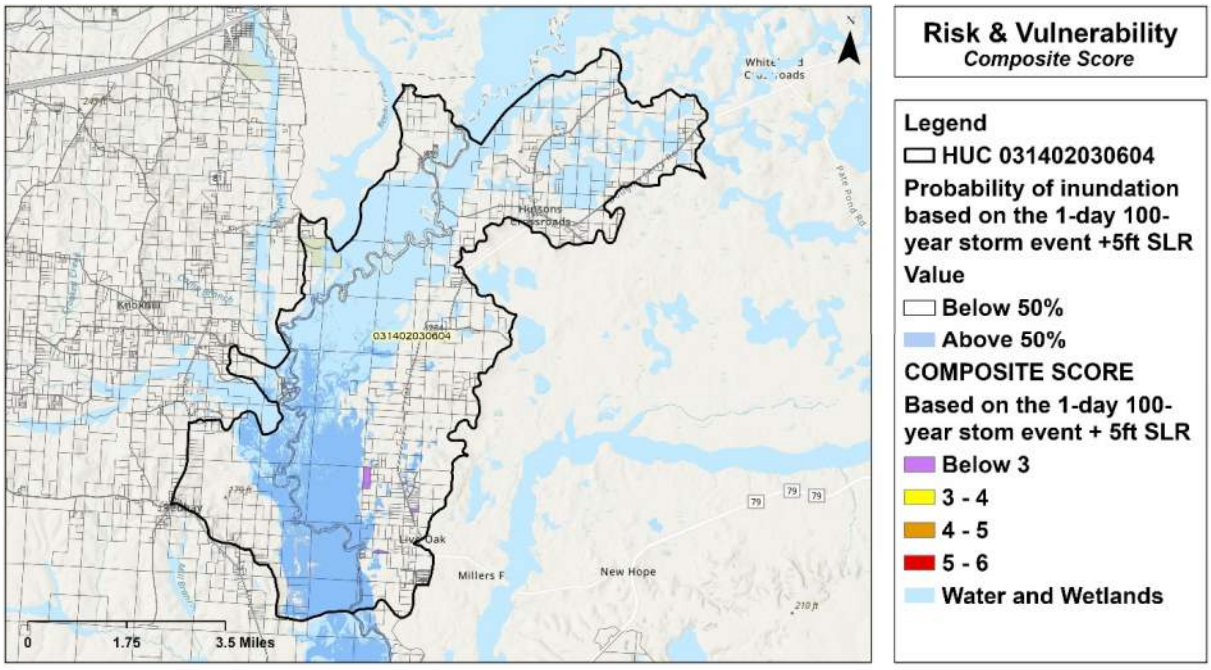


Figure 64. HUC 031402030604 sub-watershed Composite Score Risk map based on 1-day 100-year storm event + 5 ft. SRL, overlaid on the 1-day 100-year + 5 ft. SLR probability of inundation. Processed by FAU.

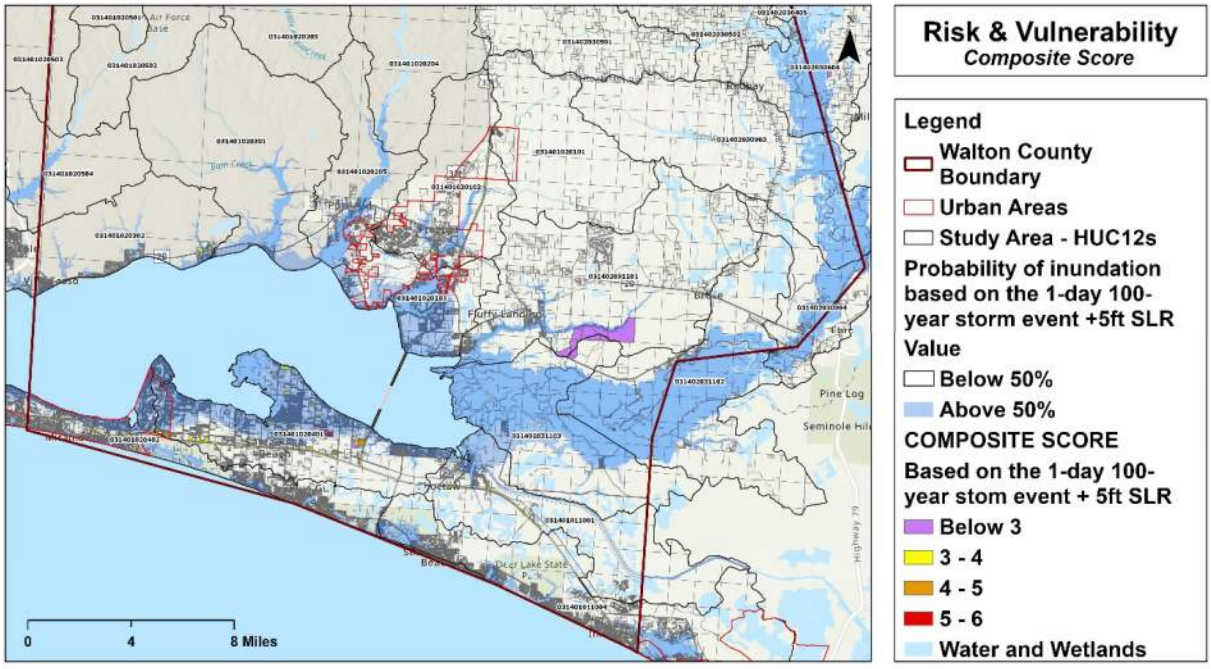


Figure 65. Coastal Area of Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

2.5.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031402030604. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.5.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031402030604. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031402030604	23937.53
All of the 1-day 100-year storm event inundation	**1122.11**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	926.34
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	133.86
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	3.42
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	195.78
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	58.50

2.5.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not**

found. indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

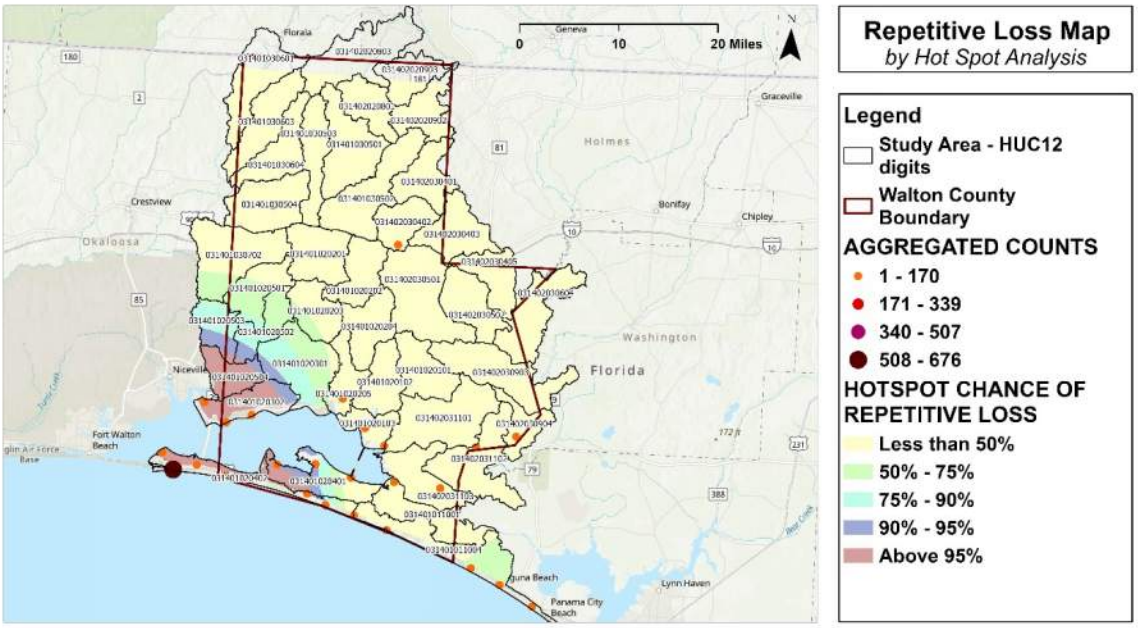


Figure 66. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.5.5 Priority Projects

Although there are some parcels falling within tiers classification 1 to 5 priority of land uses within the basin, fortunately only a few of them are within the flooding zone. Consequently, when considering the composite score, it is notable that most of the results are null. There are only five exceptions within the basin considering both 1-day 100-year storm event and 1-day 100-year + 5 feet SLR scenarios: one road (River Rd) within score 3-4, and four mobile home, with score below 3.

APPENDIX AM

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031402030903

BOYNTON CUTOFF

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 sub-watershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, HUC-12 digits (031402030903) is highlighted among all the HUCs to help identifying its location. (Figure 3).

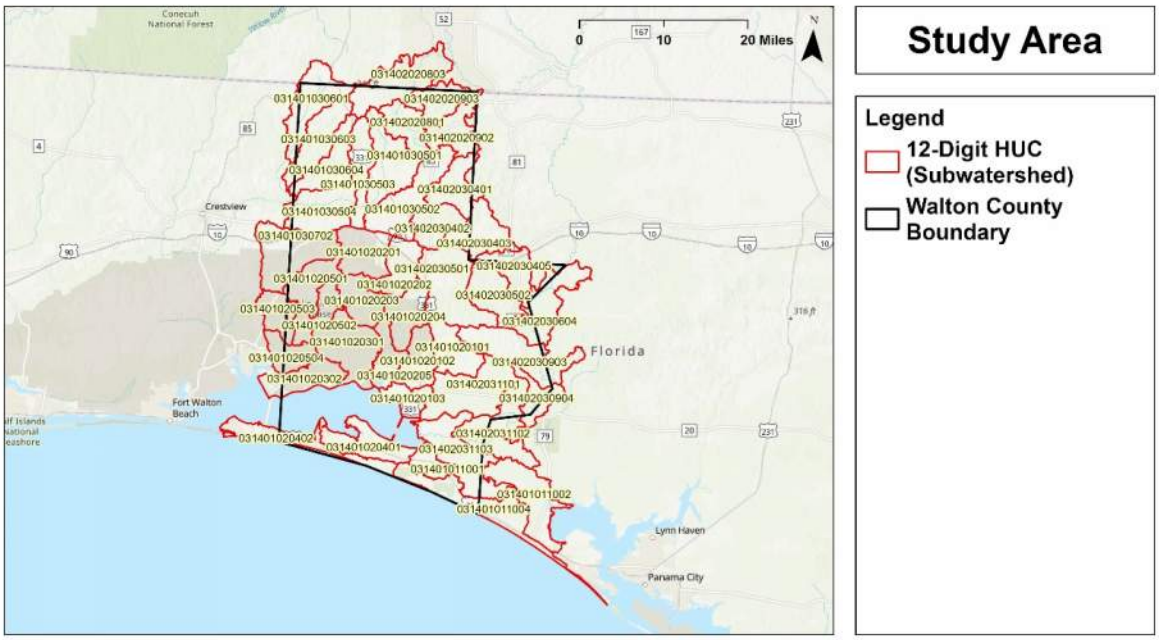

Figure 1. Walton County and all HUCs 12-digit sub-watershed, processed by FAU.

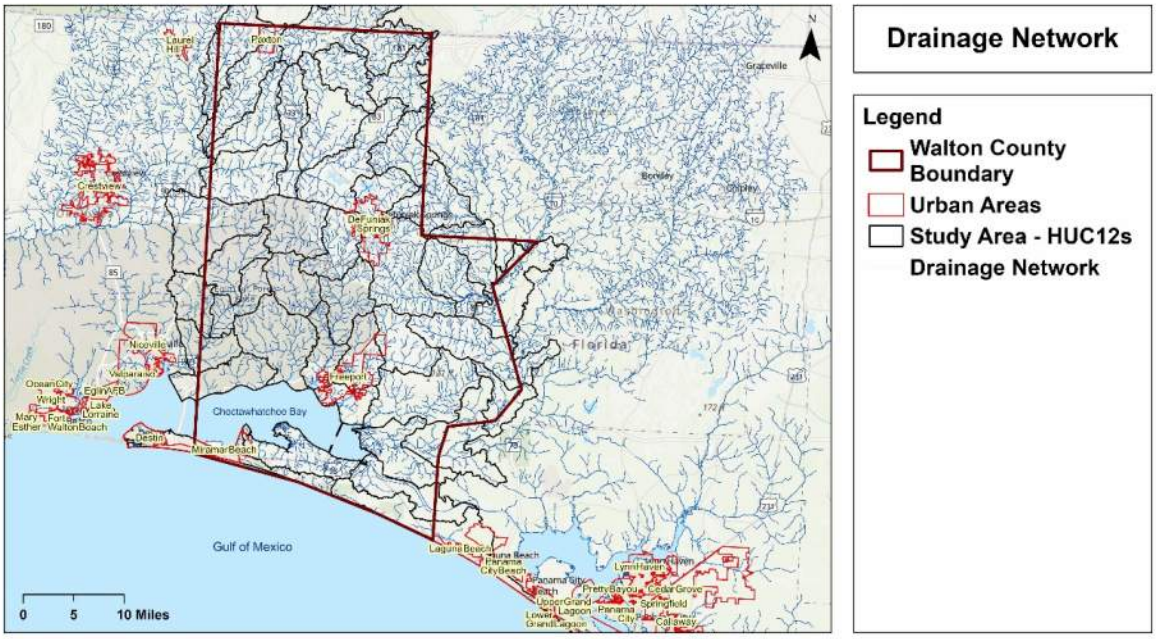

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

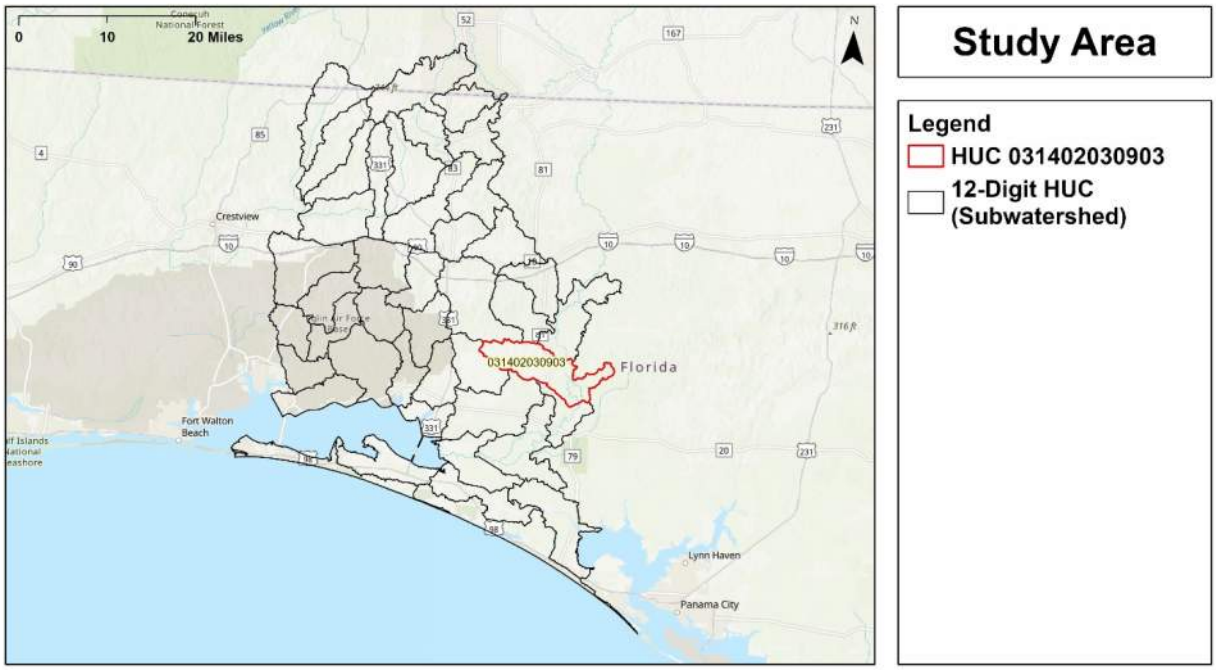

Figure 3. HUC 031402030903 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced

consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

(Source Data: FEMA)

Figures 12 and 13 is the county-wide report show the current and projected land use for the County. Based on the 2017 future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land Use in Walton County (Prepared by FAU from future land use map) versus land use in the entire watershed

Level 1 Land Use-Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

(Source Data: (NWFWMD 2017)

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 1.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.

- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

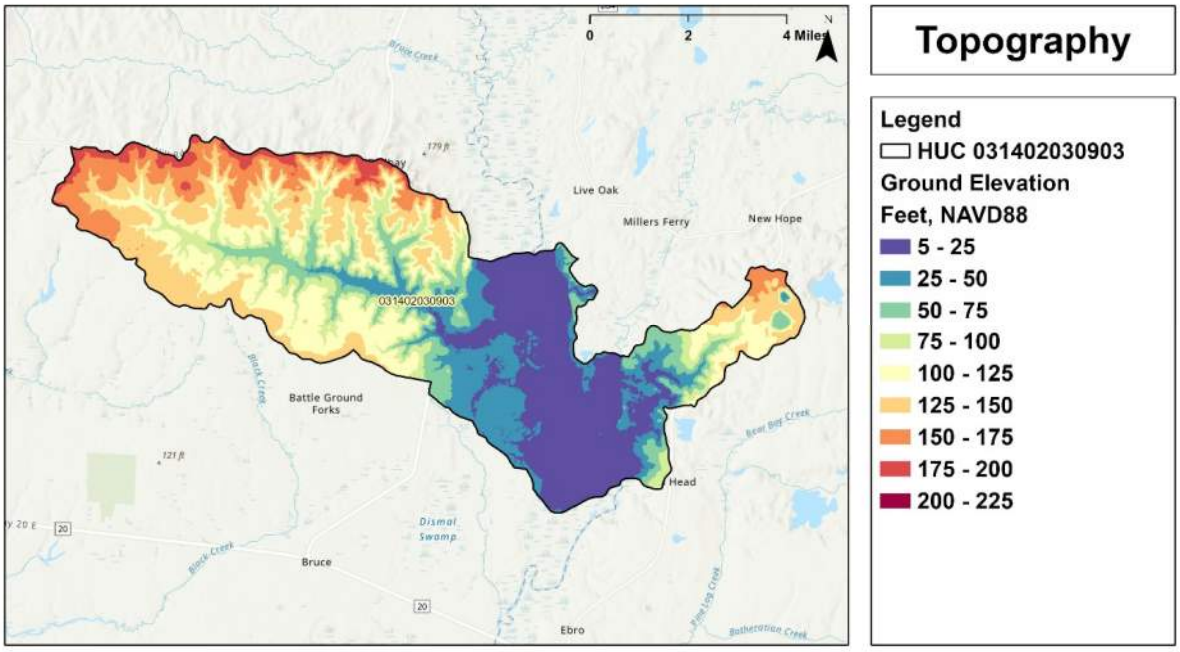

Figure 4. Topographic map of the HUC 031402030903 sub-watershed, processed by FAU

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031402030903 sub-watershed is shown in **Error! Reference source not found.**.

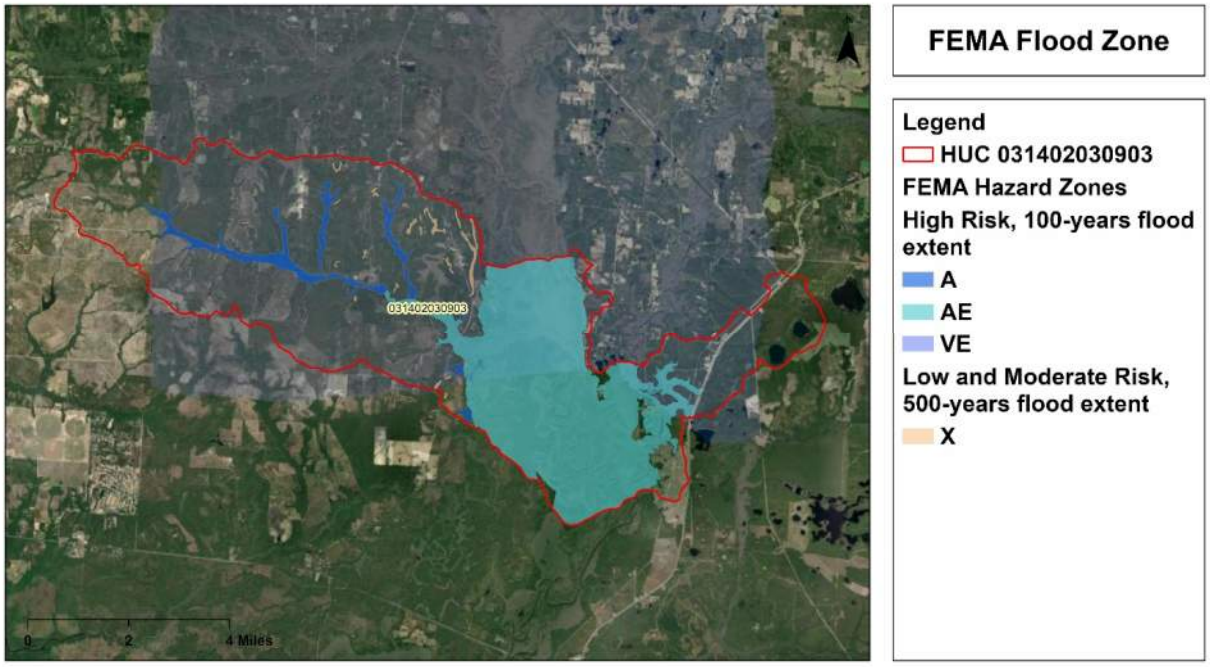

Figure 5. FEMA Flood Zone map (2020) for HUC 031402030903 sub-watershed, processed by FAU.

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031402030903 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including

various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

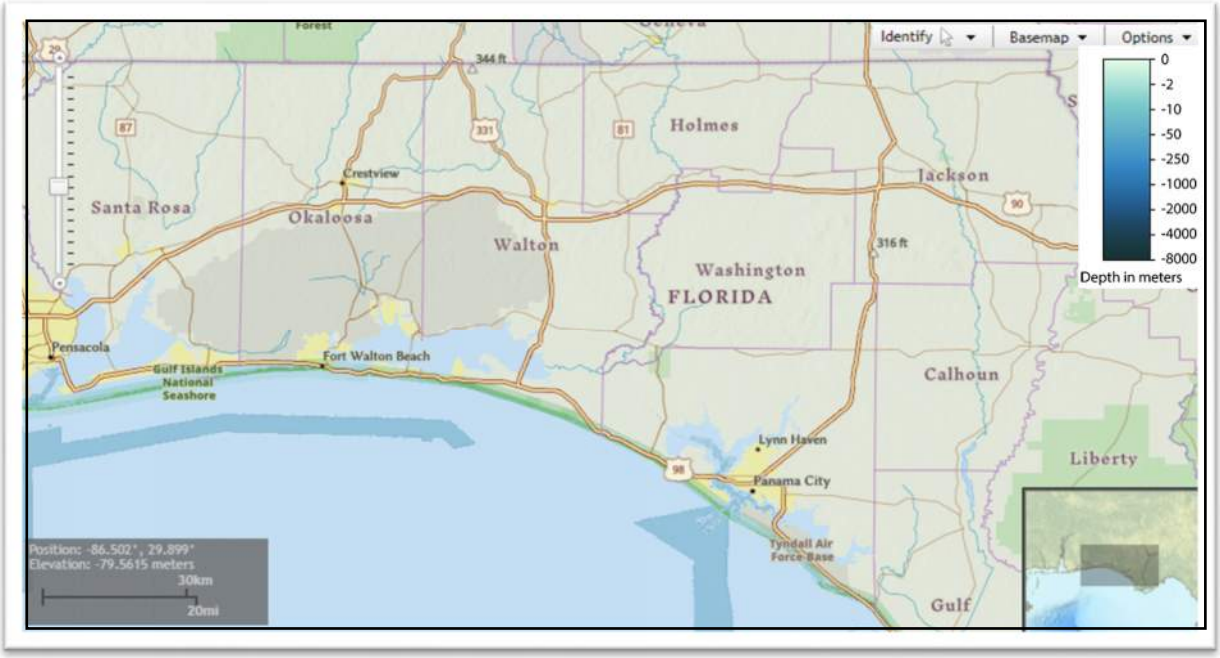

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle. Source: ncei.noaa.gov/maps/bathymetry/

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

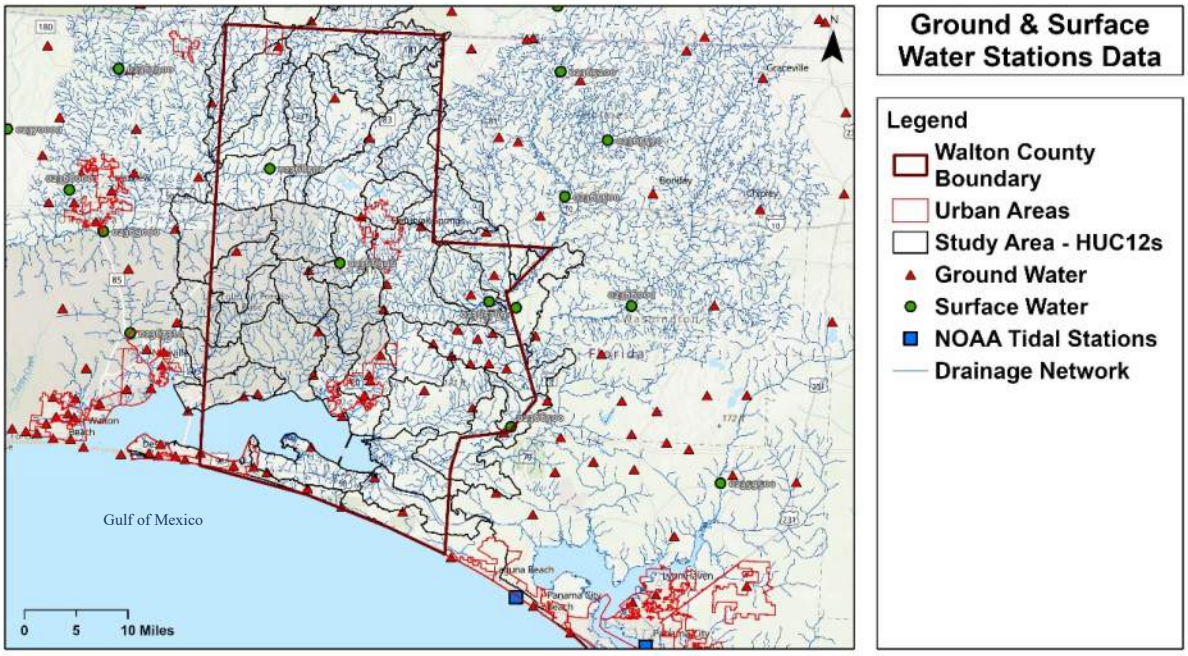

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU. Source: ncei.noaa.gov/maps/bathymetry/

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The major water bodies in the HUC 031402030903 sub-watershed include:

- Choctawhatchee River
- Holmes Creek

- Seven Runs
- Mill Branch
- McKinnon Branch
- Palmetto Branch
- Grape Head Branch
- Sugar Mill Branch

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02365769. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031402030903, which is USGS 02365769 Bruce Creek at SH 81 NR Redbay, FL.

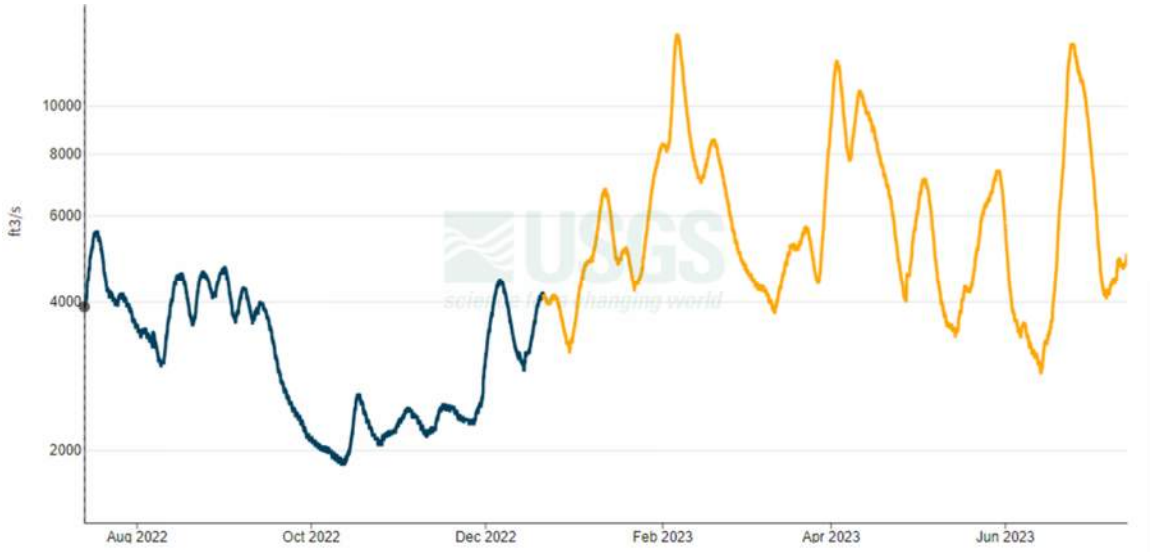

Figure 8. Average streamflow for Bruce Creek at SH 81 NR Redbay, FL (USGS 02365769 Surface-Water, June 2022 to July 2023).
Source: USGS Water Data Services (waterdata.usgs.gov/monitoring-location/02365769/#parameterCode=00065&period=P7D).

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish

a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031402030903 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031402030903 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

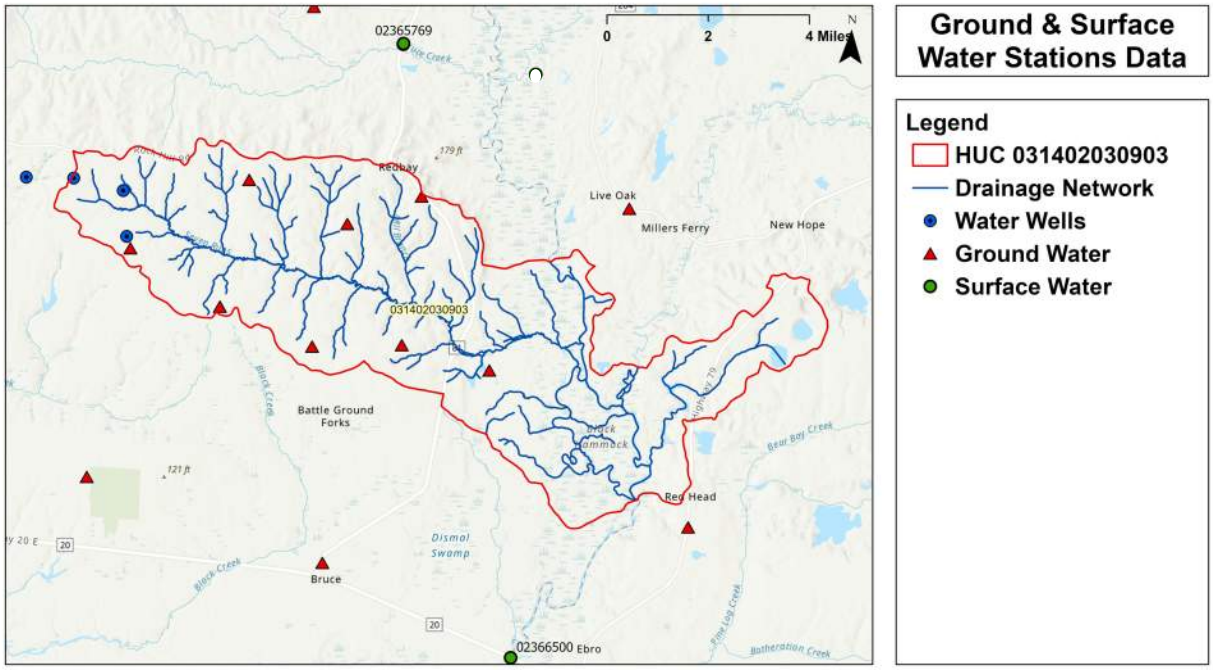

Figure 9. Ground and Surface Water Stations in the HUC 031402030903 sub-watershed, processed by FAU.

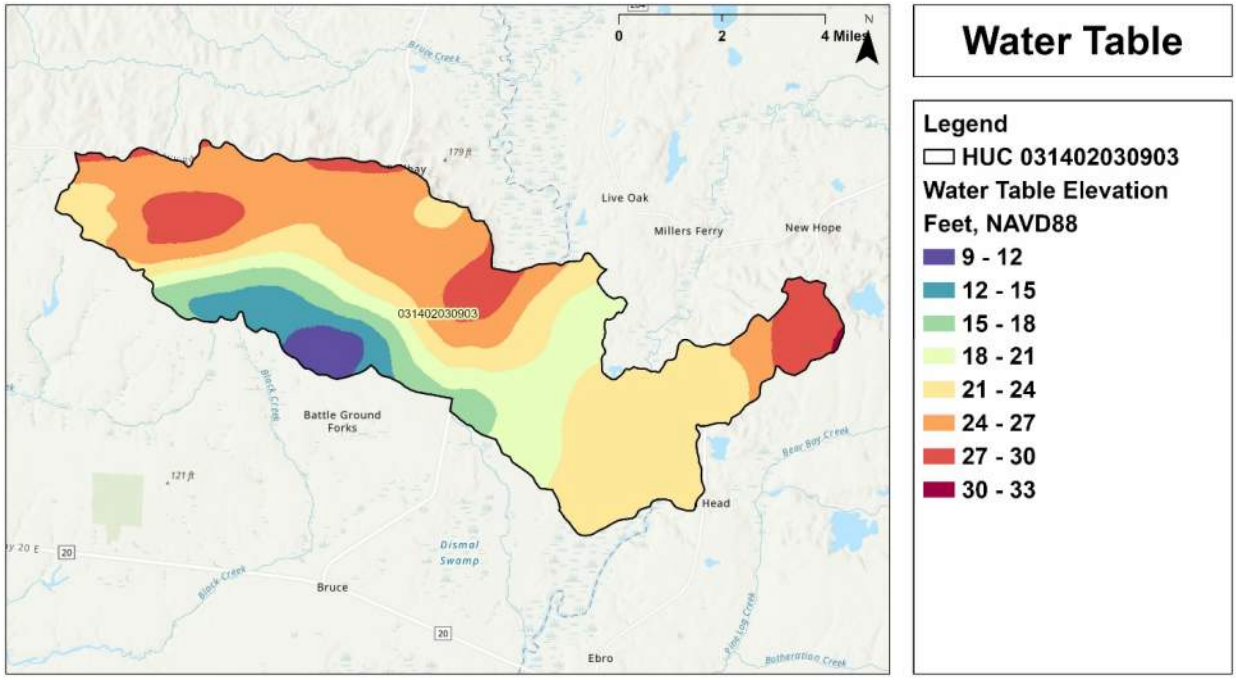

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031402030903 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the average precipitation over Walton County for every month of the year between 2011 and 2023- each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches for the entire county.

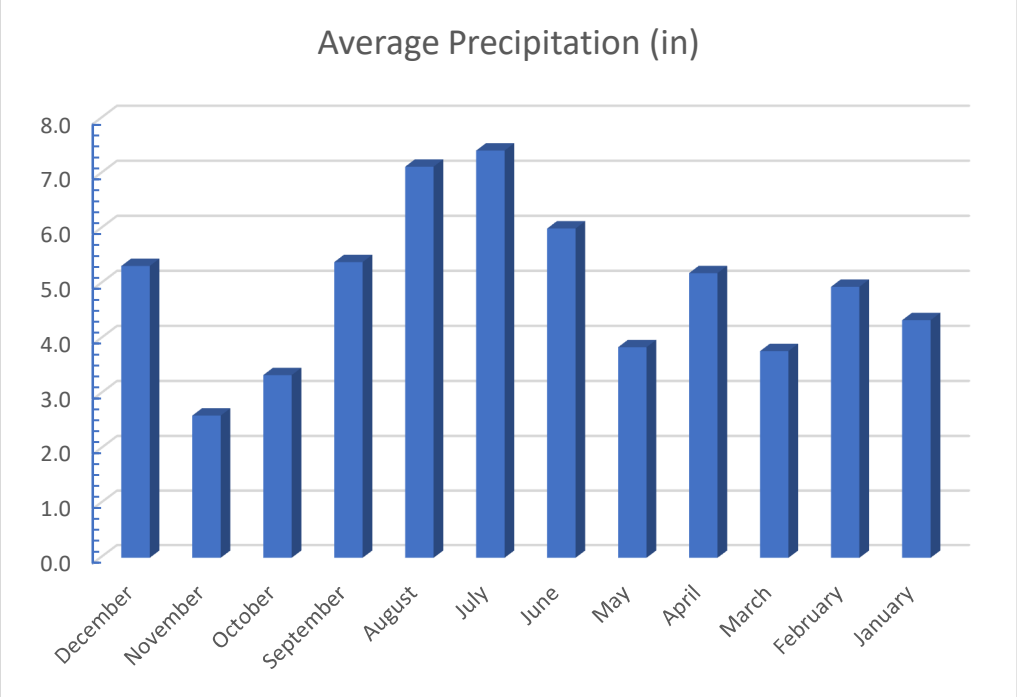

Figure 11. Monthly precipitation in Walton County, FL (2011-2023).
(Data Source: Florida Weather Data, available at https://data.usatoday.com/weather-data/walton-county/12131/1975-04-01/Table/)

While the topography (Section 1.1) and native soil (Section 1.4)create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as

opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

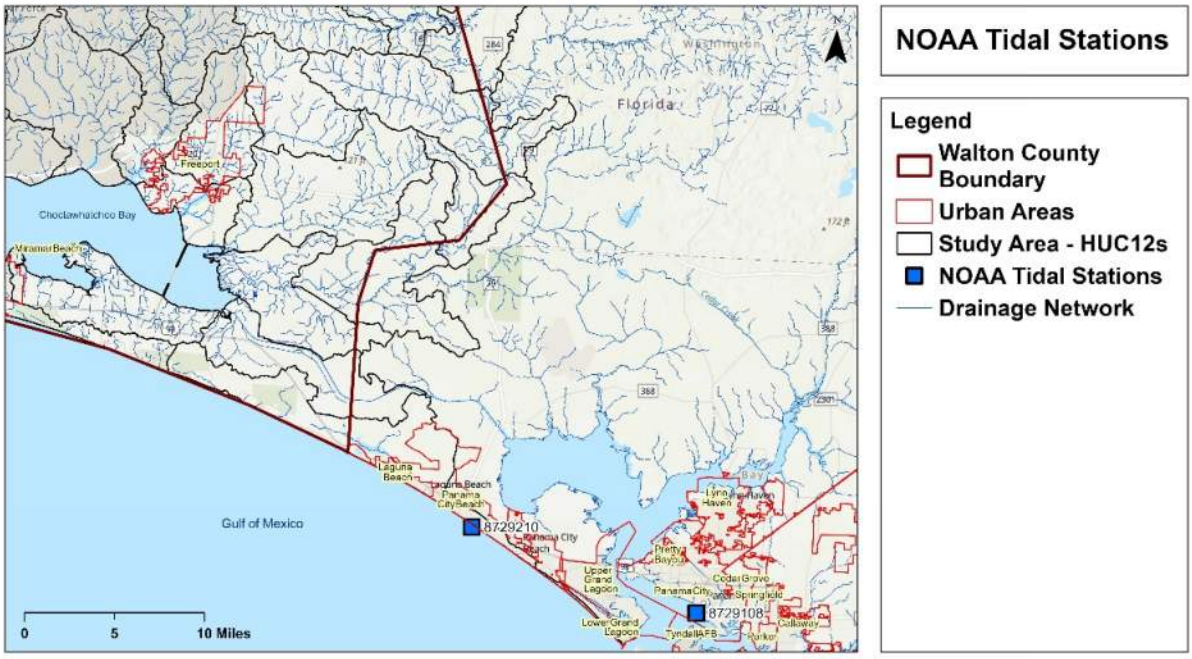

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

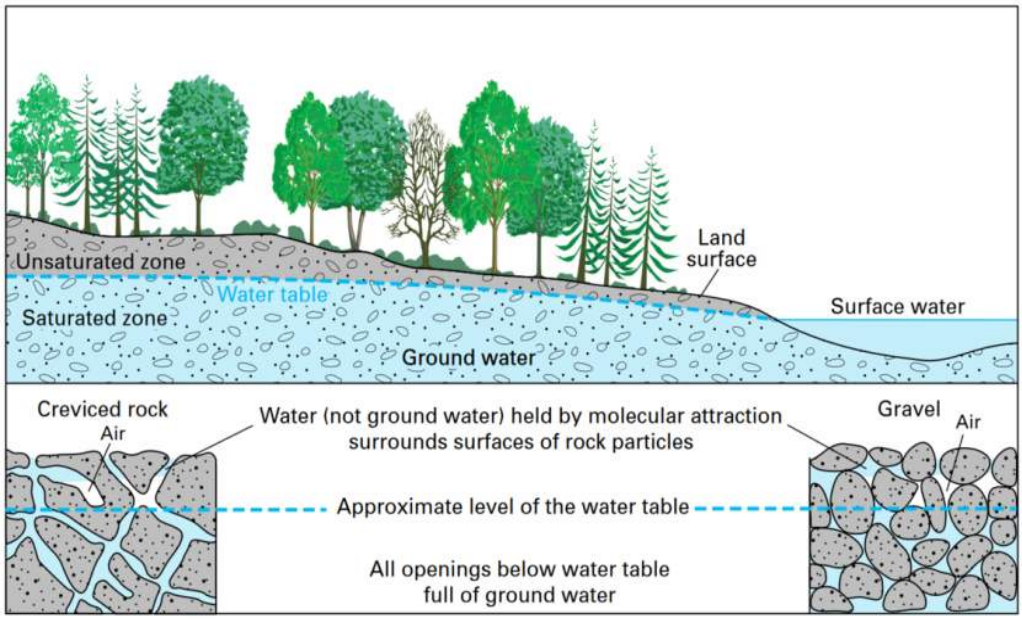

Figure 13. Zones where underground water exists.
Source: USGS, 2020.

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

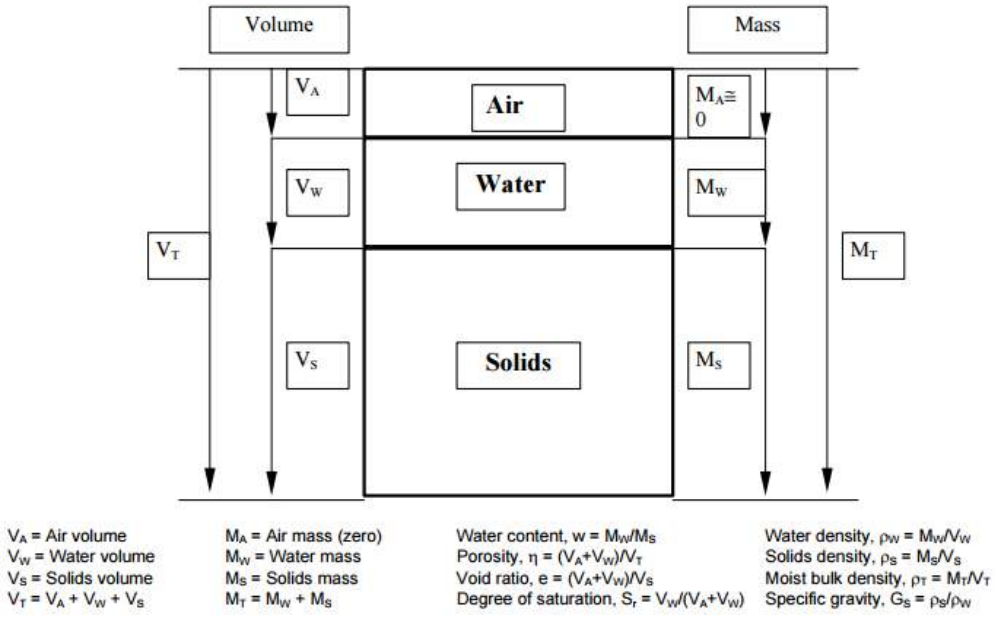

Figure 14. Saturated zone soil phase diagram and definitions.
Source: Gregory et al., 1998.

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

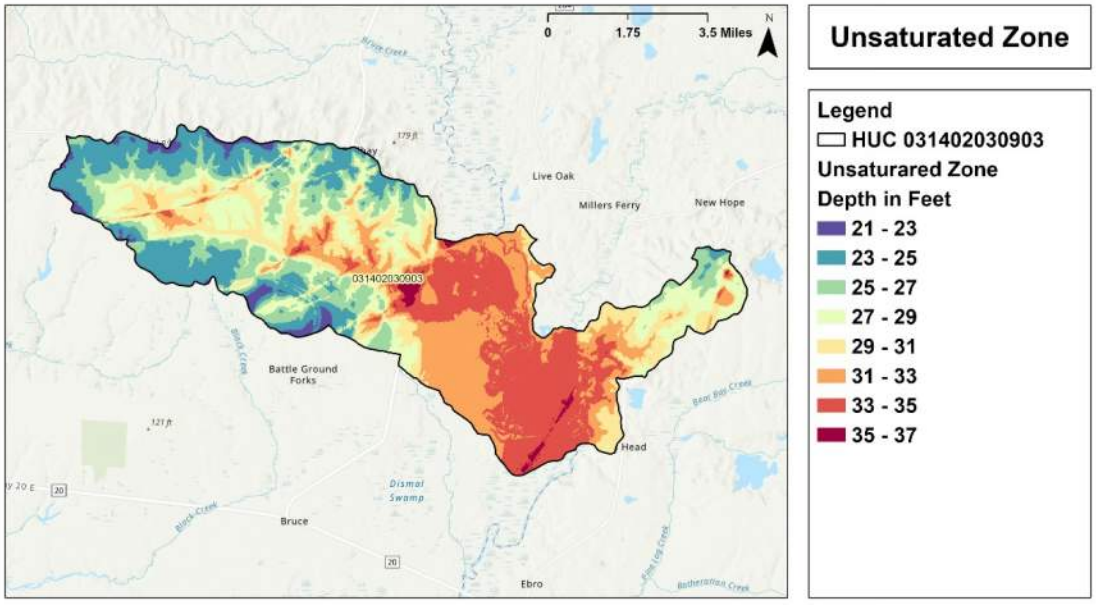

Figure 15. Unsaturated zone map for HUC 031402030903, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately favorable soil storage capacity, falling within the range of 23 to 35 feet of remaining capacity.

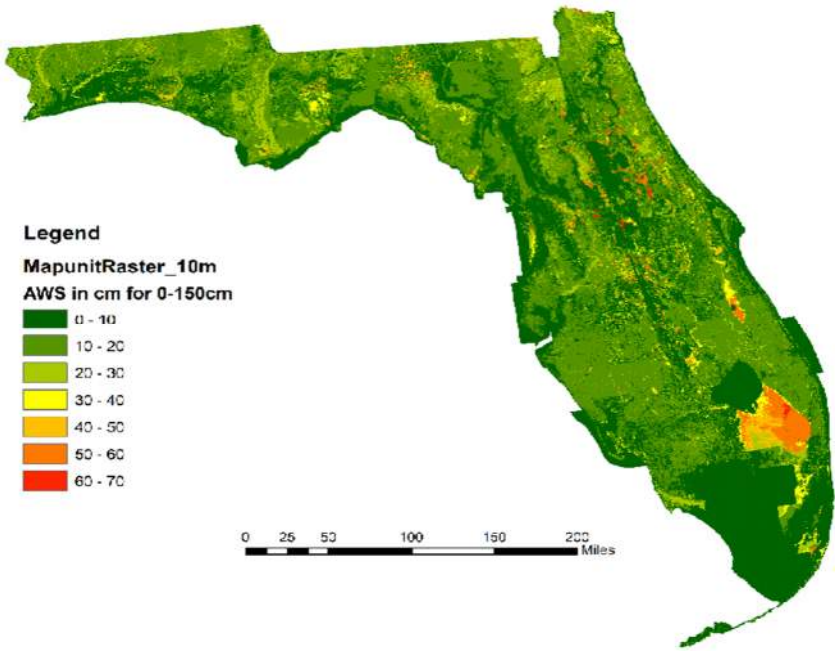

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, processed by FAU.

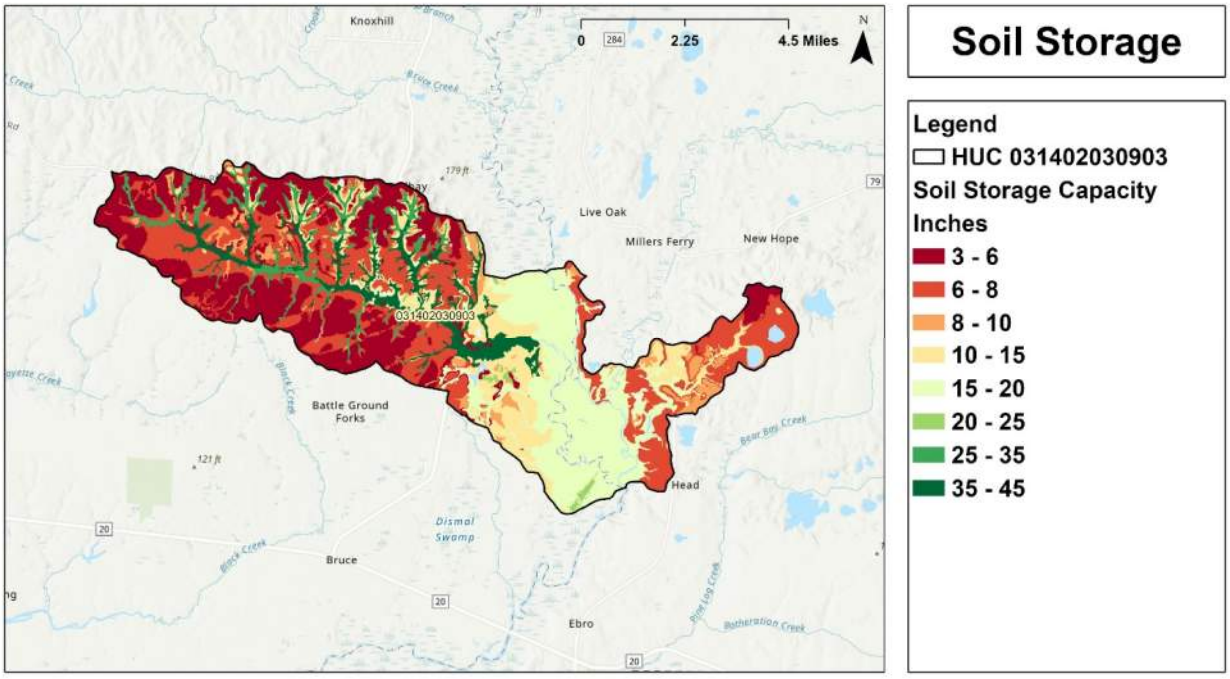

Figure 17. Water storage capacity of soil for the HUC 031402030903, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

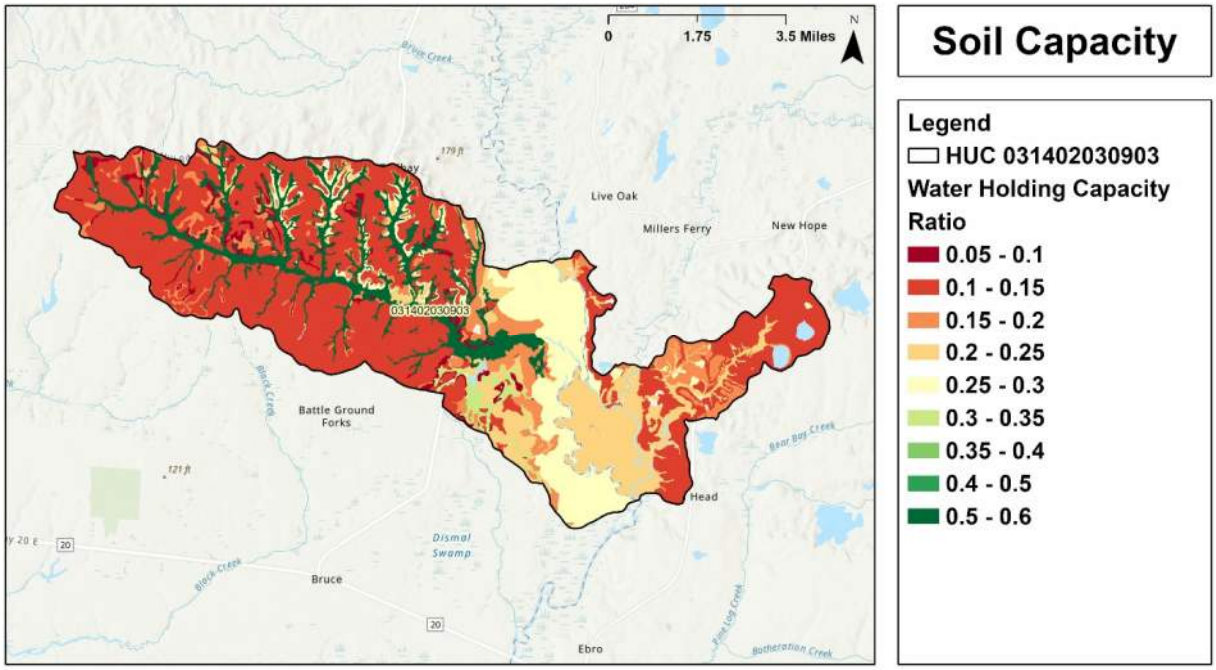

Figure 18: Water Holding Capacity (ratio) for the HUC 031402030903, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

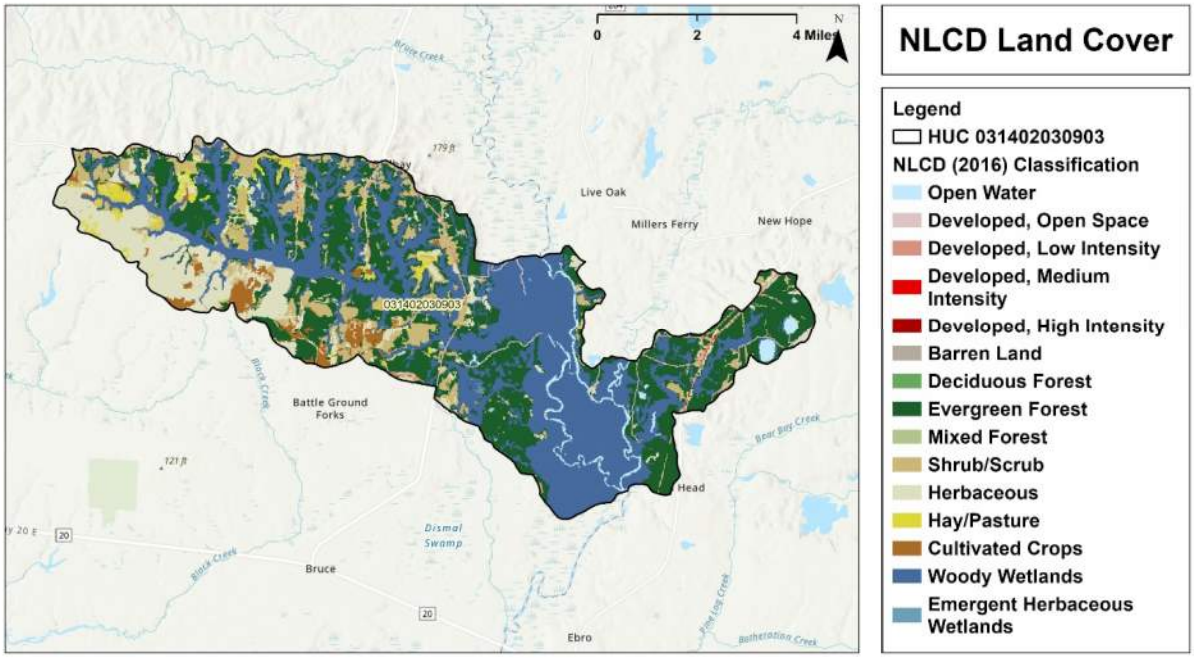

Figure 19. Land use in the HUC 031402030903 (from the NLCD 2016 database), processed by FAU.

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD 2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. . A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

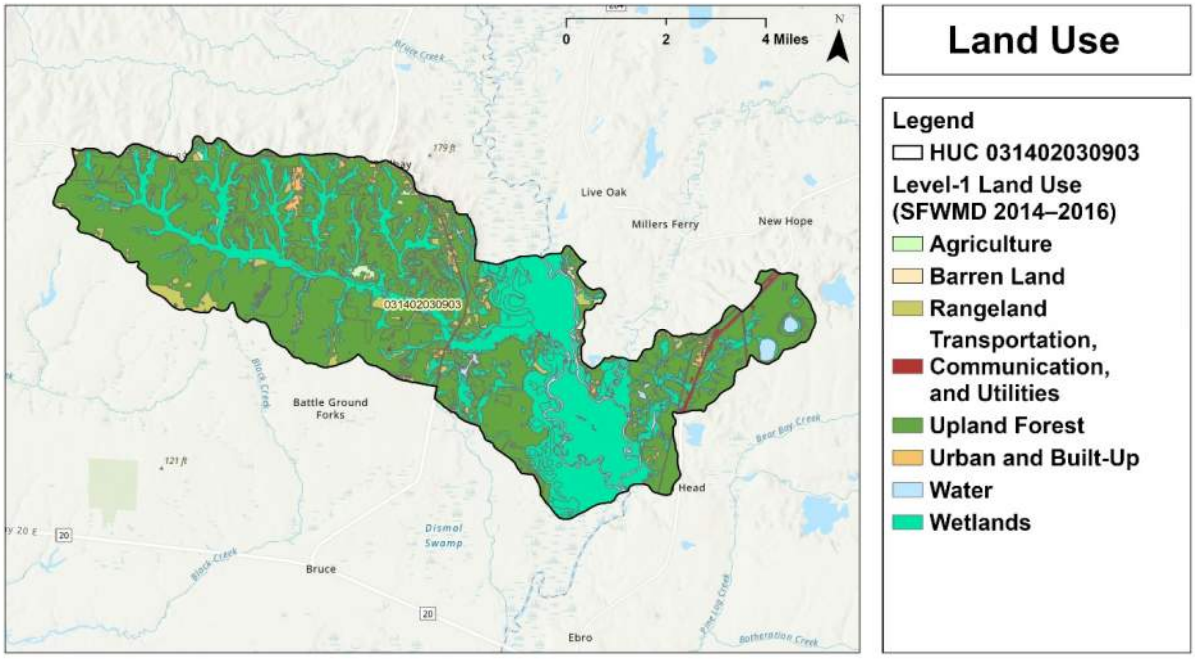

Figure 20. Land use in the HUC 031402030903 (from 2023 Florida Geographic Data Library (FGDL) database))

In the HUC 031402030502 sub-watershed, the predominant land cover is upland forest, accounting for 54.48% of the area. Wetlands comes in second at 27.72%, followed by water at 6.88%, and Transportation, Communication, and Utilities at 6.73%. Developed land constitutes a minor portion, with only 1.17% categorized as urban and built-up, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031402030903 sub-watershed

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	123.04	0.27%
Barren Land	13.25	0.03%
Rangeland	1247.11	2.72%
Transportation, Communication, and Utilities	3086.35	6.73%
Upland Forest	24975.29	54.48%
Urban and Built-Up	538.00	1.17%
Water	3152.29	6.88%
Wetlands	12705.31	27.72%
Grand Total:	**45840.65**	**100.00%**

Source Data: 2023 Florida Geographic Data Library (FGDL) database))

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

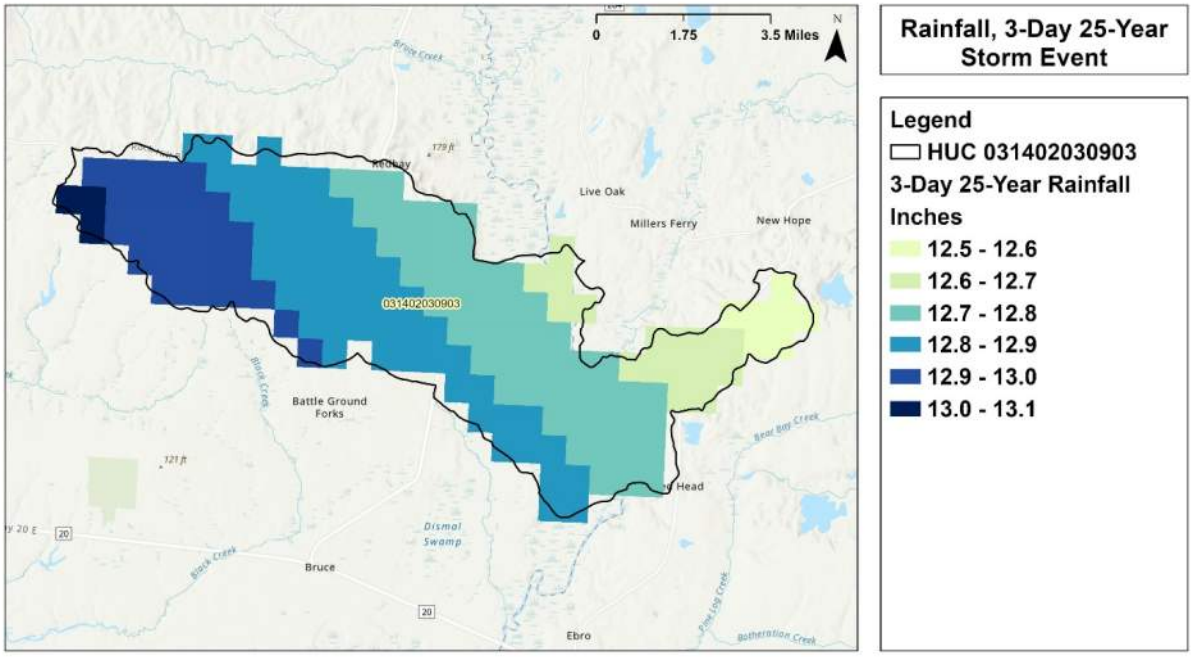

Figure 21. Rainfall distribution map across HUC 031402030903 sub-watershed, for 3-day 25-year storm event, processed by FAU.

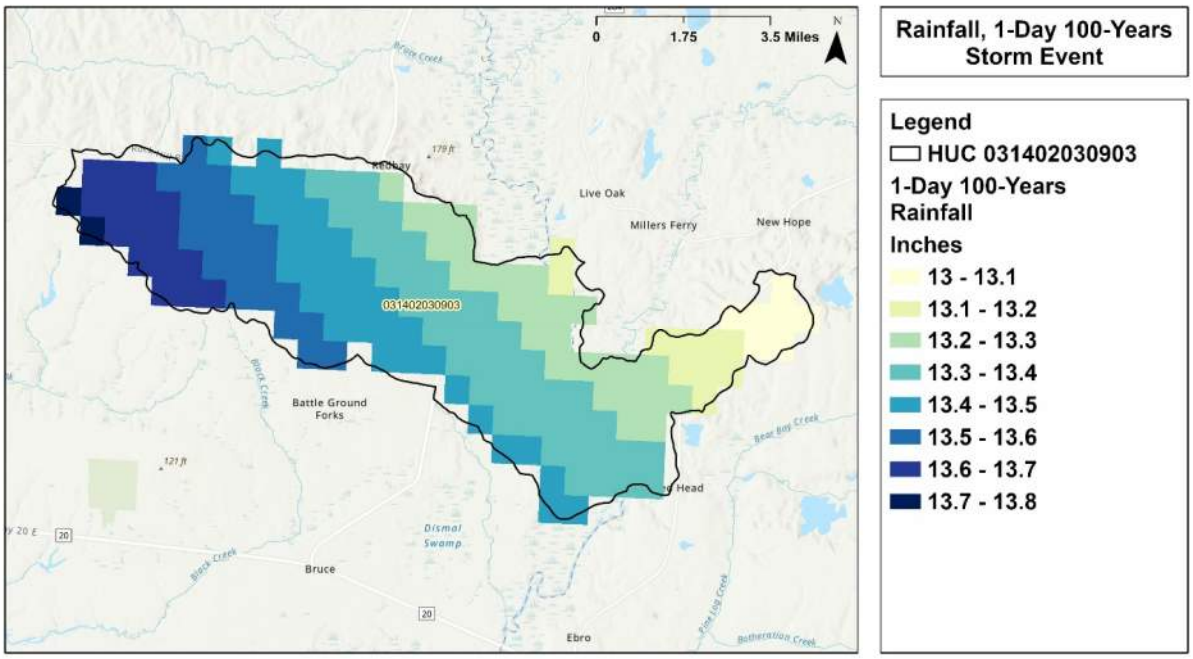

Figure 22. Rainfall distribution map across HUC 031402030903 sub-watershed, for 1-day 100-year storm event, processed by FAU.

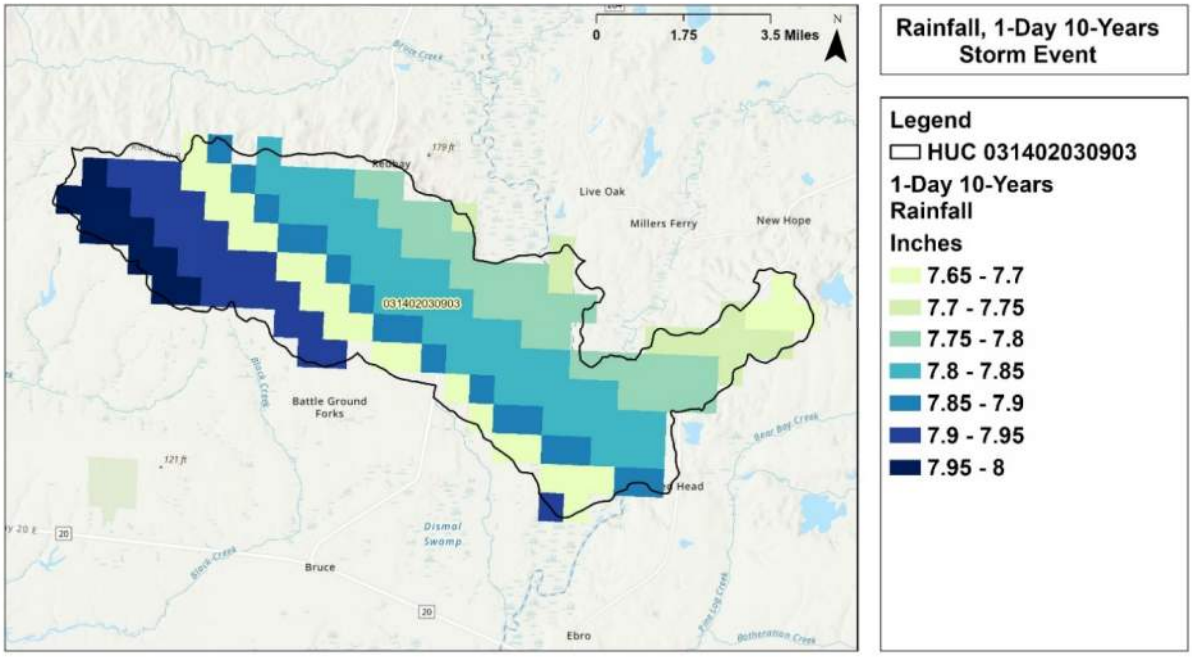

Figure 23. Rainfall distribution map across HUC 031402030903 sub-watershed, for 1-day 10-year storm event, processed by FAU.

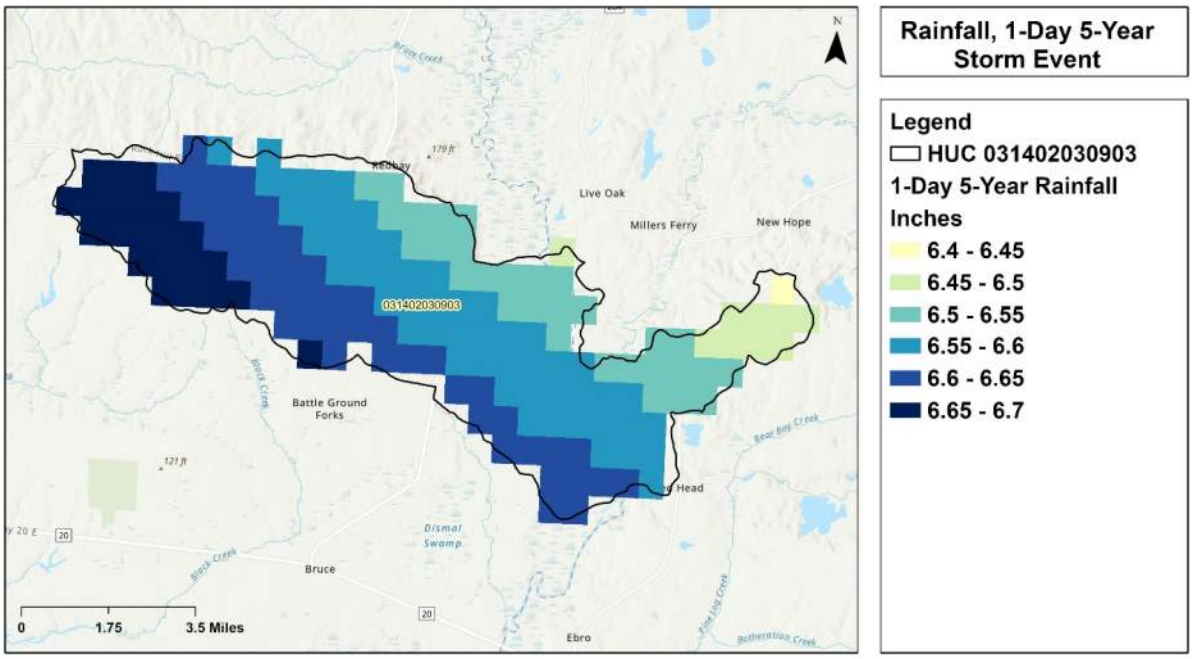

Figure 24. Rainfall distribution map across HUC 031402030903 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

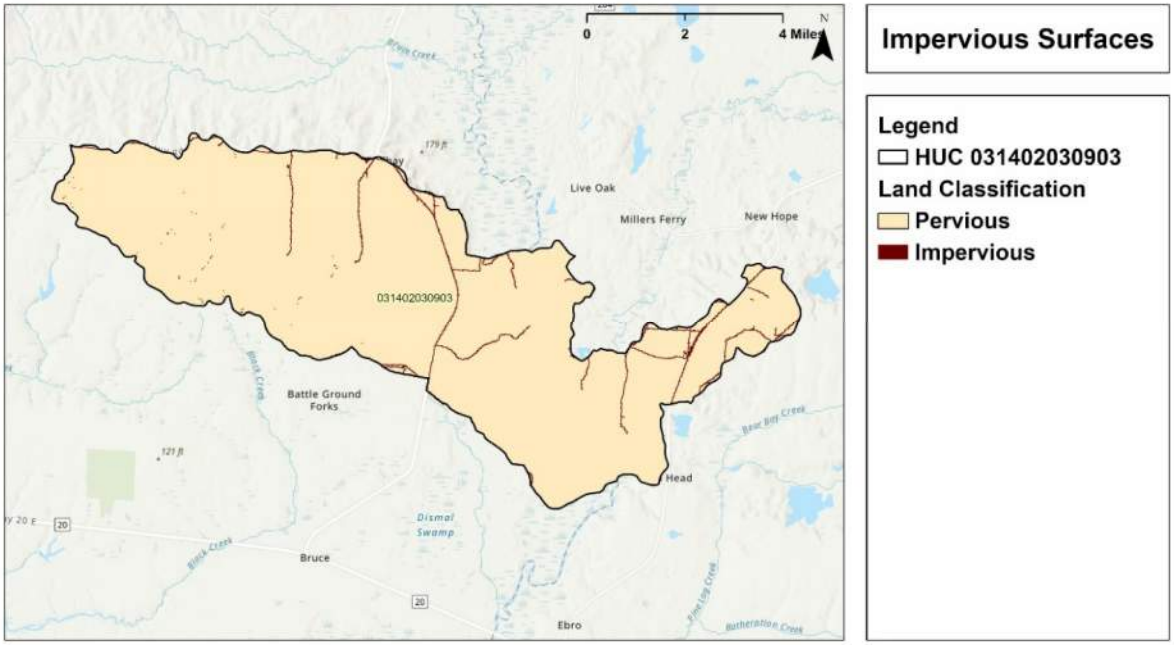

Figure 25. Impervious area map for the HUC 031402030903 sub-watershed, processed by FAU.

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

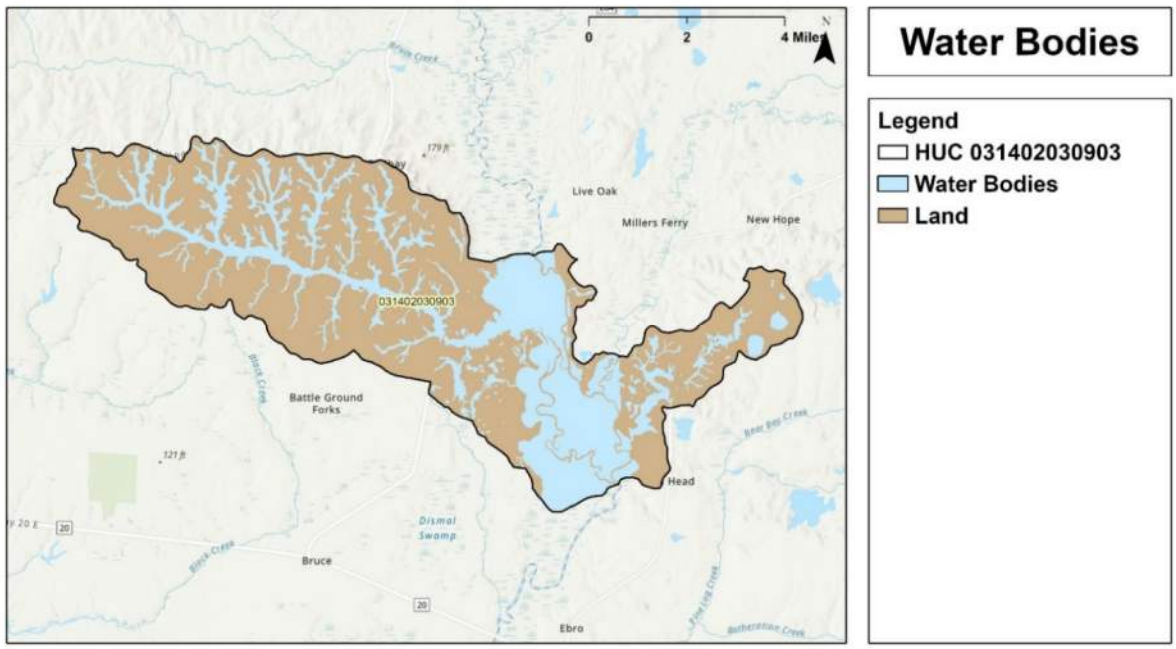

Figure 26. Water bodies map for the HUC 031402030903 sub-watershed, processed by FAU.

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

(Source: US Census Bureau 2020, and Zip-codes.com)

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.

- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

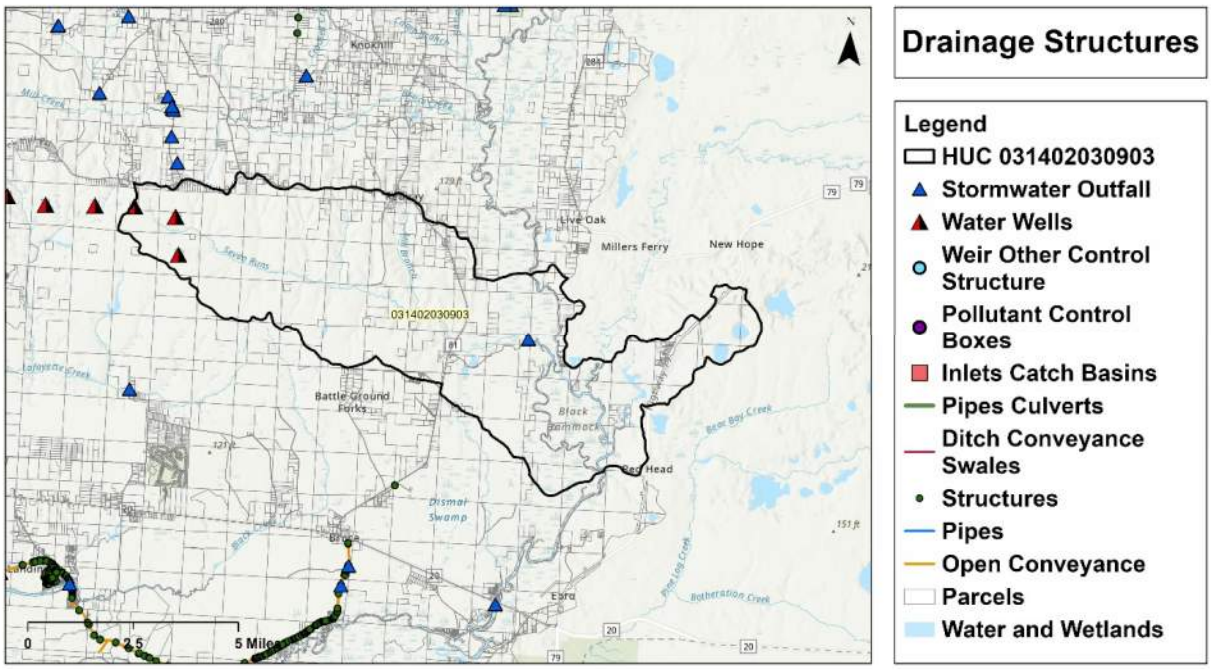

Figure 27. Stormwater Infrastructure for the HUC 031402030903. Processed by FAU.

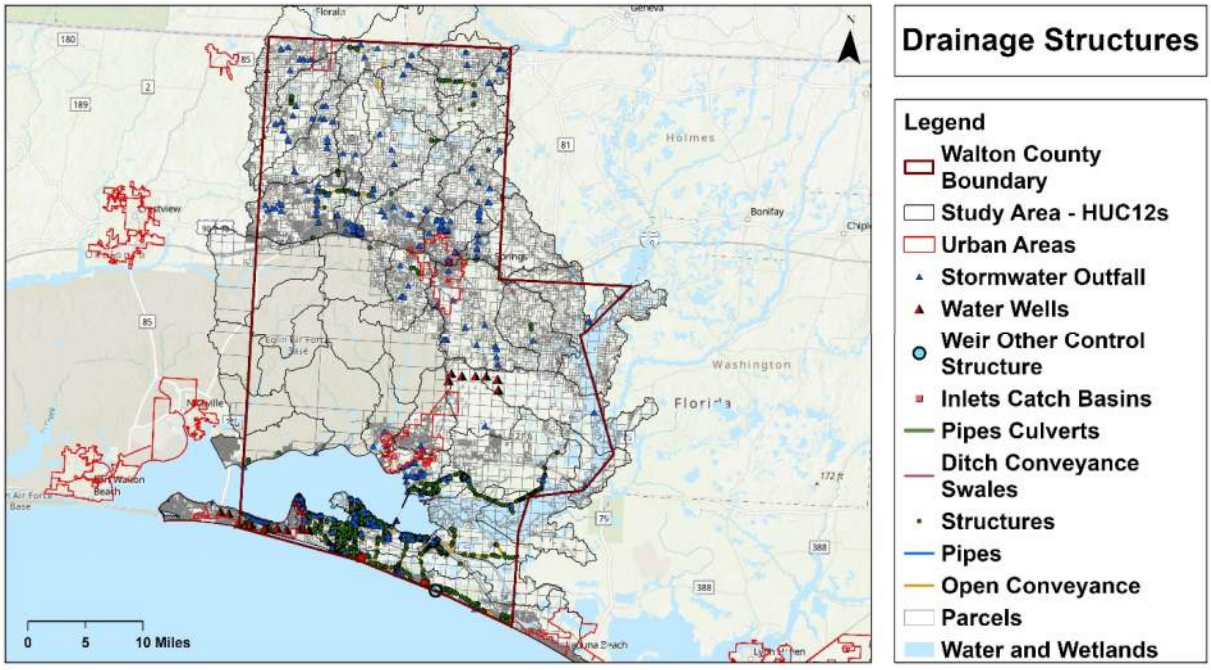

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data

can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020)

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1, analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing twater quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031402030903 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

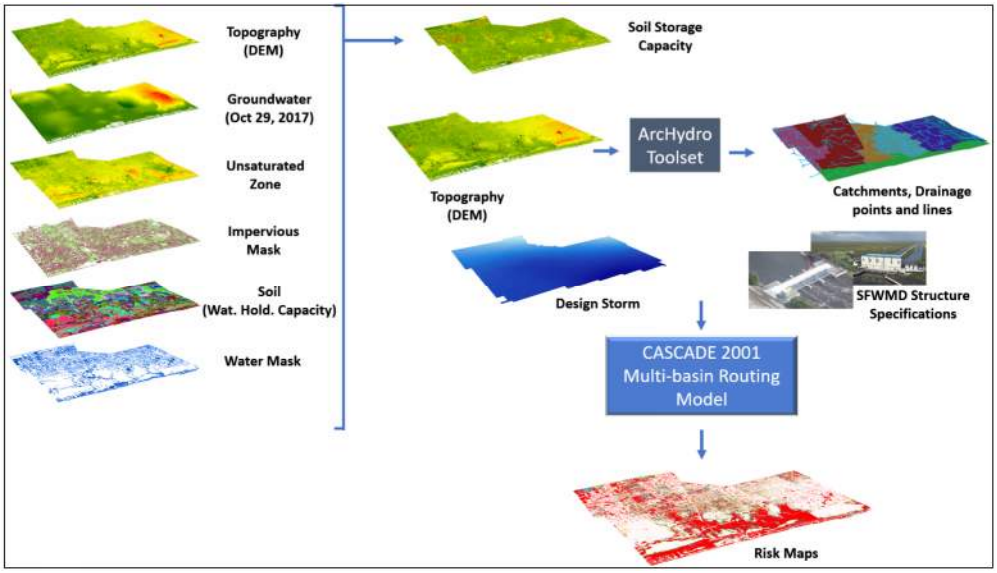

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

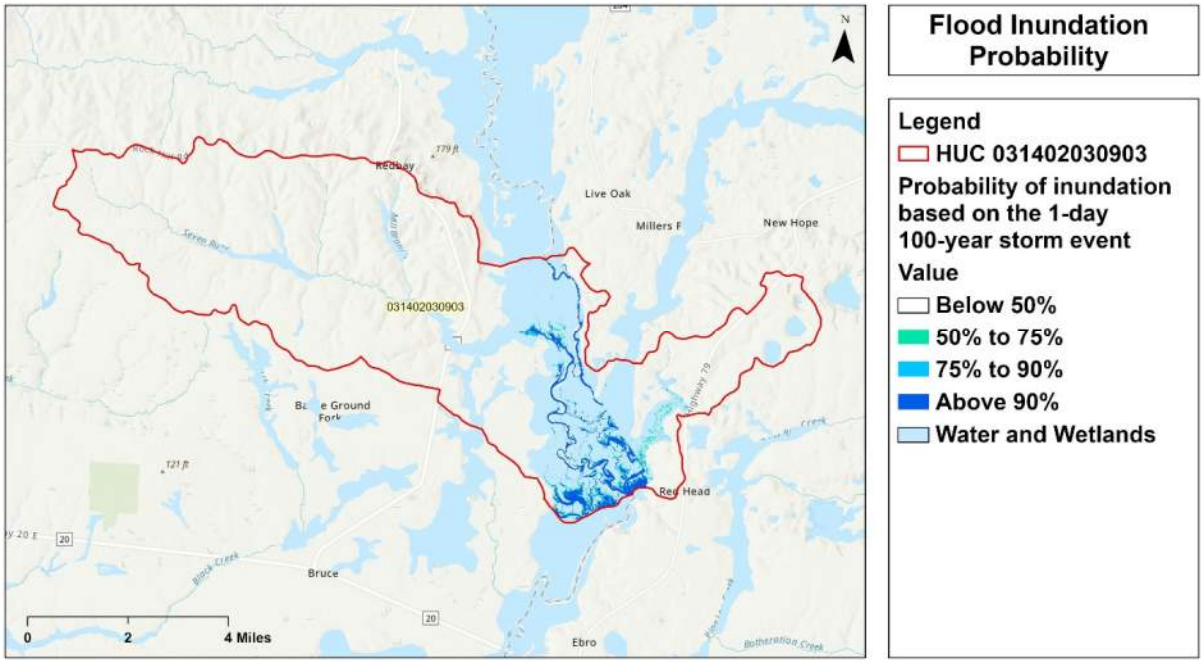

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031402030903, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes

and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 2.5 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in

the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Future Challenges of Sea Level Rise and Climate Change

Global observations from satellites and long-term data collection have made it possible to document and analyze patterns in the Earth's climate. Scientific analysis of the impact of these changes has helped to improve the understanding of future flood hazard driving forces and long-term impacts on human activities and watershed master planning (http://www.research.noaa.gov/climate/t_observing.html). Examples of impacts are rising global average air and ocean temperatures, increased and earlier snow and ice melt, shorter subtropical rainy seasons, shifted seasons, sea level rise and greater variations in temperature and precipitation (IPCC, 2013; Freas et al., 2008; Marshall et al., 2004; Bloetscher et al., 2010). Marshall et al. (2004) specifically focused on the Florida peninsula to predict changes in rainfall and warmer temperatures but interspersed lower low temperatures due to the potential loss of wetlands.

Future changes in climate will add to the existing impacts, at a time when the population of the state is expected to nearly double by 2030. Additional research and high-resolution climate modeling for the Florida peninsula and local jurisdictions is needed to help guide long-term plans like WMPs. Rainfall appears to be decreasing and temperatures rising (see **Error! Reference source not found.**).

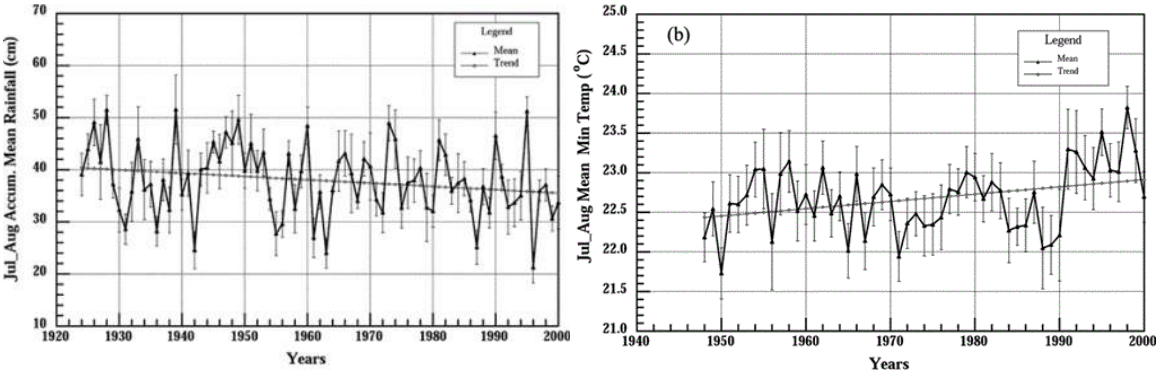

Figure 31. Change in average rainfall and change in average temp 1924 to 2000.
Note the reversed trend, which means groundwater input variability is lessened.
Source: Marshall et al., 2004.

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier

rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3 feet. Accompanying these drivers are potential changes in storm frequency and intensity, desertification, population migration, ocean acidification and coastal flooding (IPCC, 2007), exacerbated by the land cover and land use changes, which are substantially impacted by the fluxes, timing and quality of precipitation (Adrians et al., 2003; Scanlon et al., 2005; Marshall et al., 2004; Salmun and Molod, 2006), and leading to changes in the timing of peak flows and volumes (Richey and Costa-Cabral, 2006).

The results of these climatic changes are likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly An outcome of these climatic patterns is that during the past 140 years, an increase in sea levels has been observed (Bloetscher, 2012), a worrying pattern since sea level rise is a permanent phenomenon, that can be catastrophic to low lying areas in the long-term. The question is how much and how soon? Various studies (Bindoff et al., 2007; Domingues et al., 2008; Edwards, 2007; Gregory, 2008; Vermeer and Rahmstorf, 2009; Jevrejeva, Moore and Grinsted, 2010; Bloetscher, 2010, 2011; IPCC, 2007; Heimlich et al., 2009) indicate large uncertainty in projections of sea level rise by 2100. Gregory et al. (2012) note that during the last two decades, the global rate of sea level rise has been larger than the 20th-century time-mean, and Church et al. (2011) suggested that the cause was increased rates of thermal expansion, glacier mass loss, and ice discharge from icesheets. Gregory et al. (2012) suggested that there may also be increasing contributions to global sea level rise from the effects of groundwater depletion, reservoir impoundment, and loss of storage capacity in surface waters due to siltation. Measurements of Florida's east coast (Maul, 2008) show an average rate of sea level rise of 2.27 ± 0.04 mm per year from 1915 to 1992 based on tide gauge readings. Analyzing the tidal gauge readings for Florida shows that:

1. Florida average sea level rise is 2.10 ± 0.49 mm/yr

2. All but one location is within the 95% confidence limit range (the exception is Panama City where there is evidence of submergence and other land-based issues)
3. None of the Florida sea level rise rates differ statistically
4. Average global sea level rise for 1920-2000 was 2.0 mm/yr – within 95% confidence limit for Florida locations

From 1929 to 1992, over eight inches of sea, with another 6 inches added since 1992, which is already having significant impacts on coastal communities where population growth has increased the need for improved flood management strategies (Bloetscher, 2008; Parkinson, 2010; Zhang et al., 2011, 2011a; NFIP, 2011; Schmidt et al., 2011; Warner et al., 2012).

As a result, the SFRCCC (2015) adopted USACE's methodology to derive scenarios of sea level change intermediate to high rates of sea level rise for years 2030 (3" to 7") and 2060 (9" to 24") as the consensus projection to guide future planning. The path keeps increasing – now 14 inches since 1929 (**Error! Reference source not found.**) caused by thermal expansion of the ocean and melting ice caps (Jevrejeva et al., 2010; Vermeer and Rahmstorf, 2009). Sea level rise is a major concern in Florida, including Walton County, since the majority of the state's population live on the coast, involving most major commercial, residential, and economic enterprises. **Error! Reference source not found.** demonstrate the estimated sea level change for Panama City, considering the predictions of NOAA 2017. For NOAA high scenario SLR change scenario, the estimated level change is higher than 8 ft., while for the intermediate and low scenarios are about 3.9 feet and 1.7 feet respectively.

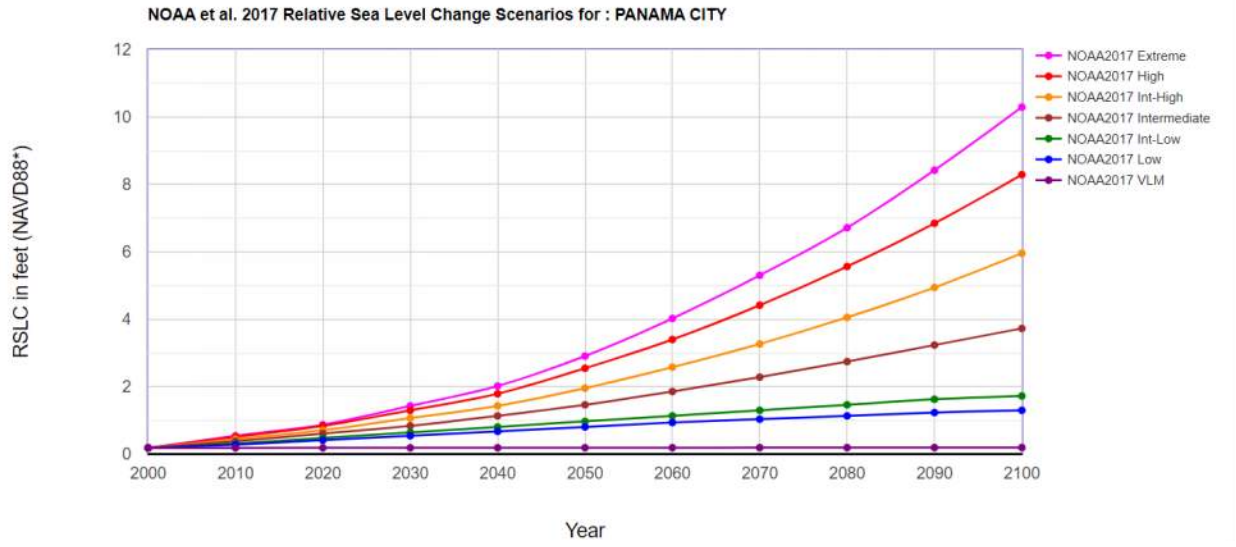

Figure 32. Relative Sea Level Change Scenarios for gauge 8729108, Panama City, FL. Source: NOAA 2017 (Source: https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html).

NOAA (2017) outlines five scenarios for sea level rise. The NFIP proposes the use of the intermediate high projection, which is 1.2 meters or 4 ft globally from current sea level elevations (**Error! Reference source not found.**).

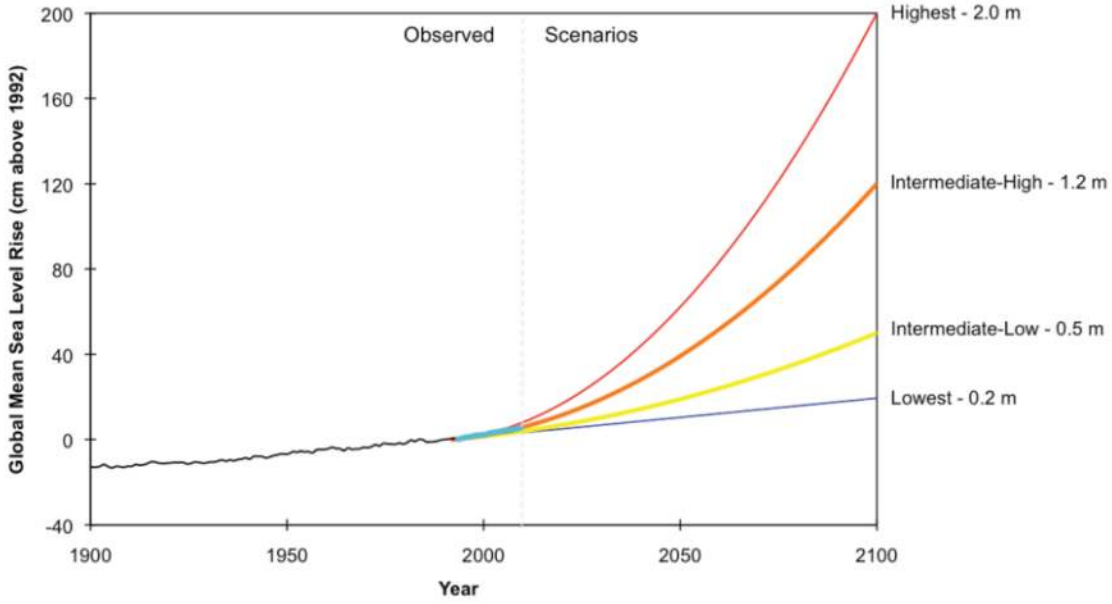

Figure 33. Graphic of global sea level rise projections from NOAA (2017). Source:https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

As sea level rises, access to roads, bridges, rail, and transit could be at risk of flooding, causing the effects of sea level rise to spread indirectly throughout the entire transportation network, affecting the overall system performance. For example, the flooding of a critical road or facility access can cause a shifting of traffic flow causing congested conditions in other roadways that are not actually flooded. Since the roadway network would be unable to carry the traffic demand, the system would experience operational failure; as a result, causing travel times and delays. Moreover, the inundation of a critical access could cause transportation connectivity problems to essential infrastructure like ports or airports. Transportation infrastructure relies on the effectiveness of flood control and stormwater drainage systems for the transportation corridors. Road integrity relies on adequate drainage. The increased risk of severe flooding in Florida's low-lying terrain can adversely affect transportation infrastructure along the coastline; roads can be inundated, and roadway beds can be damaged. Sea level rise will cause increased water table levels (FDOT, 2012), as regional water tables cannot exist naturally below mean high tide (2 feet in Florida). Adding 3 feet of sea level rise on top of groundwater would compound the risk of flooding in low-lying areas. Road bases below 5 feet NVGD would become saturated under this scenario, likely causing premature base failure. As soil storage capacity is diminished due to rising groundwater elevations associated with sea level rise, the potential for more frequently flooded roadways would likely damage pavements (FDOT, 2012). Hence sea level rise must be accounted

for in WMPs in coastal areas. To allow flexibility in the analysis due to the range of increases within the different time periods, an approach that uses incremental increases of 1, 2, and 3 feet of sea level rise is suggested for modeling. The increments can work as threshold values in planning considerations in terms of allowing planners the ability to know ahead of time where the next set of vulnerable areas will be, to allow for a proactive response approach that can be matched to the observed future rates. Sea level rise is a major concern since nearly half the US population lives within 50 miles of the coast, involving most major commercial, residential, and economic enterprises. The effects of 5 ft sea level rise, King tide, and 1-day 100-year storm event are shown in **Error! Reference source not found.**.

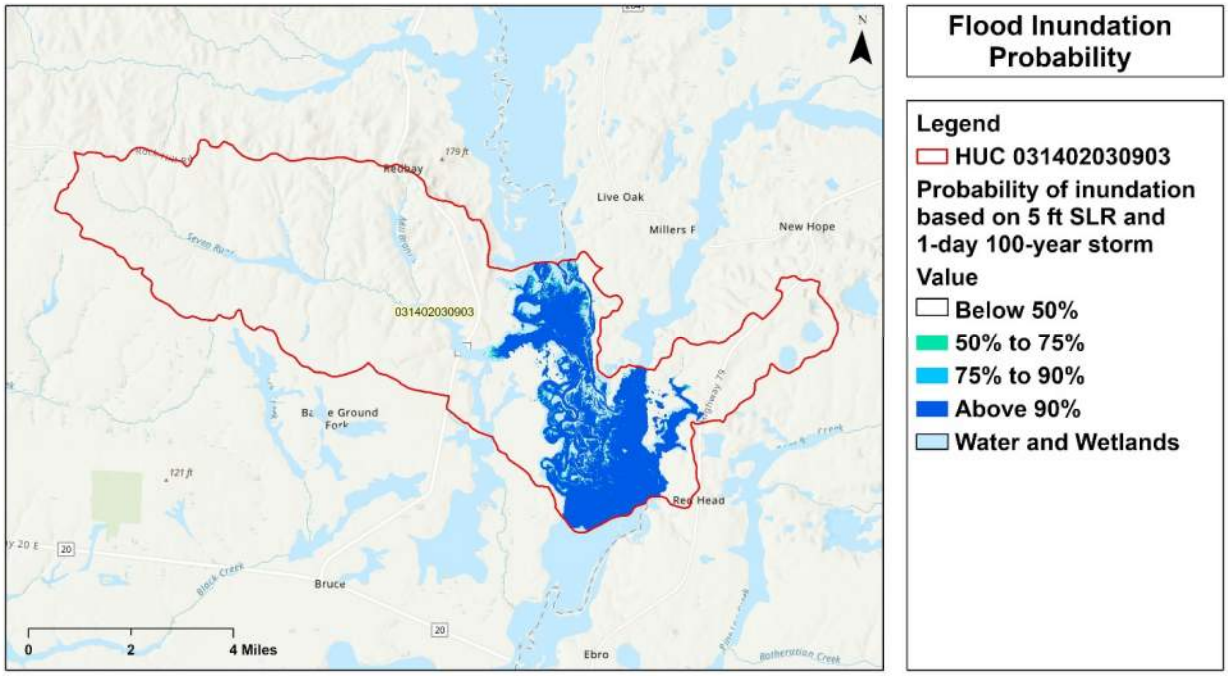

Figure 34. Flood Inundation Probability for a Sea level rise of 5 ft + 1-day 100-year storm event for HUC 031402030903 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Dark blue is area under 5 ft NAVD88 and potentially inundated at the 99th percentile tidal conditions. Processed by FAU.

2.4 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. **3-day 25-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 35)
2. **1-day 100-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 36)
3. **1-day 10-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 37)
4. **1-day 5-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 38)
5. **Sea level rise of 1 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 39)
6. **Sea level rise of 1 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations storm (Figure 40)
7. **Sea level rise of 1 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 41)
8. **Sea level rise of 1 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 42)
9. **Sea level rise of 2 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 43)
10. **Sea level rise of 2 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 44)
11. **Sea level rise of 2 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 45)
12. **Sea level rise of 2 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 46)
13. **Sea level rise of 3 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 47)
14. **Sea level rise of 3 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 48)

15. **Sea level rise of 3 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 49)
16. **Sea level rise of 3 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 50)
17. **Sea level rise of 4 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 51)
18. **Sea level rise of 4 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 52)
19. **Sea level rise of 4 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 53)
20. **Sea level rise of 4 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 54)
21. **Sea level rise of 5 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 55)
22. **Sea level rise of 5 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 56)
23. **Sea level rise of 5 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 57)
24. **Sea level rise of 5 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 58)

In all scenarios, a considerable amount of flooding is noted at the river entrance to the HUC, extending to the wetland areas. Given that this basin is connected to the ocean through the Choctawhatchee River, SLR scenarios plays an important hole, implying a considered growth as the projected scenario of rising tides rises.

The design storm simulation determined that approximately 3.1% of the HUC total area or 1.44 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 3.3% of the HUC's total area, or 1.52 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 3.1% of the HUC's total area, or 1.44 mi^2, would

be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 3.1% of the HUC's total area, or 1.44 mi^2, would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031402030903 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	45.19	1.44	96.9%	3.1%
1-day 100-year	45.10	1.52	96.7%	3.3%
1-day 10-year	45.19	1.44	96.9%	3.1%
1-day 5-year	45.19	1.44	96.9%	3.1%

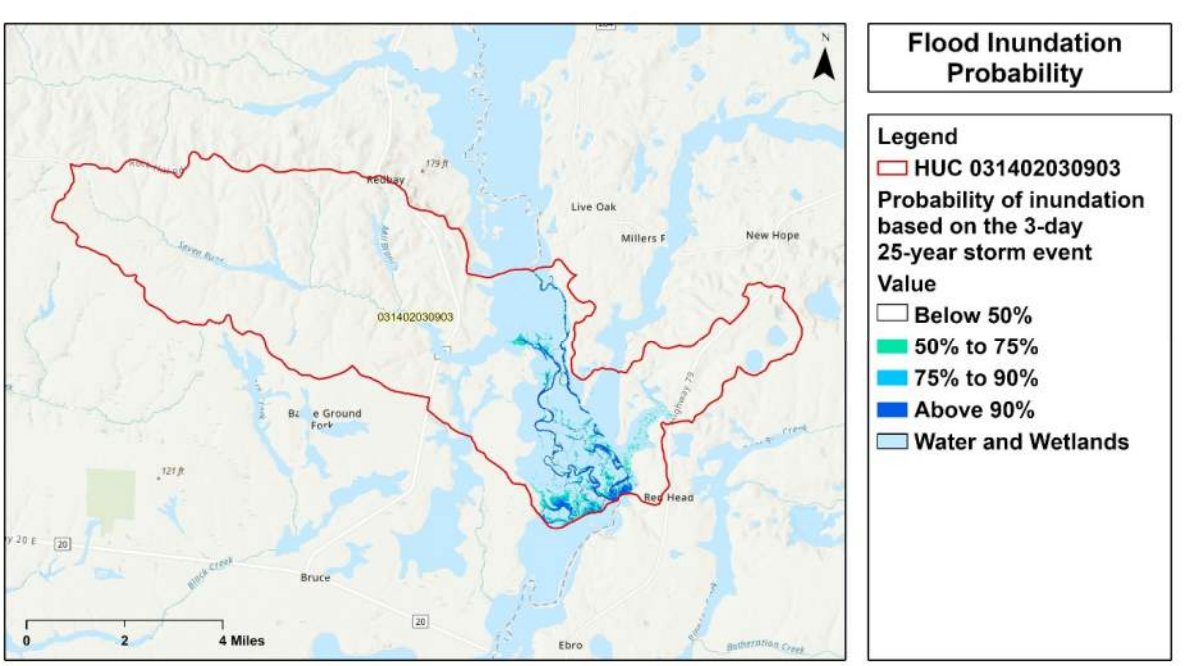

Figure 35. 3-day 25-year storm event for HUC 031402030903 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

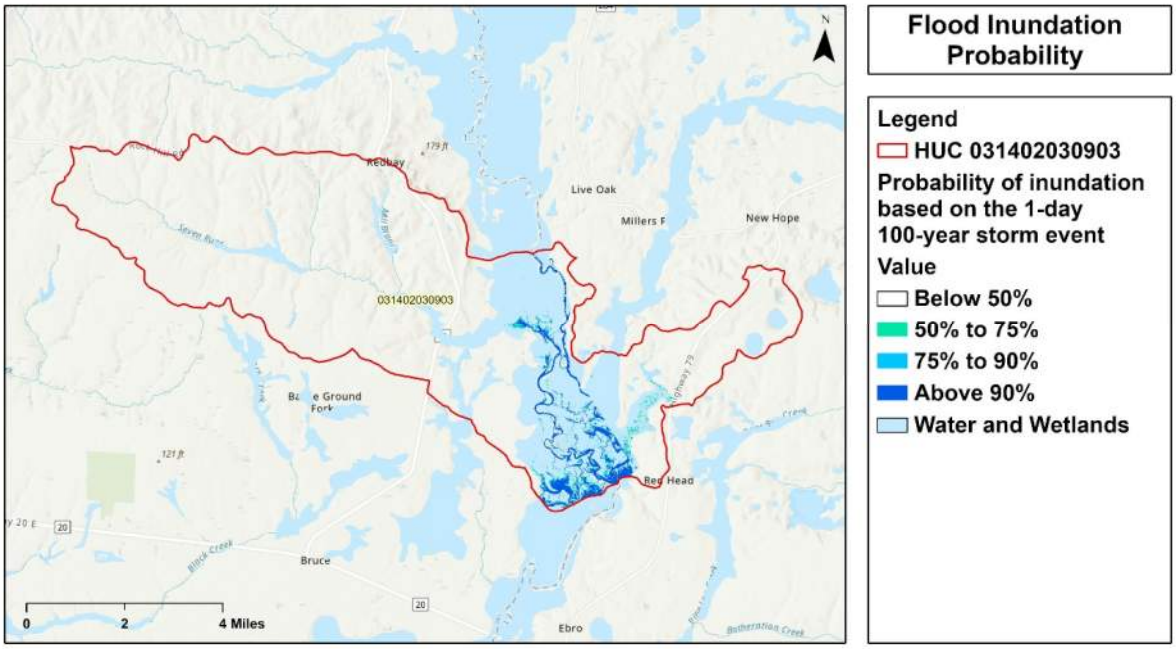

Figure 36. 1-day 100-year storm event for HUC 031402030903 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

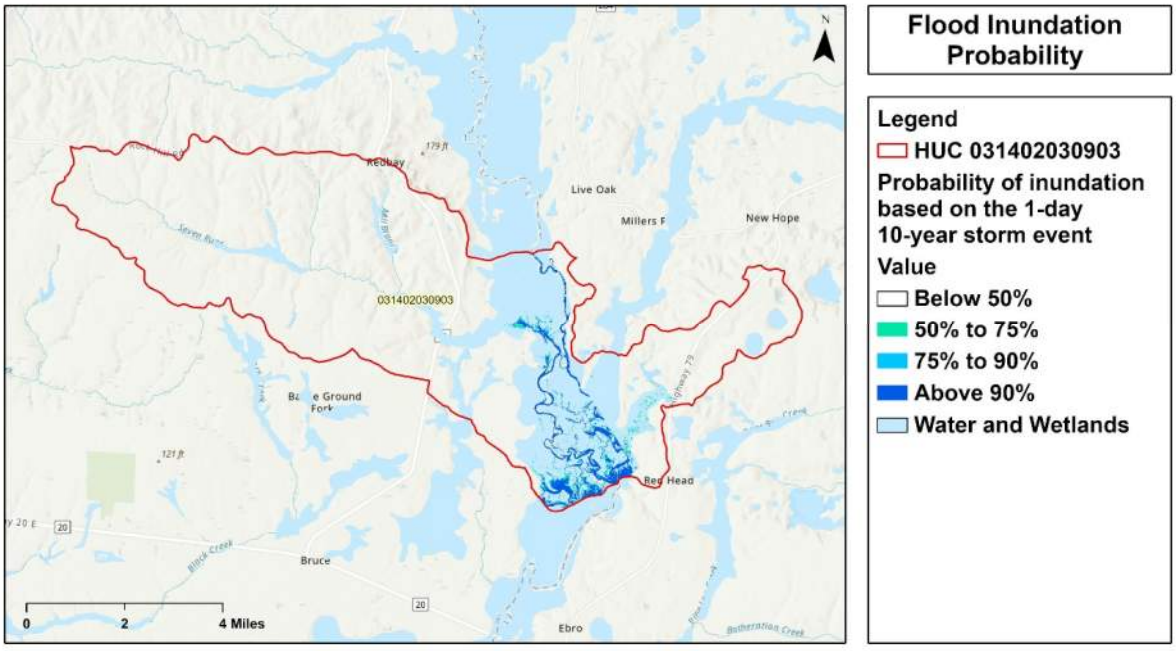

Figure 37. 1-day 10-year storm event for HUC 031402030903 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

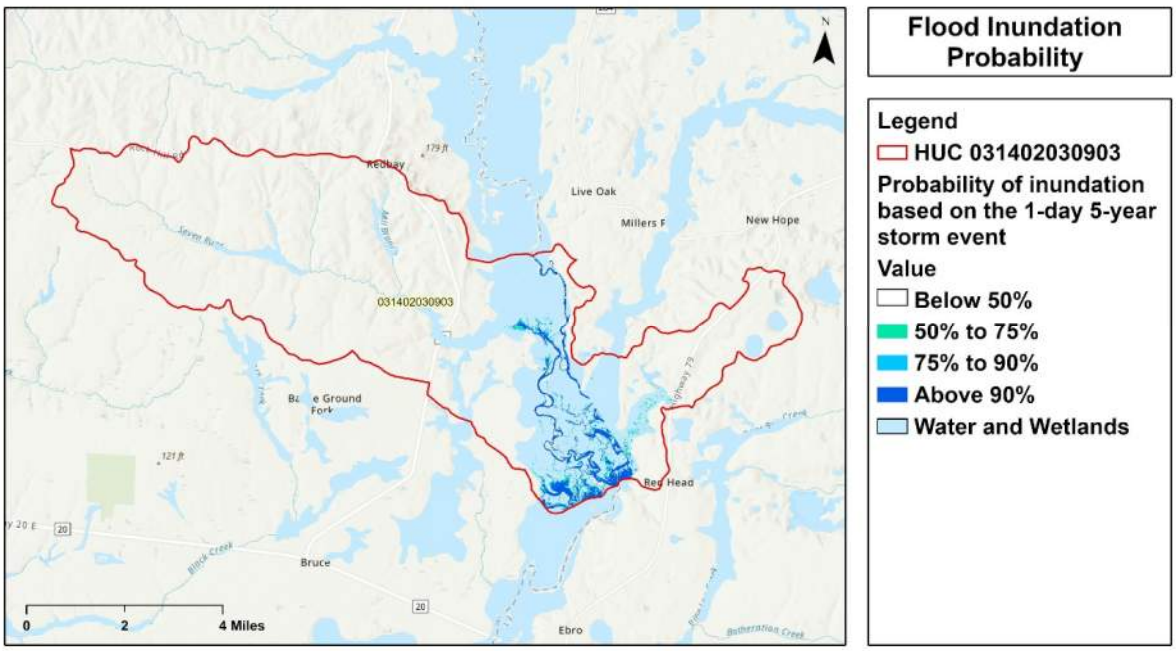

Figure 38. 1-day 5-year storm event for HUC 031402030903 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

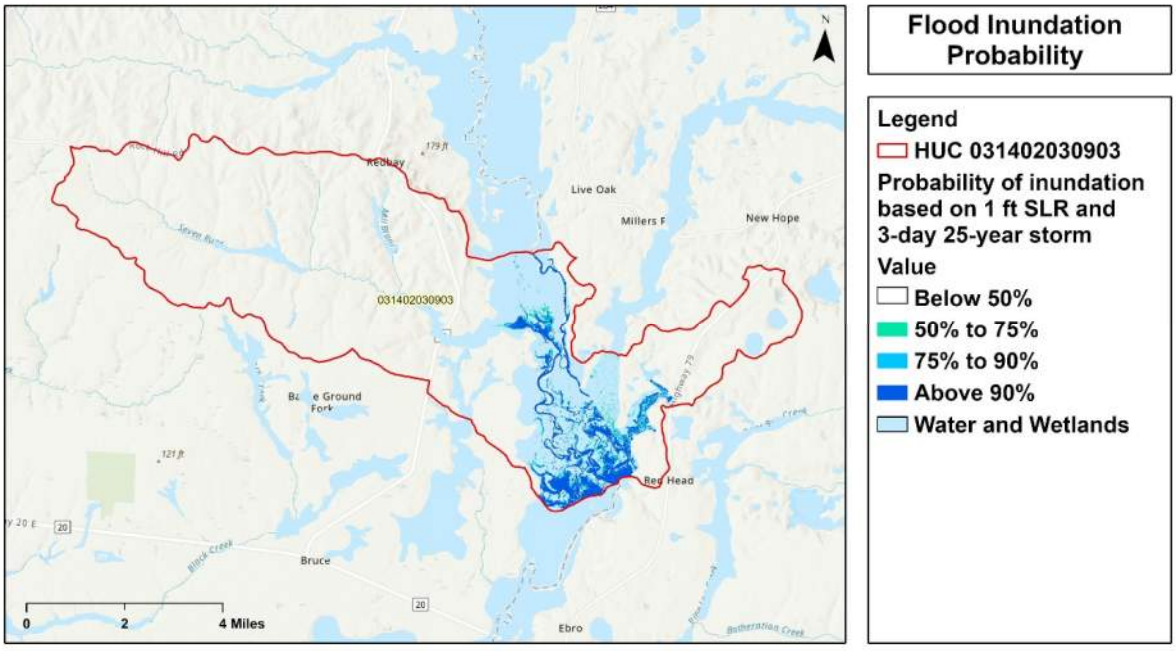

Figure 39. Sea level rise of 1 ft + 3-day 25-year storm for HUC 031402030903 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

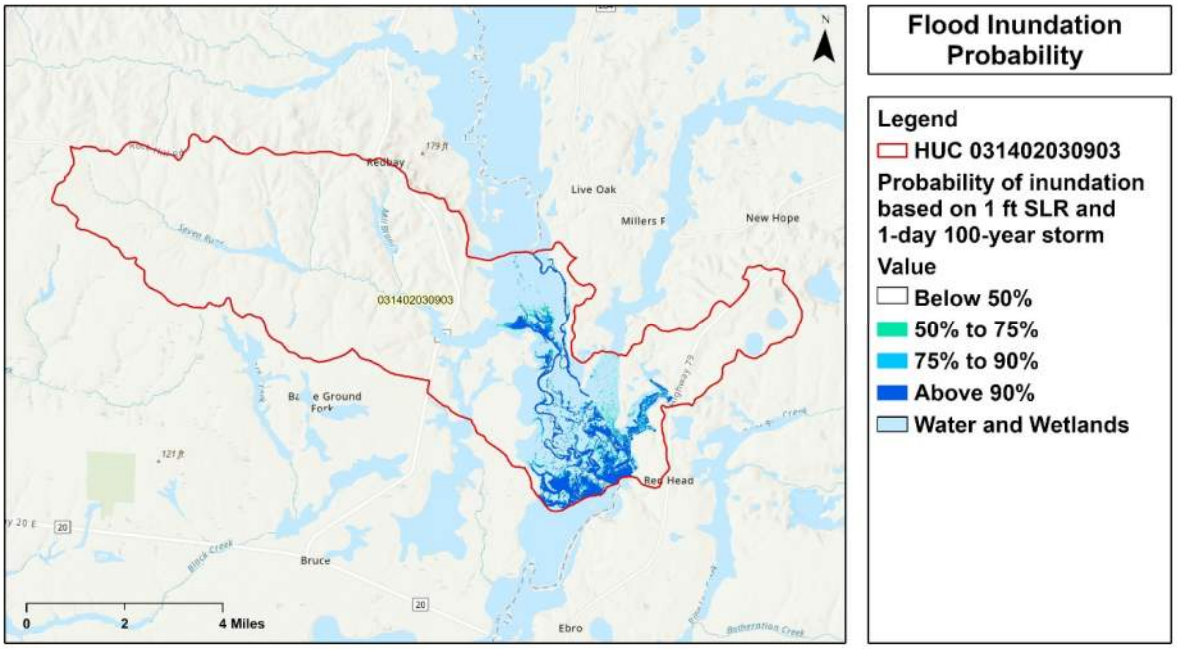

Figure 40. Sea level rise of 1 ft + 1-day 100-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

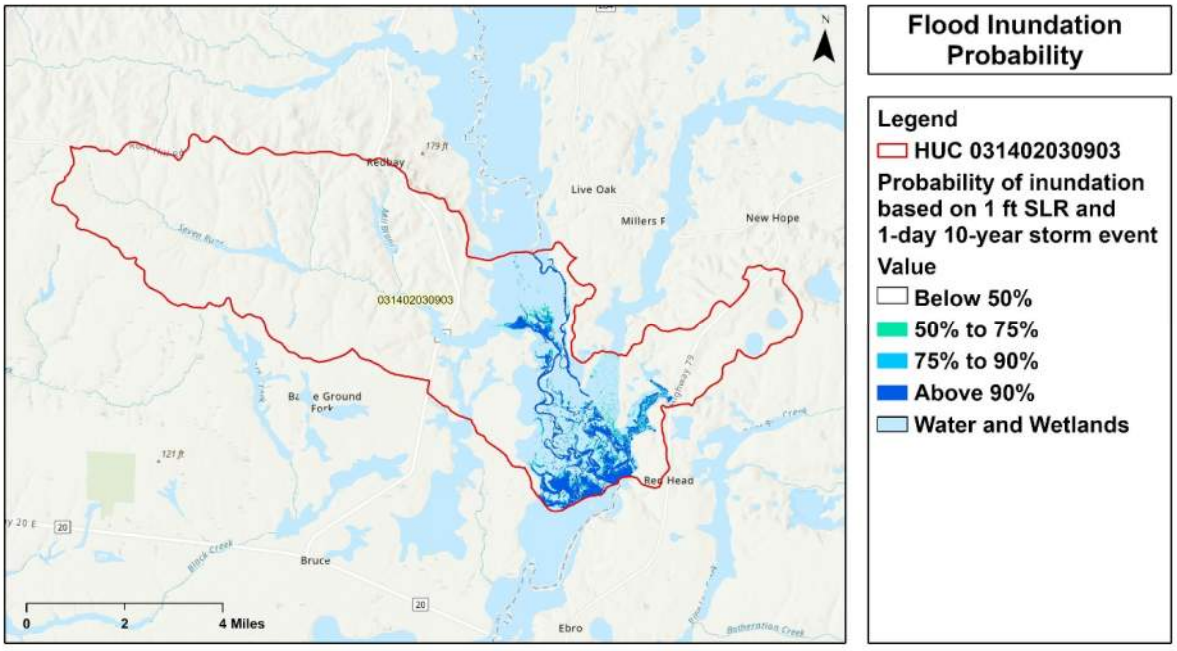

Figure 41. Sea level rise of 1 ft + 1-day 10-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

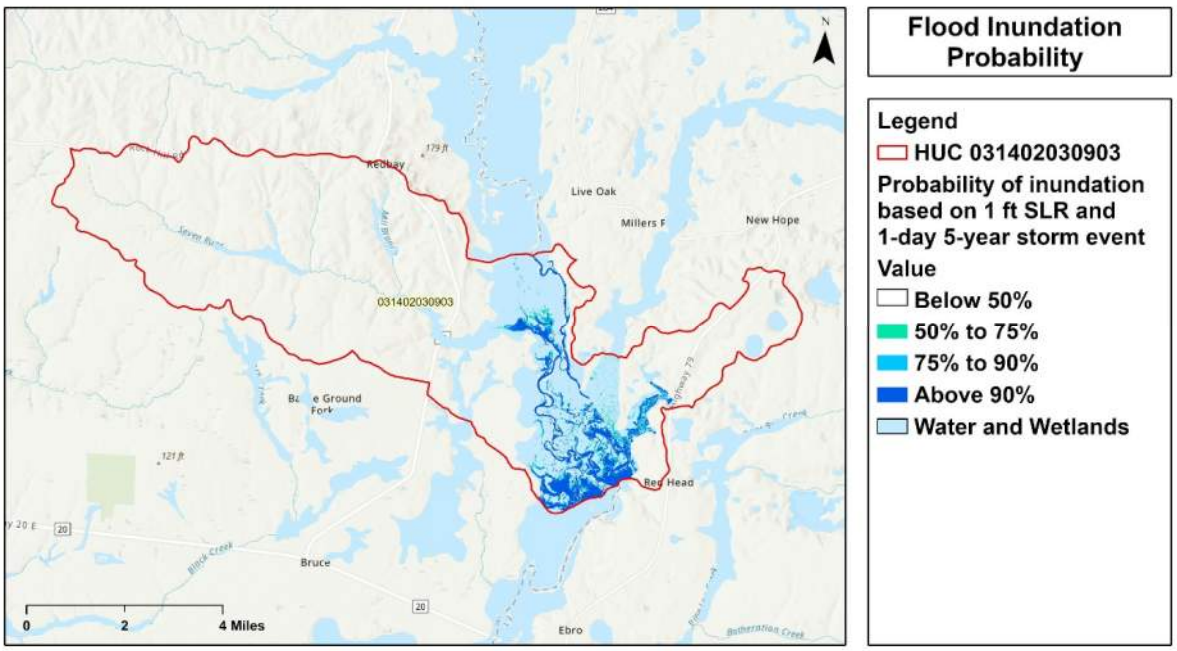

Figure 42. Sea level rise of 1 ft + 1-day 5-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

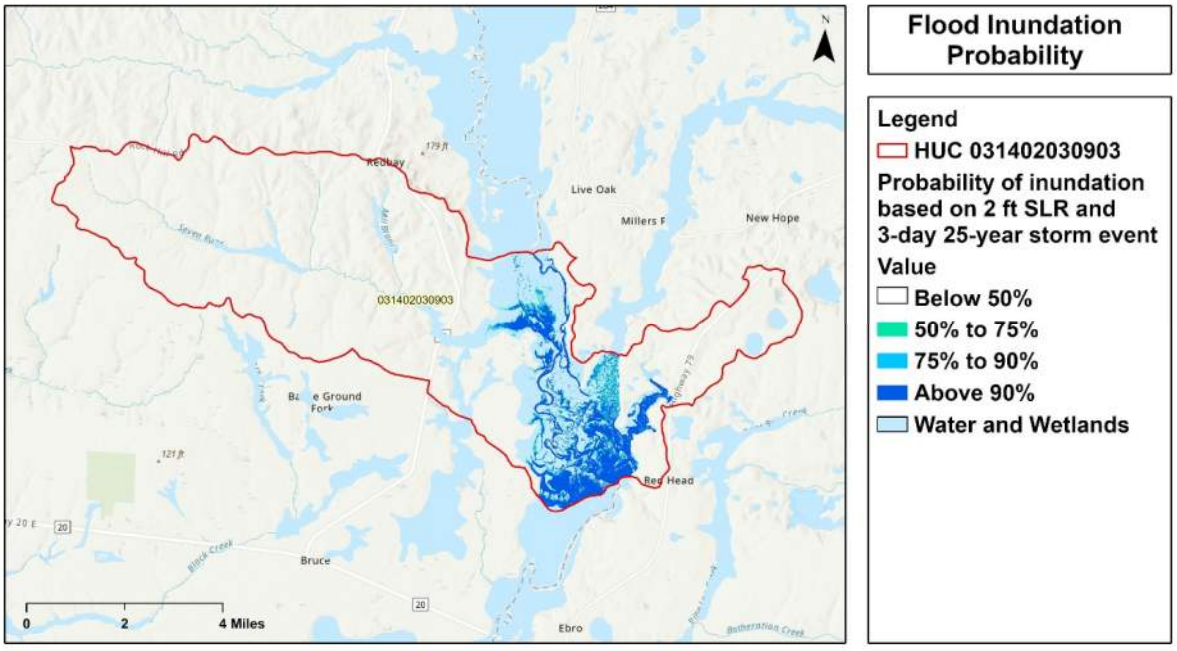

Figure 43. Sea level rise of 2 ft + 3-day 25-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

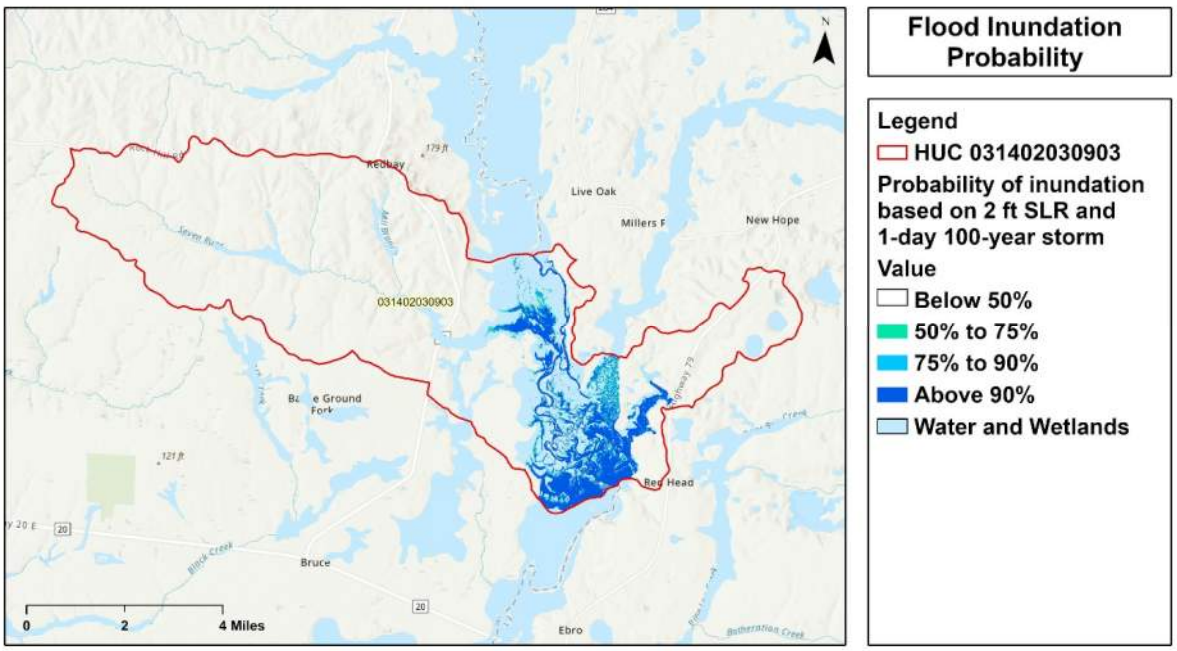

Figure 44. Sea level rise of 2 ft + 1-day 100-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

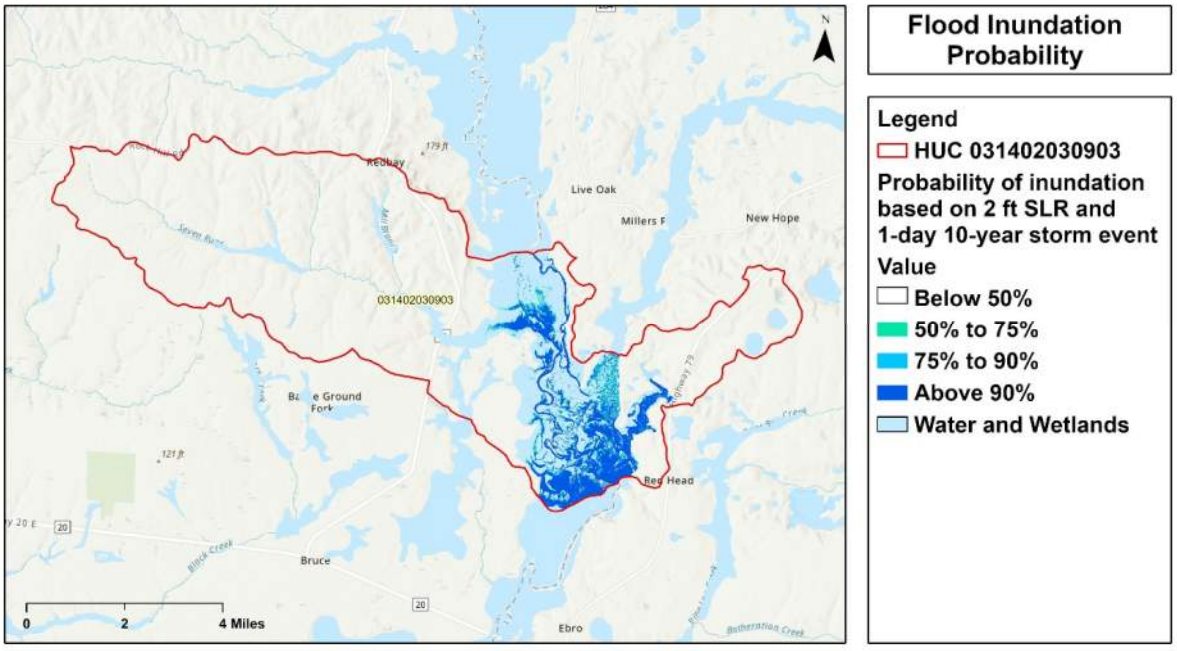

Figure 45. Sea level rise of 2 ft + 1-day 10-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

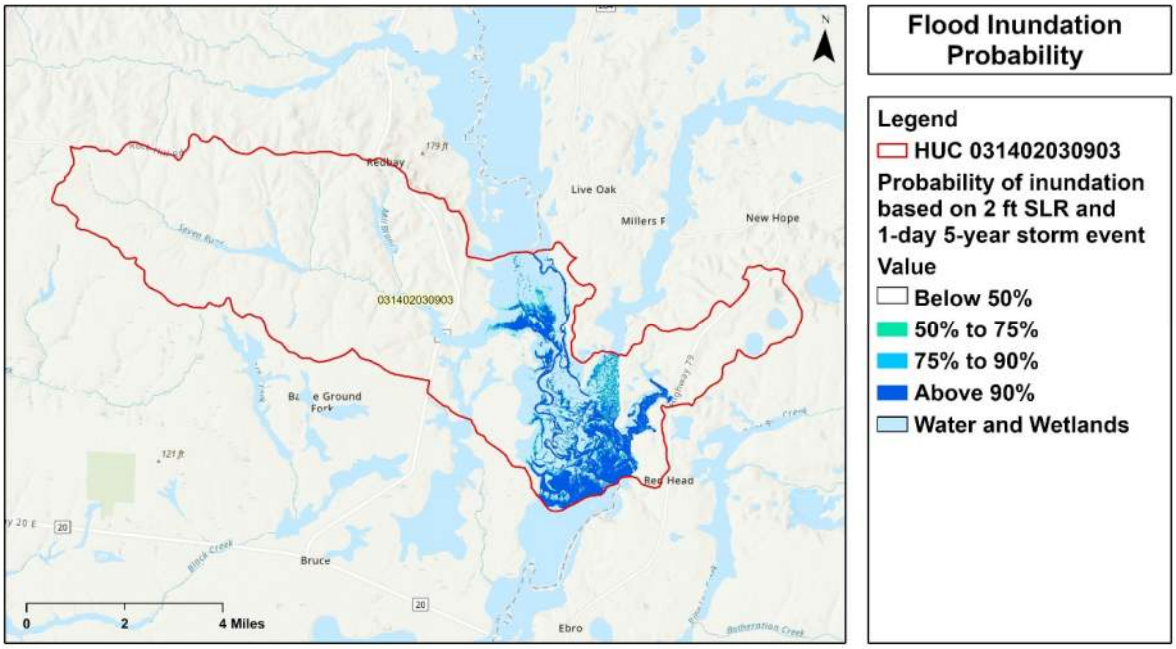

Figure 46. Sea level rise of 2 ft + 1-day 5-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

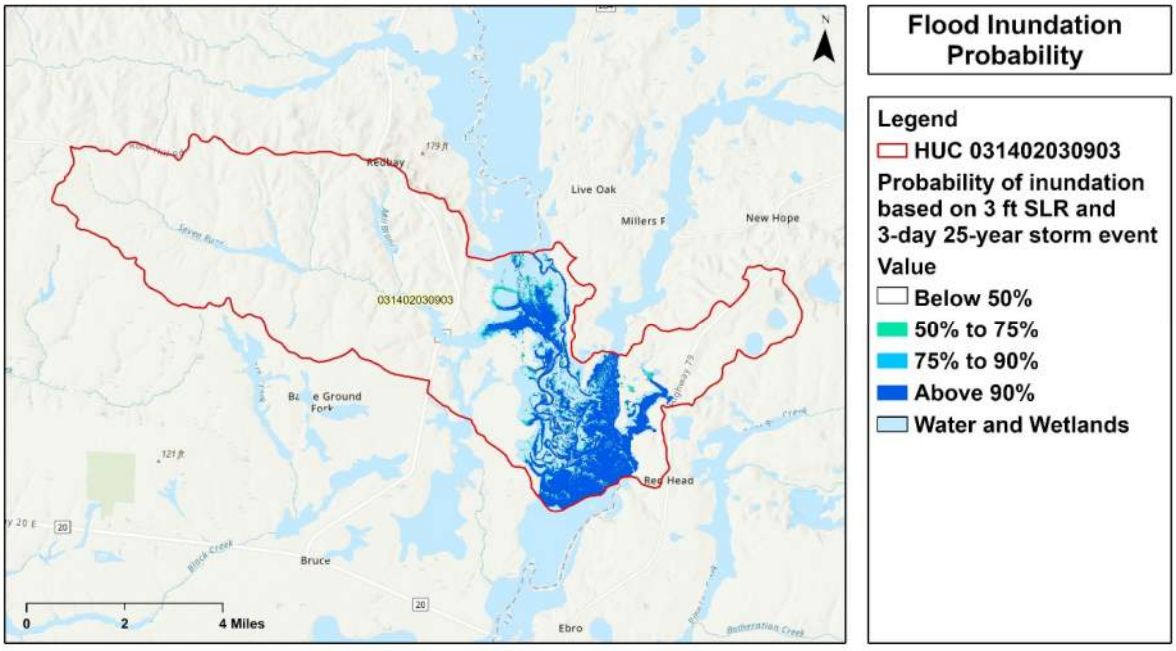

Figure 47. Sea level rise of 3 ft + 3-day 25-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

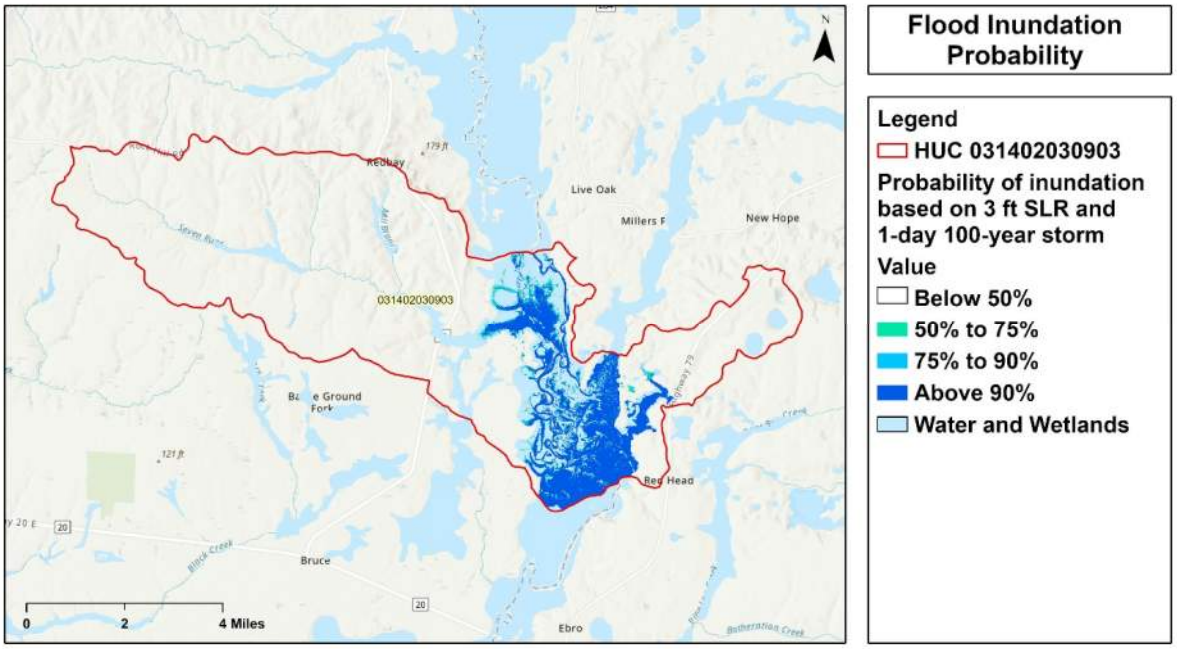

Figure 48. Sea level rise of 3 ft + 1-day 100-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

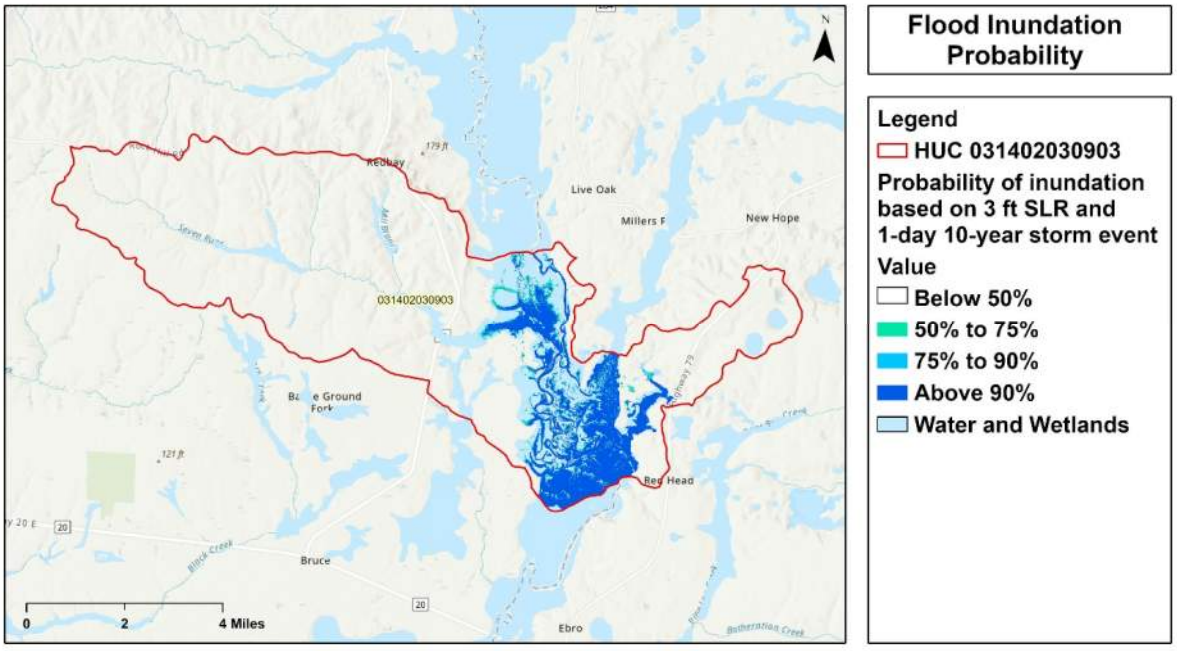

Figure 49. Sea level rise of 3 ft + 1-day 10-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

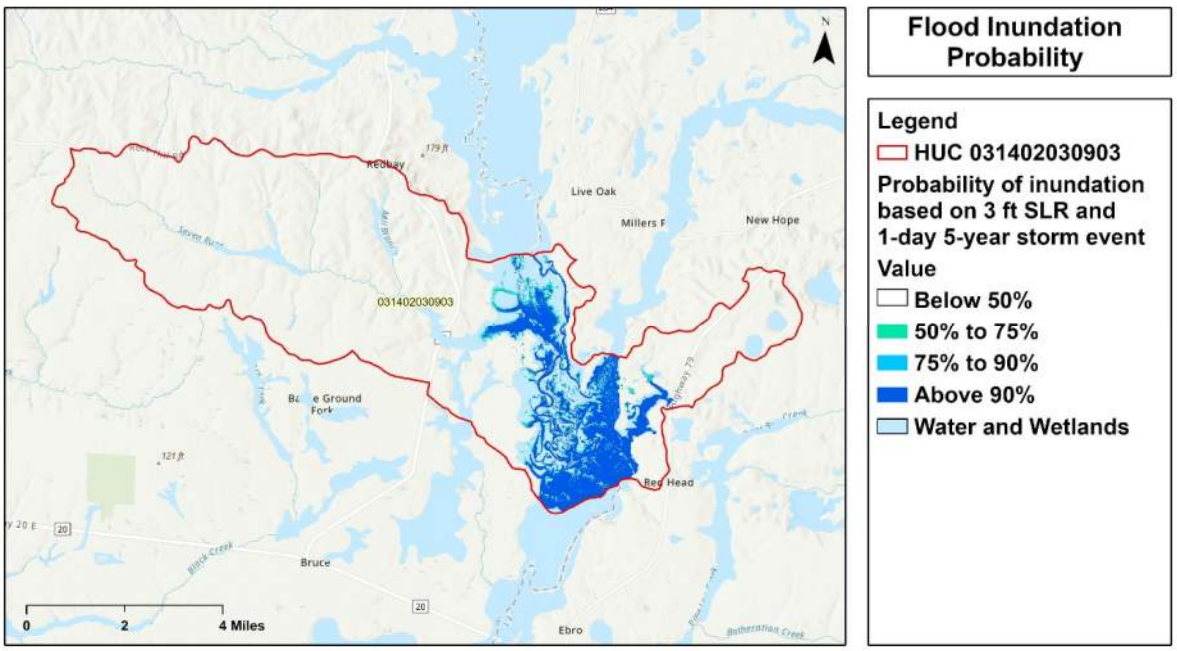

Figure 50. Sea level rise of 3 ft + 1-day 5-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

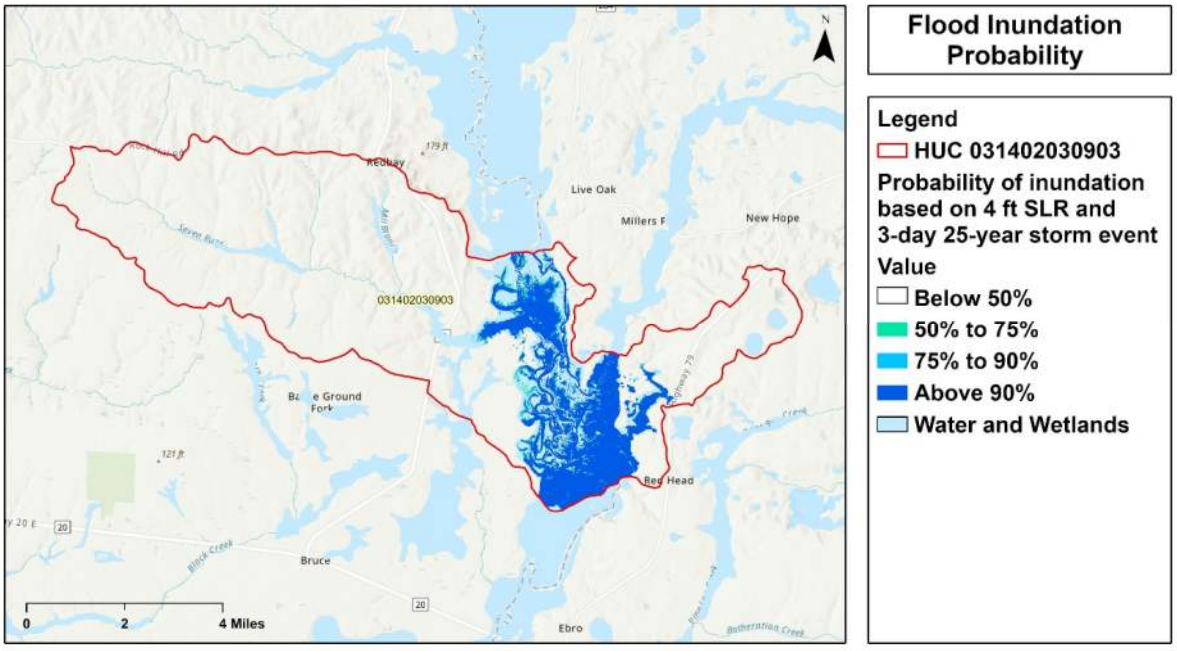

Figure 51. Sea level rise of 4 ft + 3-day 25-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

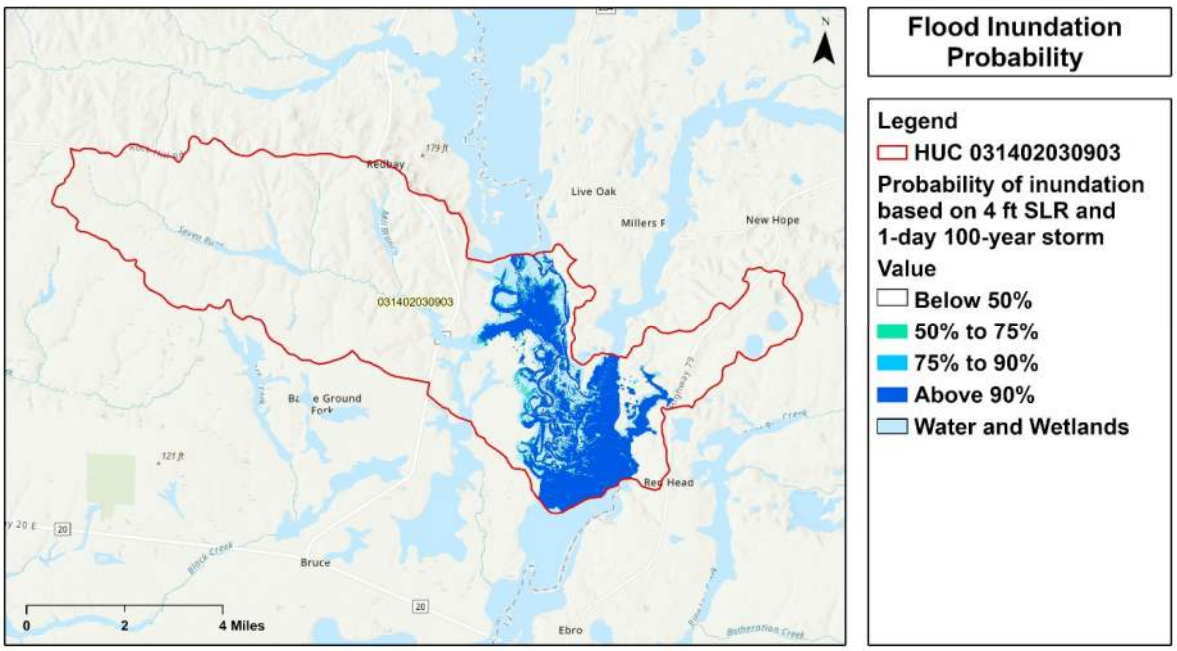

Figure 52. Sea level rise of 4 ft + 1-day 100-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

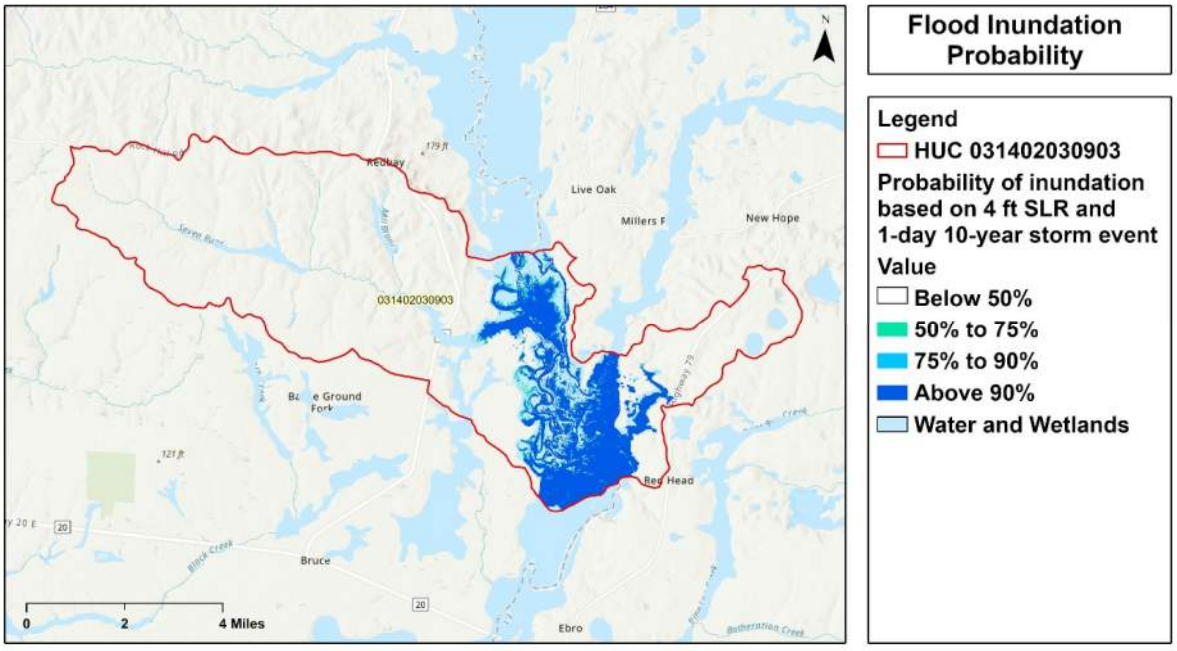

Figure 53. Sea level rise of 4 ft + 1-day 10-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

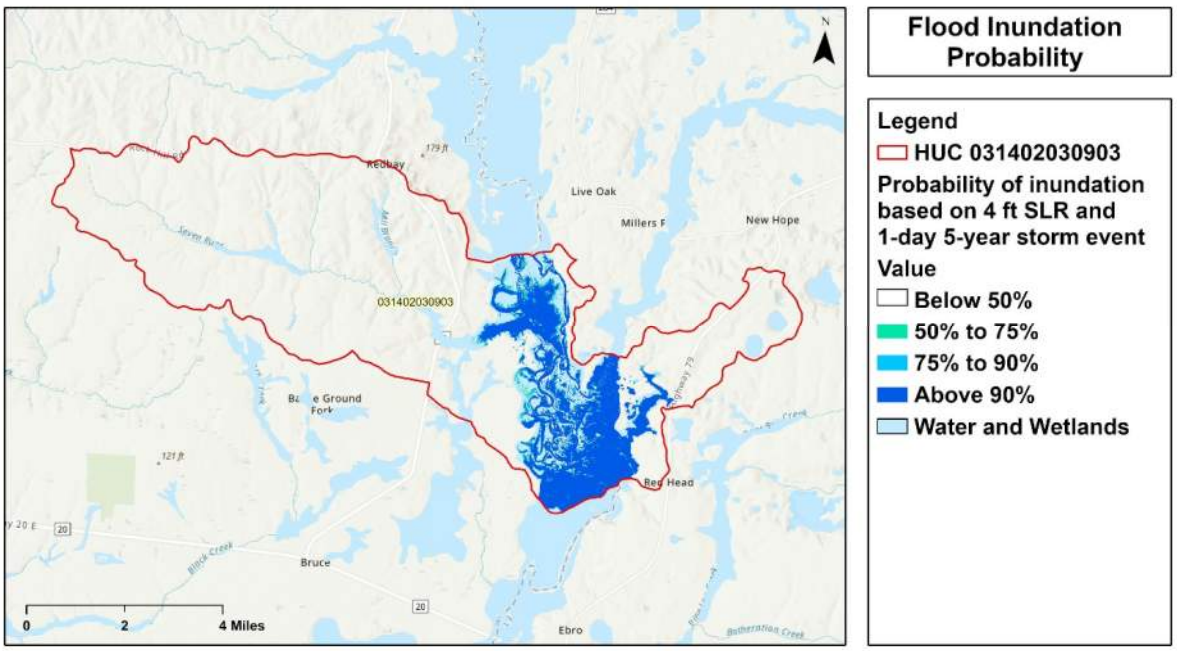

Figure 54. Sea level rise of 4 ft + 1-day 5-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

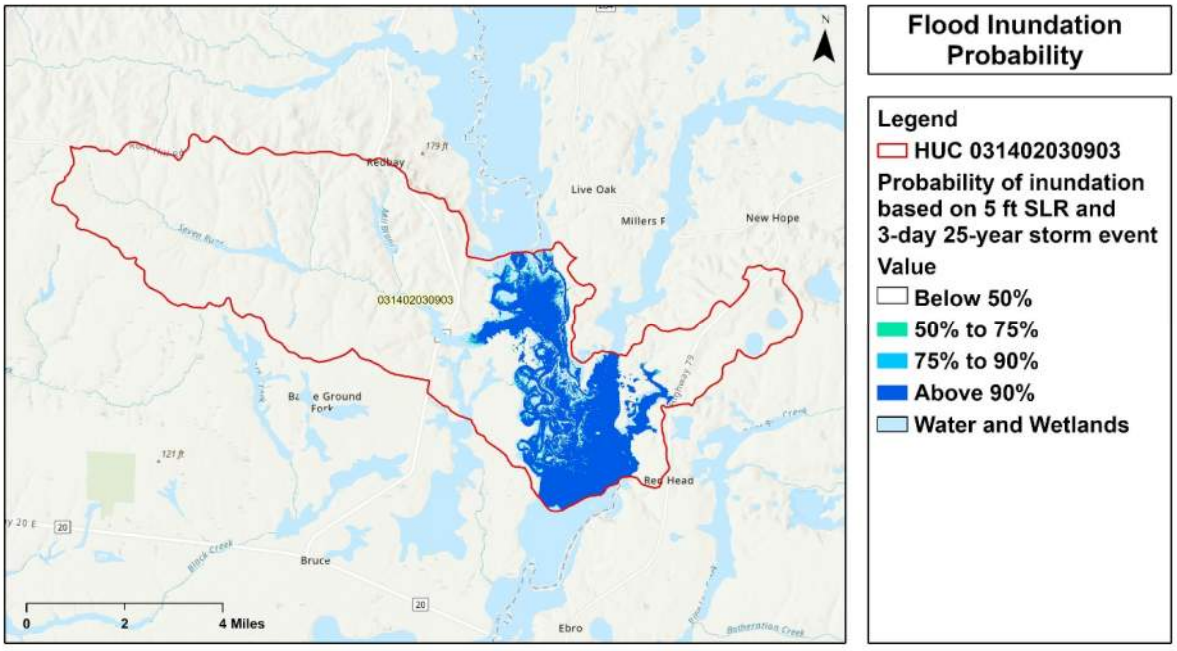

Figure 55. Sea level rise of 5 ft + 3-day 25-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

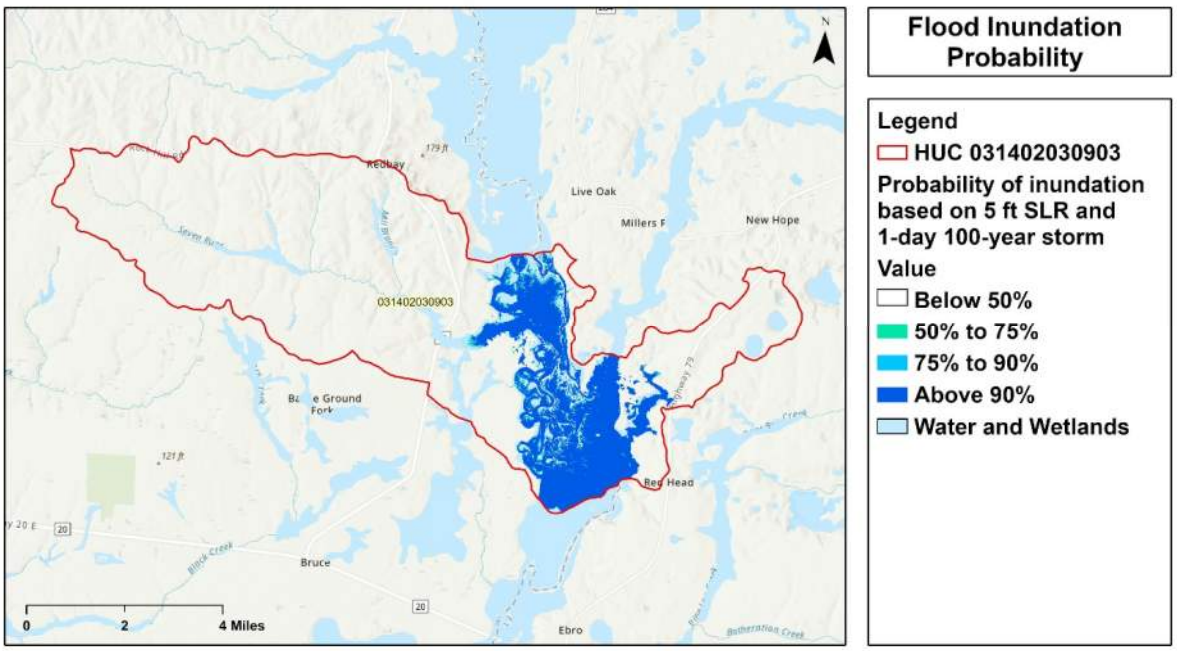

Figure 56. Sea level rise of 5 ft + 1-day 100-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

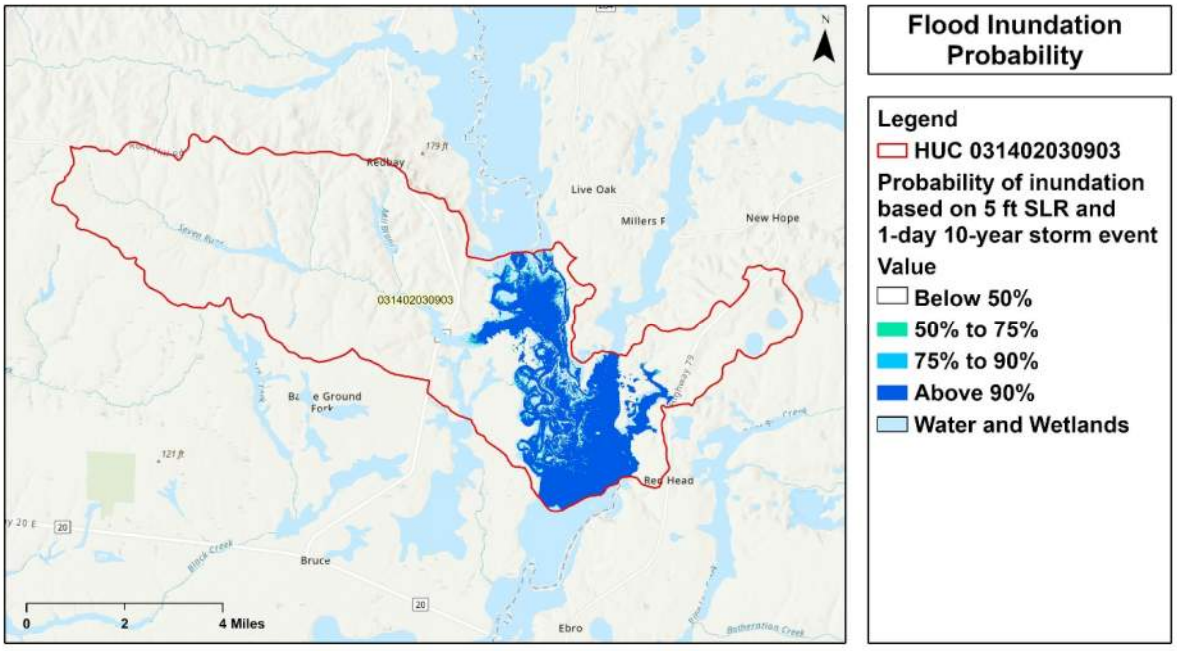

Figure 57. Sea level rise of 5 ft + 1-day 10-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

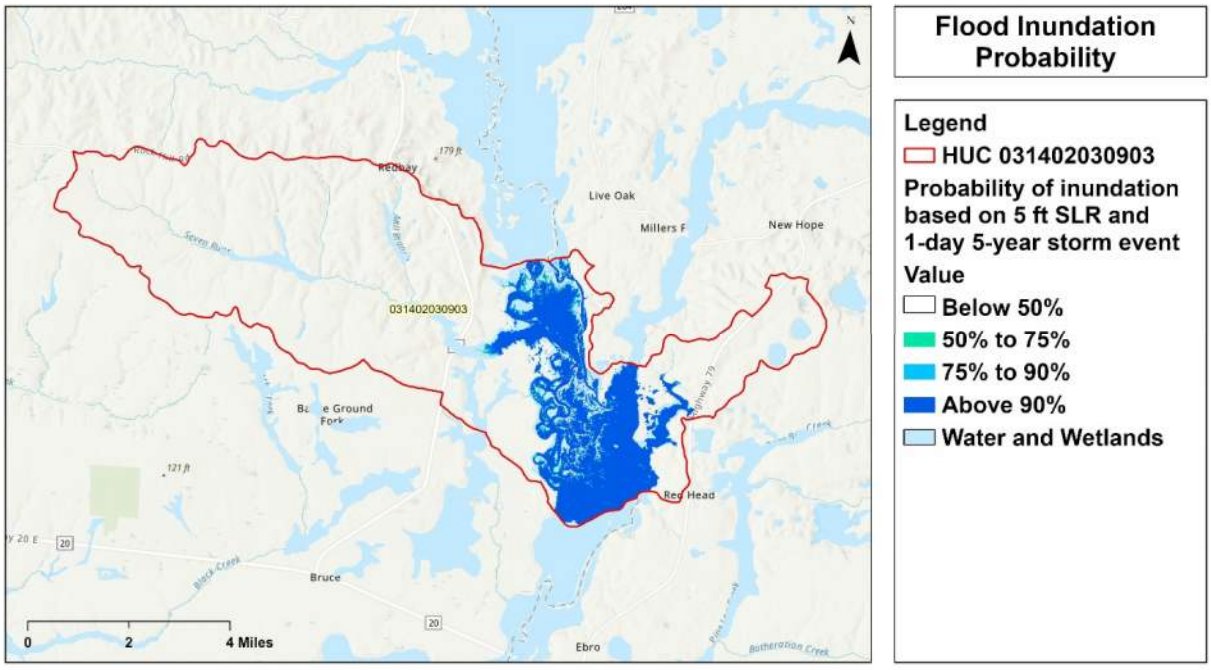

Figure 58. Sea level rise of 5 ft + 1-day 5-year storm for HUC 031402030903 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.5 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health)

requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5

27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, VegeTables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6

59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6

97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.5.1 Results

Error! Reference source not found. to **Error! Reference source not found.** depict the HUC 031402030903 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 60) overlays critical facilities onto the 1-day 100-year storm event scenario, while the third map (**Error! Reference source not found.**) represents the same overlay within the context of 5 feet of sea level rise (SLR) combined with the 1-day 100-year storm event. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 5 feet SLR + 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** and **Error! Reference source not found.** illustrate the composite score for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. **Error! Reference source not found.** represents the calculation for composite score based on 1-day 100-year storm event, while **Error! Reference source not found.** shows the calculation for composite score for the same storm event, but including a 5 feet of Sea Level Rise scenario. **Error! Reference source not found.** shows the same area zoomed out.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

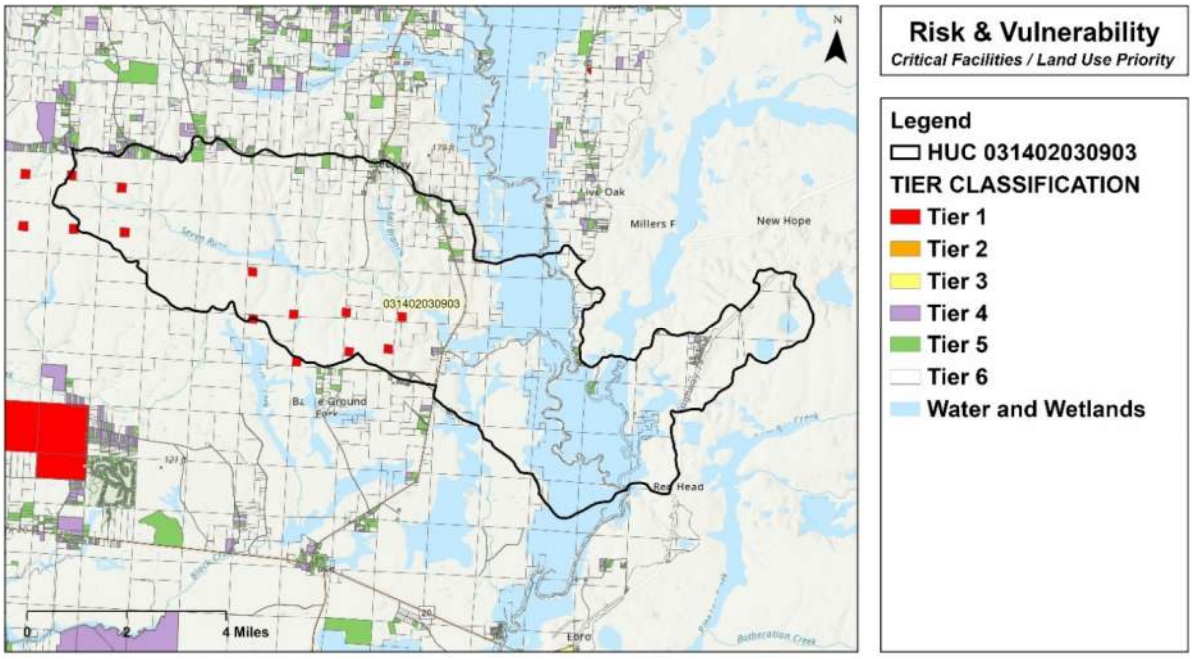

Figure 59. HUC 031402030903 sub-watershed Critical Facilities (priority of land uses) map.

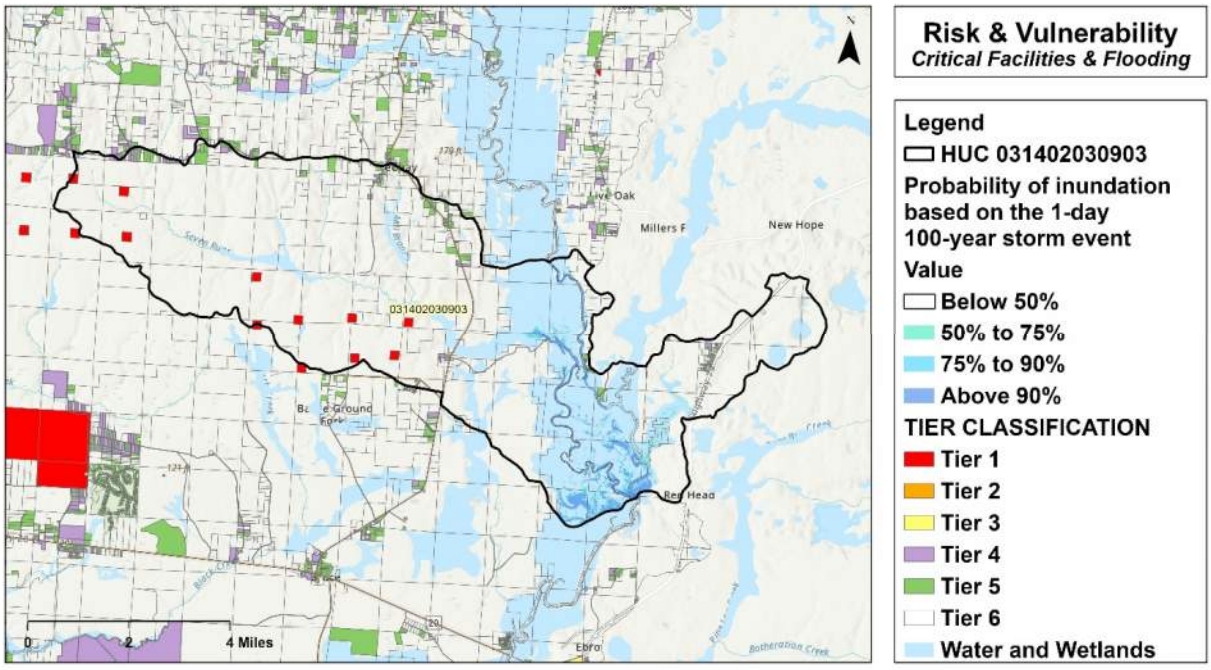

Figure 60. HUC 031402030903 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

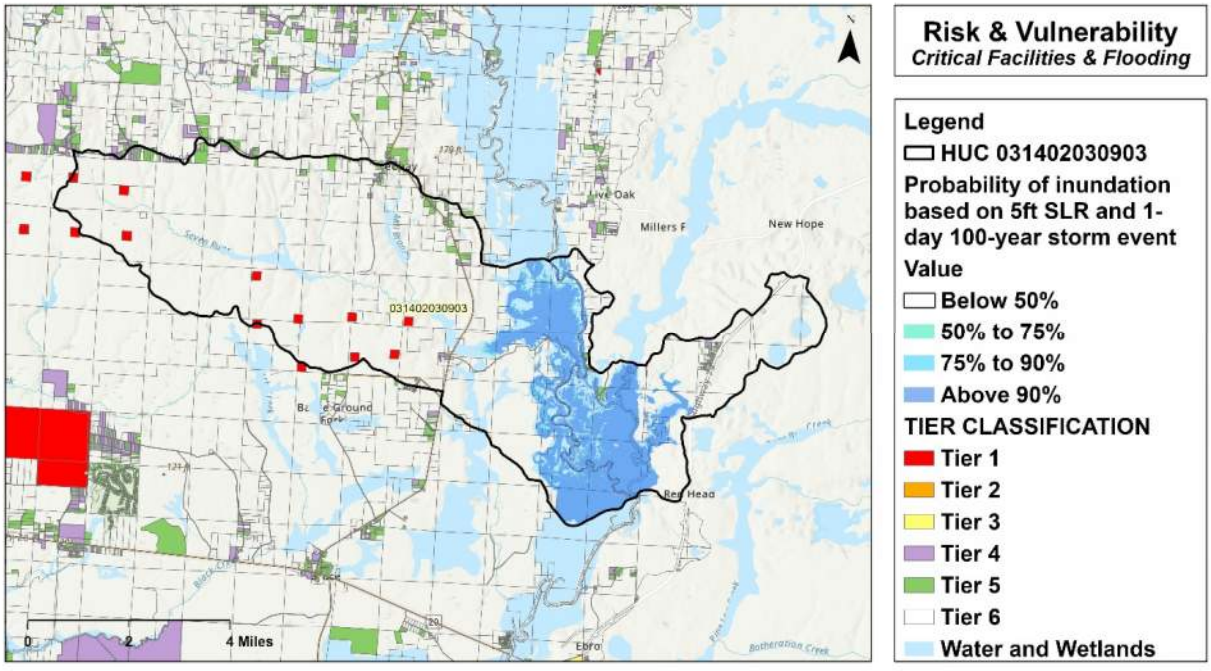

Figure 61. HUC 031402030903 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

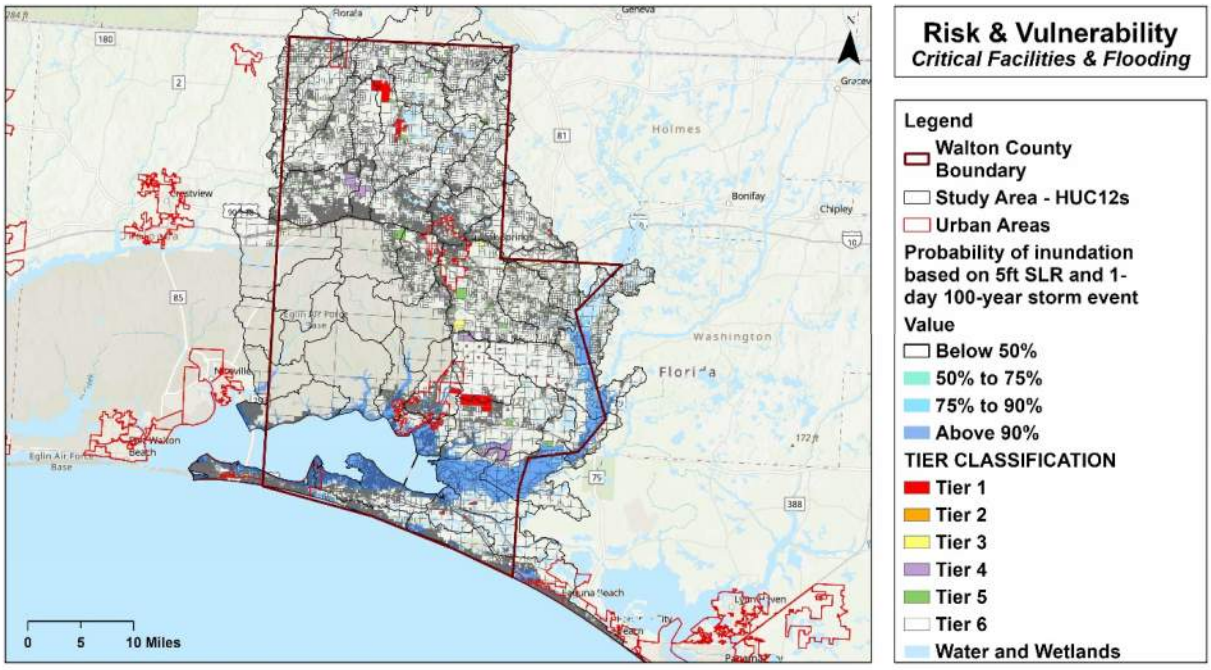

Figure 62. Walton County (mosaic) - Critical Facilities (priority of land uses) map, overlaid on the 1-day 100-year storm event + 5 ft. SLR probability of inundation for Walton County. Processed by FAU.

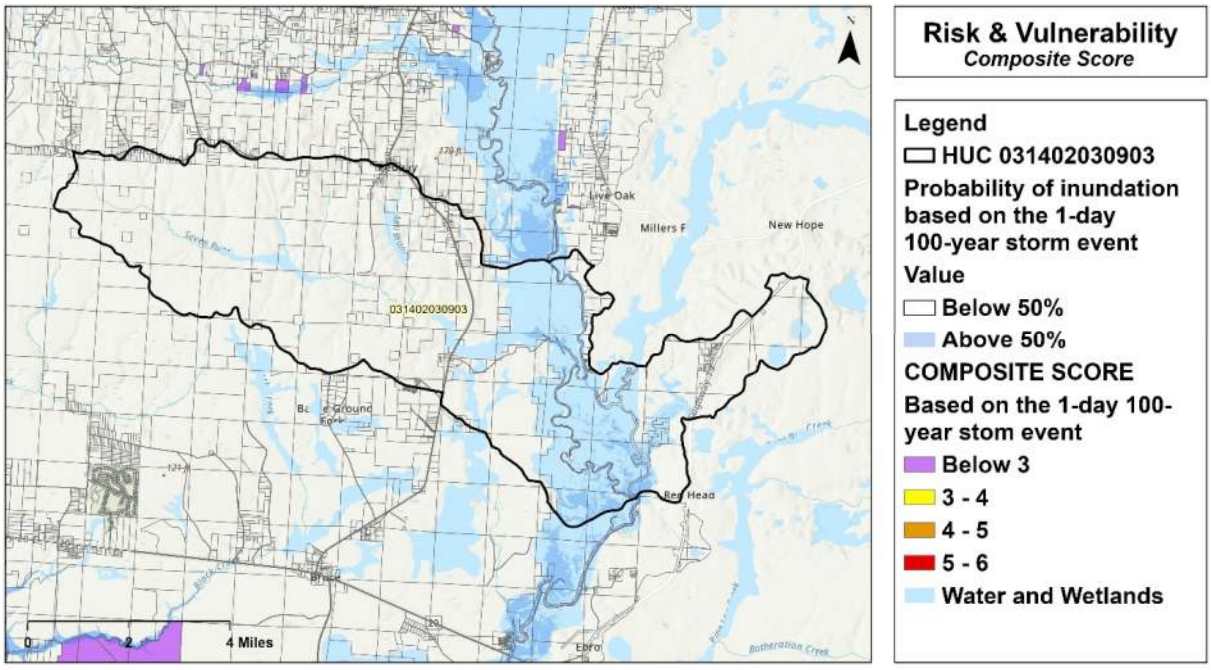

Figure 63. HUC 031402030903 sub-watershed Composite Score Risk map based on the 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation. Processed by FAU.

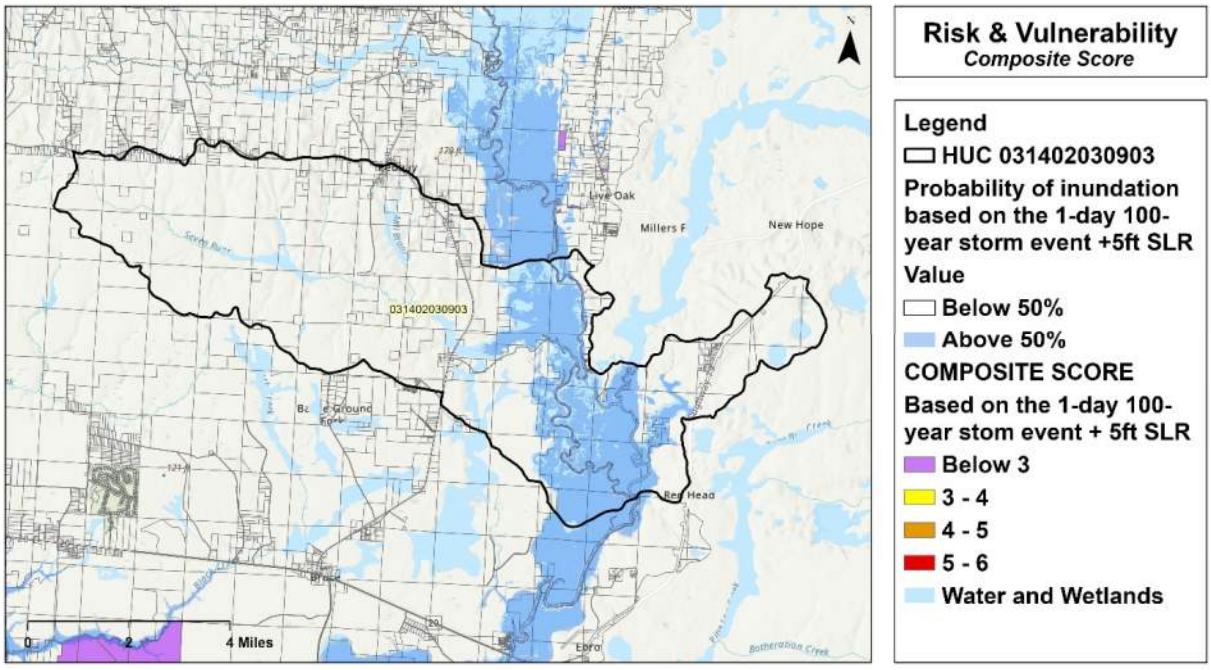

Figure 64. HUC 031402030903 sub-watershed Composite Score Risk map based on 1-day 100-year storm event + 5 ft. SRL, overlaid on the 1-day 100-year + 5 ft. SLR probability of inundation. Processed by FAU.

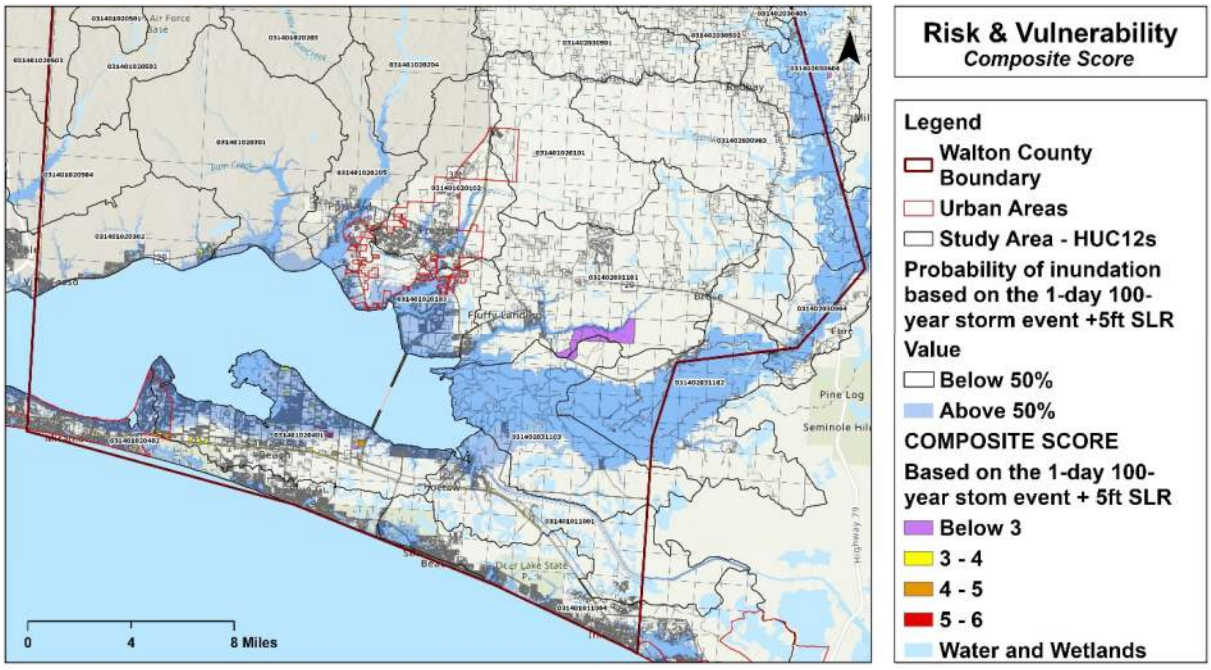

Figure 65. Coastal Area of Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

2.5.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031402030903. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.5.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It is important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031402030903. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031402030903	29841.40
All of the 1-day 100-year storm event inundation	**975.39**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	773.18
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	153.43
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	1.17
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	202.20
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	47.60

2.5.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

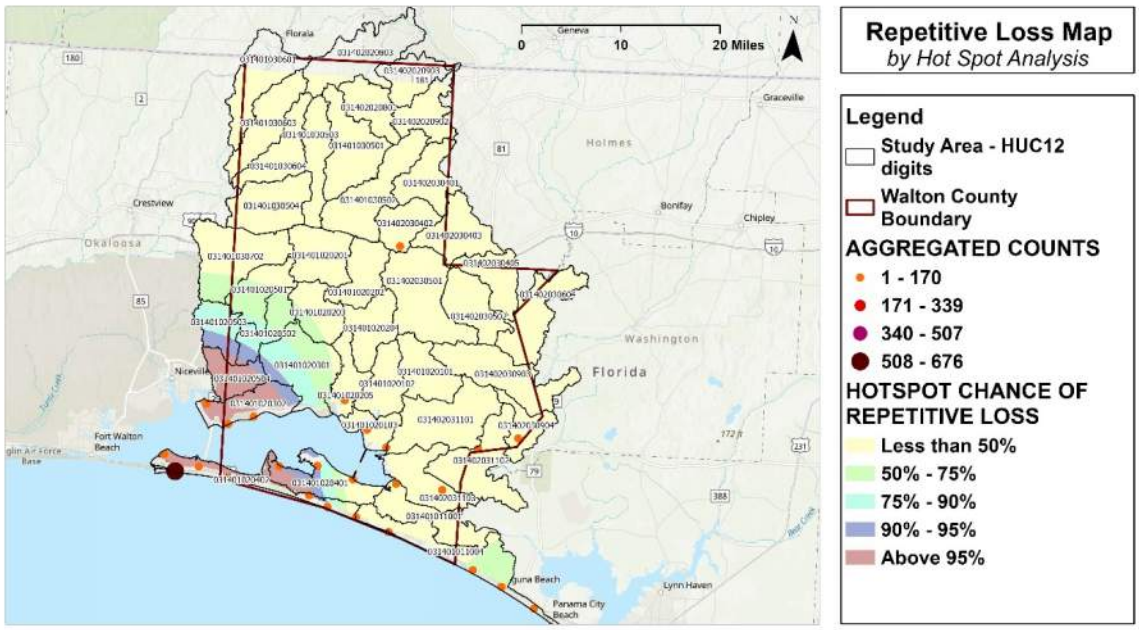

Figure 66. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU.

2.5.5 Priority Projects

The basin does not feature a significant amount of developed land. While there are some parcels falling within tiers 1, 4, and 5 of land use priority classifications within the basin, only three of them, classified as tier 5, fall within the flooding zone. This is despite the presence of substantial flooding in both 1-day 100-year storm events and 1-day 100-year + 5 feet sea-level rise scenarios. It is worth noting that there are 13 parcels classified as utilities within Tier 1 of priority land use, but fortunately, none of them are within the flooding zone.

Consequently, when considering the composite score, it is notable that the results are null, indicating no priority for intervention within the basin.

APPENDIX AN

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031402030904

BIG CYPRESS CREEK-CHOCTAWHATCHEE RIVER

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Co-Principal Investigators: Weibo Liu, Ph.D., Daniel Meeroff, Ph.D., Diana Mitsova, Ph.D., S. Nagarajan, Ph.D., Hongbo Su, Ph.D., Ramesh Teegavarapu, Ph.D., Zhixiao Xie, Ph.D., Yan Yong, Ph.D., and Caiyun Zhang, Ph.D., Ahmet Urusan, Ph.D., Shannon Egger, Eva Suarez, Ph.D.

Research Assistant: Leticia Sabio

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Table 11. Impacted Adjustment Areas for HUC 031402030904. Processed by FAU. 79

X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 sub-watershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 digits (031402030904) is highlighted among all the HUCs to help identifying its location. (Figure 3).

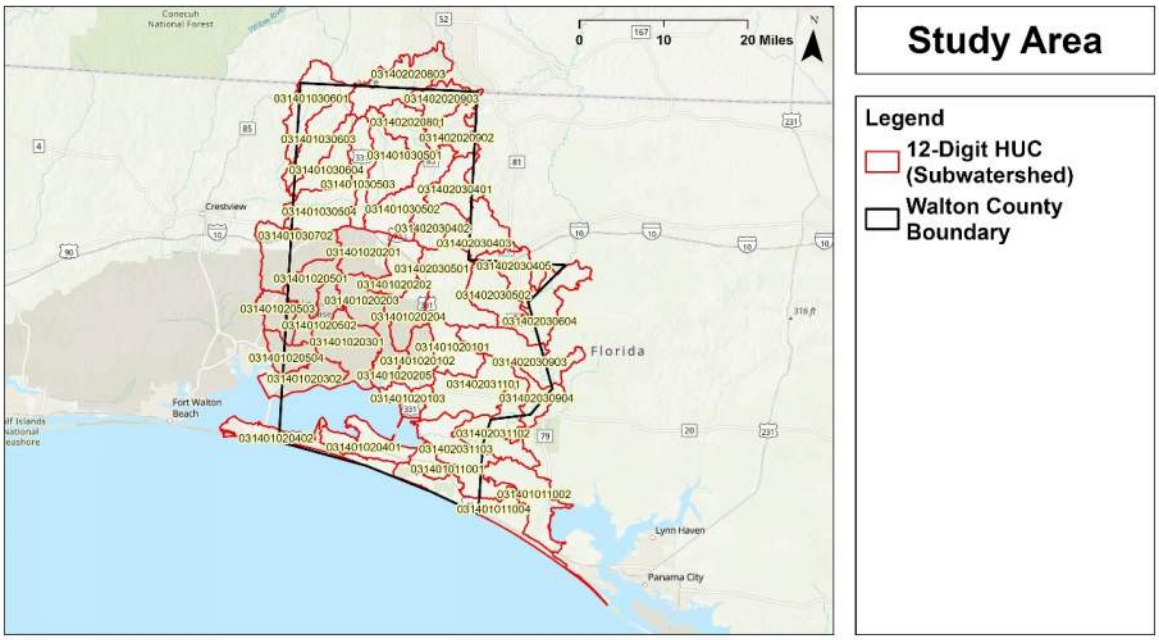

Figure 1. Walton County and all HUCs 12-digit sub-watershed, processed by FAU.

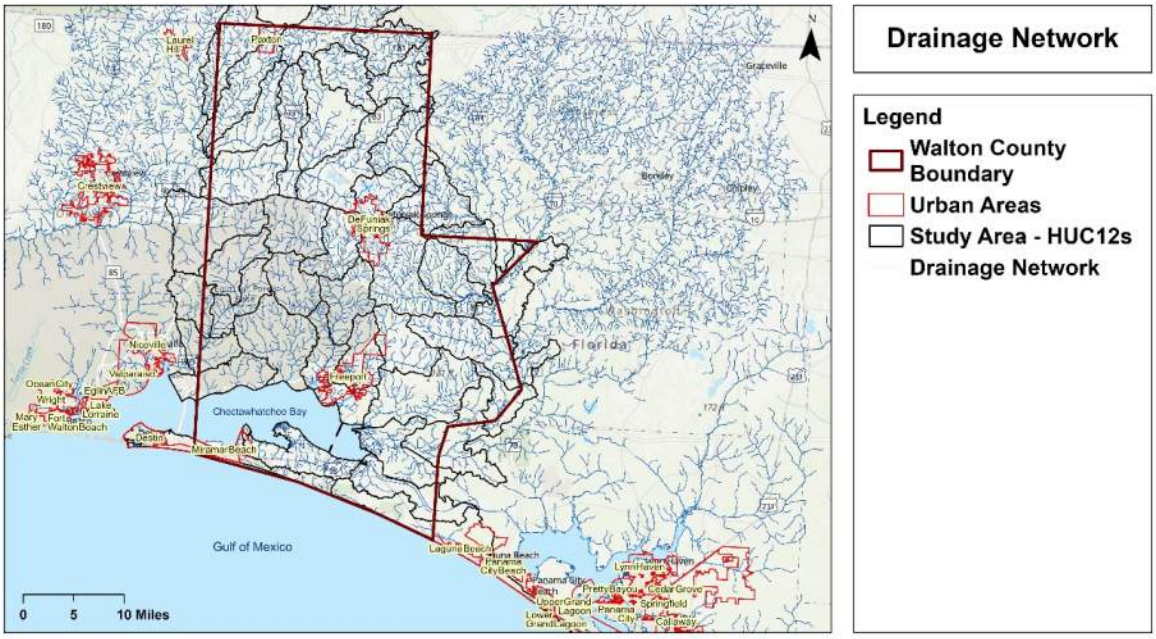

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

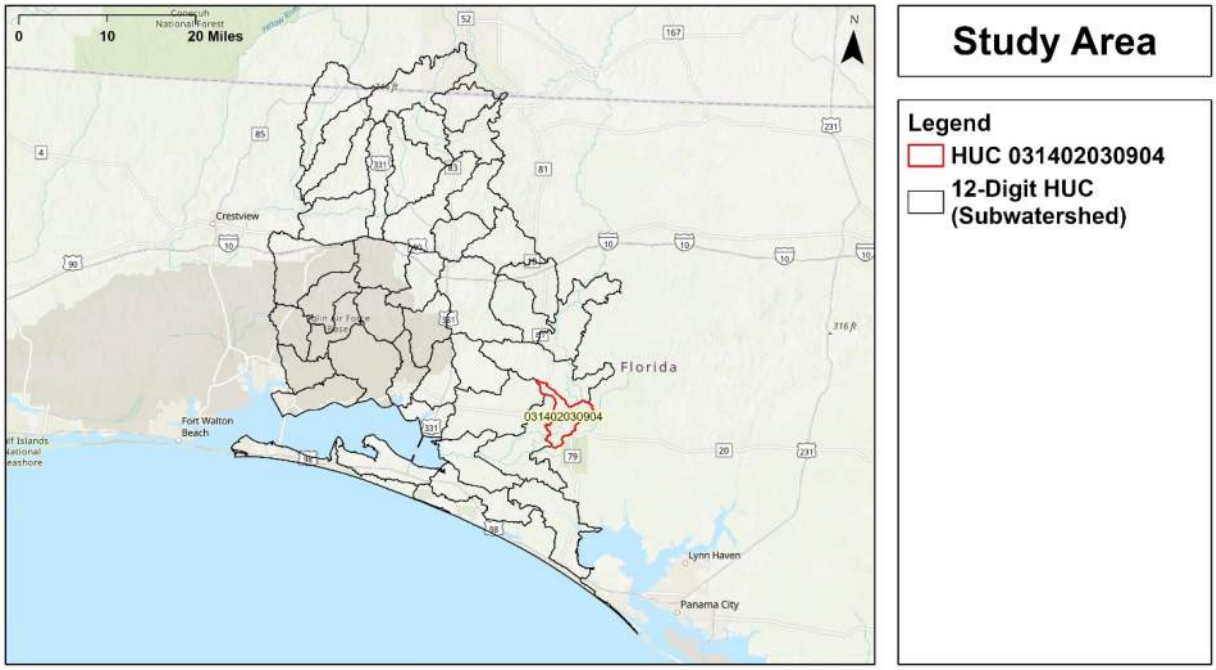

Figure 3. HUC 031402030904 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state, with a height of 345 feet in its northern end. With a population of 75,305 residents according to

the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

(Source Data: FEMA)

Figures 12 and 13 is the county-wide report show the current and projected land use for the County. Based on the 2017 future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land Use in Walton County (Prepared by FAU from future land use map) versus land use in the entire watershed

Level 1 Land Use-Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

(Source Data: (NWFWMD 2017)

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 1.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

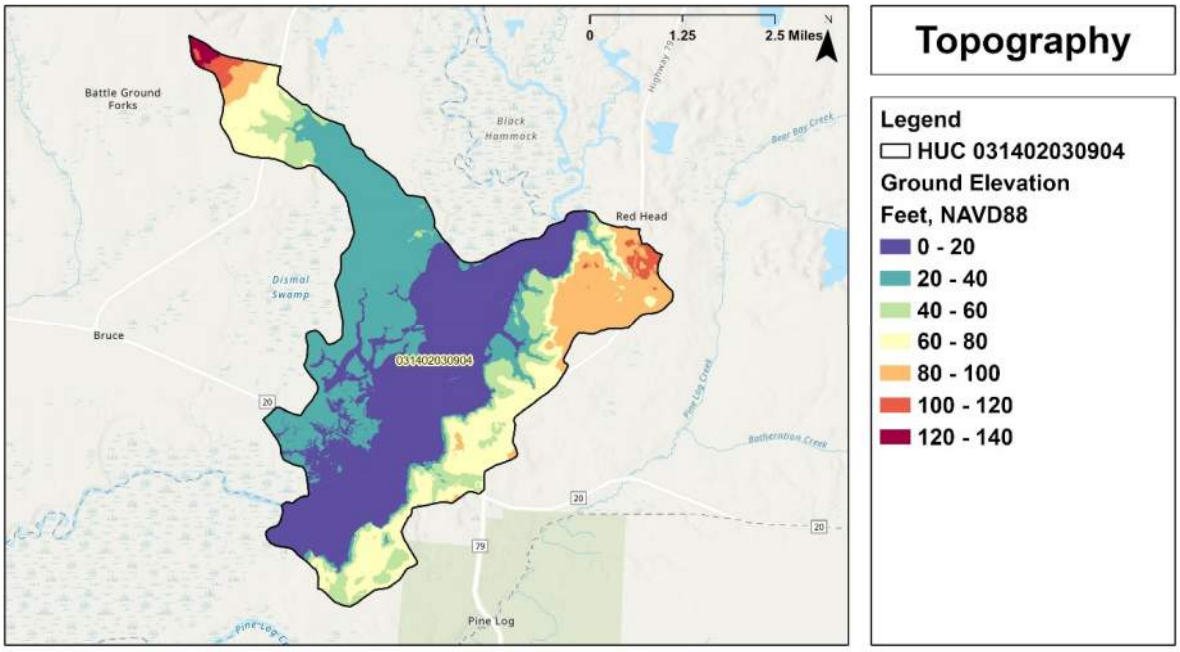

Figure 4. Topographic map of the HUC 031402030904 sub-watershed, processed by FAU. (Data Source: USGS)

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031402030904 sub-watershed is shown in **Error! Reference source not found.**.

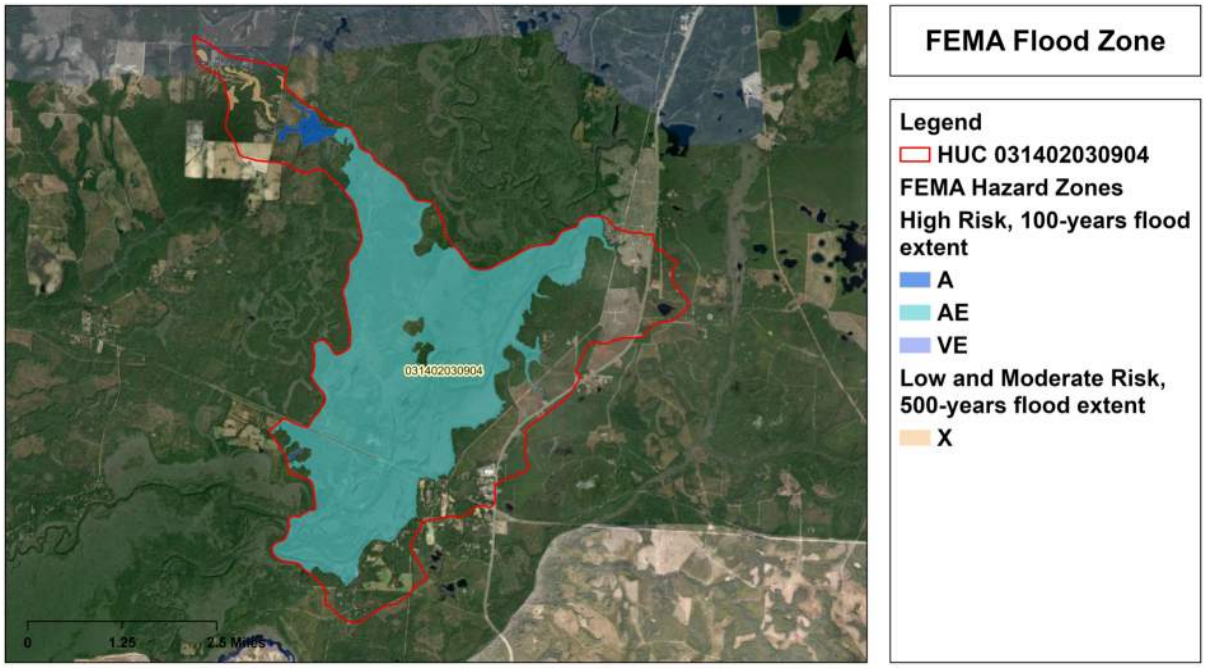

Figure 5. FEMA Flood Zone map (2020) for HUC 031402030904 sub-watershed, processed by FAU.
(Data Source: FEMA)

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031402030904 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

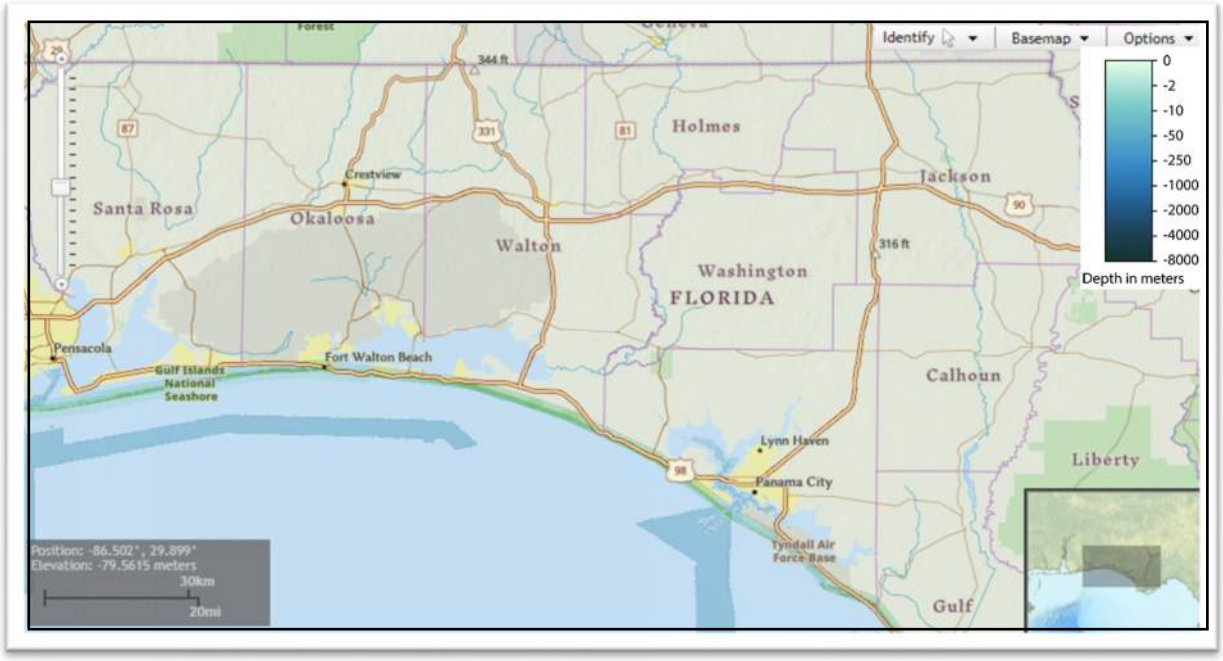

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
(Source: ncei.noaa.gov/maps/bathymetry/)

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

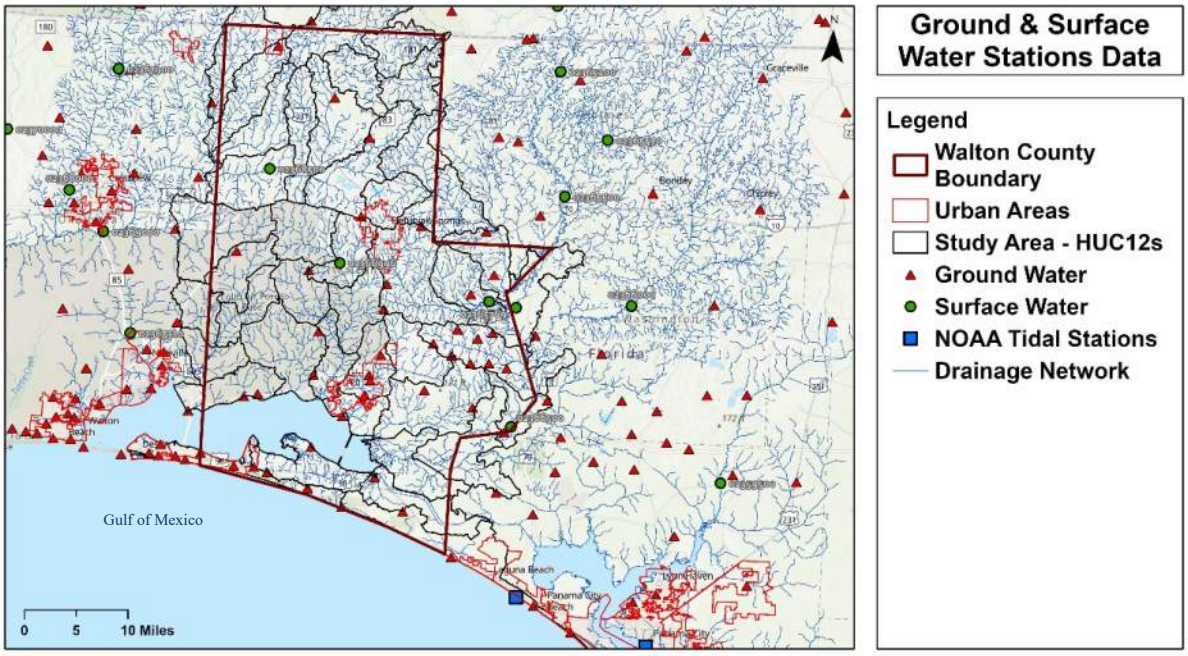

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.
(Data Source: USEPA – National Hydrographic Dataset (NHD) and NOAA's Tides)

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The major water bodies in the HUC 031402030904 sub-watershed include:

- Choctawhatchee River
- Big Cypress Creek
- Graveyard Creek
- Red Head Branch

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS Choctawhatchee River NR Bruce FLA (site number 02366500) within the HUC 031402030904.

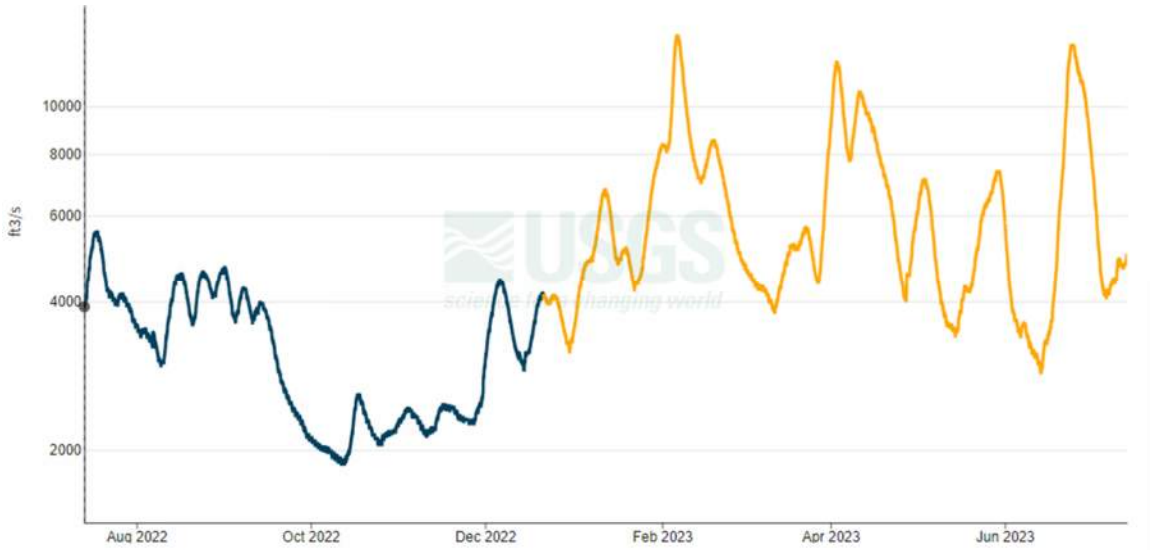

Figure 8. Average streamflow for Choctawhatchee River NR Bruce FLA (USGS 02366500 Surface-Water, June 2022 to July 2023).
(Source: USGS Water Data Services, available at https://waterdata.usgs.gov/monitoring-location/02366500/#parameterCode=00065&period=P365D)

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99^{th}- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98^{th} - 100^{th} percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific

mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031402030904 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031402030904 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

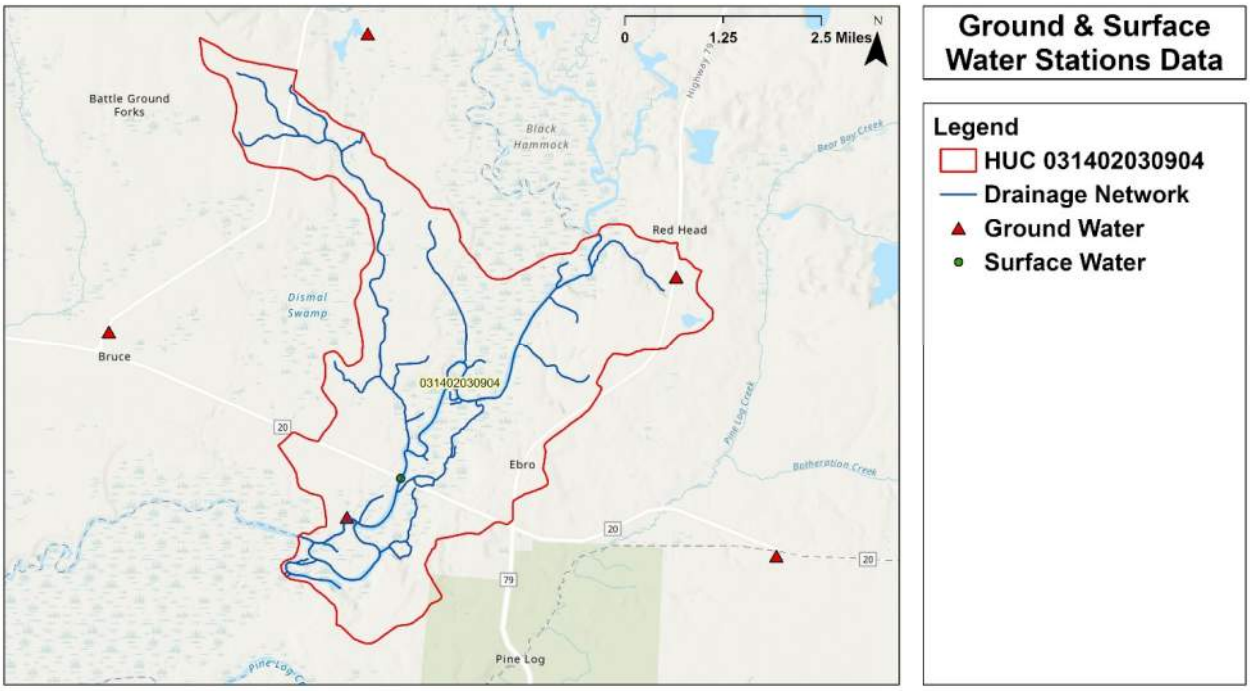

Figure 9. Ground and Surface Water Stations in the HUC 031402030904 sub-watershed, processed by FAU.
(Data Source: USEPA – National Hydrographic Dataset (NHD)

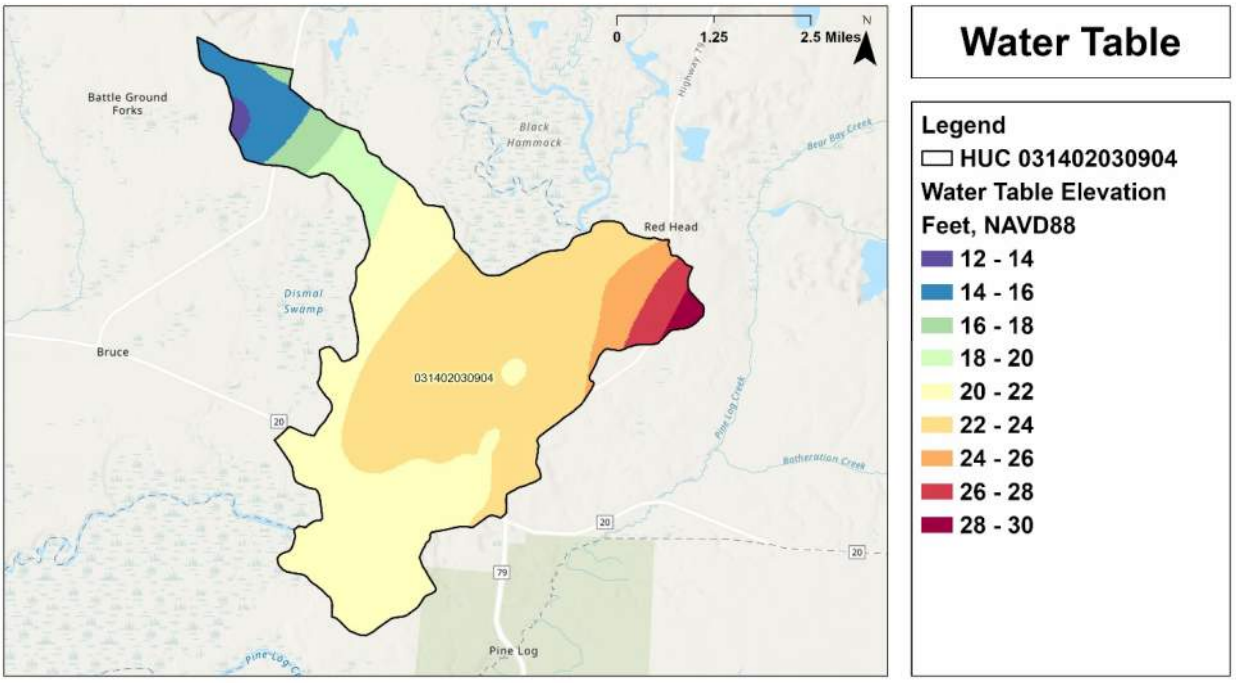

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031402030904 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.
(Data Source: USGS and NWFWMD)

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the average precipitation over Walton County for every month of the year between 2011 and 2023- each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches for the entire county.

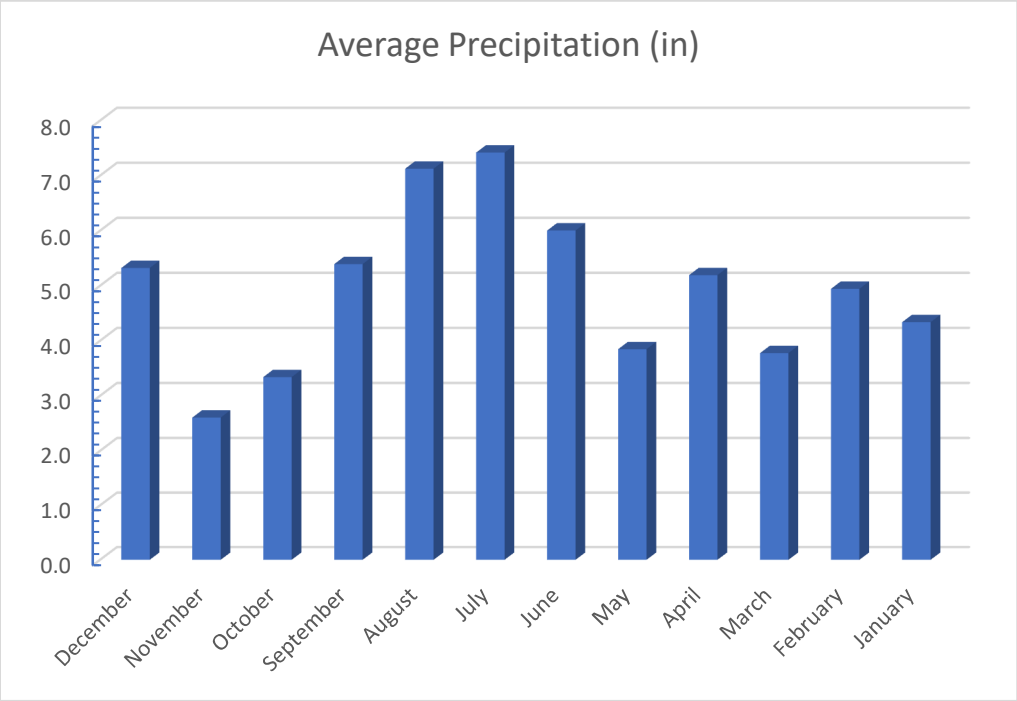

Figure 11. Monthly precipitation in Walton County, FL (2011-2023).
(Data Source: Florida Weather Data, available at https://data.usatoday.com/weather-data/walton-county/12131/1975-04-01/table/)

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is no NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

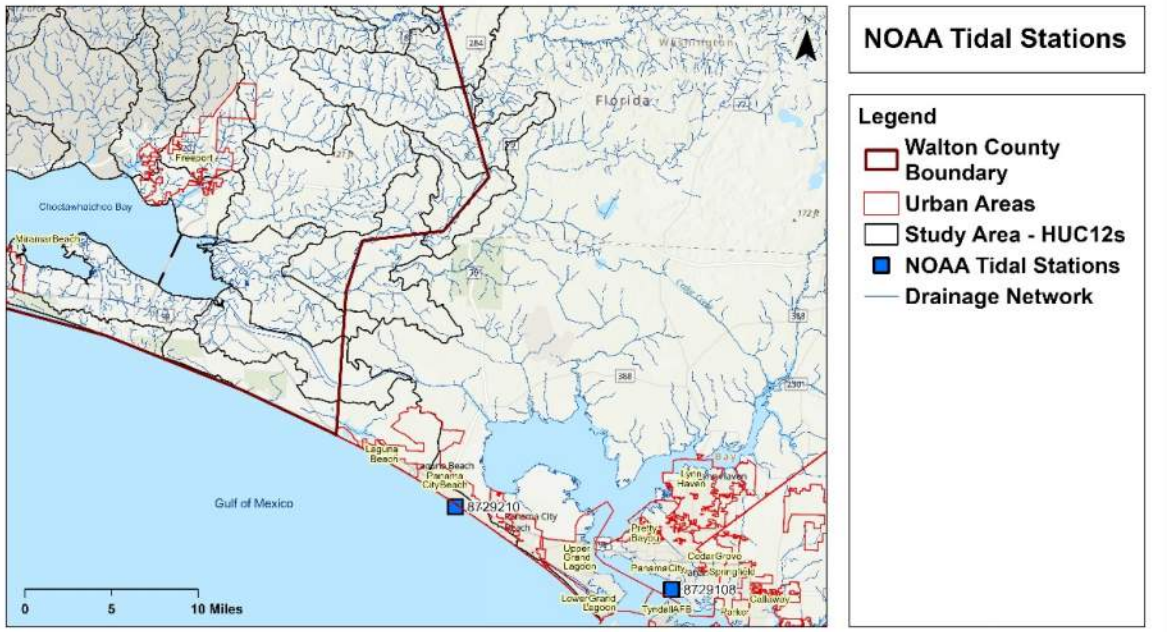

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.
(Data Source: USEPA – National Hydrographic Dataset (NHD) and NOAA's Tides)

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in **Error! Reference source not found.**.

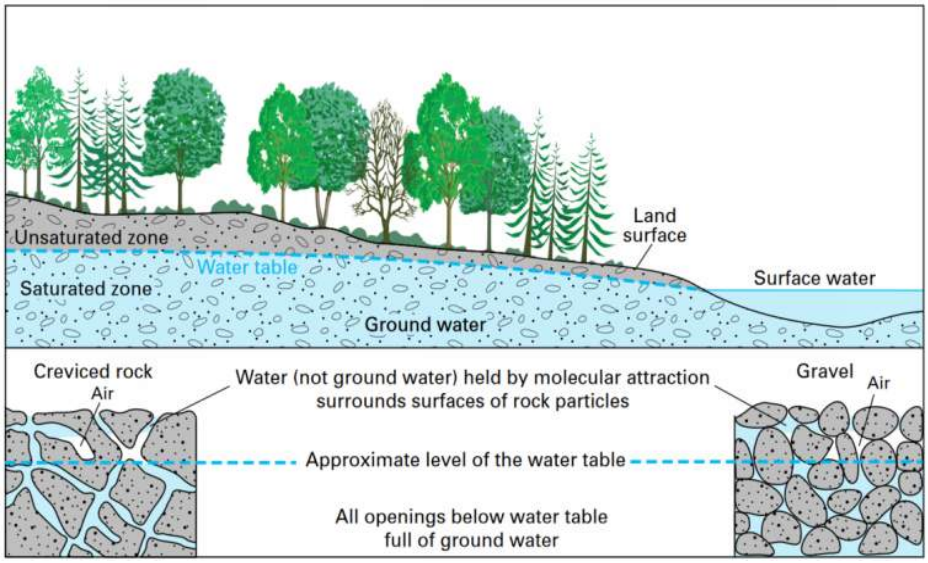

Figure 13. Zones where underground water exists.
(Source: USGS, 2020)

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in **Error! Reference source not found.**. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

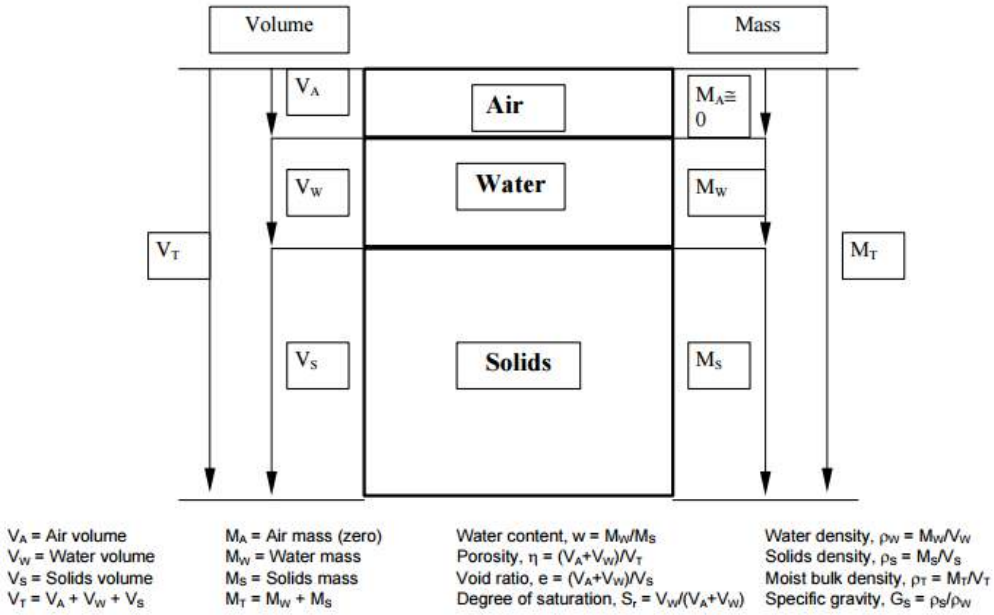

Figure 14. Saturated zone soil phase diagram and definitions.
(Source: Gregory et al., 1998.)

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

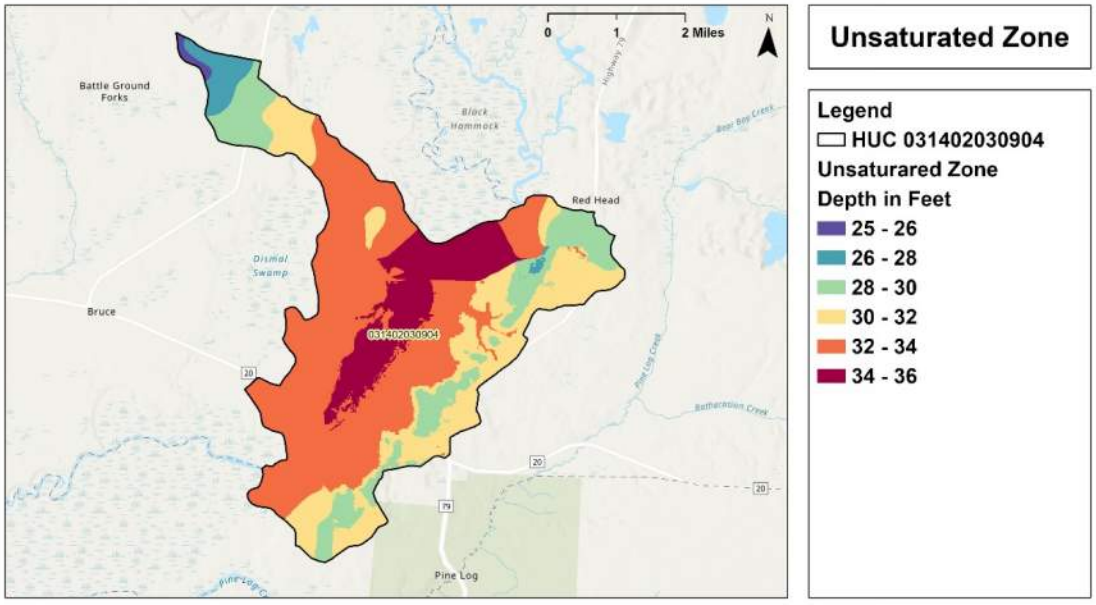

Figure 15. Unsaturated zone map for HUC 031402030904, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately favorable soil storage capacity, falling within the range of 28 to 36 feet of remaining capacity.

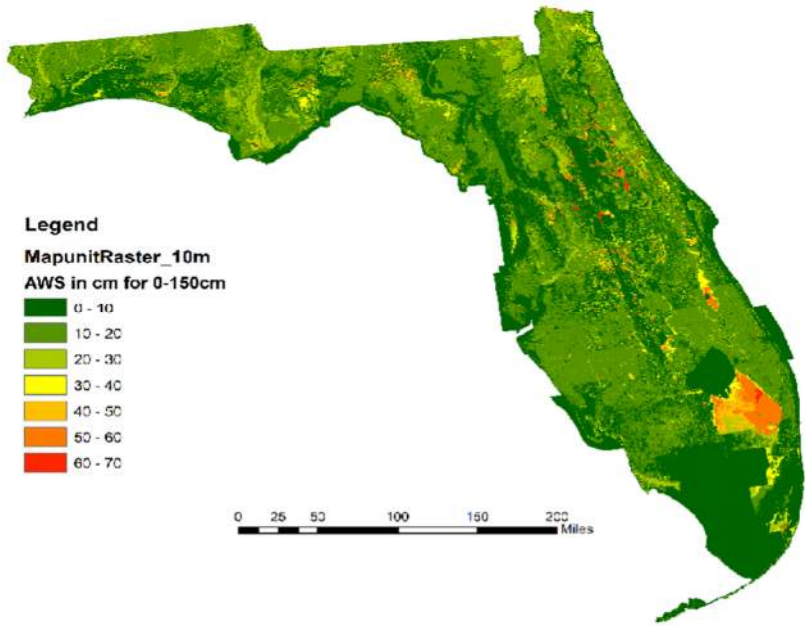

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.
(Data Source: USDA - SSURGO)

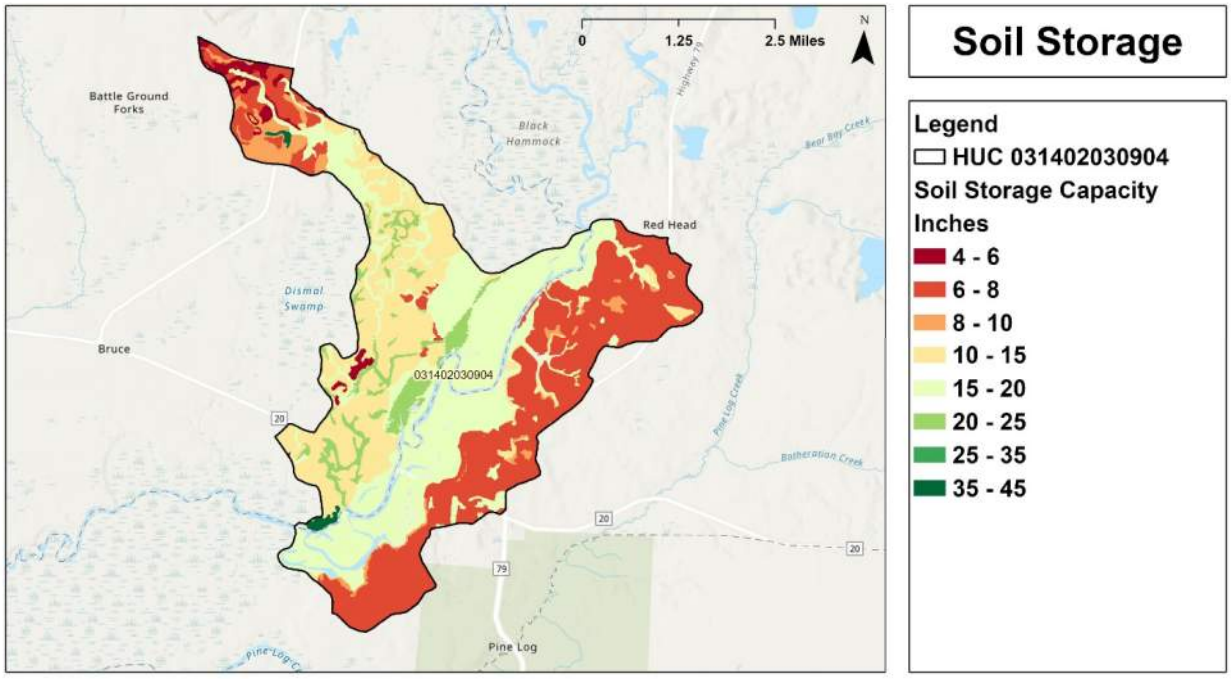

Figure 17. Water storage capacity of soil for the HUC 031402030904, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

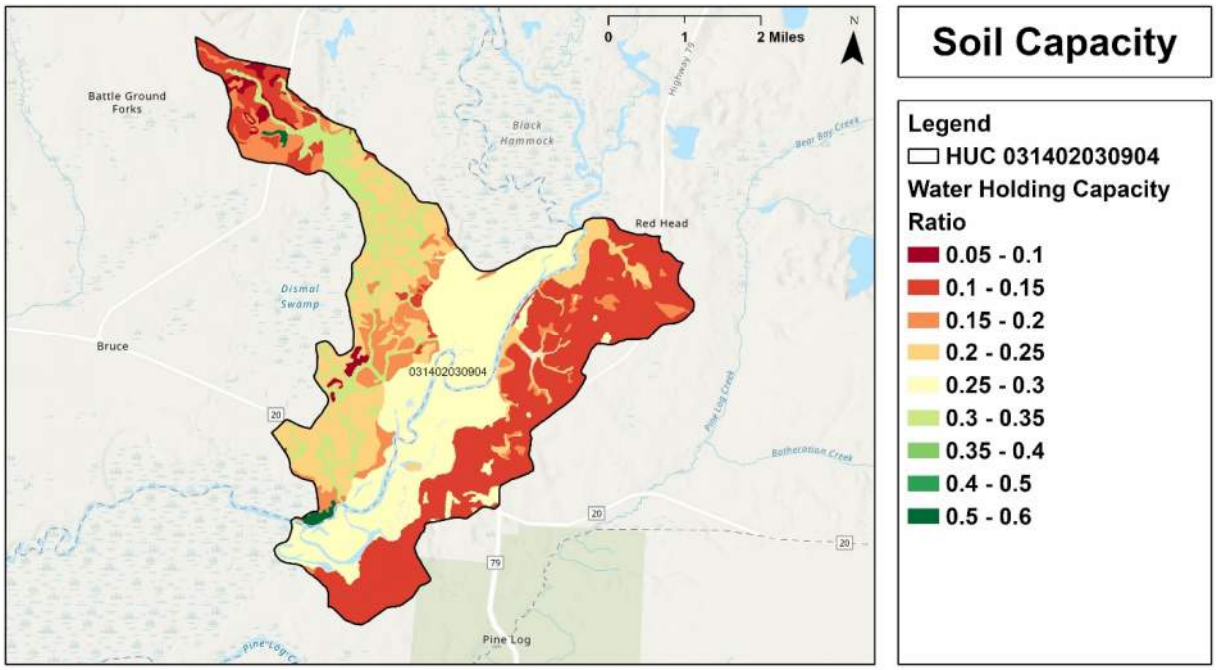

Figure 18. Water Holding Capacity (ratio) for the HUC 031402030904, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

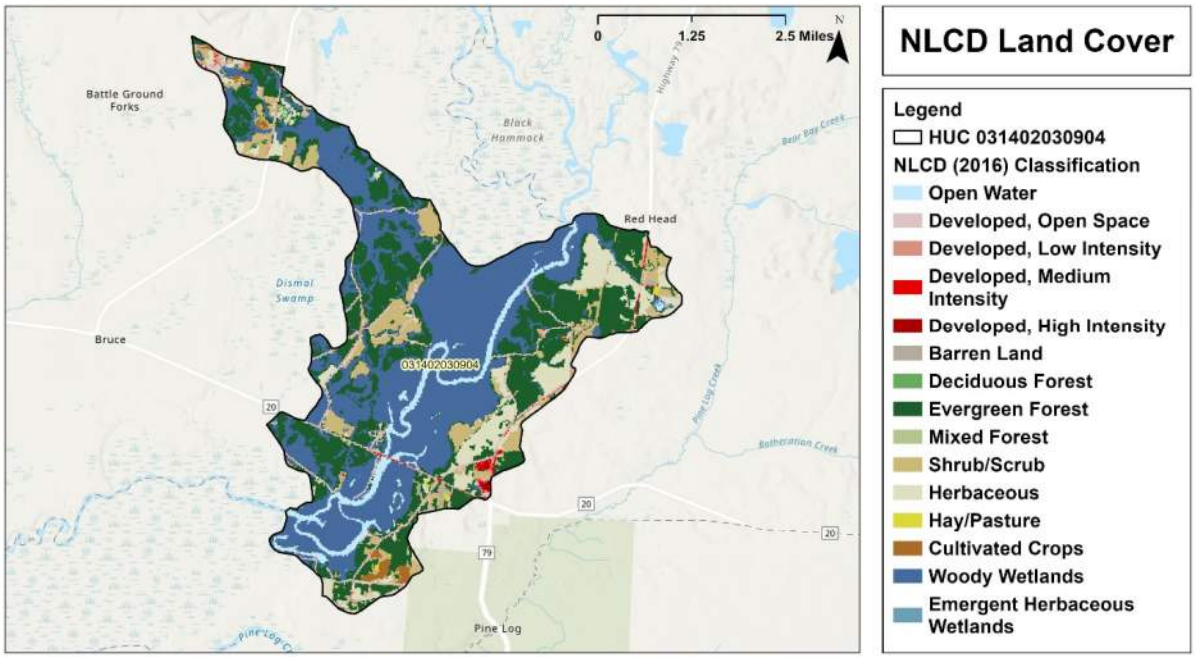

Figure 19. Land use in the HUC 031402030904 (from the NLCD 2016 database), processed by FAU.
(Source Data: NLCD, 2016)

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD 2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. . A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

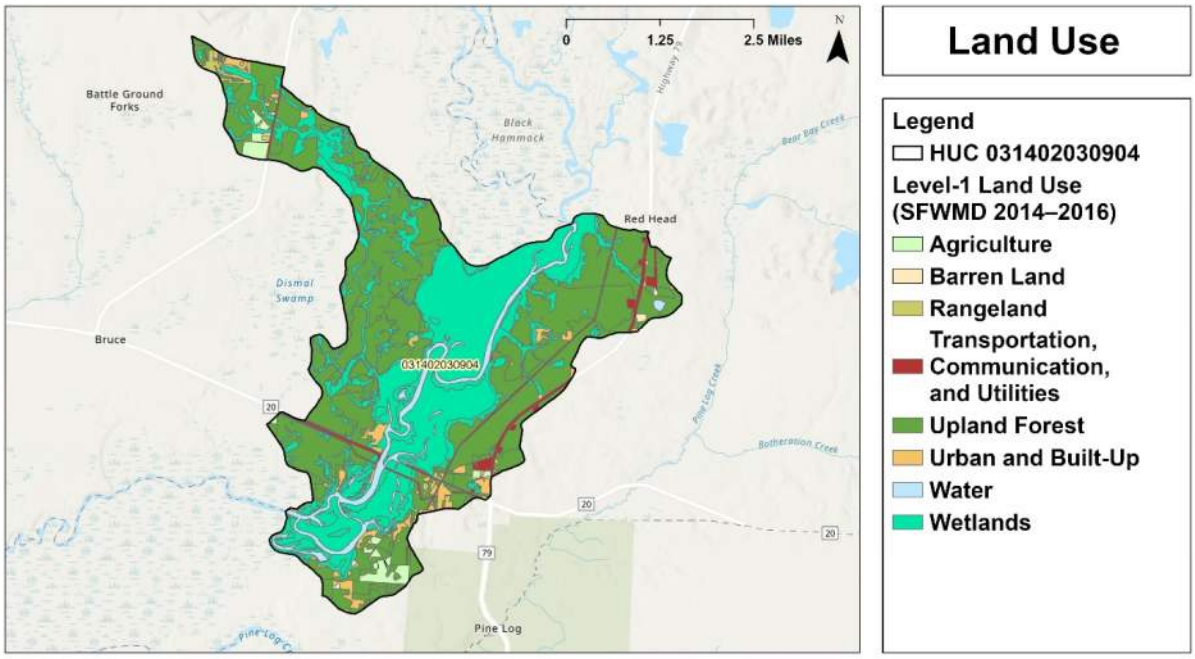

Figure 20. Land use in the HUC 031402030904 processed by FAU.
(Source Data: 2023 Florida Geographic Data Library (FGDL) database))

In the HUC 031402030904 sub-watershed, the predominant land cover is upland forest, accounting for 41.26% of the area. Wetlands comes in second at 30.70%, followed by Transportation, Communication, and Utilities at 12.68%, and water at 12.06%. Developed land constitutes a minor portion, with only 1.35% categorized as urban and built-up, as shown in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031402030904 sub-watershed

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	343.22	1.38%
Barren Land	15.14	0.06%
Rangeland	127.08	0.51%
Transportation, Communication, and Utilities	3142.31	12.68%
Upland Forest	10230.03	41.26%
Urban and Built-Up	335.11	1.35%
Water	2988.58	12.06%
Wetlands	7609.74	30.70%
Grand Total:	**24791.21**	**100.00%**

(Source Data: 2023 Florida Geographic Data Library (FGDL) database))

Table 4. Roughness and CN Values for Each Land Use Code

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

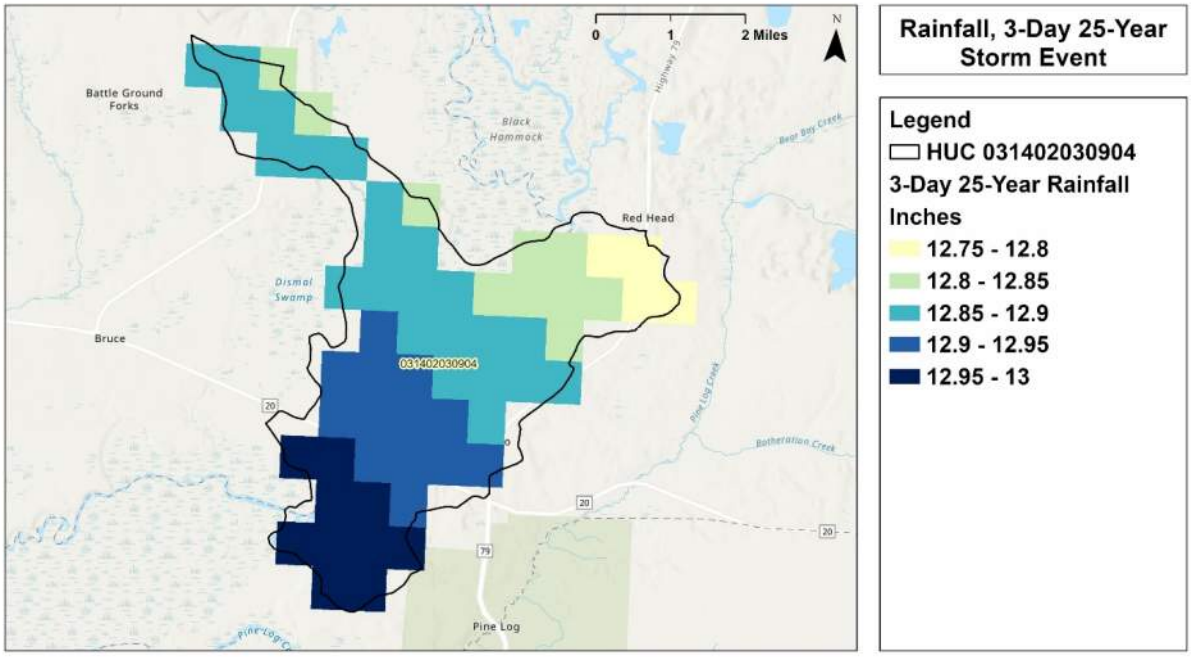

Figure 21. Rainfall distribution map across HUC 031402030904 sub-watershed, for 3-day 25-year storm event, processed by FAU.
(Source Data: NOAA Atlas 14 Database)

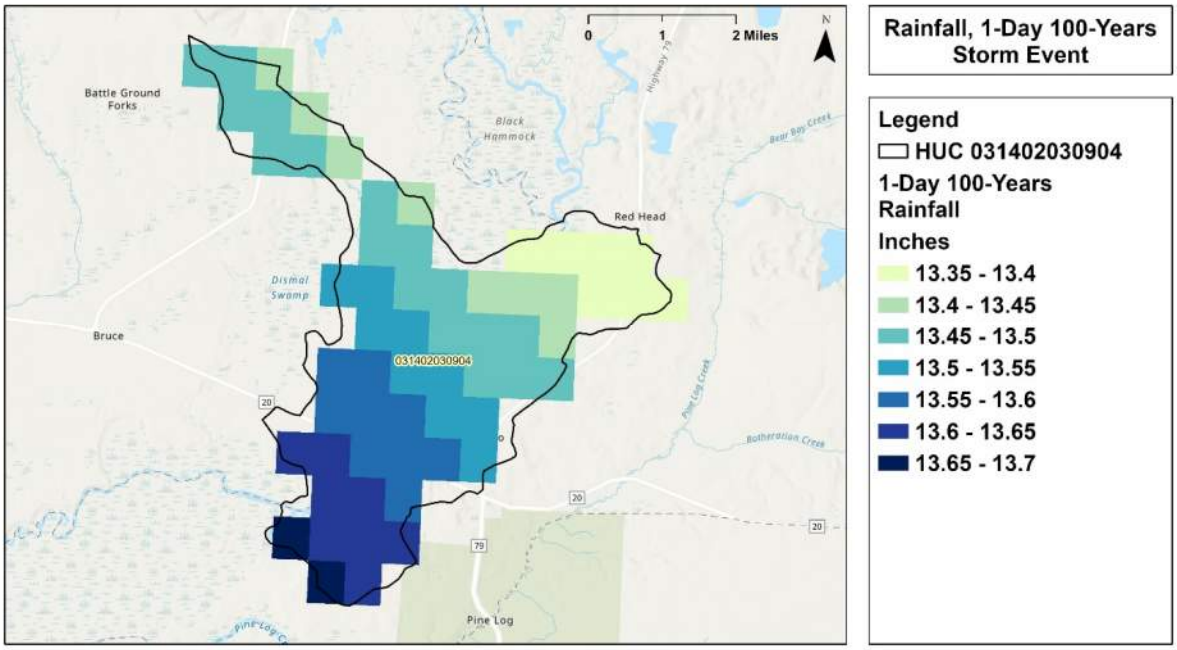

Figure 22. Rainfall distribution map across HUC 031402030904 sub-watershed, for 1-day 100-year storm event, processed by FAU.
(Source Data: NOAA Atlas 14 Database)

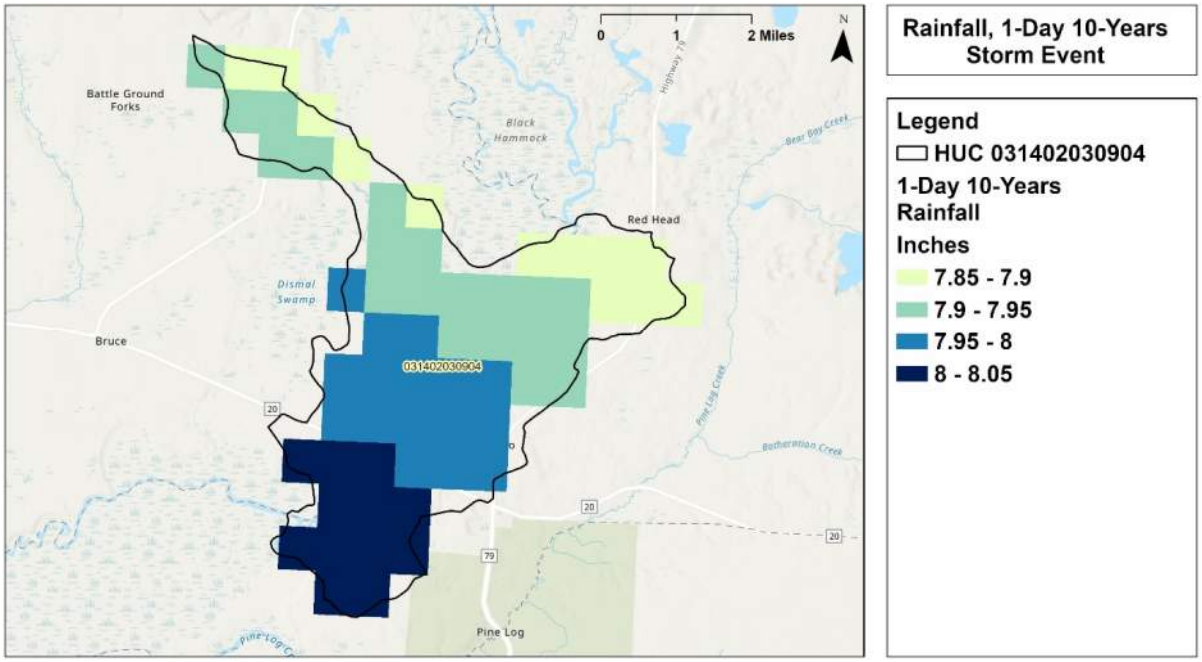

Figure 23. Rainfall distribution map across HUC 031402030904 sub-watershed, for 1-day 10-year storm event, processed by FAU.
(Source Data: NOAA Atlas 14 Database)

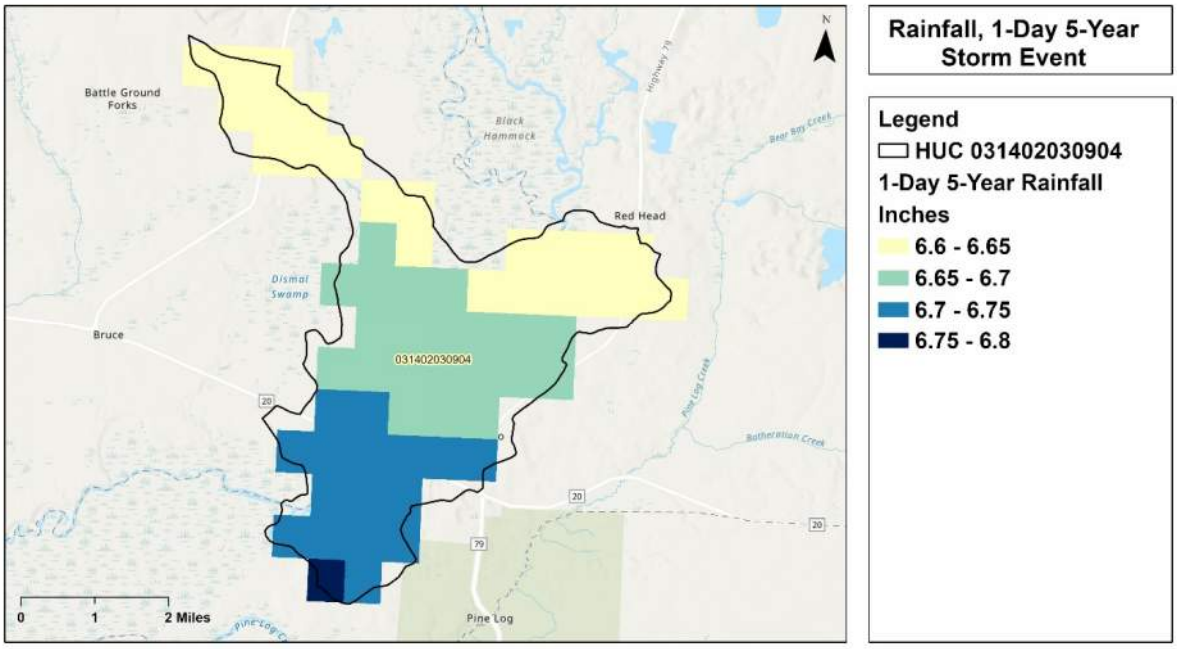

Figure 24. Rainfall distribution map across HUC 031402030904 sub-watershed, for 1-day 5-year storm event, processed by FAU.
(Source Data: NOAA Atlas 14 Database)

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

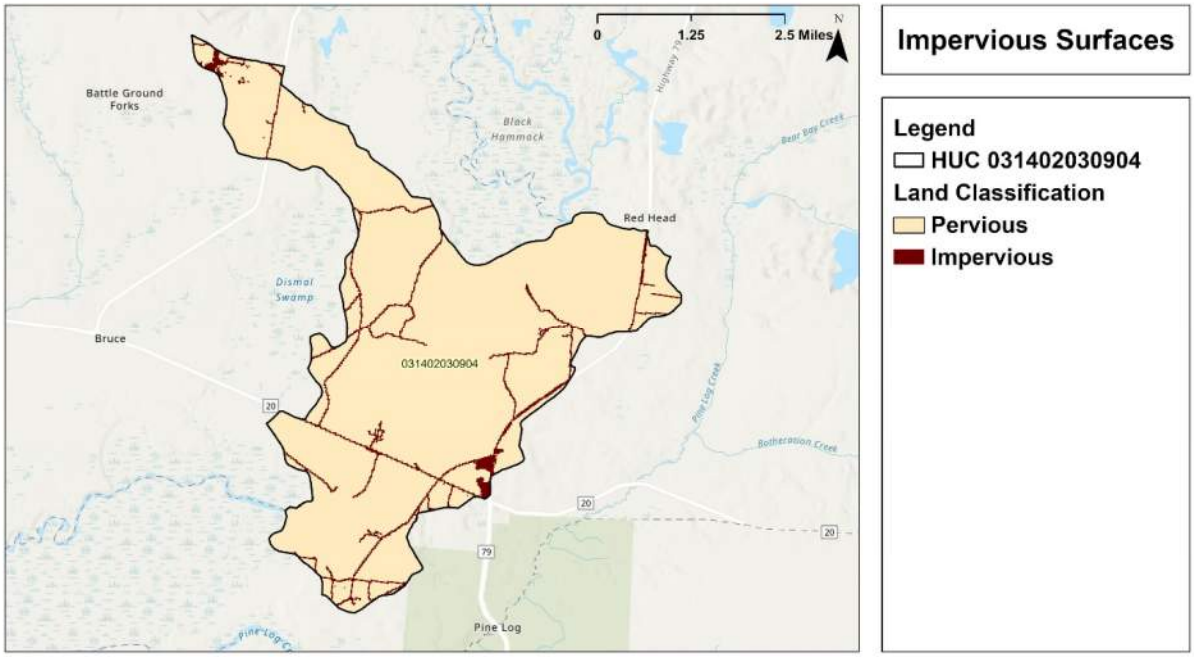

Figure 25. Impervious area map for the HUC 031402030904 sub-watershed, processed by FAU. (Source Data: NLCD, 2016)

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

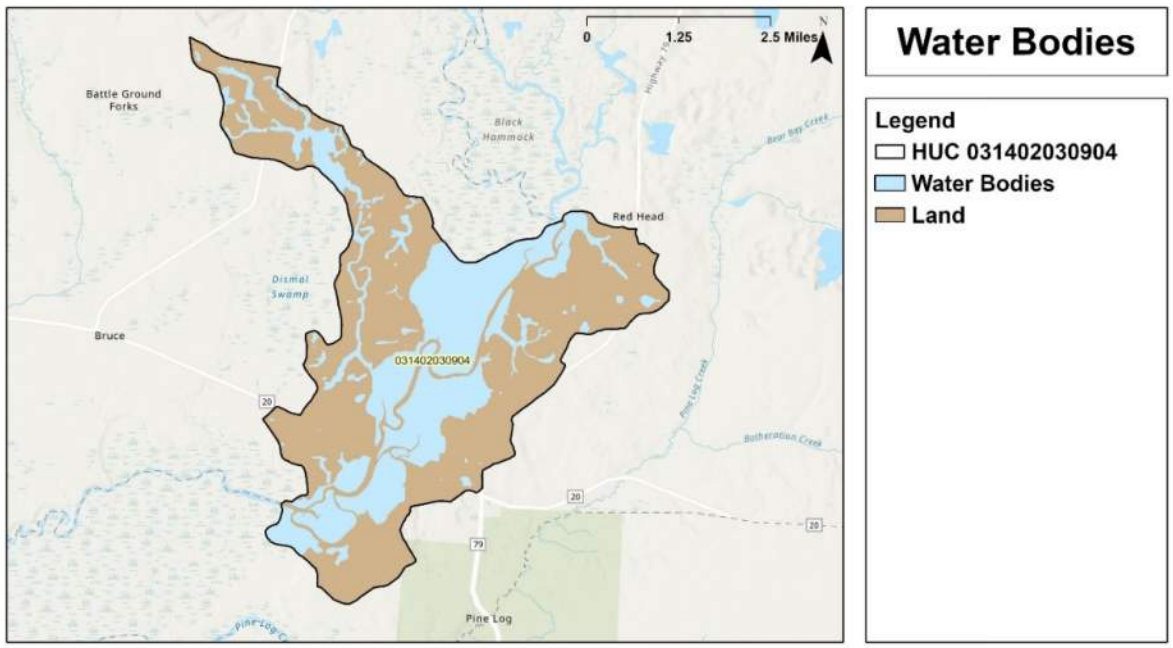

Figure 26. Water bodies map for the HUC 031402030904 sub-watershed, processed by FAU. (Source Data: USEPA – National Hydrographic Dataset (NHD))

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

(Source: US Census Bureau 2020, and Zip-codes.com)

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.

- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

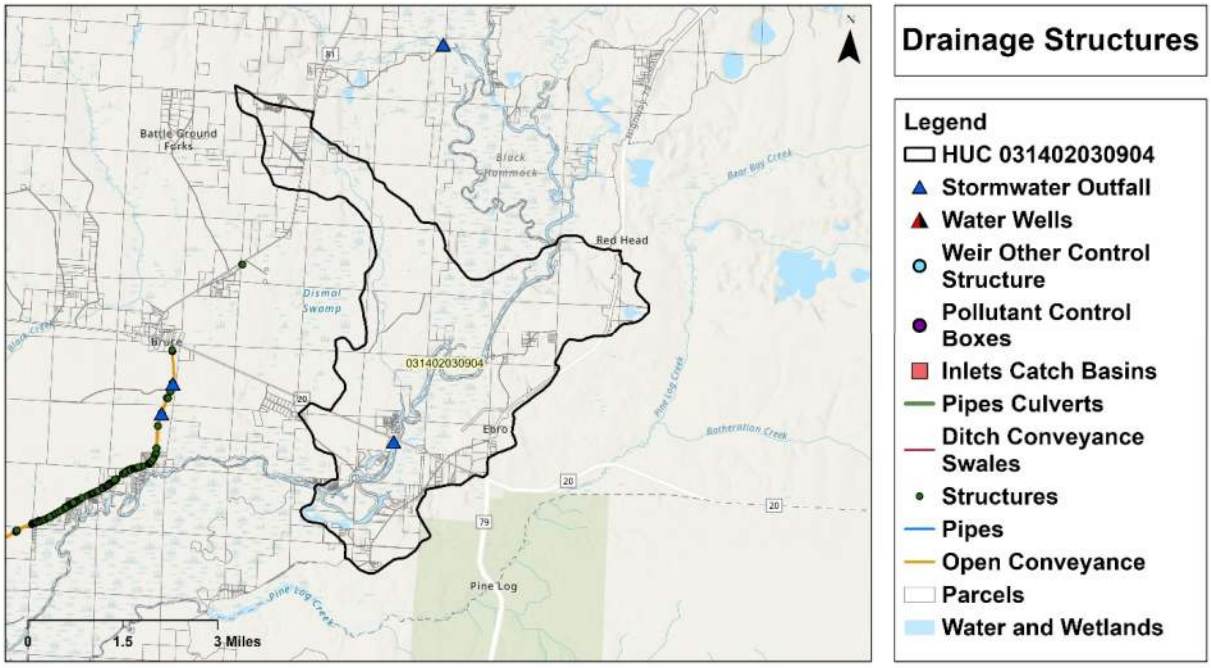

Figure 27. Stormwater Infrastructure for the HUC 031402030904. Processed by FAU.
(Source Data: Walton County Storm Asset Inventory and Stormwater Inventory)

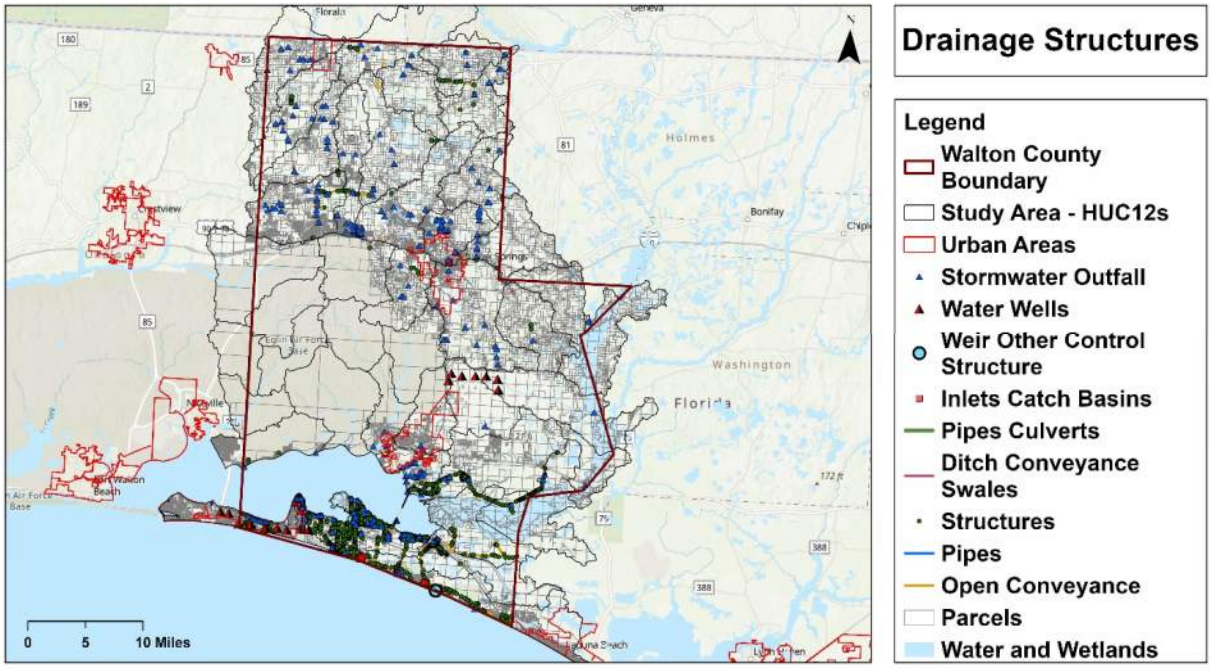

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.
(Source Data: Walton County Storm Asset Inventory and Stormwater Inventory)

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in **Error! Reference source not found.**. The data can be used to model the impacts of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020)

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1, analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031402030904 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD DBHYDRO website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. Figure 29 shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

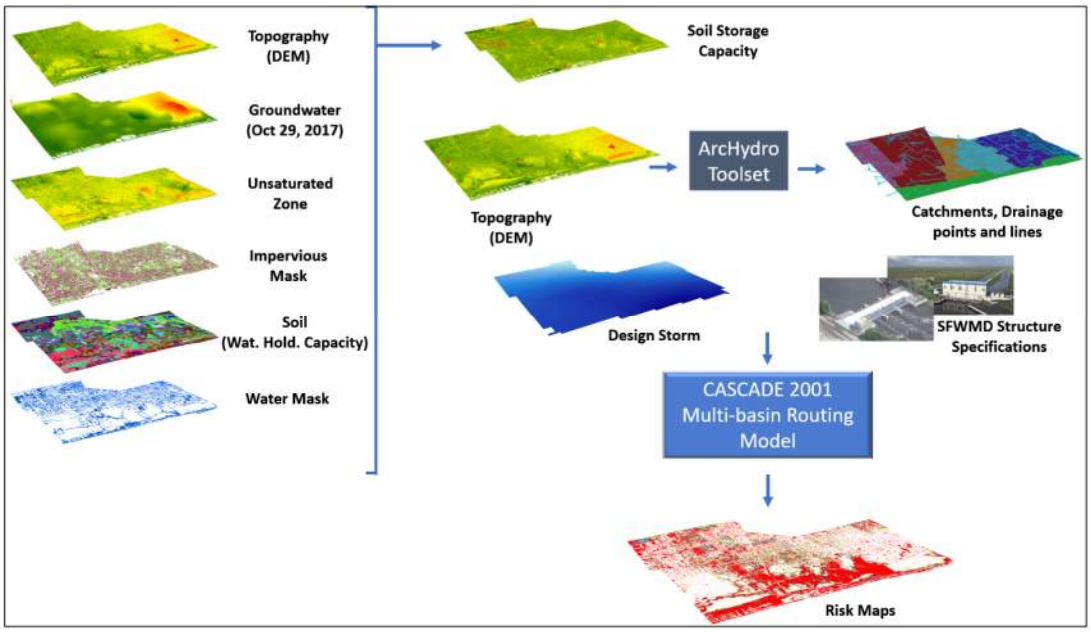

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

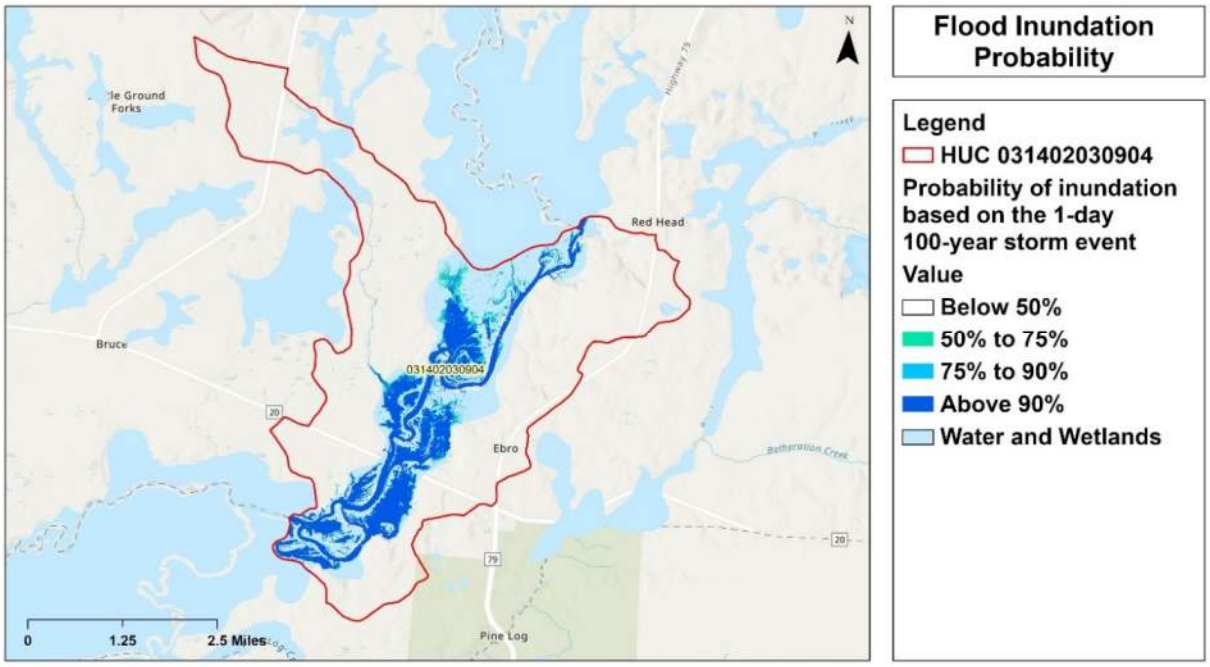

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031402030904, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes

and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 2.5 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in

the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Future Challenges of Sea Level Rise and Climate Change

Global observations from satellites and long-term data collection have made it possible to document and analyze patterns in the Earth's climate. Scientific analysis of the impact of these changes has helped to improve the understanding of future flood hazard driving forces and long-term impacts on human activities and watershed master planning (http://www.research.noaa.gov/climate/t_observing.html). Examples of impacts are rising global average air and ocean temperatures, increased and earlier snow and ice melt, shorter subtropical rainy seasons, shifted seasons, sea level rise and greater variations in temperature and precipitation (IPCC, 2013; Freas et al., 2008; Marshall et al., 2004; Bloetscher et al., 2010). Marshall et al. (2004) specifically focused on the Florida peninsula to predict changes in rainfall and warmer temperatures but interspersed lower low temperatures due to the potential loss of wetlands.

Future changes in climate will add to the existing impacts, at a time when the population of the state is expected to nearly double by 2030. Additional research and high-resolution climate modeling for the Florida peninsula and local jurisdictions is needed to help guide long-term plans like WMPs. Rainfall appears to be decreasing and temperatures rising (see **Error! Reference source not found.**).

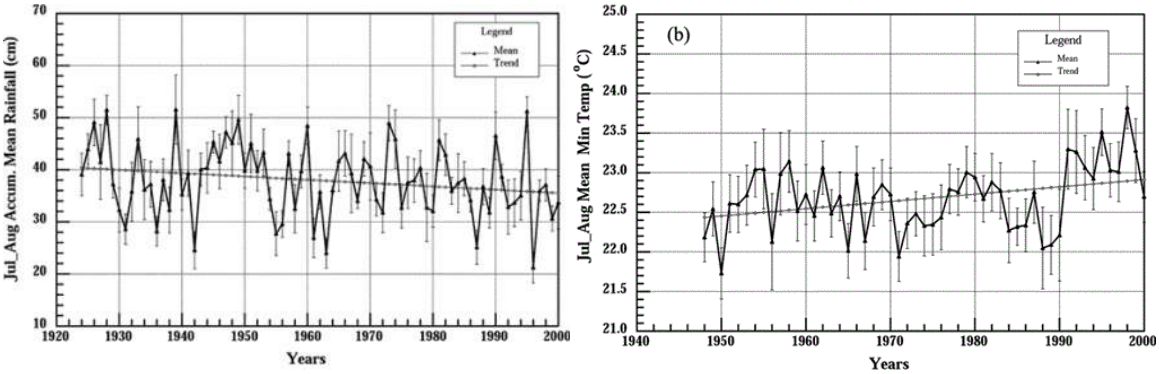

Figure 31. Change in average rainfall and change in average temp 1924 to 2000.
Note the reversed trend, which means groundwater input variability is lessened.
(Source: Marshall et al., 2004)

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier

rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3 feet. Accompanying these drivers are potential changes in storm frequency and intensity, desertification, population migration, ocean acidification and coastal flooding (IPCC, 2007), exacerbated by the land cover and land use changes, which are substantially impacted by the fluxes, timing and quality of precipitation (Adrians et al., 2003; Scanlon et al., 2005; Marshall et al., 2004; Salmun and Molod, 2006), and leading to changes in the timing of peak flows and volumes (Richey and Costa-Cabral, 2006).

The results of these climatic changes are likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly An outcome of these climatic patterns is that during the past 140 years, an increase in sea levels has been observed (Bloetscher, 2012), a worrying pattern since sea level rise is a permanent phenomenon, that can be catastrophic to low lying areas in the long-term. The question is how much and how soon? Various studies (Bindoff et al., 2007; Domingues et al., 2008; Edwards, 2007; Gregory, 2008; Vermeer and Rahmstorf, 2009; Jevrejeva, Moore and Grinsted, 2010; Bloetscher, 2010, 2011; IPCC, 2007; Heimlich et al., 2009) indicate large uncertainty in projections of sea level rise by 2100. Gregory et al. (2012) note that during the last two decades, the global rate of sea level rise has been larger than the 20th-century time-mean, and Church et al. (2011) suggested that the cause was increased rates of thermal expansion, glacier mass loss, and ice discharge from icesheets. Gregory et al. (2012) suggested that there may also be increasing contributions to global sea level rise from the effects of groundwater depletion, reservoir impoundment, and loss of storage capacity in surface waters due to siltation. Measurements of Florida's east coast (Maul, 2008) show an average rate of sea level rise of 2.27 ± 0.04 mm per year from 1915 to 1992 based on tide gauge readings. Analyzing the tidal gauge readings for Florida shows that:

1. Florida average sea level rise is 2.10 ± 0.49 mm/yr

2. All but one location is within the 95% confidence limit range (the exception is Panama City where there is evidence of submergence and other land-based issues)
3. None of the Florida sea level rise rates differ statistically
4. Average global sea level rise for 1920-2000 was 2.0 mm/yr – within 95% confidence limit for Florida locations

From 1929 to 1992, over eight inches of sea, with another 6 inches added since 1992, which is already having significant impacts on coastal communities where population growth has increased the need for improved flood management strategies (Bloetscher, 2008; Parkinson, 2010; Zhang et al., 2011, 2011a; NFIP, 2011; Schmidt et al., 2011; Warner et al., 2012).

As a result, the SFRCCC (2015) adopted USACE's methodology to derive scenarios of sea level change intermediate to high rates of sea level rise for years 2030 (3" to 7") and 2060 (9" to 24") as the consensus projection to guide future planning. The path keeps increasing – now 14 inches since 1929 (**Error! Reference source not found.**) caused by thermal expansion of the ocean and melting ice caps (Jevrejeva et al., 2010; Vermeer and Rahmstorf, 2009). Sea level rise is a major concern in Florida, including Walton County, since the majority of the state's population live on the coast, involving most major commercial, residential, and economic enterprises. **Error! Reference source not found.** demonstrate the estimated sea level change for Panama City, considering the predictions of NOAA 2017. For NOAA high scenario SLR change scenario, the estimated level change is higher than 8 ft., while for the intermediate and low scenarios are about 3.9 feet and 1.7 feet respectively.

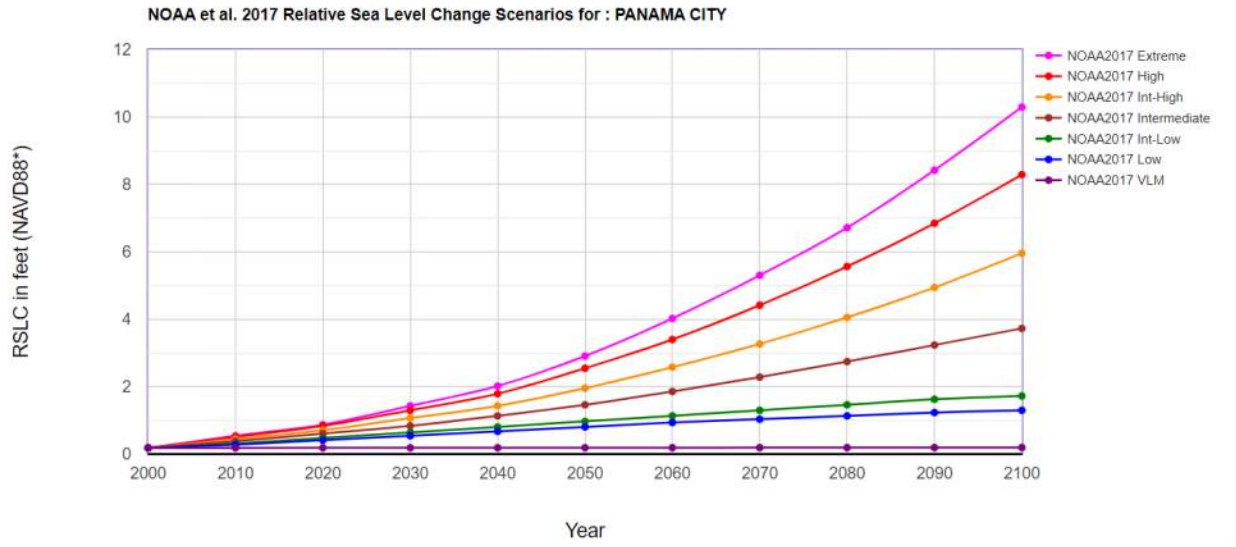

Figure 32. Relative Sea Level Change Scenarios for gauge 8729108, Panama City, FL. (Source: NOAA, 2017 available at https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html)

NOAA (2017) outlines five scenarios for sea level rise. The NFIP proposes the use of the intermediate high projection, which is 1.2 meters or 4 ft globally from current sea level elevations (**Error! Reference source not found.**).

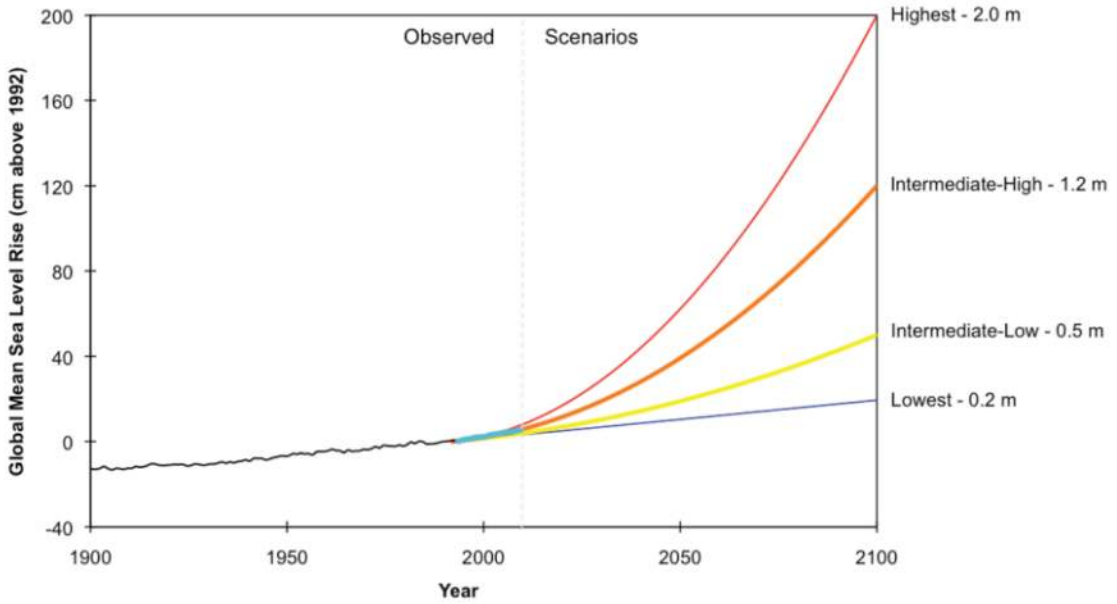

Figure 33. Graphic of global sea level rise projections from NOAA (2017).
(Source: NOAA, 2017 available at https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf)

As sea level rises, access to roads, bridges, rail, and transit could be at risk of flooding, causing the effects of sea level rise to spread indirectly throughout the entire transportation network, affecting the overall system performance. For example, the flooding of a critical road or facility access can cause a shifting of traffic flow causing congested conditions in other roadways that are not actually flooded. Since the roadway network would be unable to carry the traffic demand, the system would experience operational failure; as a result, causing travel times and delays. Moreover, the inundation of a critical access could cause transportation connectivity problems to essential infrastructure like ports or airports. Transportation infrastructure relies on the effectiveness of flood control and stormwater drainage systems for the transportation corridors. Road integrity relies on adequate drainage. The increased risk of severe flooding in Florida's low-lying terrain can adversely affect transportation infrastructure along the coastline; roads can be inundated, and roadway beds can be damaged. Sea level rise will cause increased water table levels (FDOT, 2012), as regional water tables cannot exist naturally below mean high tide (2 feet in Florida). Adding 3 feet of sea level rise on top of groundwater would compound the risk of flooding in low-lying areas. Road bases below 5 feet NVGD would become saturated under this scenario, likely causing premature base failure. As soil storage capacity is diminished due to rising

groundwater elevations associated with sea level rise, the potential for more frequently flooded roadways would likely damage pavements (FDOT, 2012). Hence sea level rise must be accounted for in WMPs in coastal areas. To allow flexibility in the analysis due to the range of increases within the different time periods, an approach that uses incremental increases of 1, 2, and 3 feet of sea level rise is suggested for modeling. The increments can work as threshold values in planning considerations in terms of allowing planners the ability to know ahead of time where the next set of vulnerable areas will be, to allow for a proactive response approach that can be matched to the observed future rates. Sea level rise is a major concern since nearly half the US population lives within 50 miles of the coast, involving most major commercial, residential, and economic enterprises. The effects of 5 ft sea level rise, King tide, and 1-day 100-year storm event are shown in **Error! Reference source not found.**.

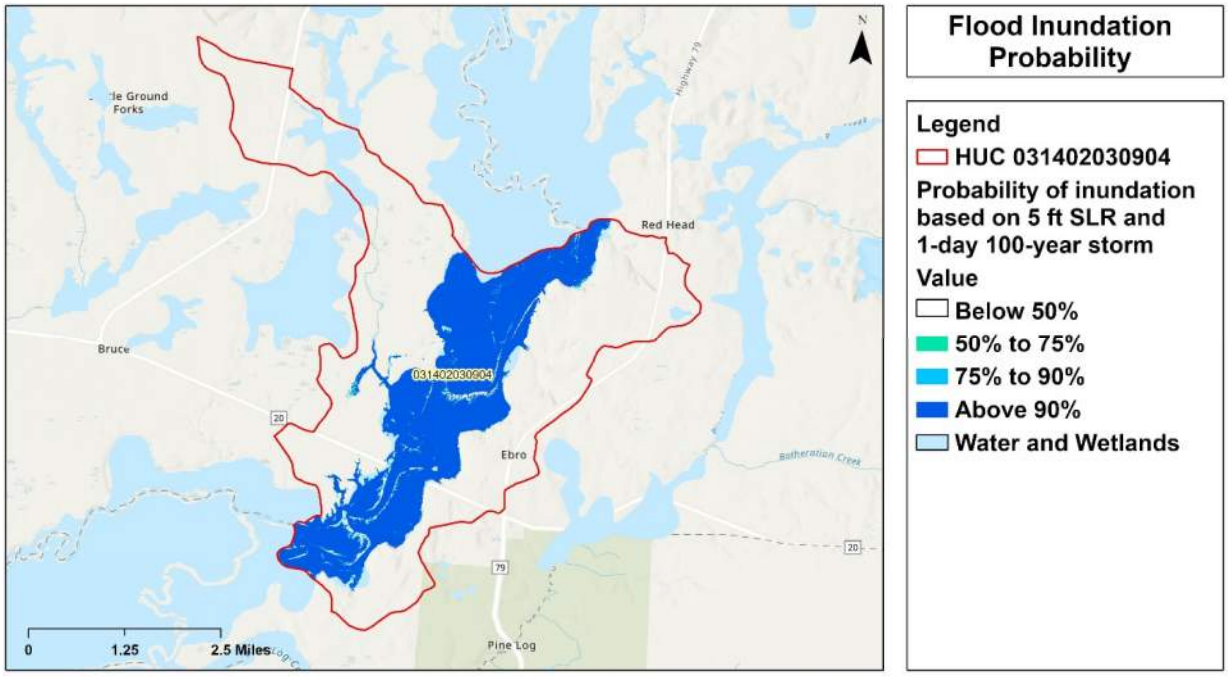

Figure 34. Flood Inundation Probability for a Sea level rise of 5 ft + 1-day 100-year storm event for HUC 031402030904 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Dark blue is area under 5 ft NAVD

2.4 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. **3-day 25-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 35)
2. **1-day 100-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 36)
3. **1-day 10-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 37)
4. **1-day 5-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 38)
5. **Sea level rise of 1 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 39)
6. **Sea level rise of 1 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations storm (Figure 40)
7. **Sea level rise of 1 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 41)
8. **Sea level rise of 1 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 42)
9. **Sea level rise of 2 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 43)
10. **Sea level rise of 2 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 44)
11. **Sea level rise of 2 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 45)
12. **Sea level rise of 2 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 46)
13. **Sea level rise of 3 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 47)
14. **Sea level rise of 3 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 48)

15. **Sea level rise of 3 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 49)
16. **Sea level rise of 3 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 50)
17. **Sea level rise of 4 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 51)
18. **Sea level rise of 4 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 52)
19. **Sea level rise of 4 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 53)
20. **Sea level rise of 4 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 54)
21. **Sea level rise of 5 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 55)
22. **Sea level rise of 5 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 56)
23. **Sea level rise of 5 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 57)
24. **Sea level rise of 5 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 58)

In all scenarios, a great amount of flooding is noted at the river entrance to the HUC, following the flow path along with the wetland areas until the next HUC. As this basin connects to the ocean though Choctawhatchee River, SLR scenarios plays an important hole, implying a considered growth as the projected scenario of rising tides rises.

The design storm simulation determined that approximately 14.26% of the HUC total area or 2.47 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 14.82% of the HUC's total area, or 2.56 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 13.35% of the HUC's total area,

or 2.31 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 17.97% of the HUC's total area, or 3.11 mi², would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031402030904 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	14.82	2.47	85.73%	14.26%
1-day 100-year	14.72	2.56	85.18%	14.82%
1-day 10-year	14.98	2.31	86.65%	13.35%
1-day 5-year	14.18	3.11	82.02%	17.97%

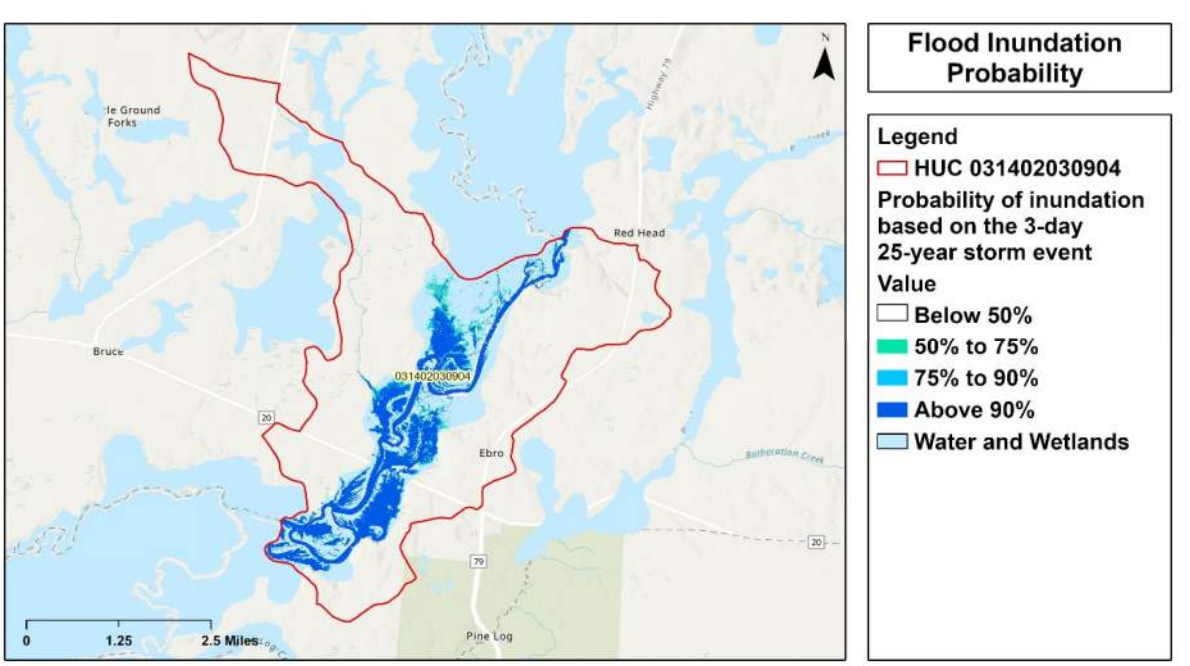

Figure 35. 3-day 25-year storm event for HUC 031402030904 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

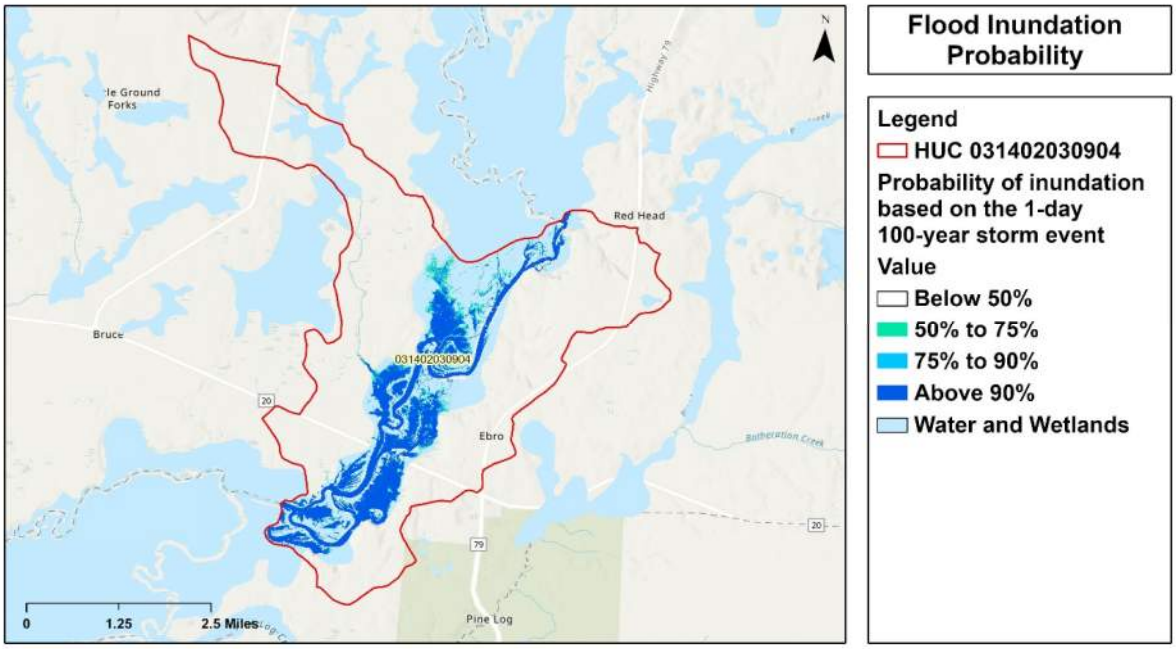

Figure 36. 1-day 100-year storm event for HUC 031402030904 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

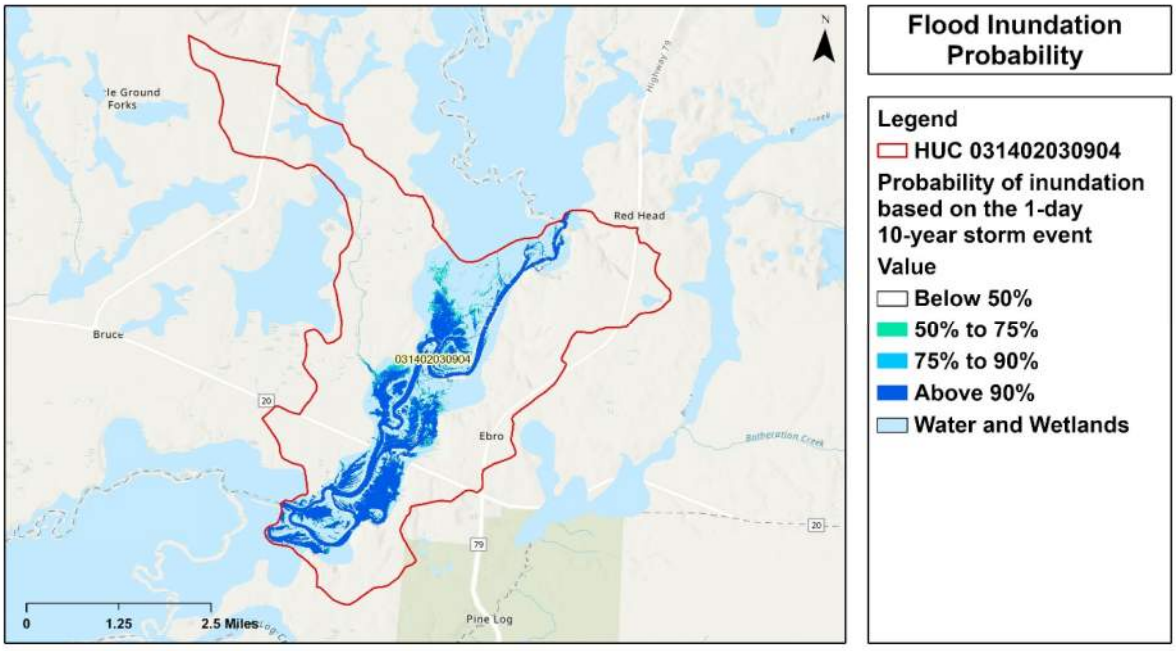

Figure 37. 1-day 10-year storm event for HUC 031402030904 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

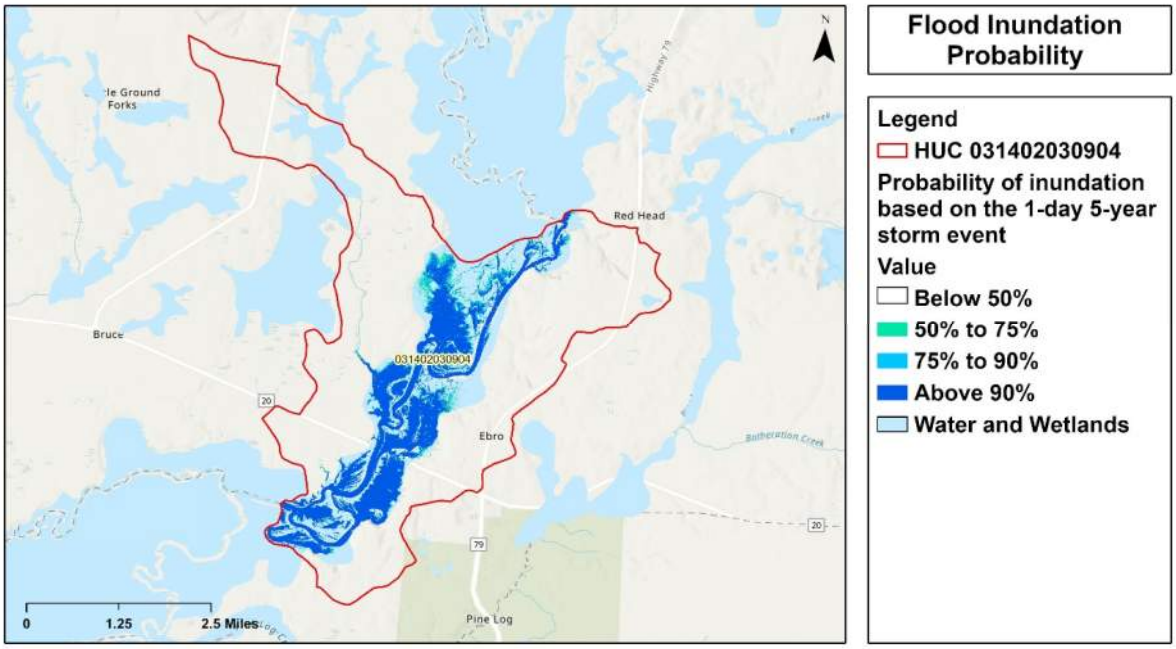

Figure 38. 1-day 5-year storm event for HUC 031402030904 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

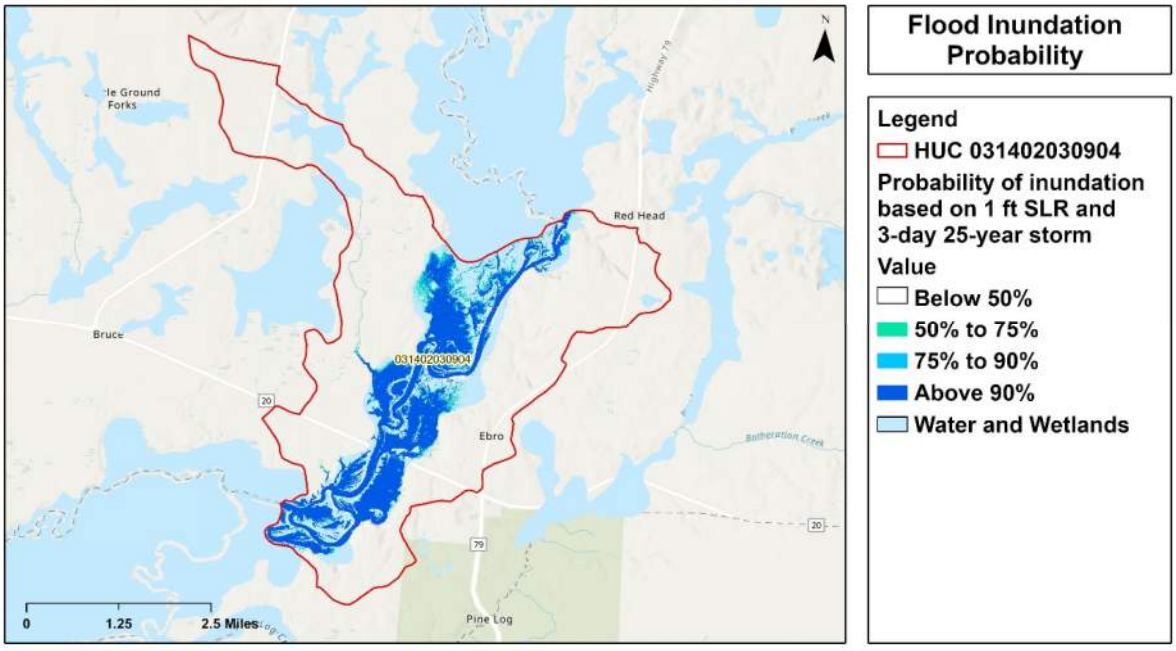

Figure 39. Sea level rise of 1 ft + 3-day 25-year storm for HUC 031402030904 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

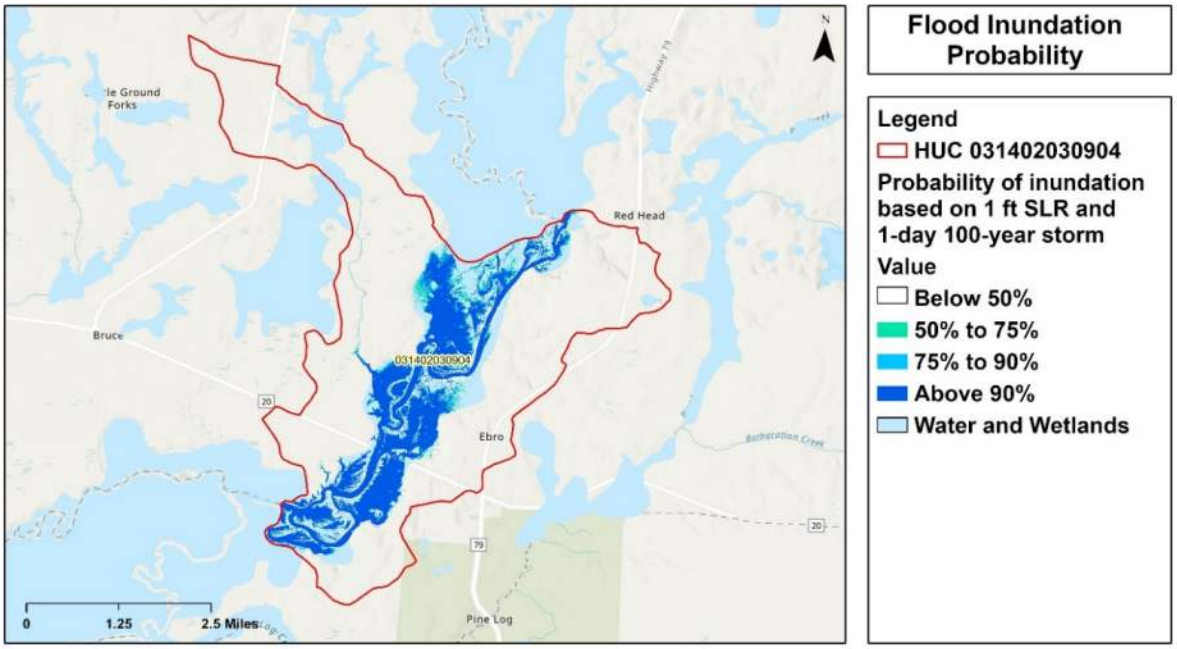

Figure 40. Sea level rise of 1 ft + 1-day 100-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

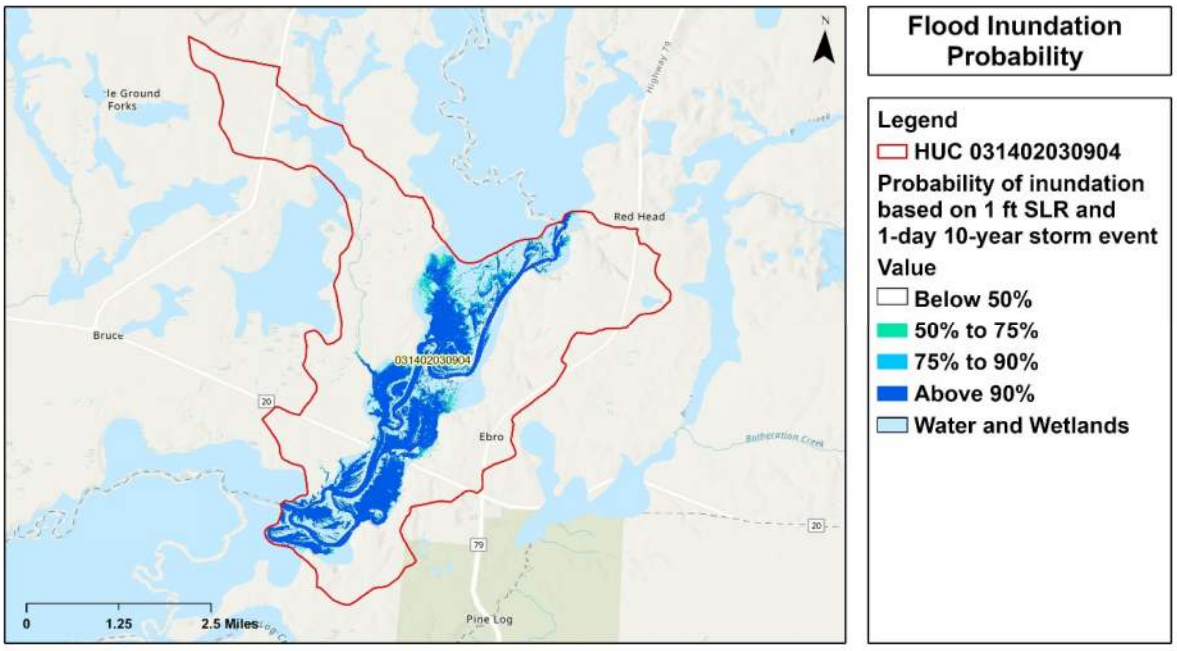

Figure 41. Sea level rise of 1 ft + 1-day 10-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

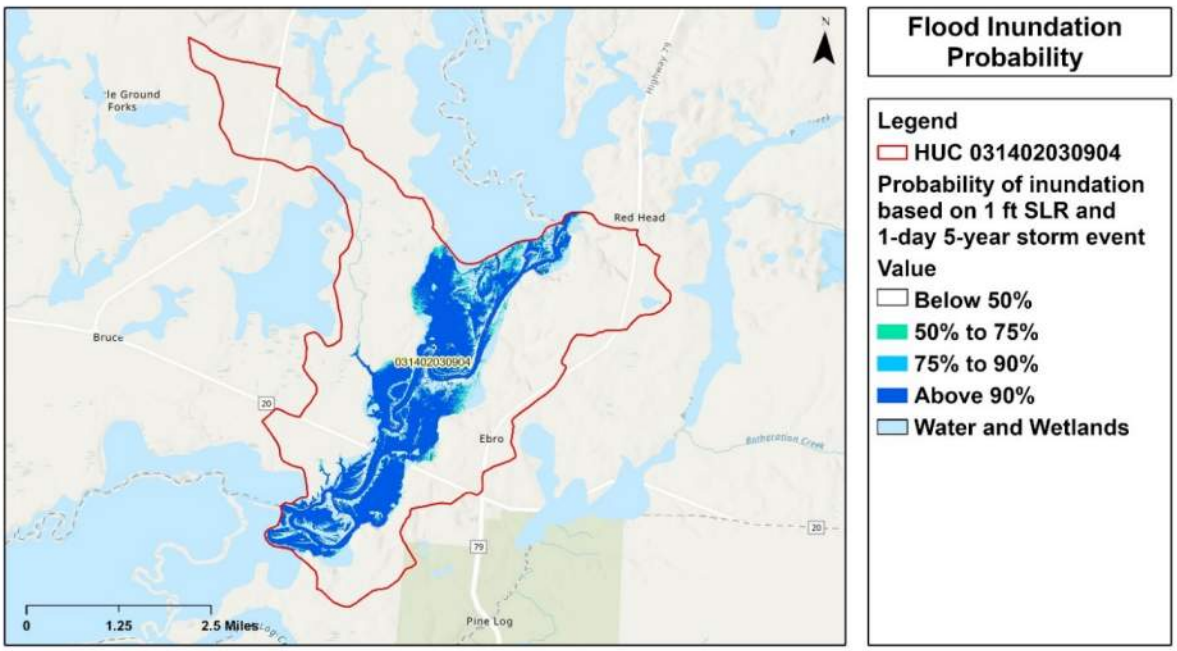

Figure 42. Sea level rise of 1 ft + 1-day 5-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

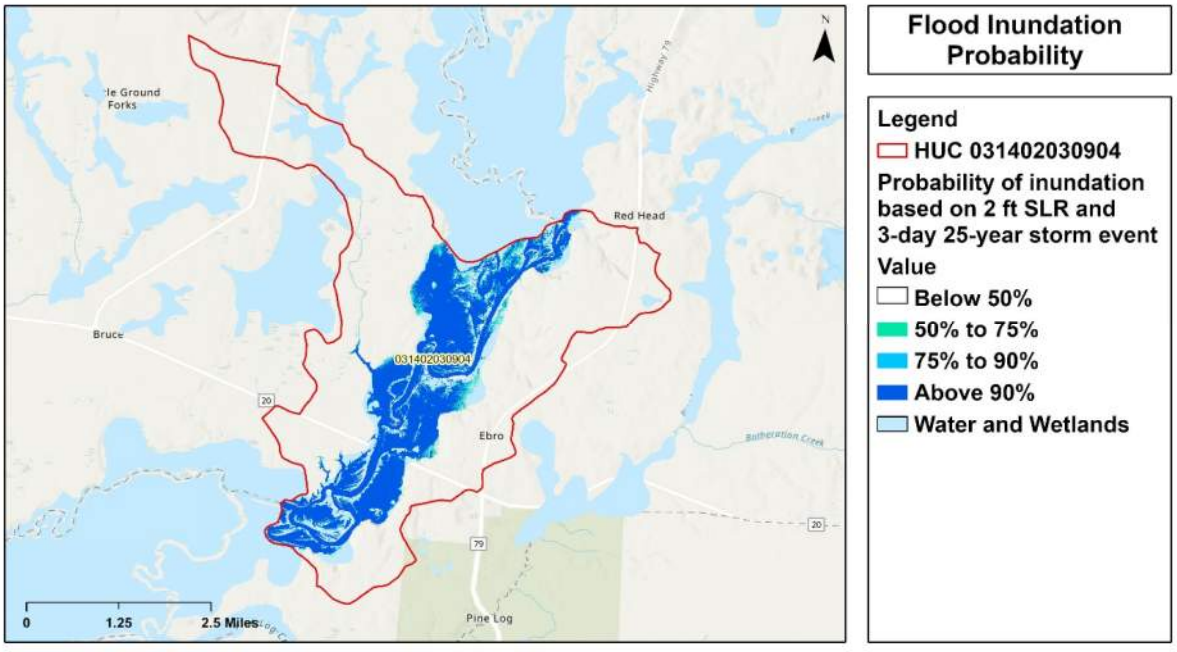

Figure 43. Sea level rise of 2 ft + 3-day 25-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

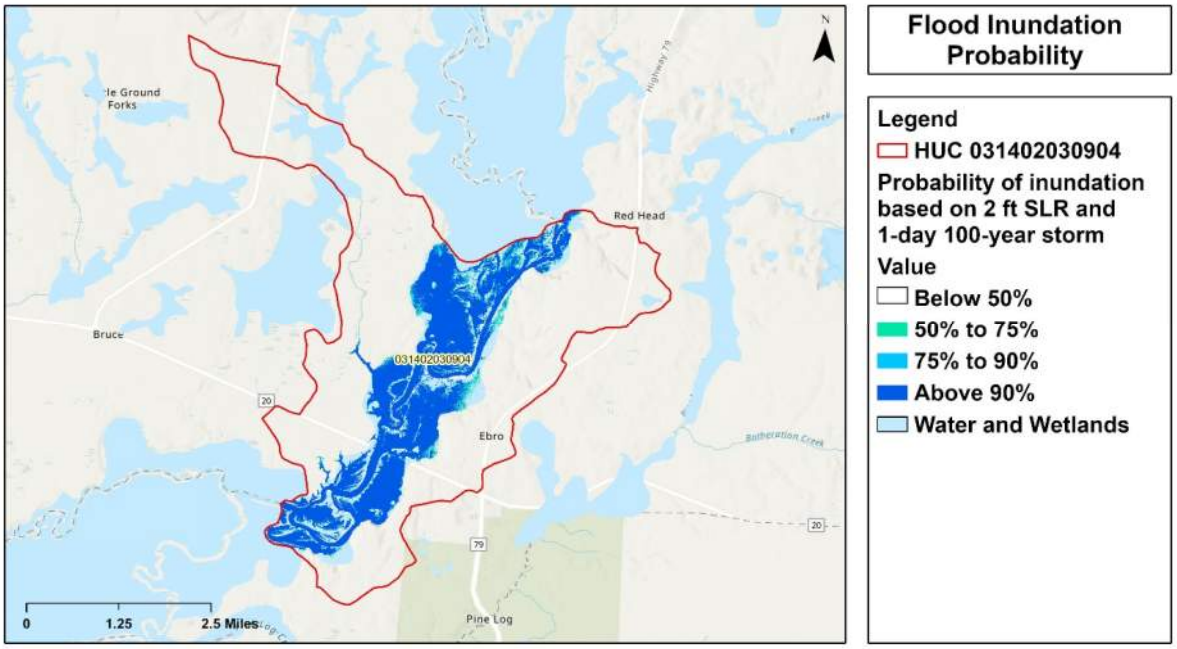

Figure 44. Sea level rise of 2 ft + 1-day 100-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

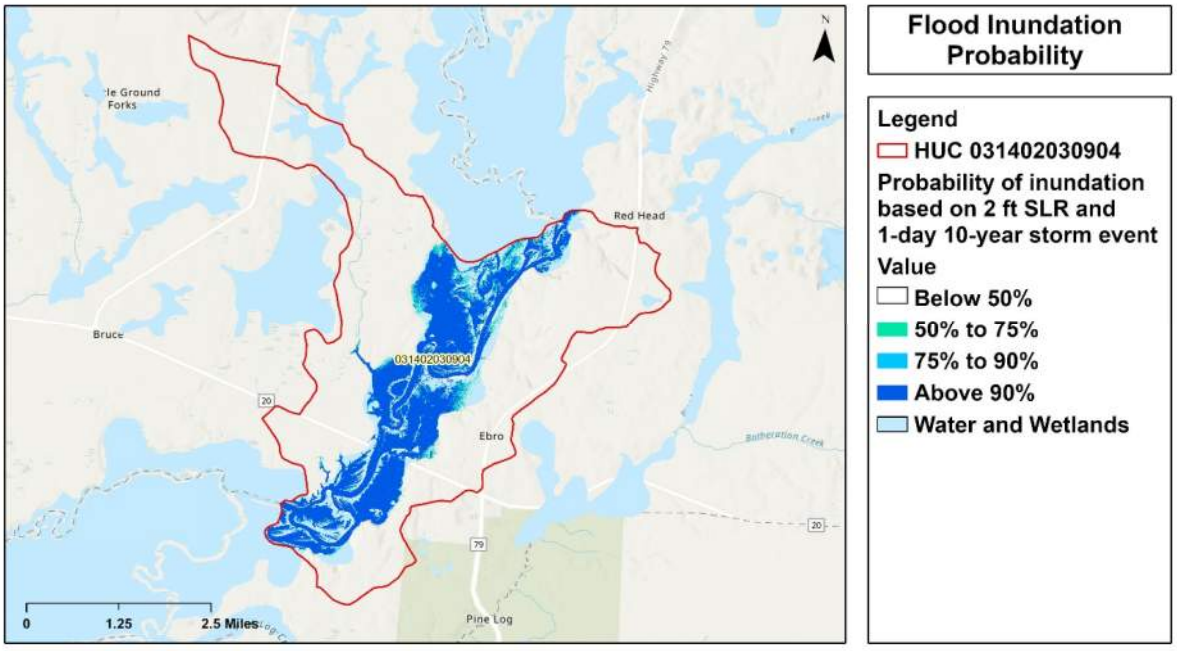

Figure 45. Sea level rise of 2 ft + 1-day 10-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

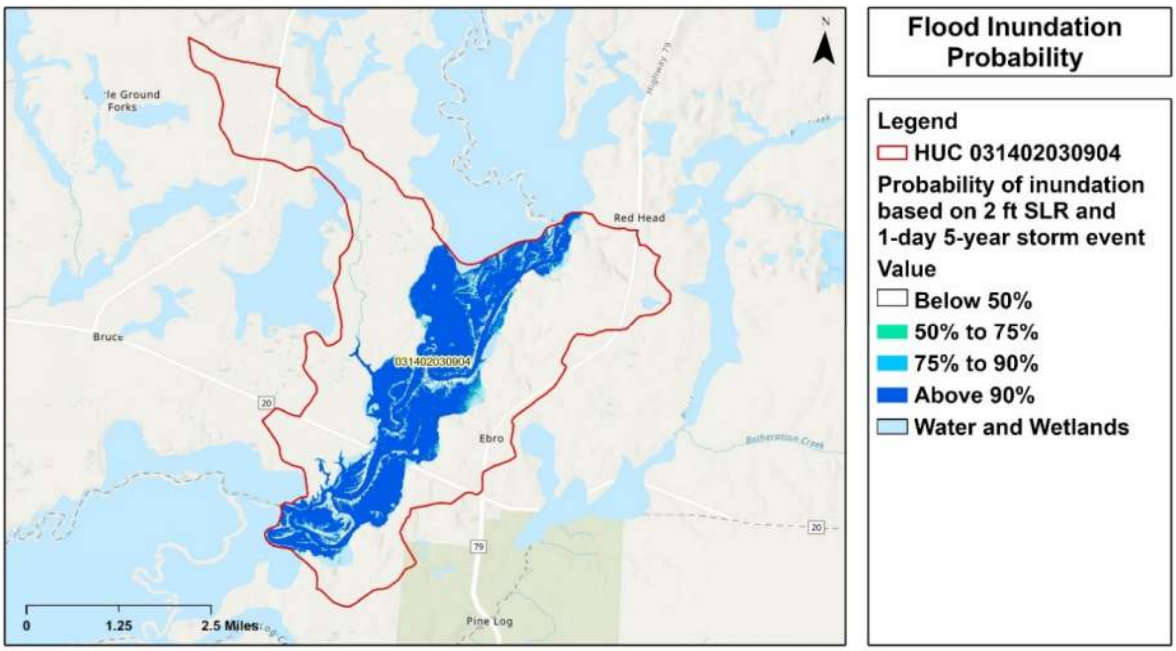

Figure 46. Sea level rise of 2 ft + 1-day 5-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

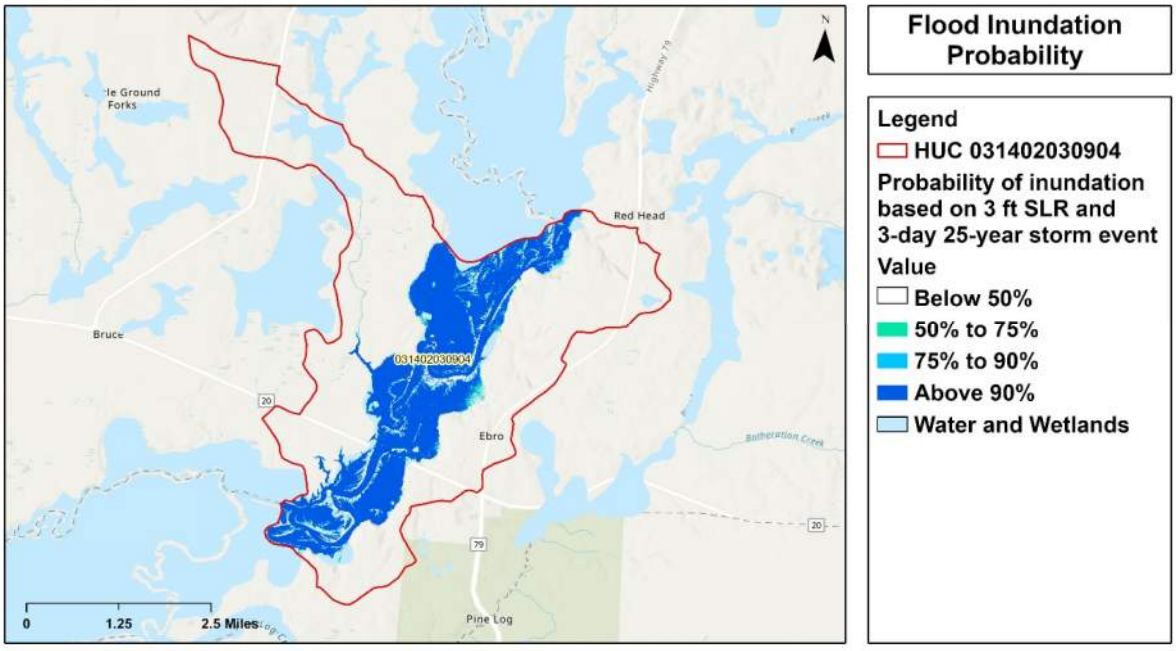

Figure 47. Sea level rise of 3 ft + 3-day 25-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

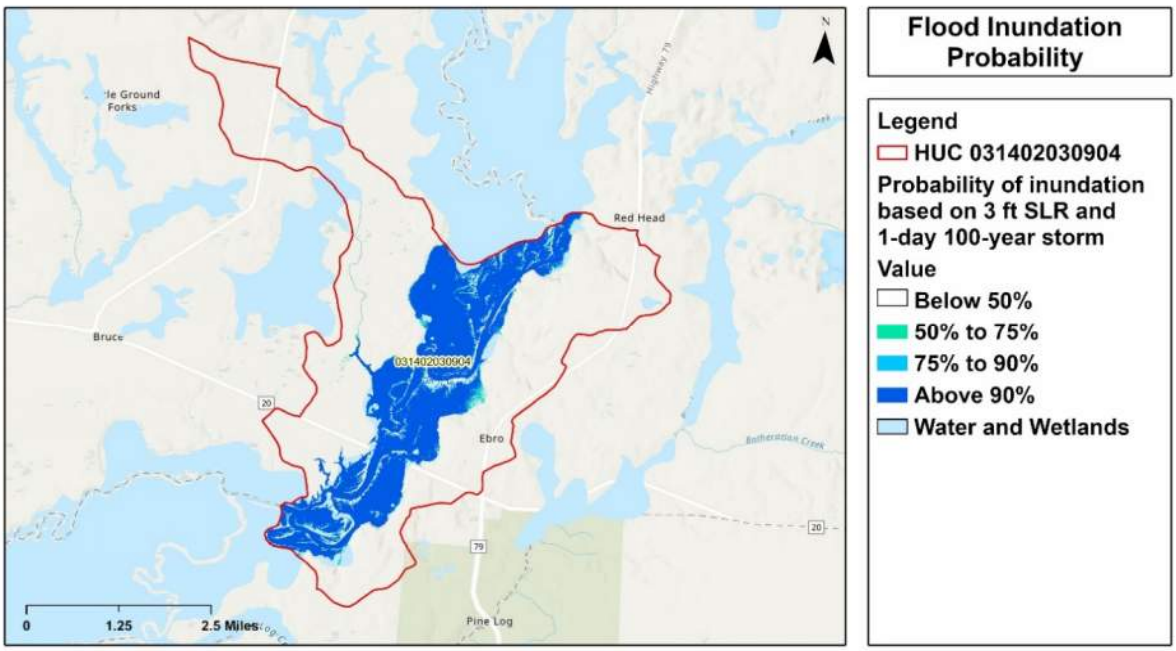

Figure 48. Sea level rise of 3 ft + 1-day 100-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

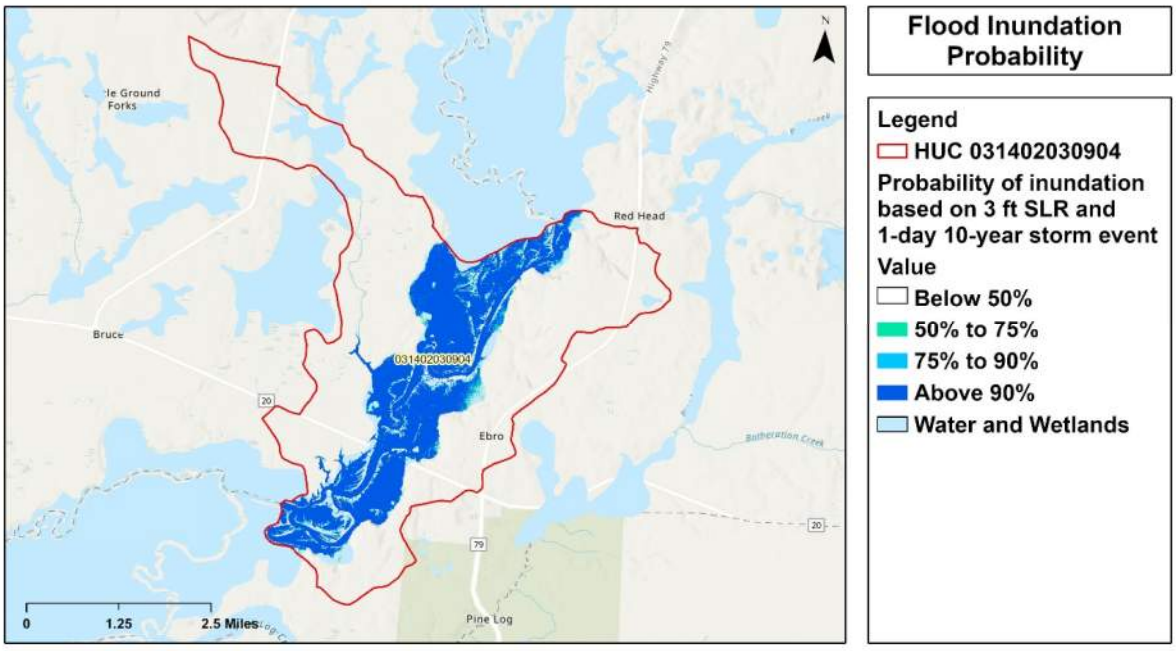

Figure 49. Sea level rise of 3 ft + 1-day 10-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

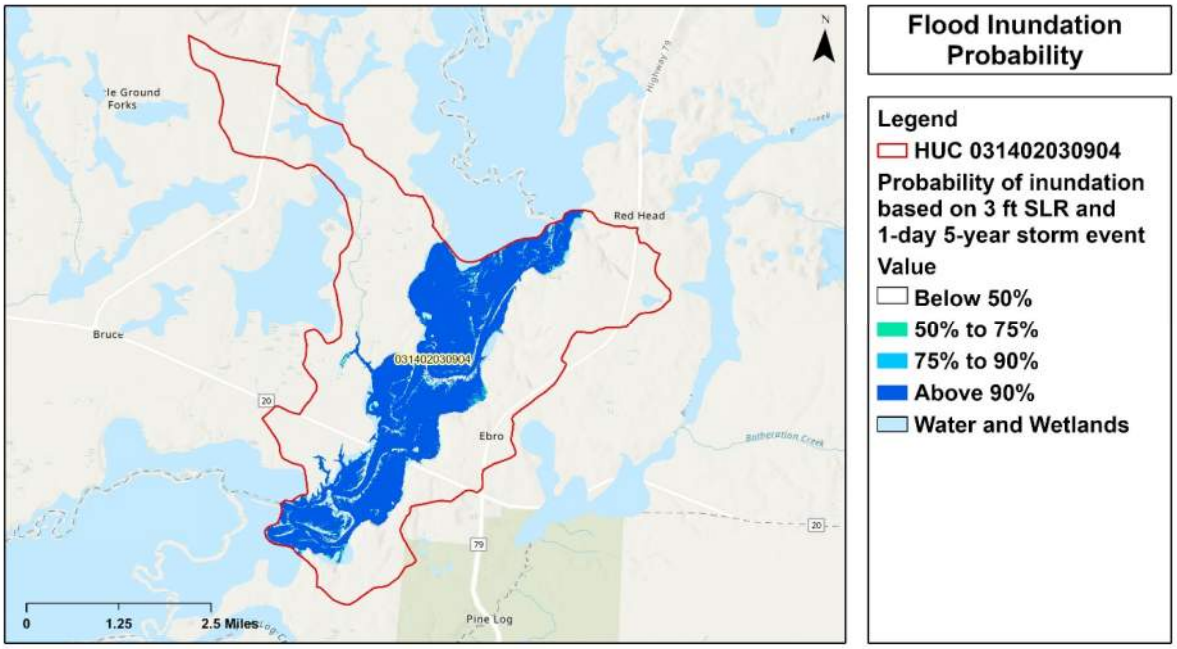

Figure 50. Sea level rise of 3 ft + 1-day 5-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

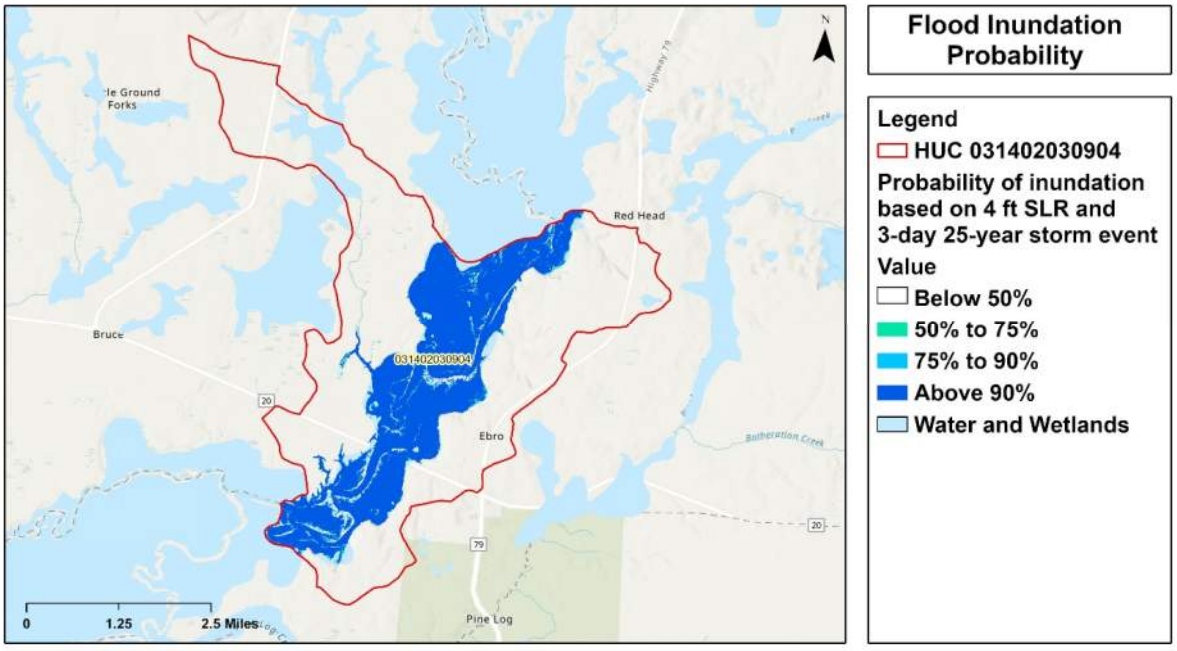

Figure 51. Sea level rise of 4 ft + 3-day 25-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

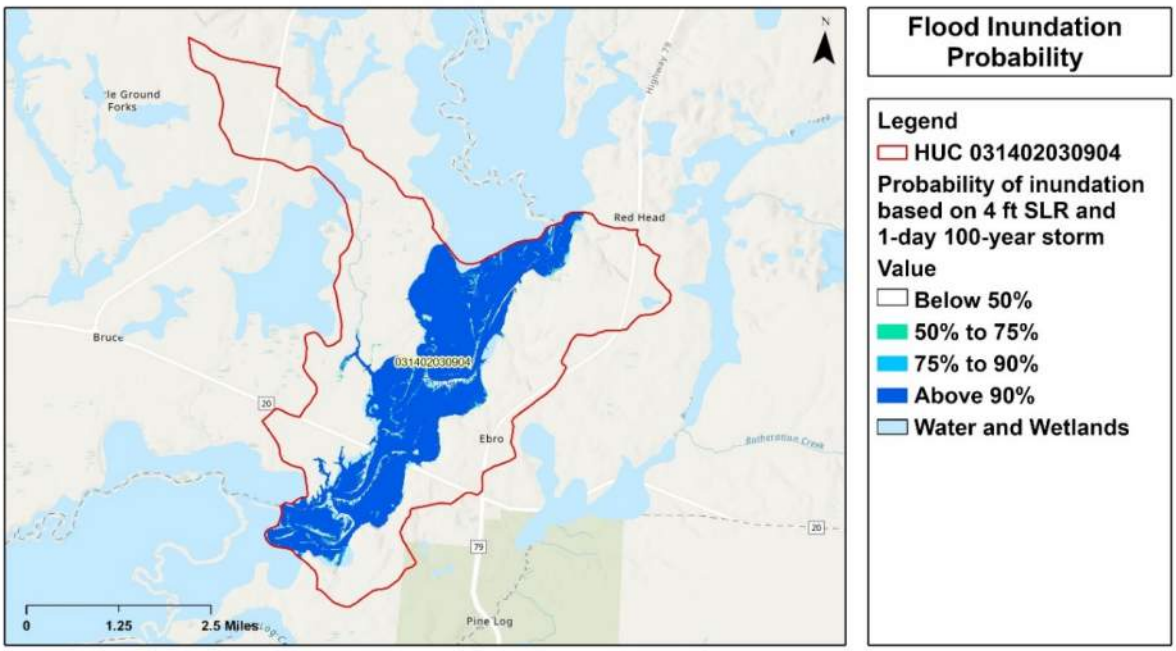

Figure 52. Sea level rise of 4 ft + 1-day 100-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

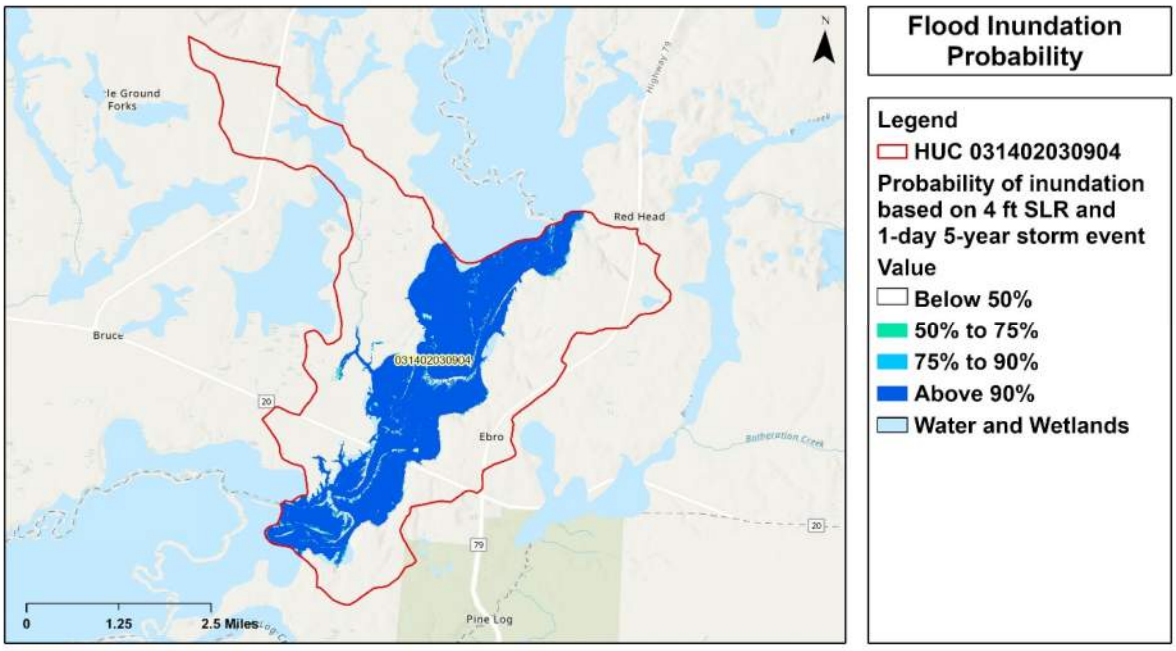

Figure 53. Sea level rise of 4 ft + 1-day 10-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

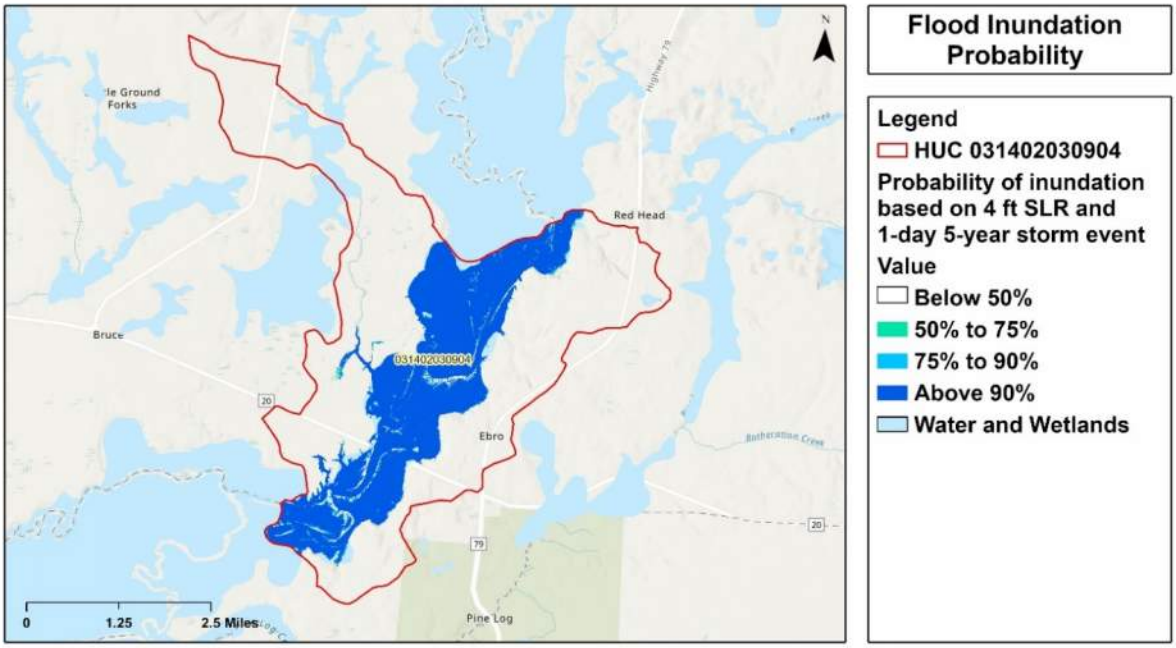

Figure 54. Sea level rise of 4 ft + 1-day 5-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

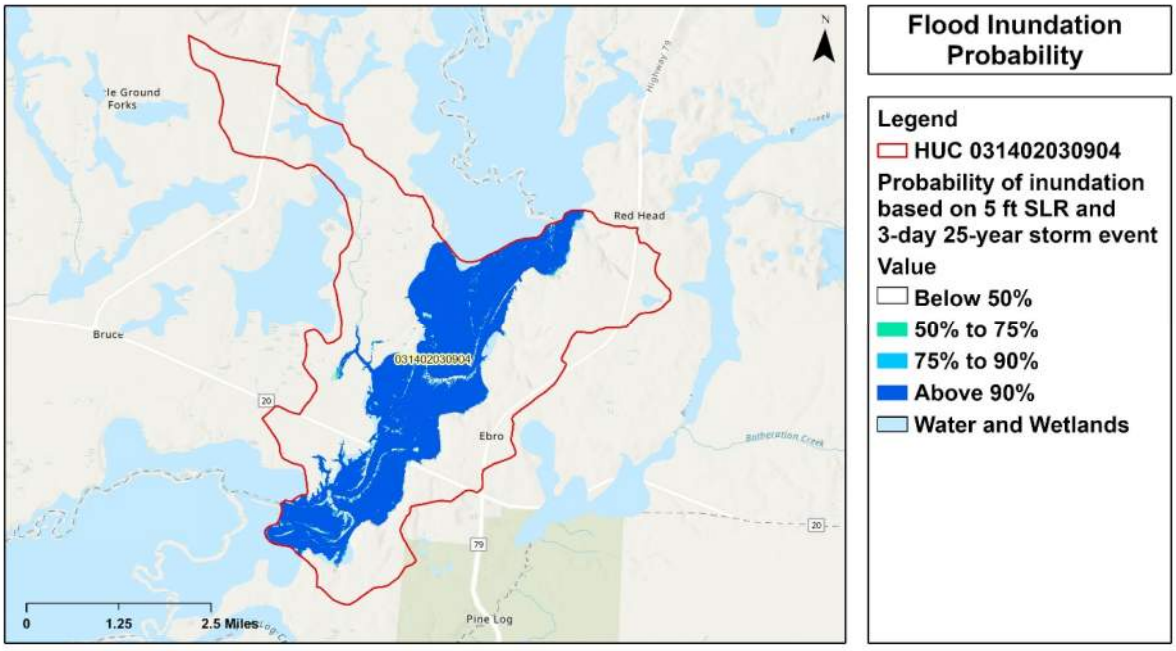

Figure 55. Sea level rise of 5 ft + 3-day 25-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

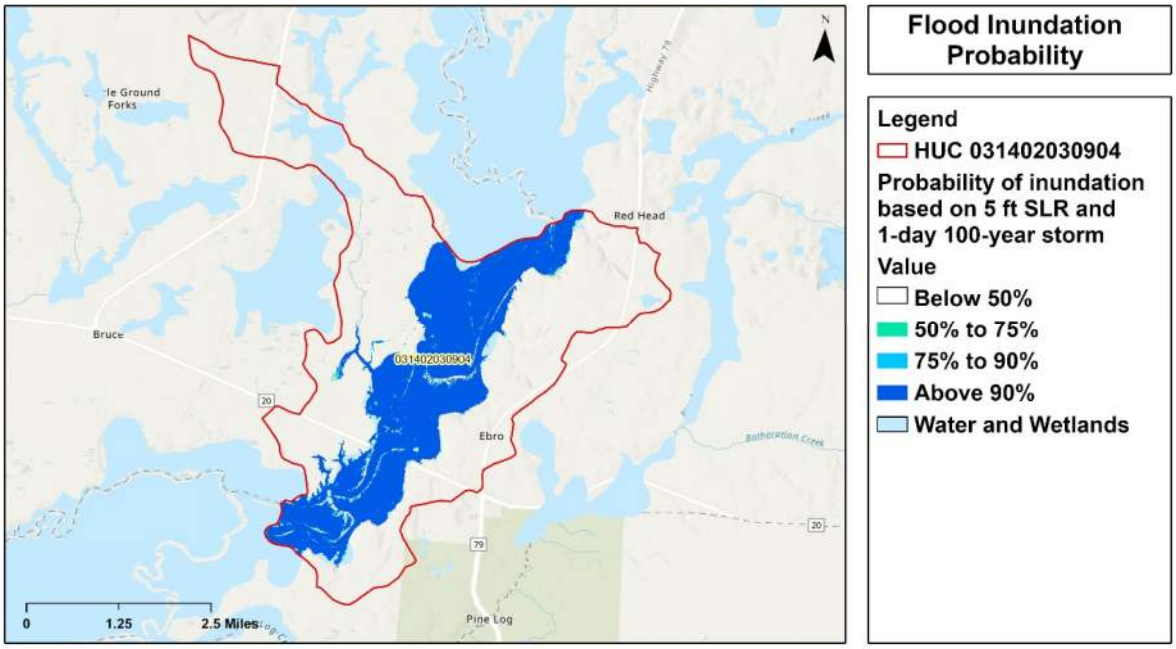

Figure 56. Sea level rise of 5 ft + 1-day 100-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

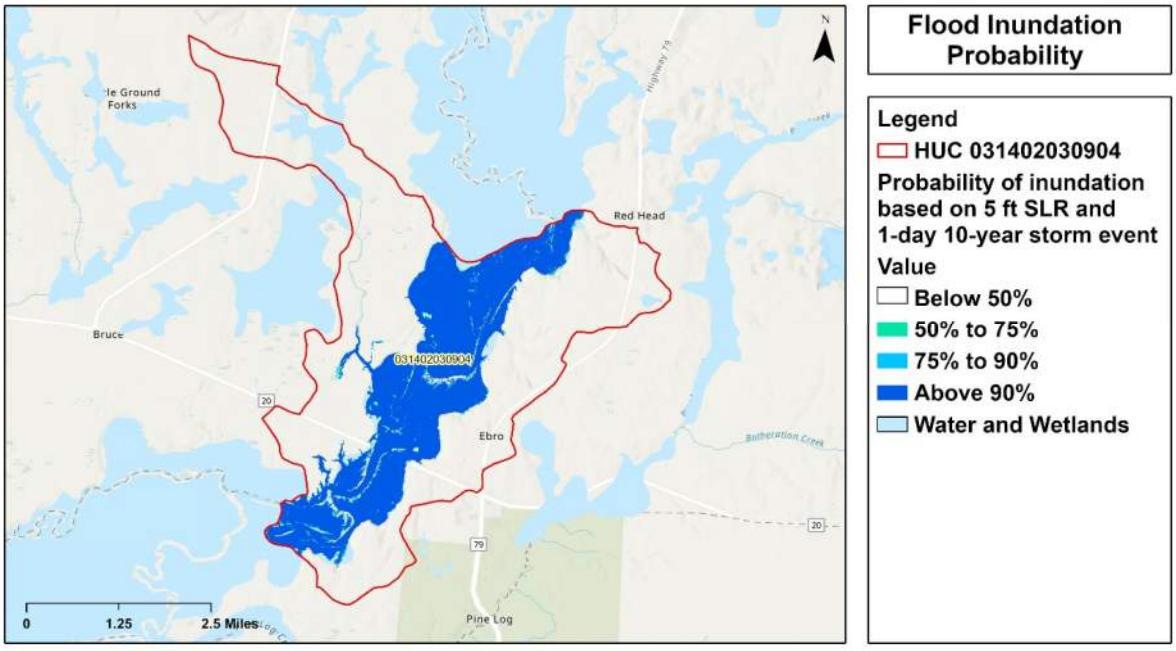

Figure 57. Sea level rise of 5 ft + 1-day 10-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

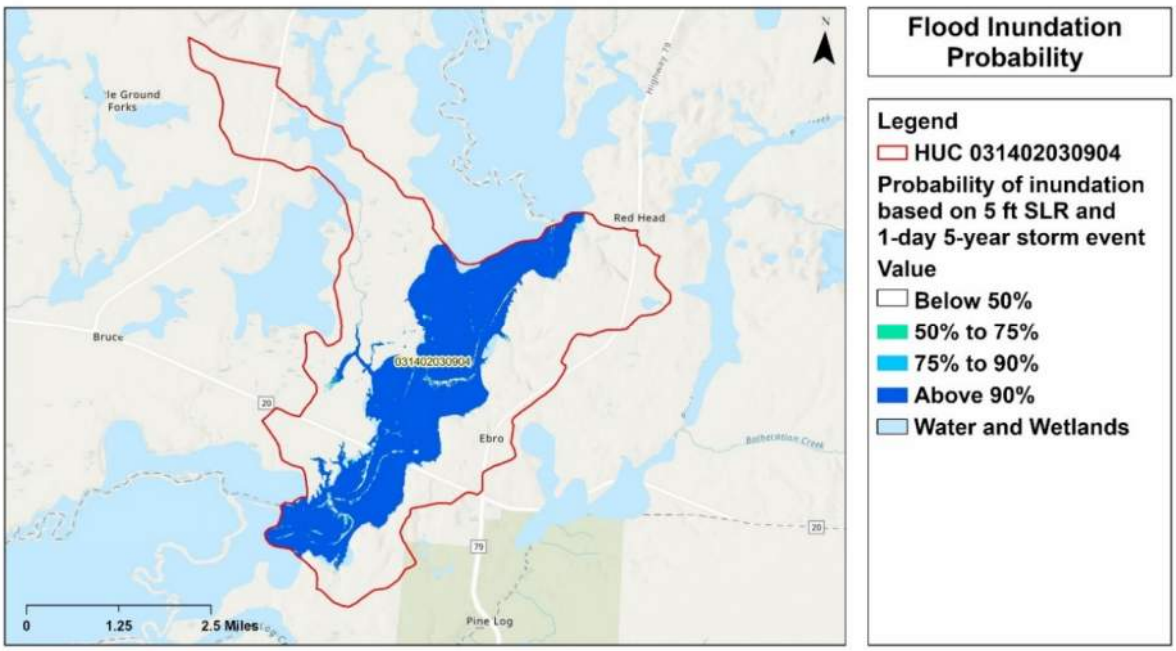

Figure 58. Sea level rise of 5 ft + 1-day 5-year storm for HUC 031402030904 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.5 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health) requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older,

poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3

28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6

60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6

97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.5.1 Results

Error! Reference source not found. to **Error! Reference source not found.** depict the HUC 031402030904 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 60) overlays critical facilities onto the 1-day 100-year storm event scenario, while the third map (**Error! Reference source not found.**) represents the same overlay within the context of 5 feet of sea level rise (SLR) combined with the 1-day 100-year storm event. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 5 feet SLR + 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** and **Error! Reference source not found.** illustrate the composite score for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. **Error! Reference source not found.** represents the calculation for composite score based on 1-day 100-year storm event, while **Error! Reference source not found.** shows the calculation for composite score for the same storm event, but including a 5 feet of Sea Level Rise scenario. **Error! Reference source not found.** shows the same area zoomed out.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

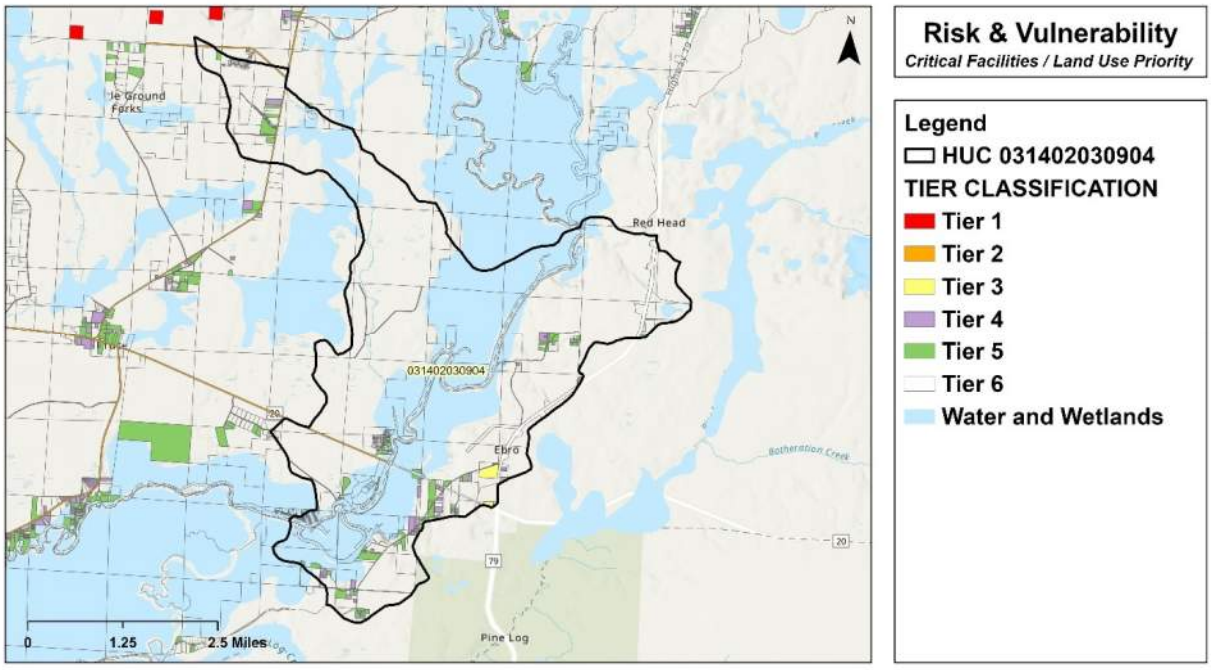

Figure 59. HUC 031402030904 sub-watershed Critical Facilities (priority of land uses) map.

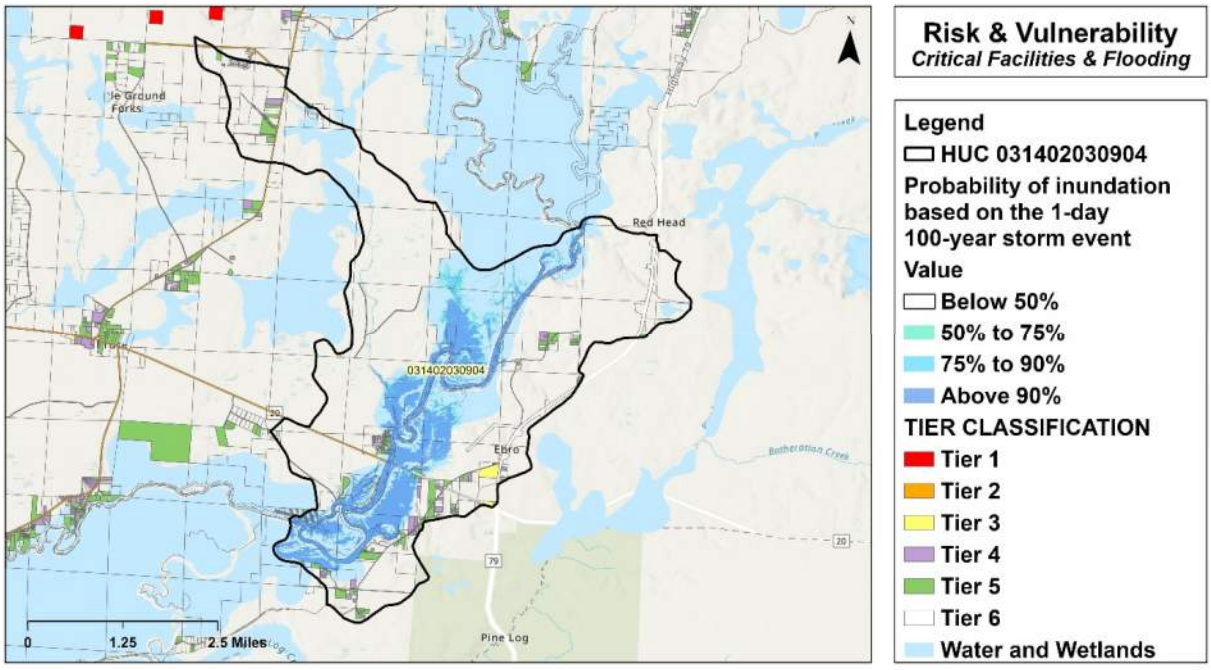

Figure 60. HUC 031402030904 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

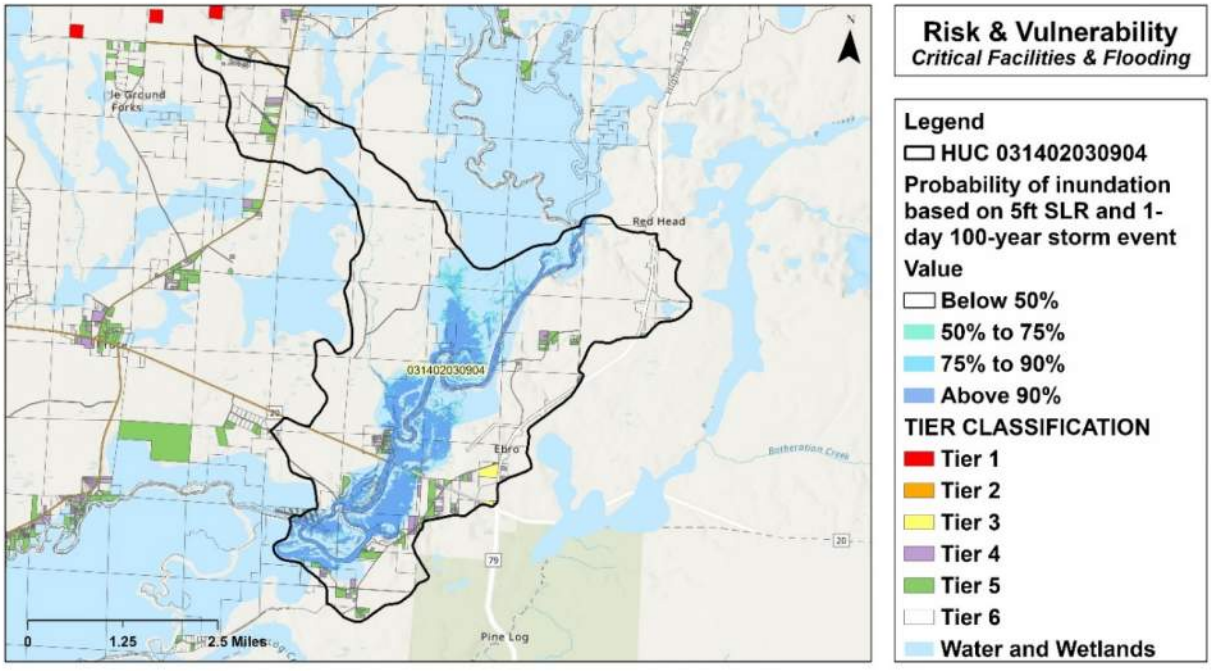

Figure 61. HUC 031402030904 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

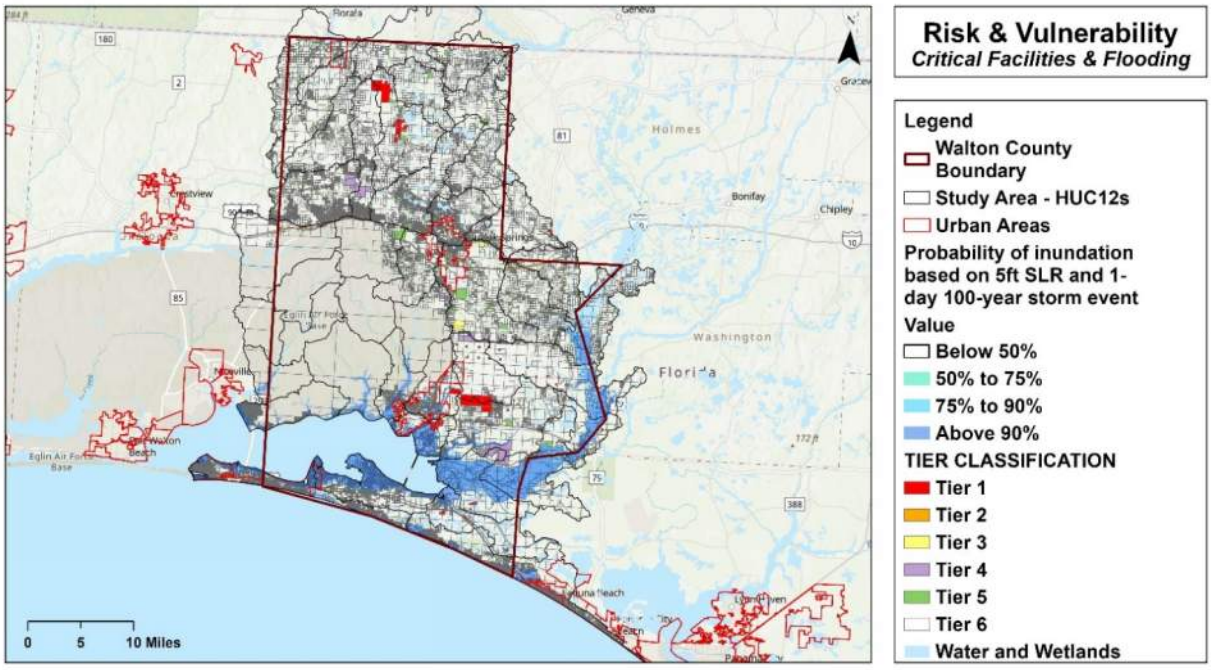

Figure 62. Walton County (mosaic) - Critical Facilities (priority of land uses) map, overlaid on the 1-day 100-year storm event + 5 ft. SLR probability of inundation for Walton County. Processed by FAU.

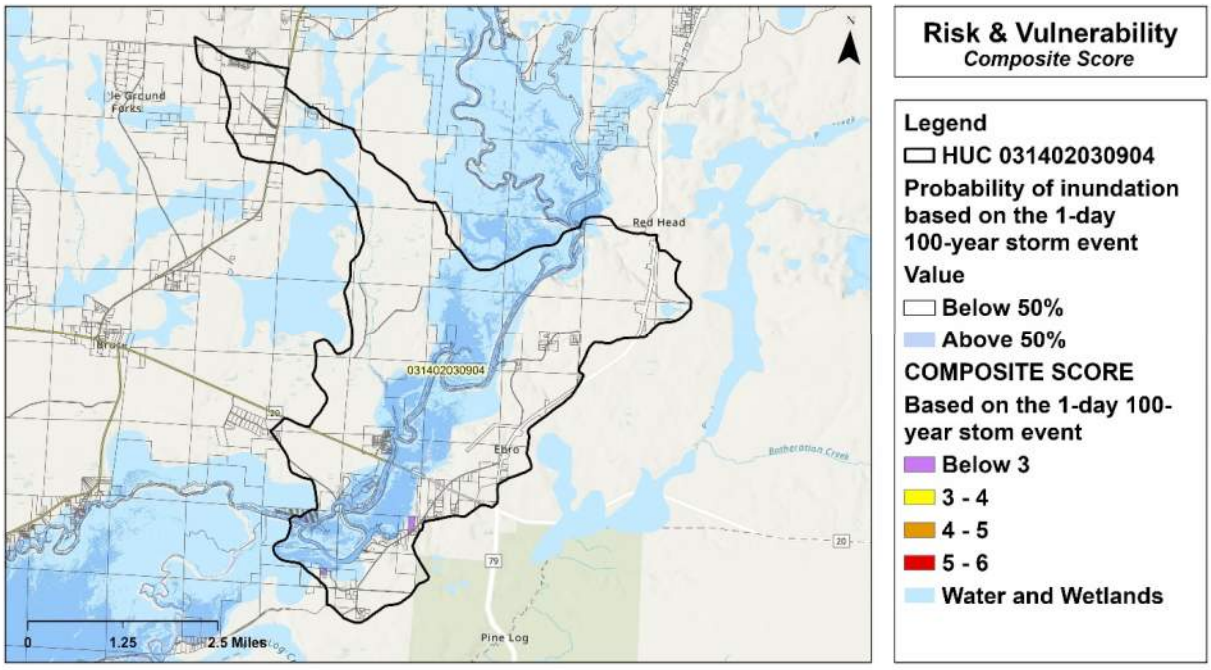

Figure 63. HUC 031402030904 sub-watershed Composite Score Risk map based on the 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation. Processed by FAU.

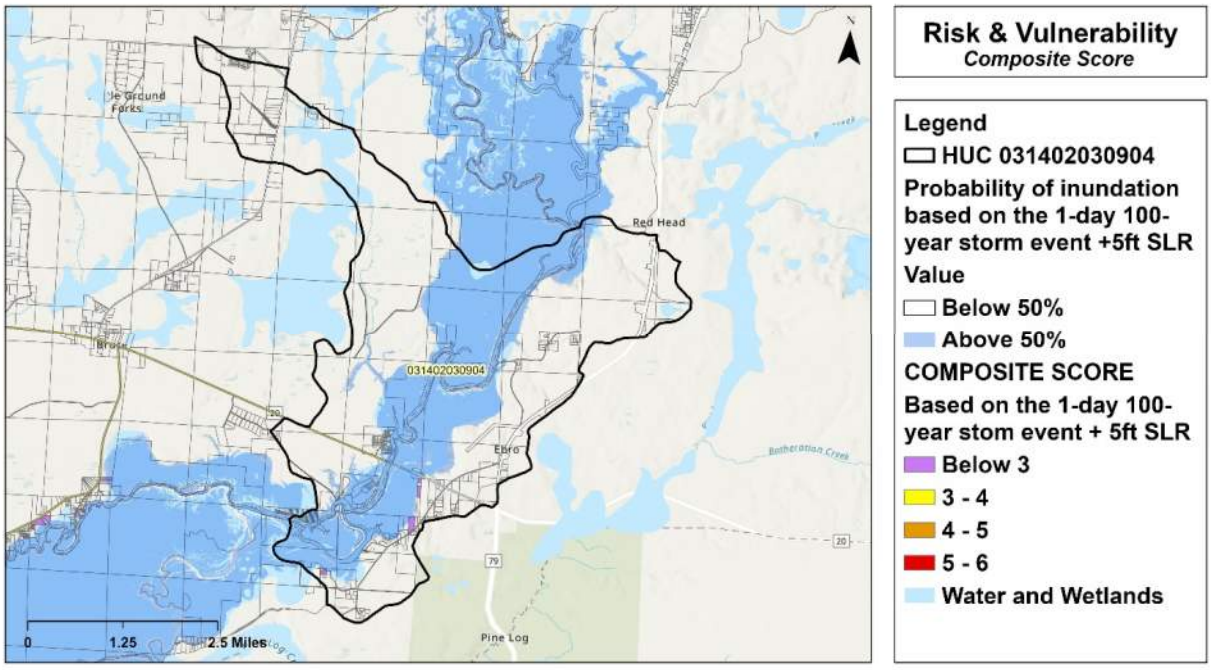

Figure 64. HUC 031402030904 sub-watershed Composite Score Risk map based on 1-day 100-year storm event + 5 ft. SRL, overlaid on the 1-day 100-year + 5 ft. SLR probability of inundation. Processed by FAU.

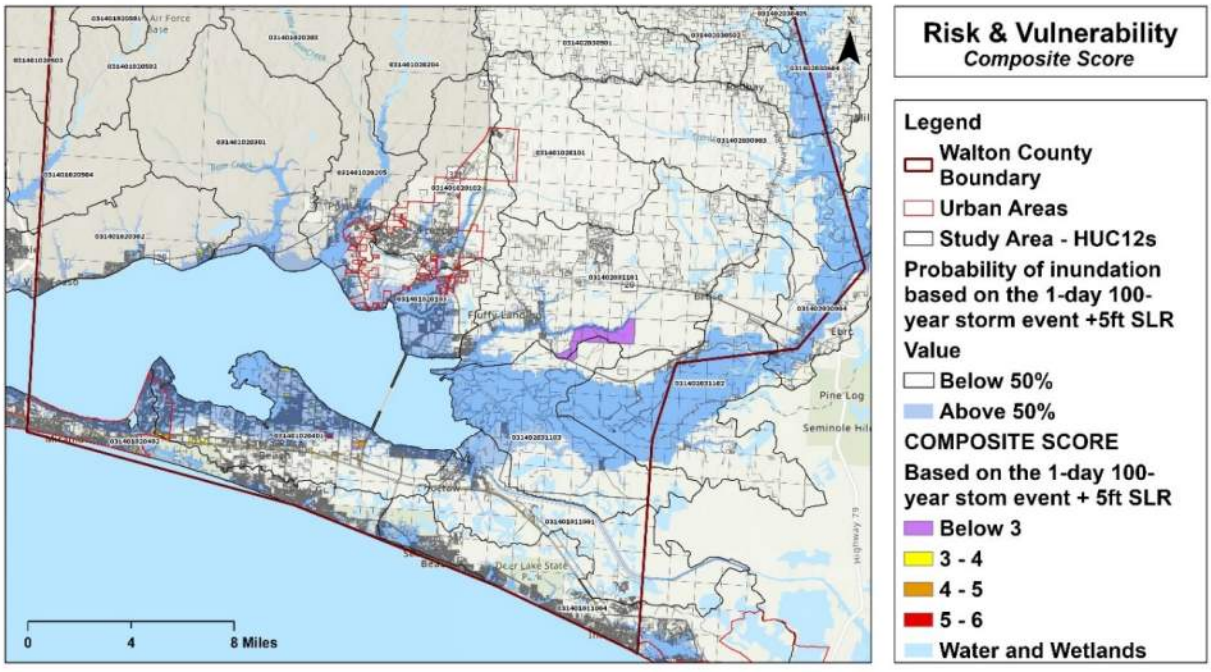

Figure 65. Coastal Area of Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

2.5.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031402030904. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.5.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031402030904. Processed by FAU.

AREAS	ACRES
HUC-12 Sub-watershed: 031402030904	11061.00
All of the 1-day 100-year storm event inundation	**1638.95**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	1182.57
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	85.04
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	19.13
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	456.38
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	352.21

2.5.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

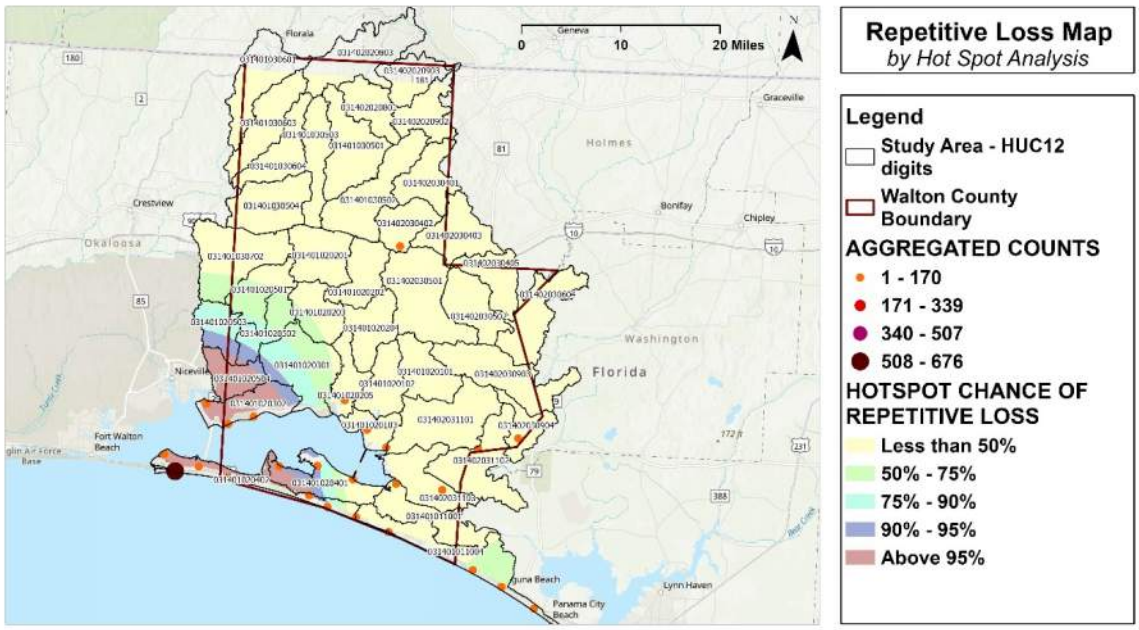

Figure 66. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU. (Source Data: FEMA)

2.5.5 Priority Projects

The basin does not display a significant amount of developed land. While there are some parcels falling within tiers 2 to 5 of land use priority classifications within the basin, fortunately, only a few of them are within the flooding zone, despite the presence of substantial flooding in both 1-day 100-year storm events and 1-day 100-year + 5 feet sea level rise scenarios.

Consequently, when considering the composite score, it is notable that most of the results are null. There are as total 11 results for composite score within the basin. In the score range of 3-4, there are seven parcels, comprising three mobile homes and four roads (Us Hwy 20, Choctawhatchee River Rd, Cowford Rd, and Road Row). Lastly, there are four parcels with scores below 3, all of which are mobile homes. There is no parcel with a score 4-5 and 5-6 composite score, therefore the priorities within the basin are relatively low.

APPENDIX AO

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031402031101

BLACK CREEK-MITCHELL RIVER

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 sub-watershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 (031402031101) is highlighted among all the HUCs to help identifying its location. (Figure 3).

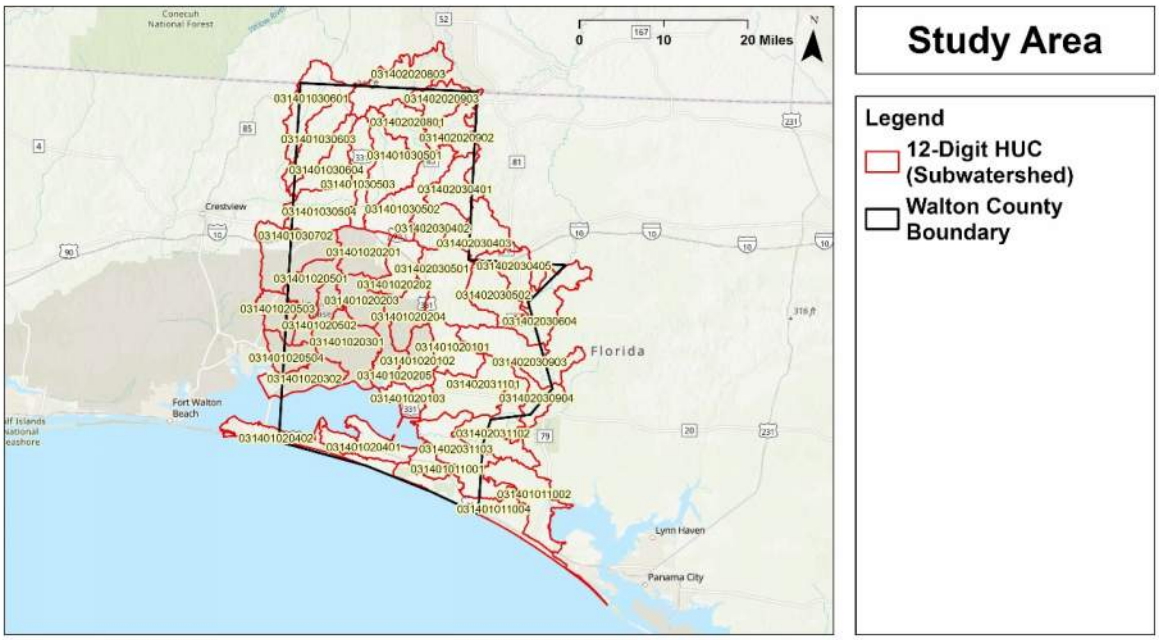

Figure 1. Walton County and all HUCs 12-digit sub-watershed, processed by FAU.

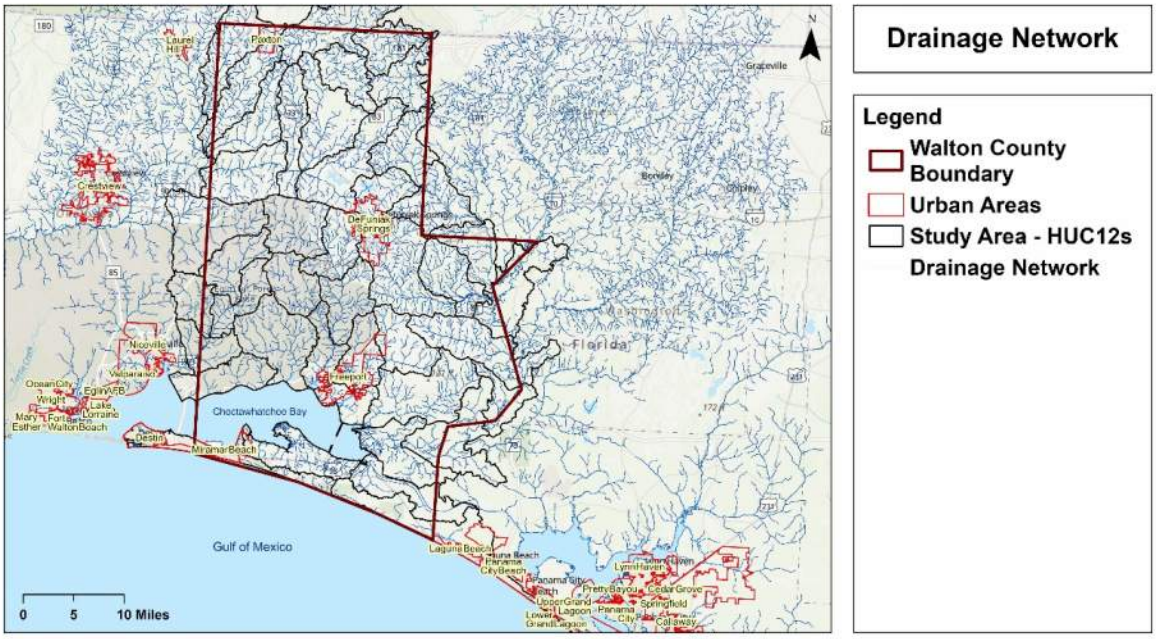

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

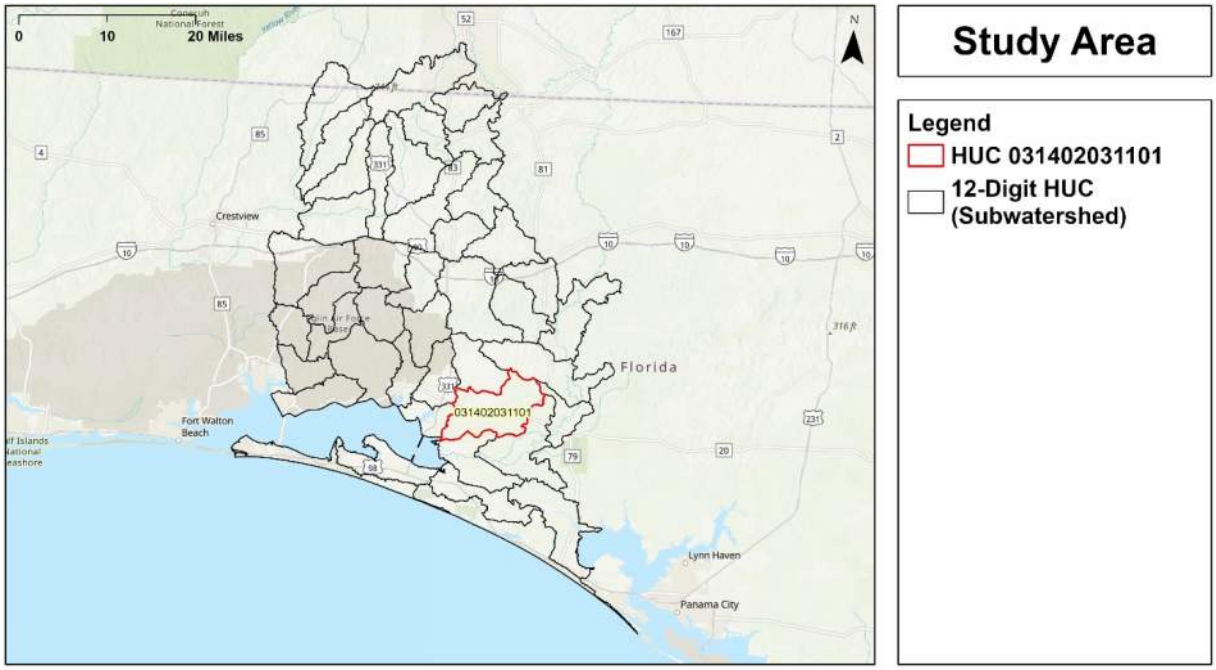

Figure 3. HUC 031402031101 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state,

with a height of 345 feet in its northern end. With a population of 75,305 residents according to the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development, tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife

management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

(Source Data: FEMA)

Figures 12 and 13 is the county-wide report show the current and projected land use for the County. Based on the 2017 future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land Use in Walton County (Prepared by FAU from future land use map) versus land use in the entire watershed

Level 1 Land Use-Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

(Source Data: (NWFWMD 2017)

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 1.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

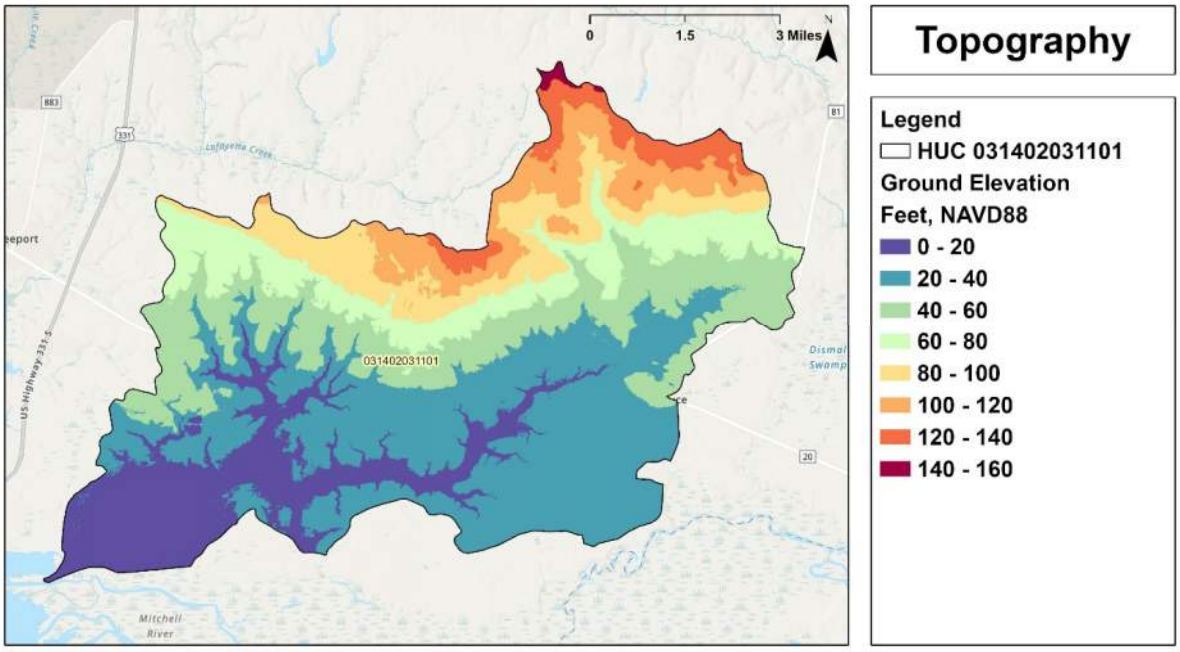

Figure 4. Topographic map of the HUC 031402031101 sub-watershed, processed by FAU. (Data Source: USGS)

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031402031101 sub-watershed is shown in **Error! Reference source not found.**.

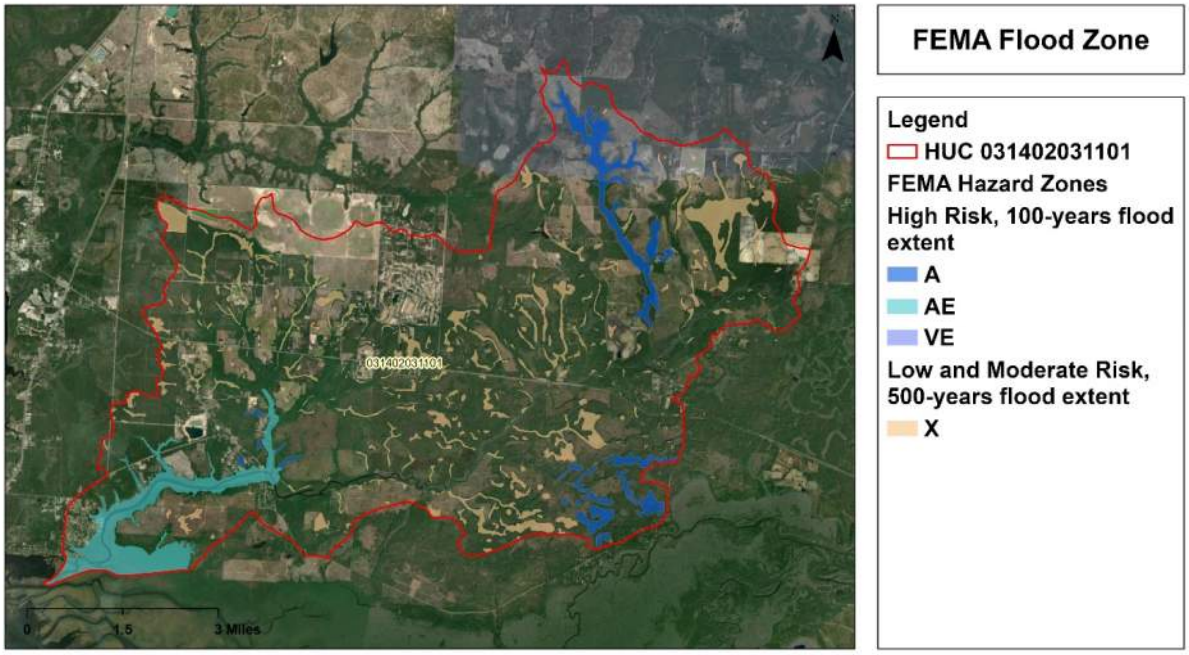

Figure 5. FEMA Flood Zone map (2020) for HUC 031402031101 sub-watershed, processed by FAU.
(Data Source: FEMA)

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031402031101 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem.

This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

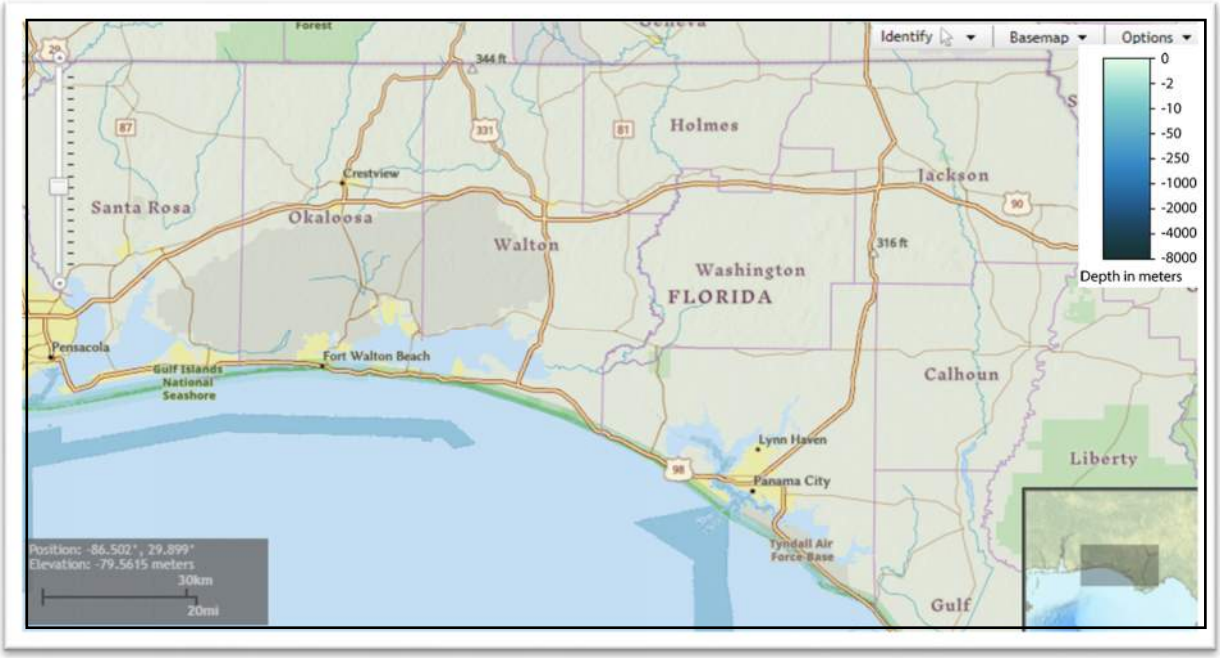

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
(Source: ncei.noaa.gov/maps/bathymetry/)

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

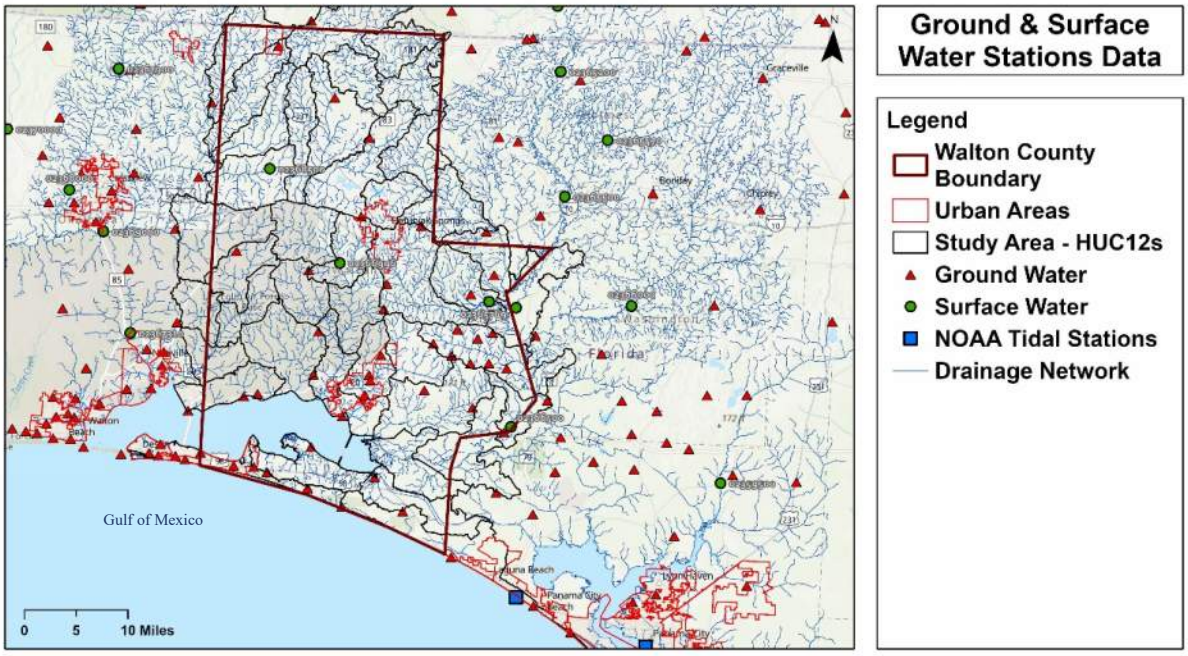

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.
(Data Source: USEPA – National Hydrographic Dataset (NHD) and NOAA's Tides)

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The major water bodies in the HUC 031402031101 sub-watershed include:

- Black Creek
- Camp Creek
- Turnpike Branch
- Walker Branch
- Pate Branch
- Joyce Branch
- Silcox Branch
- McIver Branch
- Little Black Creek

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031402031101, which is USGS 02366500 Choctawhatchee River NR Bruce FLA.

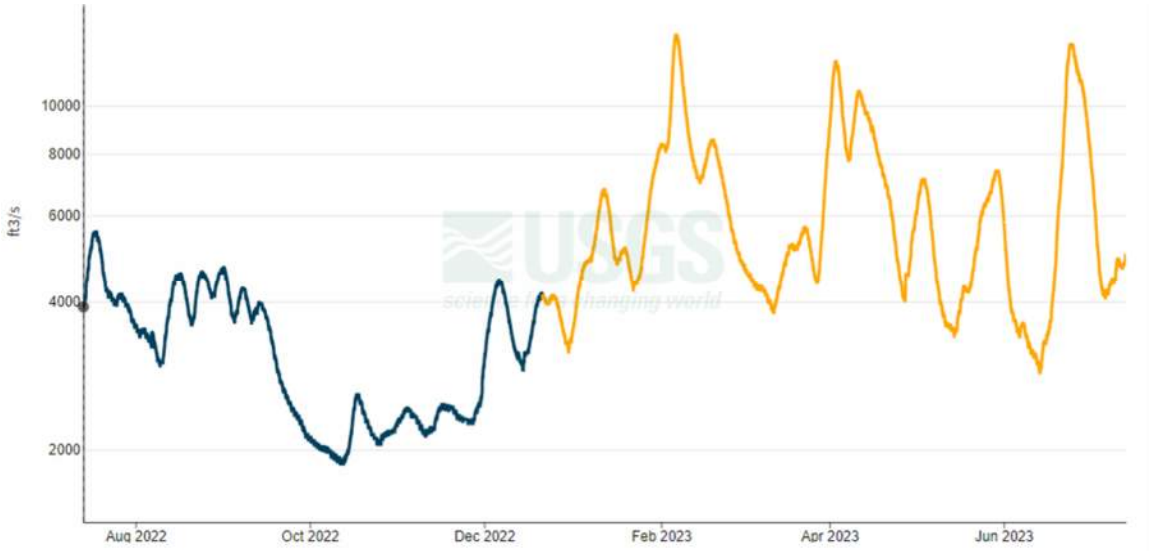

Figure 8. Average streamflow for Choctawhatchee River NR Bruce FLA (USGS 02366500 Surface-Water, June 2022 to July 2023).
(Source: USGS Water Data Services, available at https://waterdata.usgs.gov/monitoring-location/02366500/#parameterCode=00065&period=P365D)

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are

controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031402031101 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031402031101 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The

datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

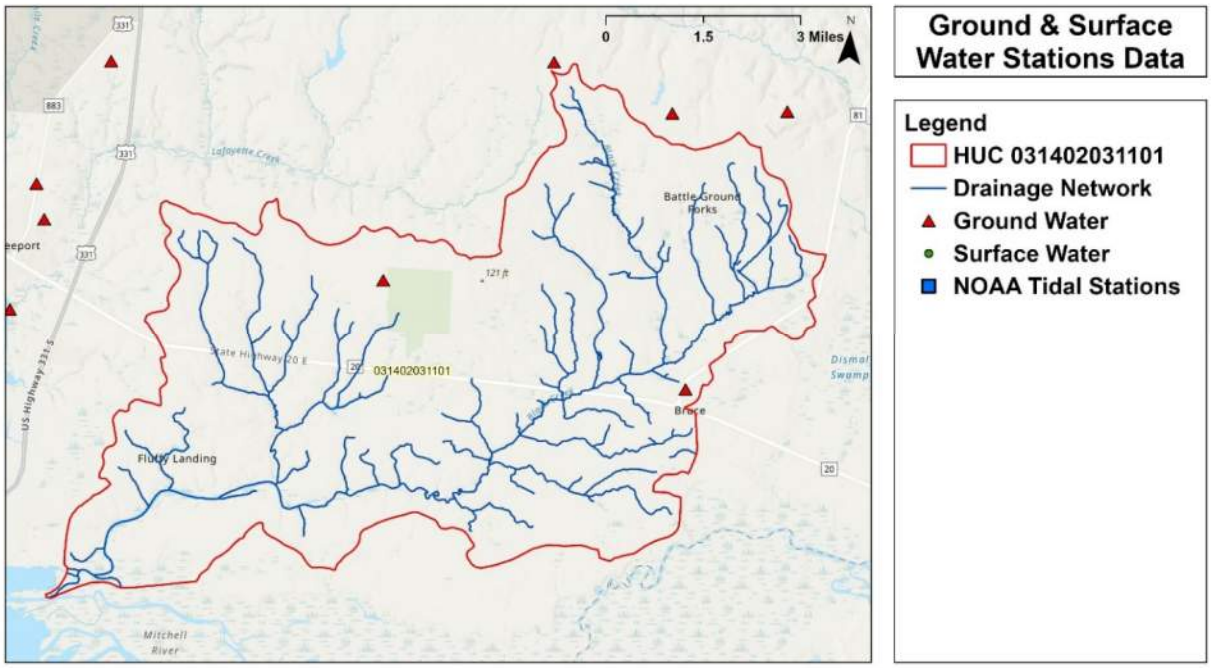

Figure 9. Ground and Surface Water Stations in the HUC 031402031101 sub-watershed, processed by FAU.
(Data Source: USEPA – National Hydrographic Dataset (NHD)

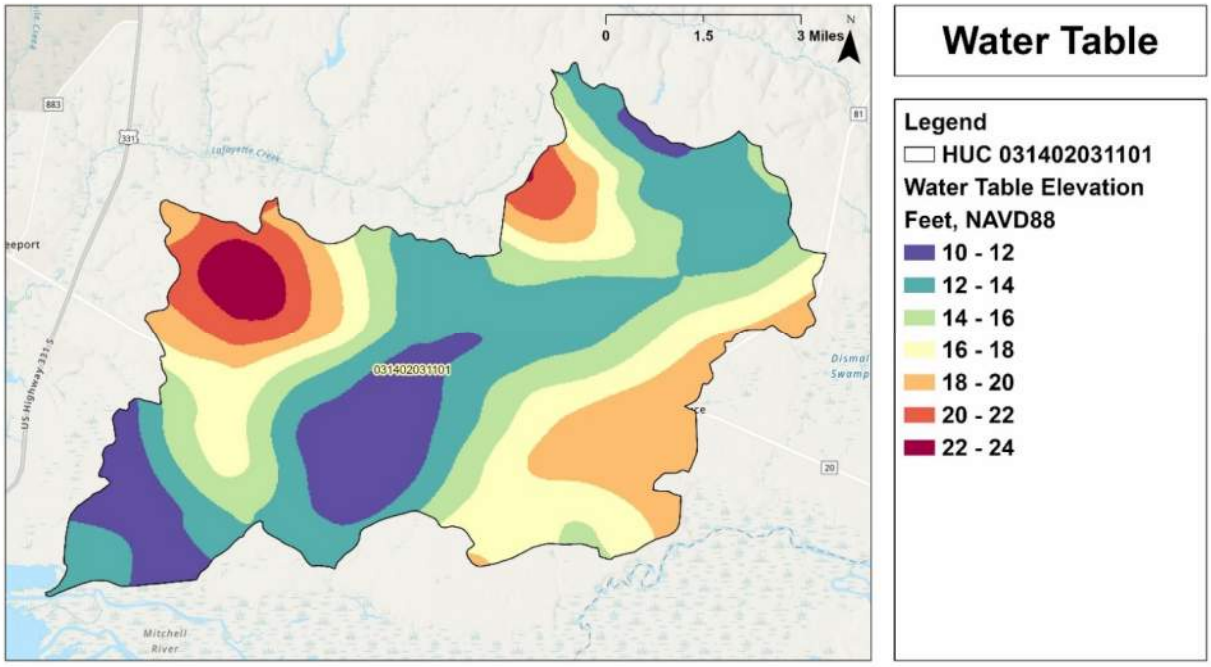

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031402031101 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU. (Data Source: USGS and NWFWMD)

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the average precipitation over Walton County for every month of the year between 2011 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches for the entire county.

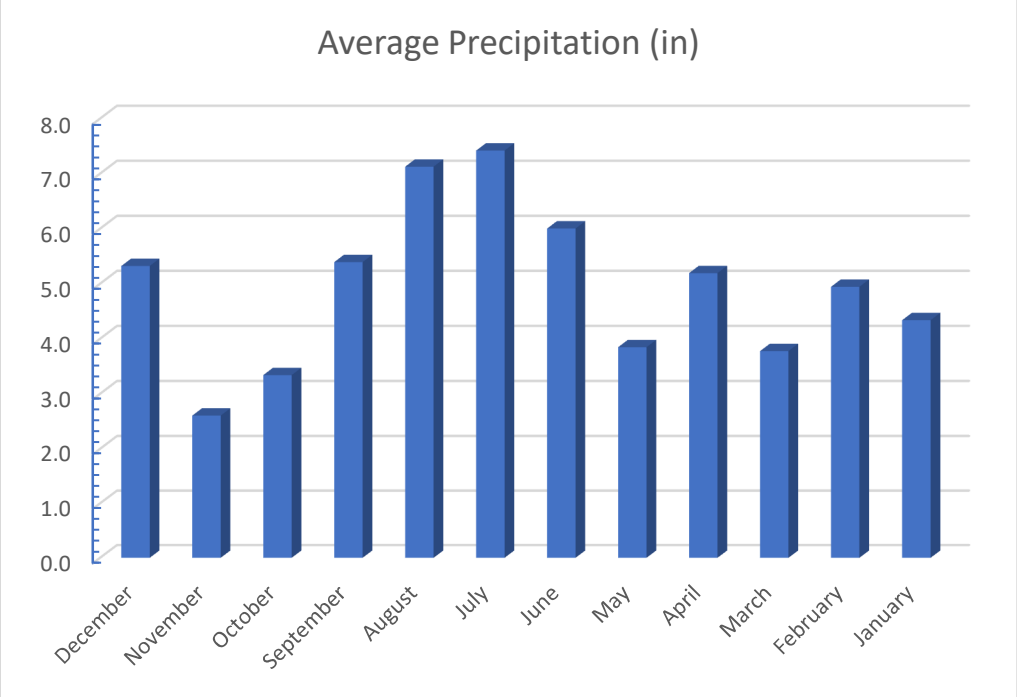

Figure 11. Monthly precipitation in Walton County, FL (2011-2023).
(Data Source: Florida Weather Data, available at https://data.usatoday.com/weather-data/walton-county/12131/1975-04-01/table/)

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is none NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

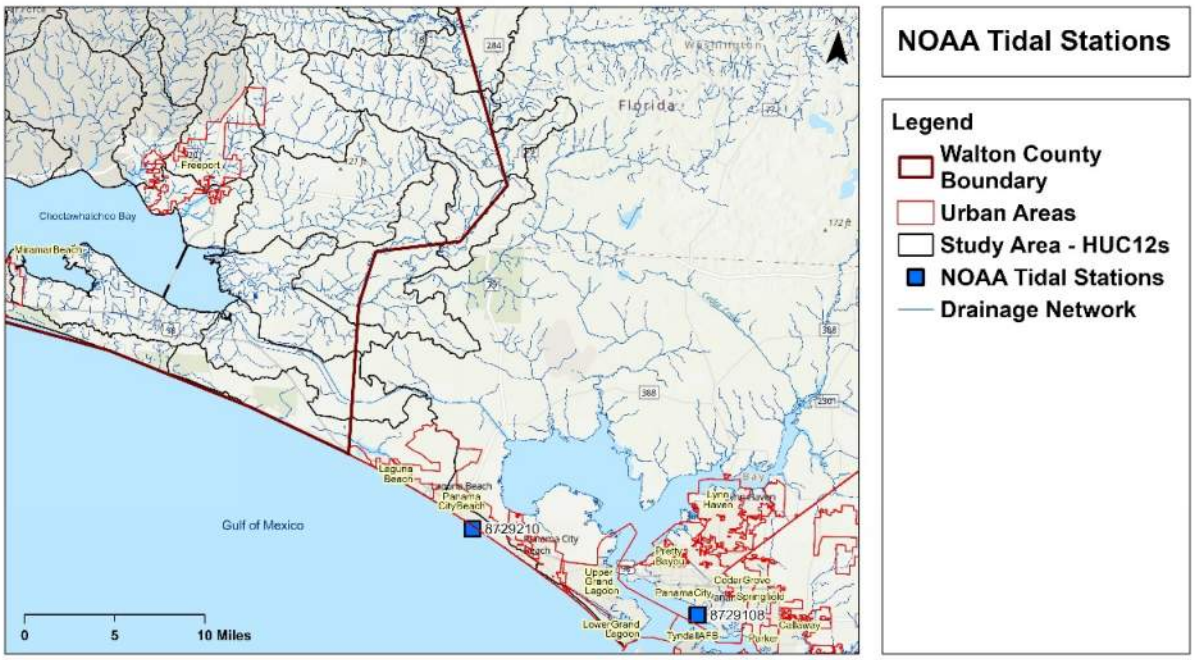

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.
(Data Source: USEPA – National Hydrographic Dataset (NHD) and NOAA's Tides)

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in Figure 13.

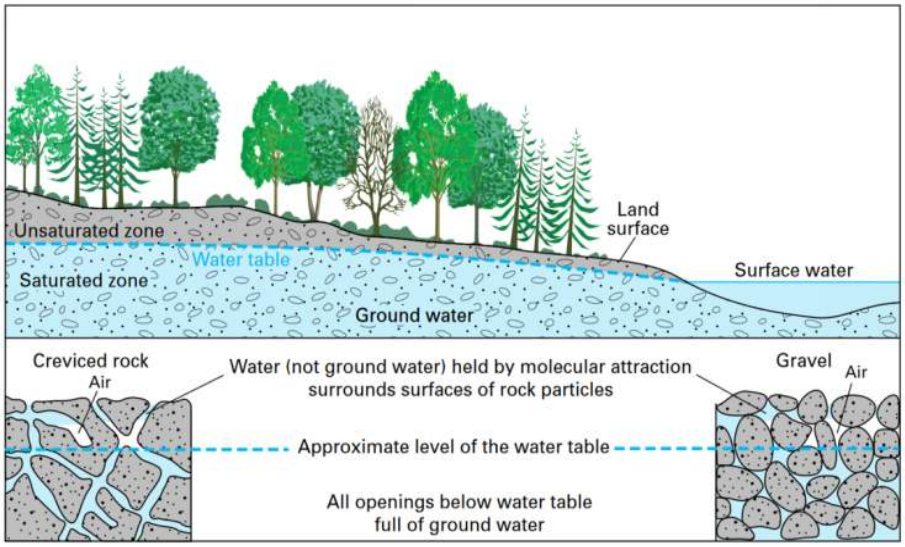

Figure 13. Zones where underground water exists.
(Source: USGS, 2020)

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in Figure 14. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

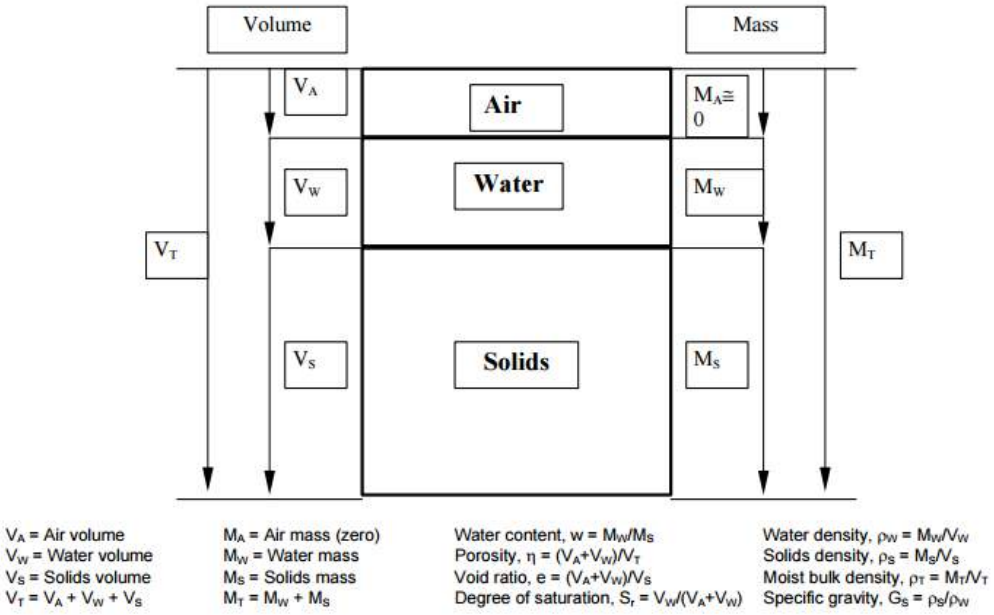

Figure 14. Saturated zone soil phase diagram and definitions.
(Source: Gregory et al., 1998.)

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

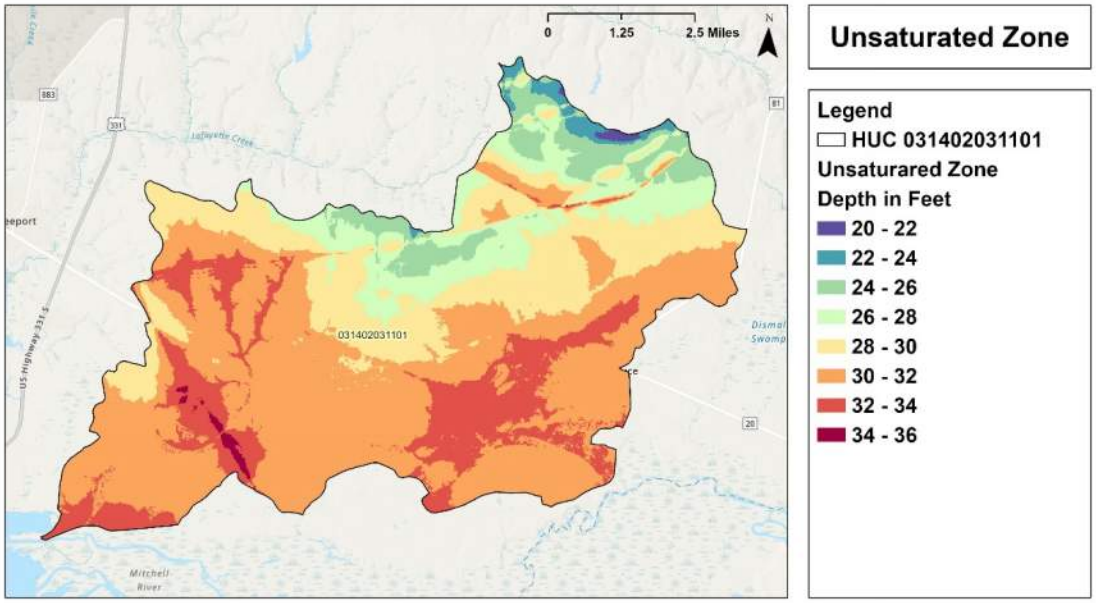

Figure 15. Unsaturated zone map for HUC 031402031101, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately favorable soil storage capacity, falling within the range of 24 to 34 feet of remaining capacity.

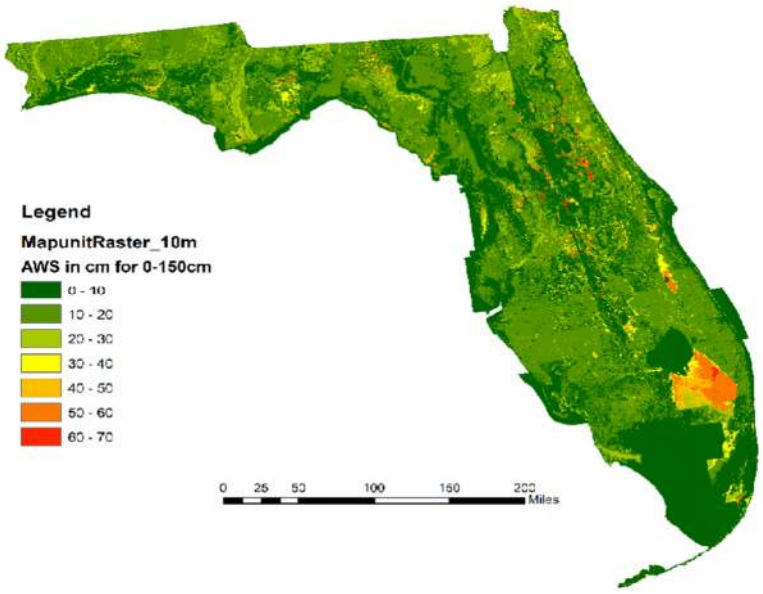

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.
(Data Source: USDA - SSURGO)

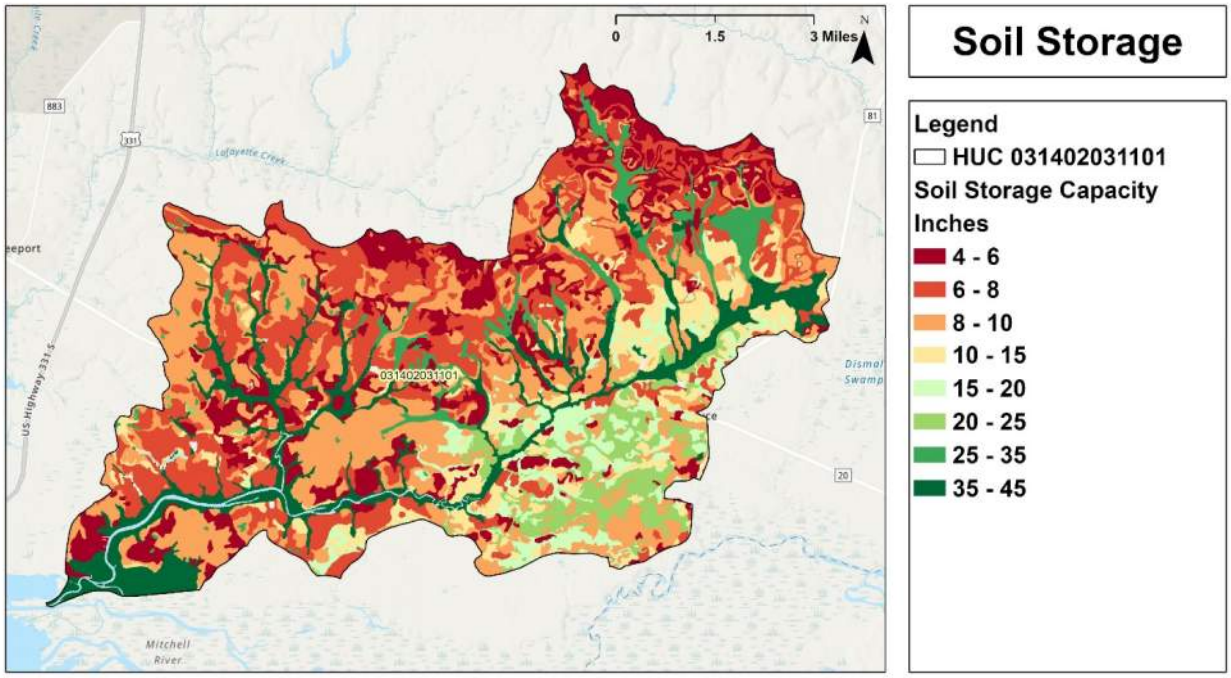

Figure 17. Water storage capacity of soil for the HUC 031402031101, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

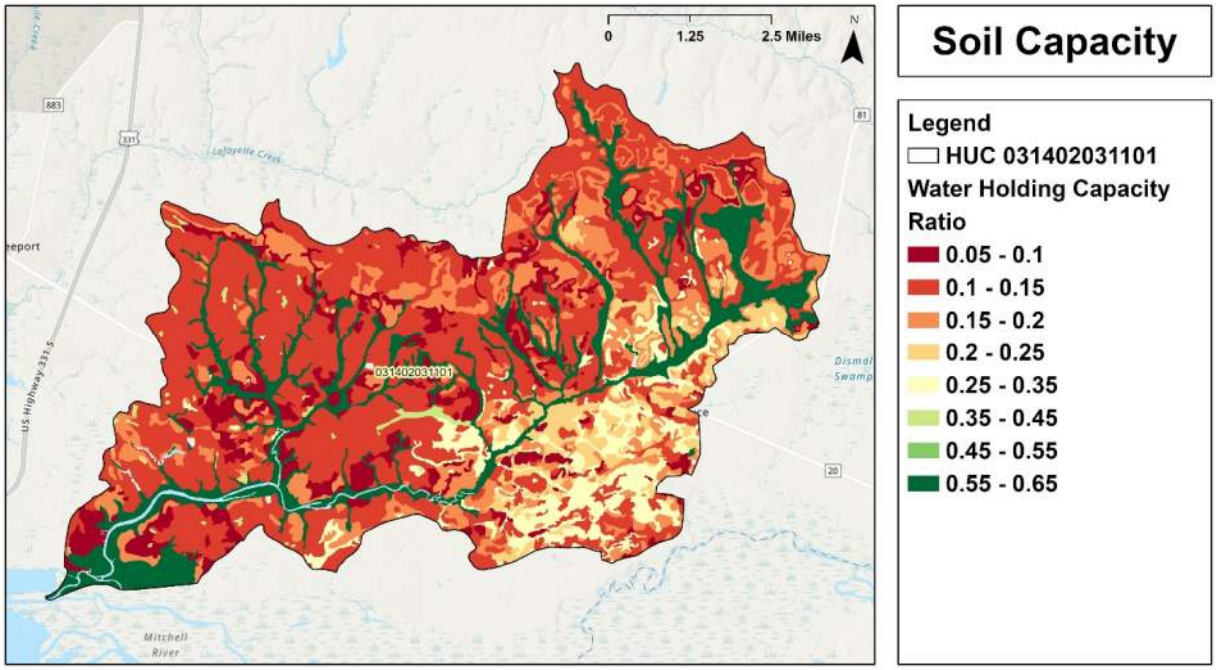

Figure 18. Water Holding Capacity (ratio) for the HUC 031402031101, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

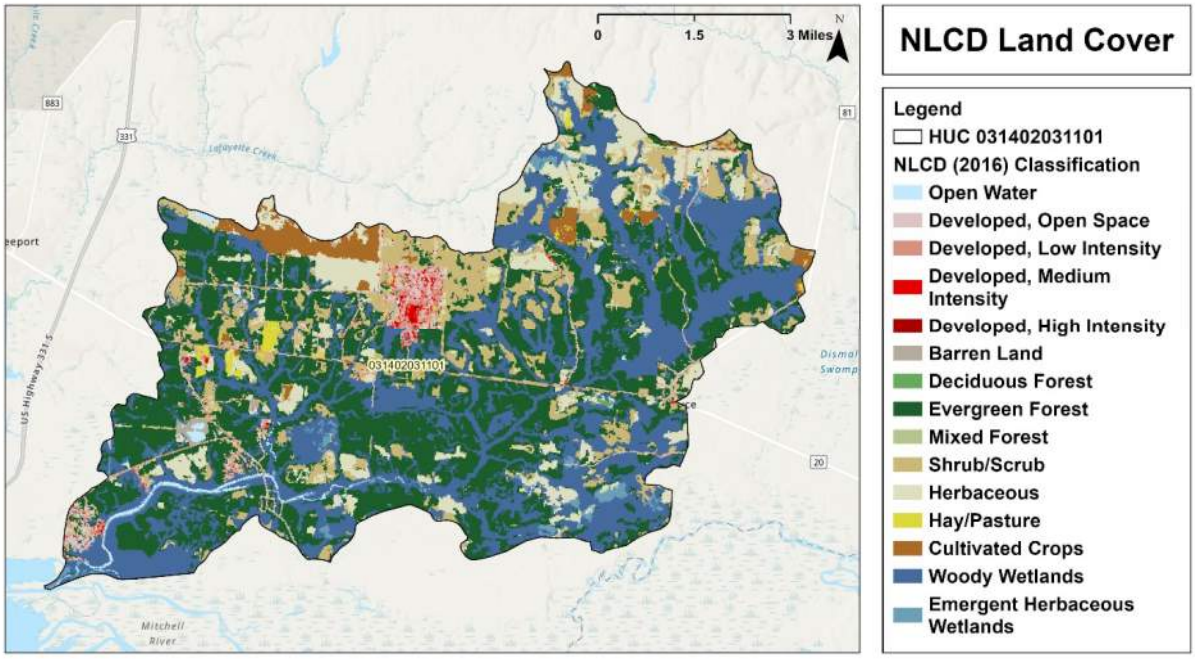

Figure 19. Land use in the HUC 031402031101 (from the NLCD 2016 database), processed by FAU.
(Source Data: NLCD, 2016)

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

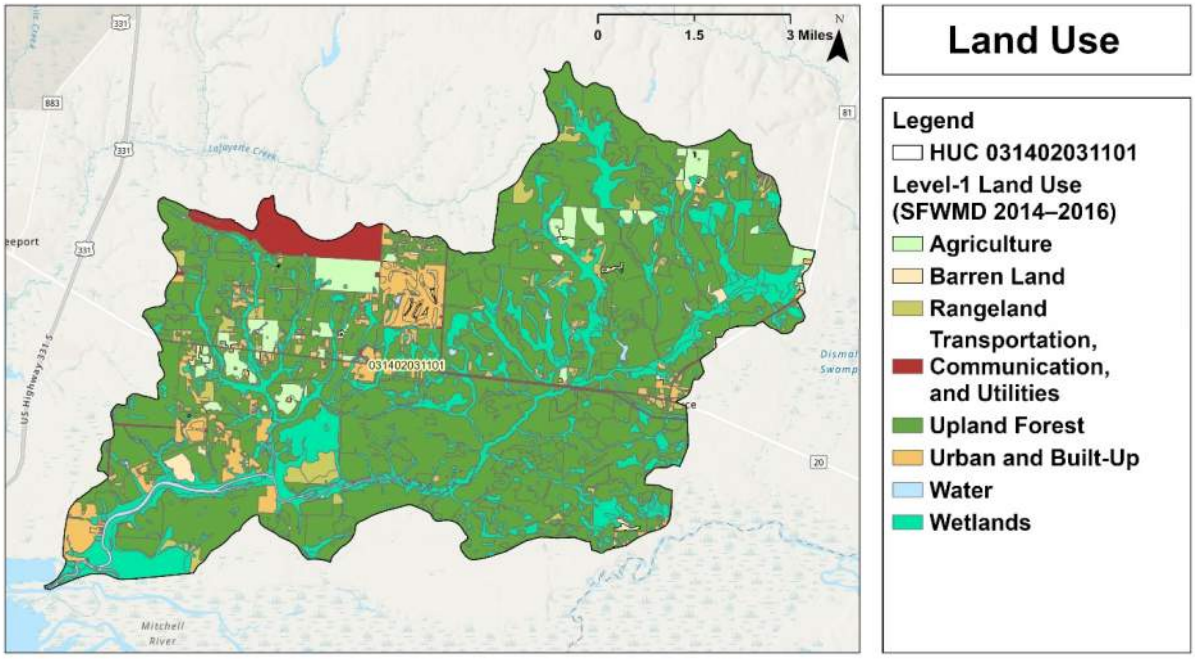

Figure 20. Land use in the HUC 031402031101 as processed by FAU.
(Source Data: 2023 Florida Geographic Data Library (FGDL) database))

In the HUC 031402031101 sub-watershed, the predominant land cover is upland forest, accounting for 53.51% of the area. Wetlands comes in second at 23.50%, followed by Transportation, Communication, and Utilities at 8.26%. Developed land constitutes a minor portion, with only 3.80% categorized as urban and built-up, as indicated in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031402031101 sub-watershed

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	1388.84	2.50%
Barren Land	190.16	0.34%
Rangeland	1472.21	2.65%
Transportation, Communication, and Utilities	4598.41	8.26%
Upland Forest	29773.44	53.51%
Urban and Built-Up	2114.08	3.80%
Water	3031.52	5.45%
Wetlands	13073.72	23.50%
Grand Total:	**55642.39**	**100.00%**

(Source Data: 2023 Florida Geographic Data Library (FGDL) database))

Table 4. Roughness and CN Values for Each Land Use Code

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

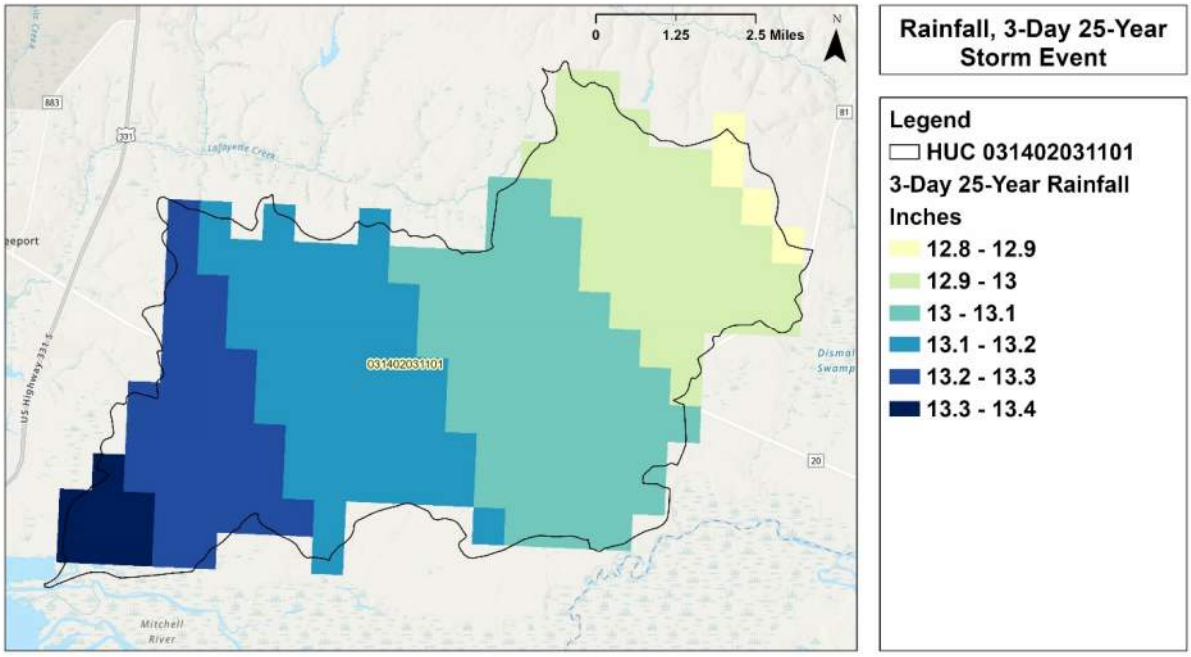

Figure 21. Rainfall distribution map across HUC 031402031101 sub-watershed, for 3-day 25-year storm event, processed by FAU.
(Source Data: NOAA Atlas 14 Database)

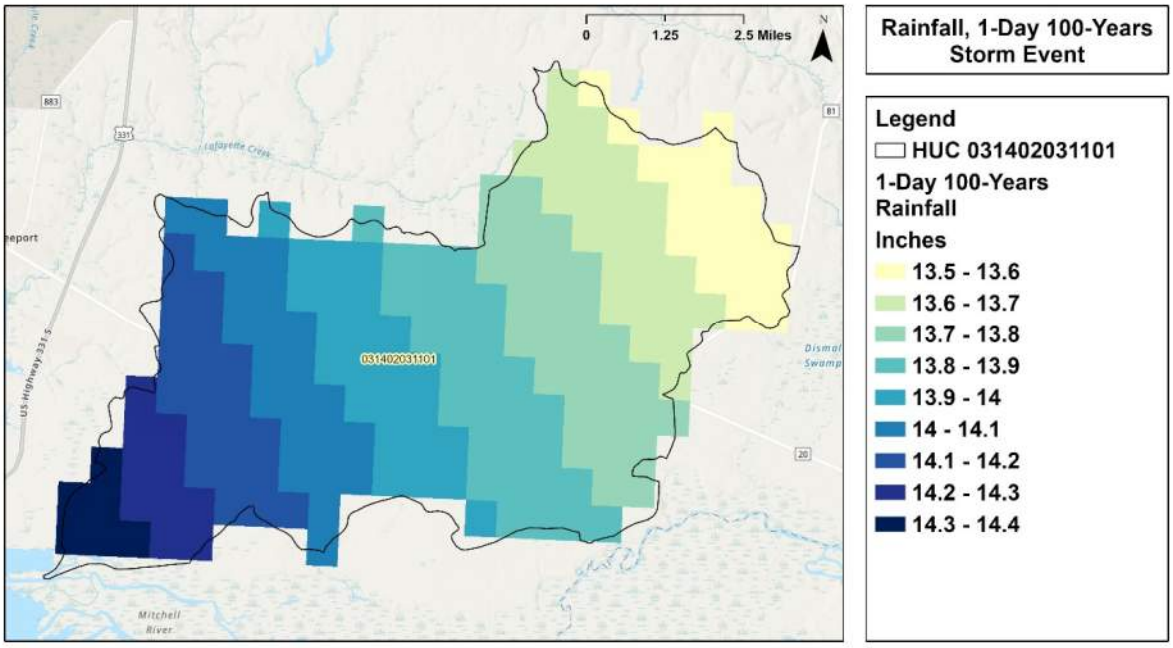

Figure 22. Rainfall distribution map across HUC 031402031101 sub-watershed, for 1-day 100-year storm event, processed by FAU.
(Source Data: NOAA Atlas 14 Database)

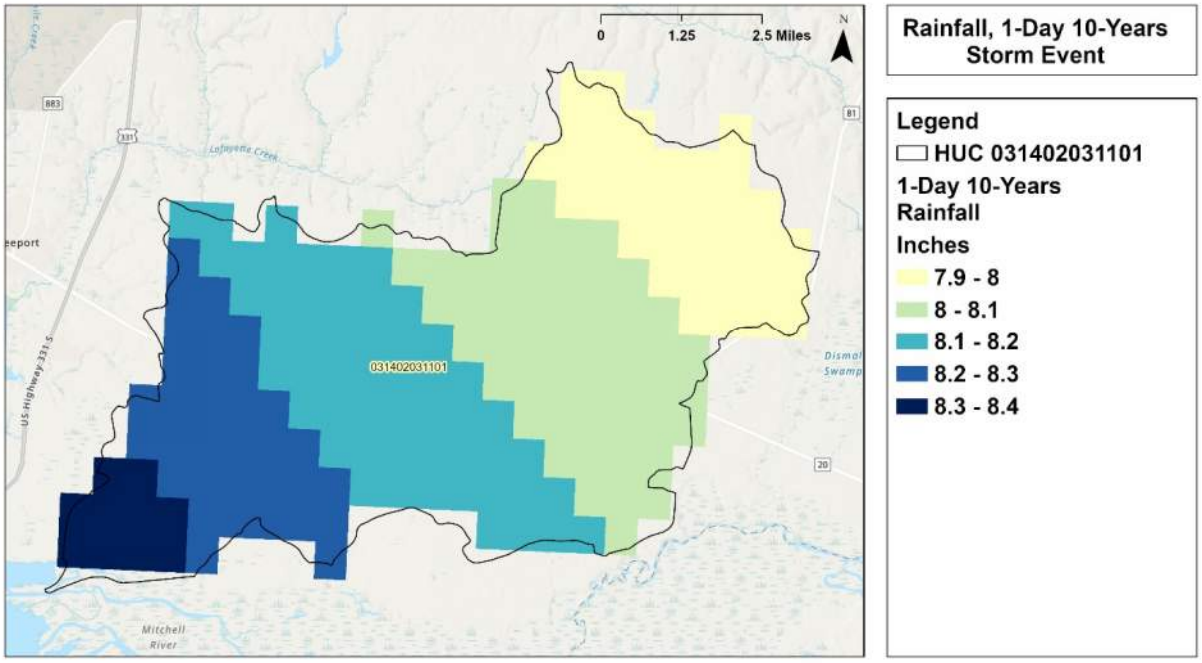

Figure 23. Rainfall distribution map across HUC 031402031101 sub-watershed, for 1-day 10-year storm event, processed by FAU.

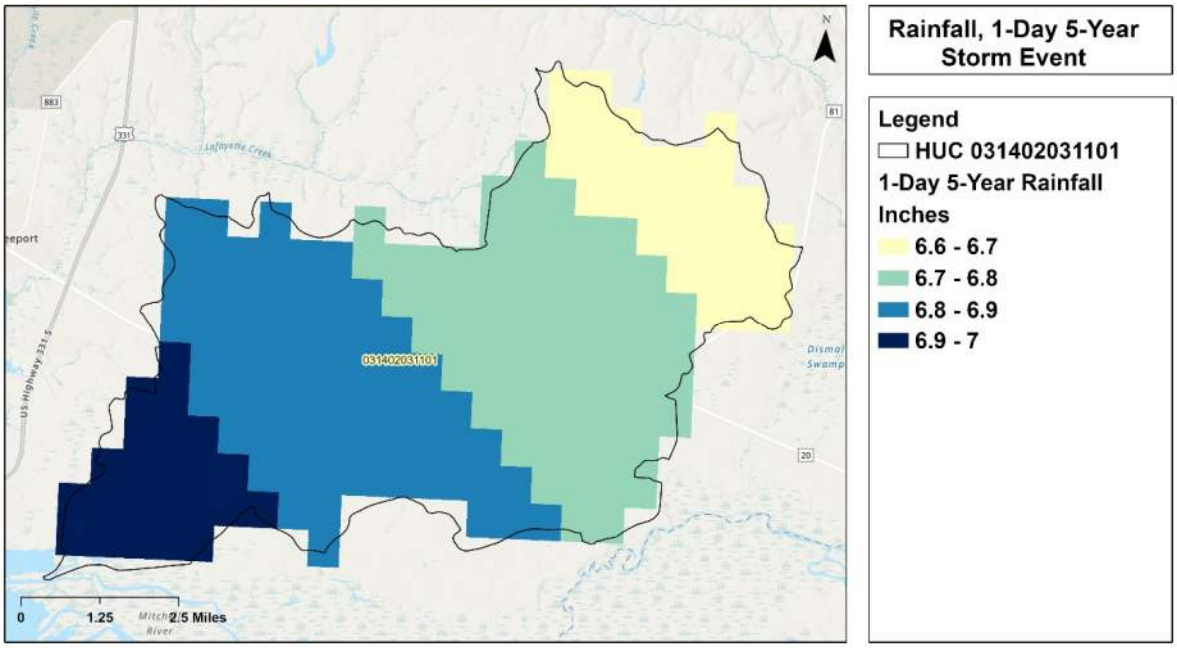

Figure 24. Rainfall distribution map across HUC 031402031101 sub-watershed, for 1-day 5-year storm event, processed by FAU.
(Source Data: NOAA Atlas 14 Database)

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

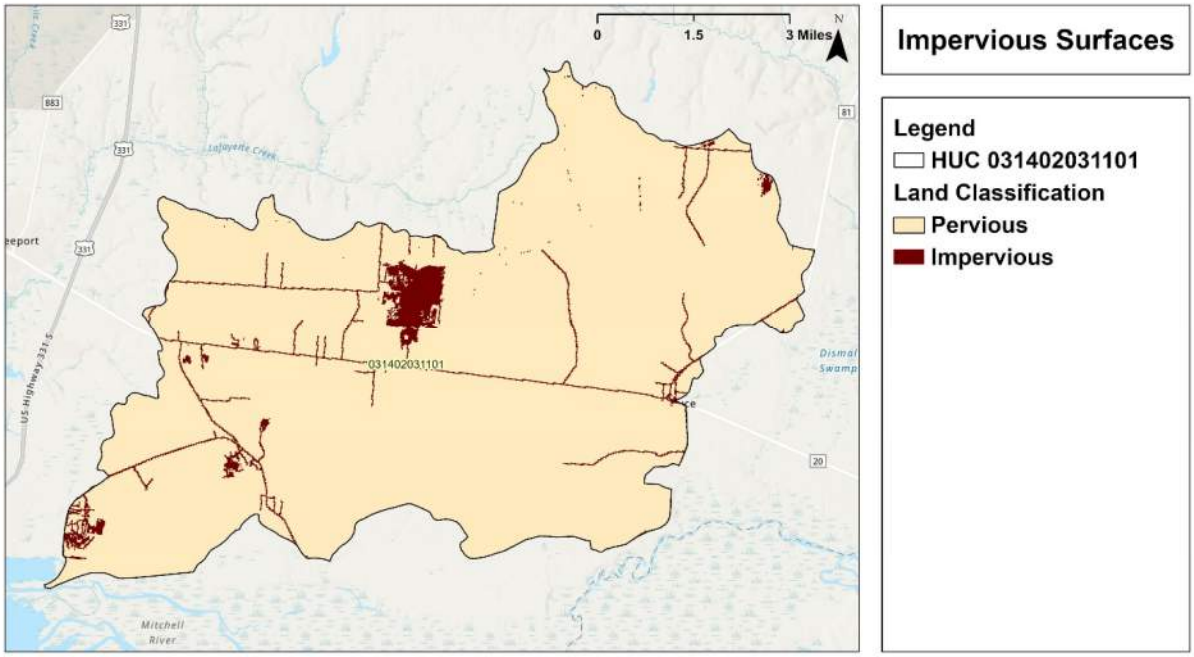

Figure 25. Impervious area map for the HUC 031402031101 sub-watershed, processed by FAU. (Source Data: NLCD, 2016)

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

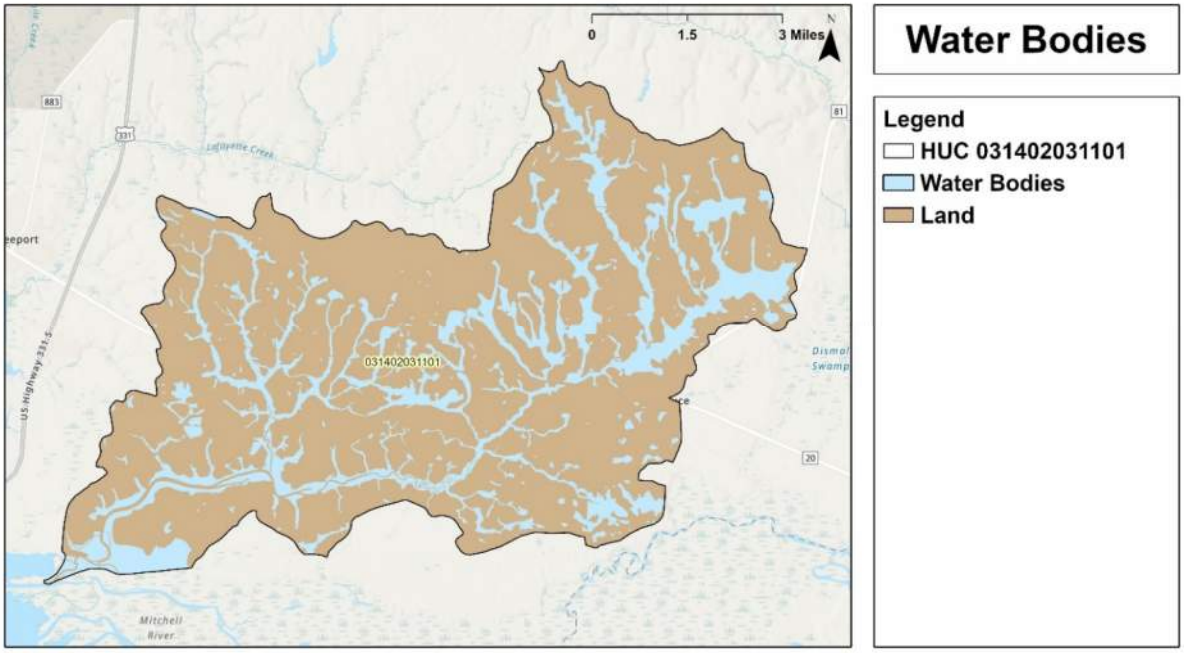

Figure 26. Water bodies map for the HUC 031402031101 sub-watershed, processed by FAU. (Source Data: USEPA – National Hydrographic Dataset (NHD))

1.10. Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

(Source: US Census Bureau 2020, and Zip-codes.com)

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.
- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

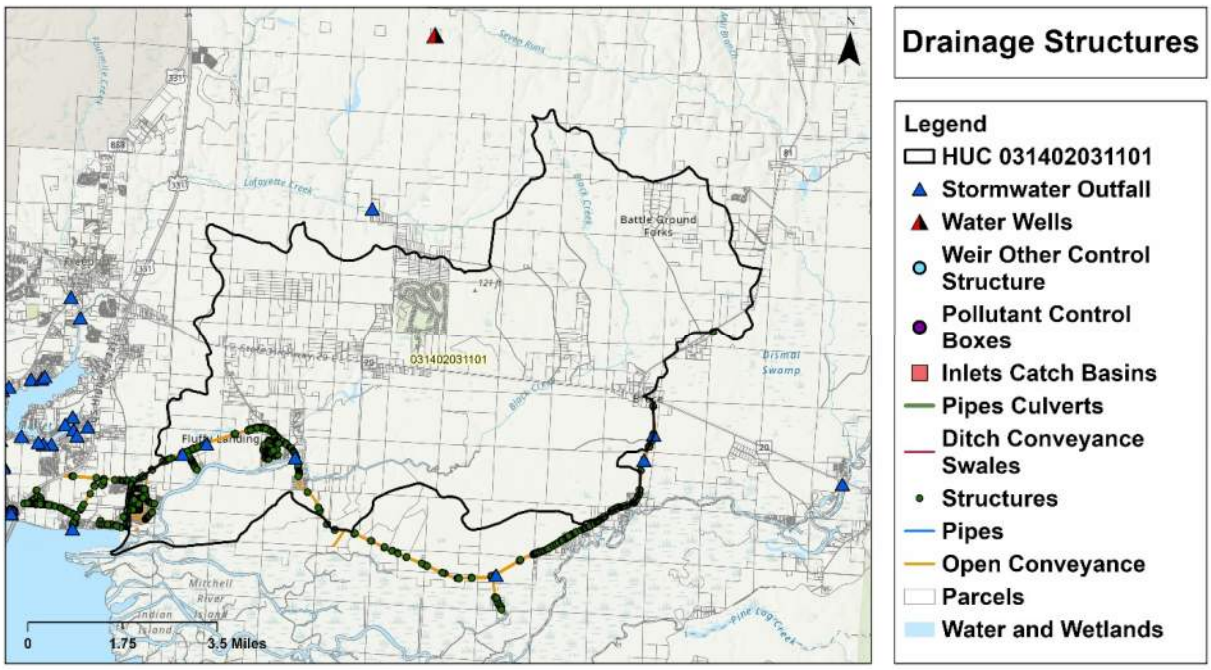

Figure 27. Stormwater Infrastructure for the HUC 031402031101. Processed by FAU.
(Source Data: Walton County Storm Asset Inventory and Stormwater Inventory)

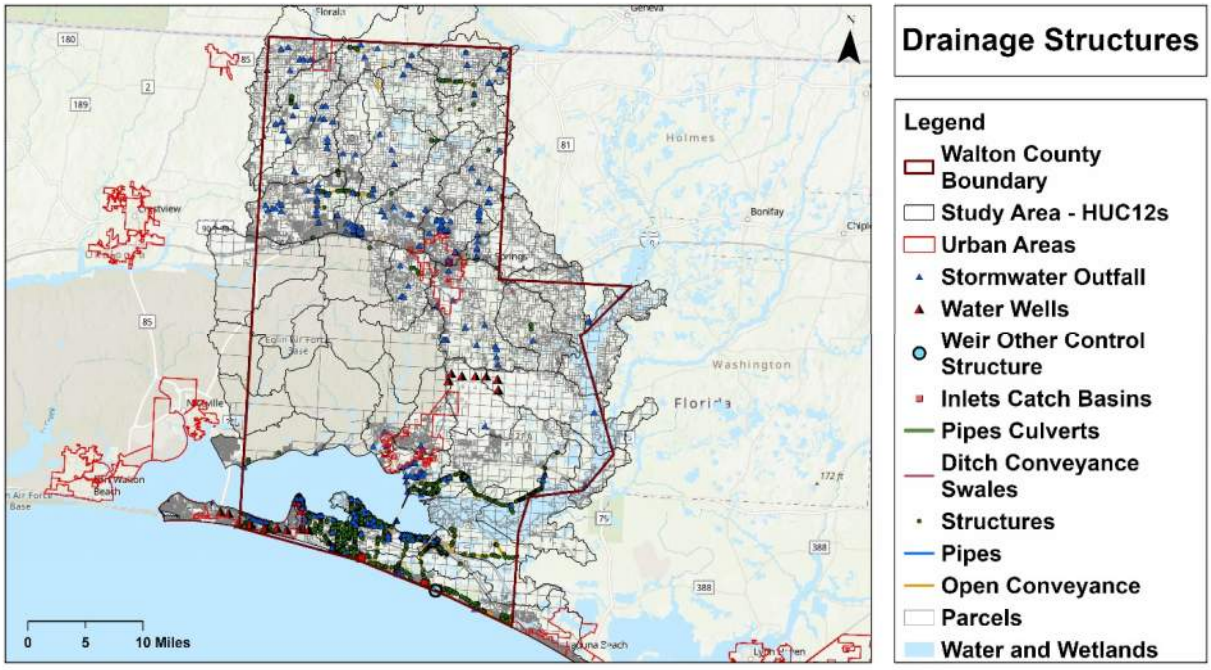

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.
(Source Data: Walton County Storm Asset Inventory and Stormwater Inventory)

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in Table 5. The data can be used to model the impacts

of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020)

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1, analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031402031101 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

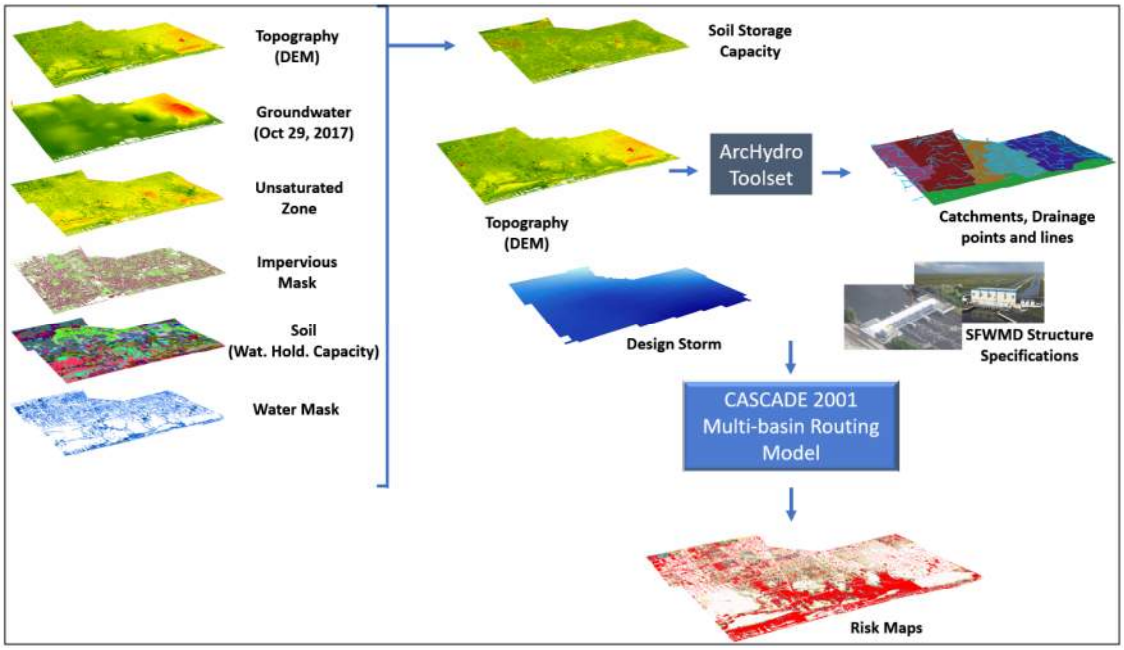

Figure 29. Screening tool methodology for creating flood risk maps

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)

= 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (Figure 30), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

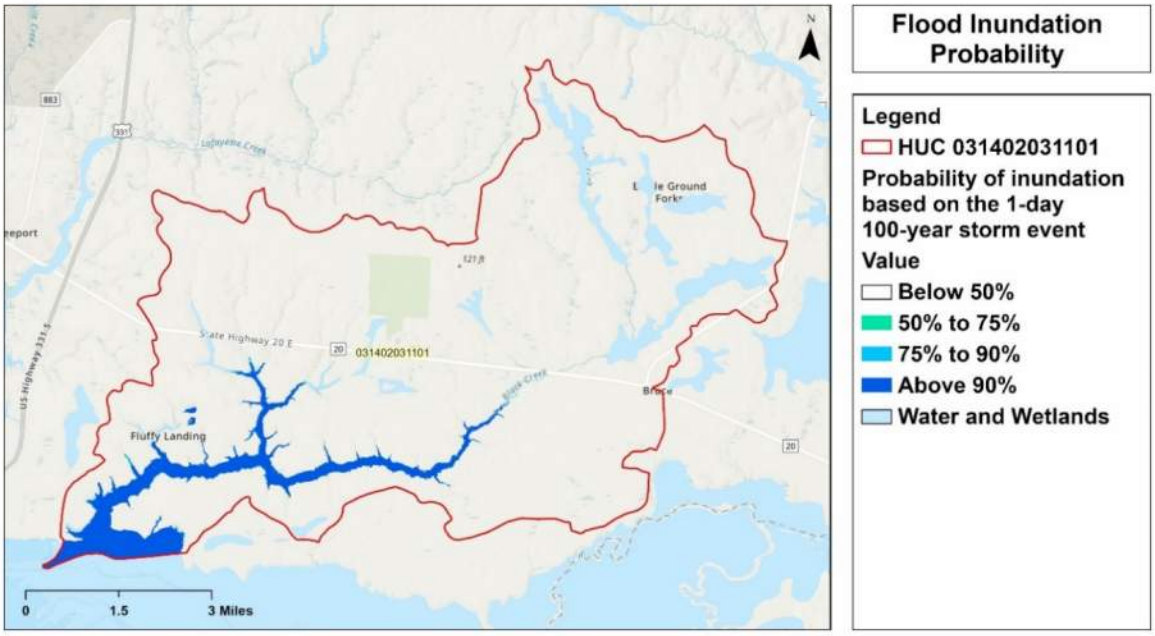

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031402031101, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation

and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 2.5 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations,

Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Future Challenges of Sea Level Rise and Climate Change

Global observations from satellites and long-term data collection have made it possible to document and analyze patterns in the Earth's climate. Scientific analysis of the impact of these changes has helped to improve the understanding of future flood hazard driving forces and long-term impacts on human activities and watershed master planning (http://www.research.noaa.gov/climate/t_observing.html). Examples of impacts are rising global average air and ocean temperatures, increased and earlier snow and ice melt, shorter subtropical rainy seasons, shifted seasons, sea level rise and greater variations in temperature and precipitation (IPCC, 2013; Freas et al., 2008; Marshall et al., 2004; Bloetscher et al., 2010). Marshall et al. (2004) specifically focused on the Florida peninsula to predict changes in rainfall and warmer temperatures but interspersed lower low temperatures due to the potential loss of wetlands.

Future changes in climate will add to the existing impacts, at a time when the population of the state is expected to nearly double by 2030. Additional research and high-resolution climate modeling for the Florida peninsula and local jurisdictions is needed to help guide long-term plans like WMPs. Rainfall appears to be decreasing and temperatures rising (see **Error! Reference source not found.**).

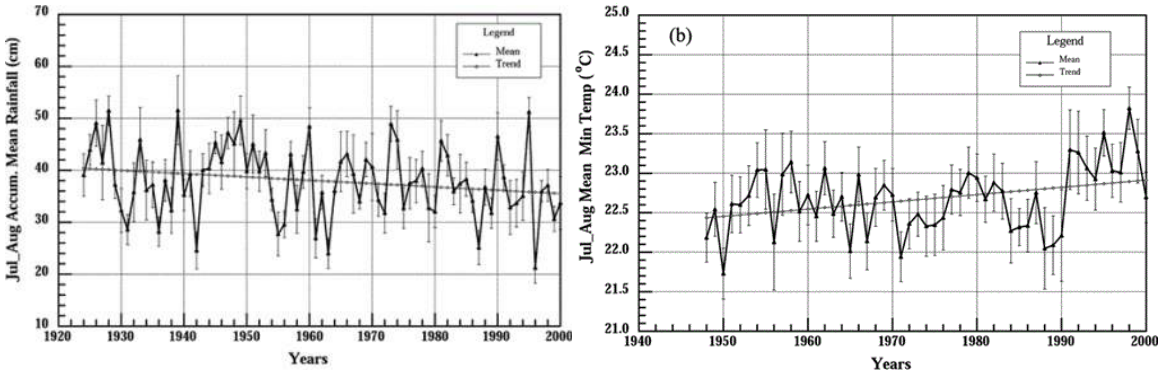

Figure 31. Change in average rainfall and change in average temp 1924 to 2000.
Note the reversed trend, which means groundwater input variability is lessened.
(Source: Marshall et al., 2004)

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3 feet. Accompanying these drivers are potential changes in storm frequency and intensity, desertification, population migration, ocean acidification and coastal flooding (IPCC, 2007), exacerbated by the land cover and land use changes, which are substantially impacted by the fluxes, timing and quality of precipitation (Adrians et al., 2003; Scanlon et al., 2005; Marshall et al., 2004; Salmun and Molod, 2006), and leading to changes in the timing of peak flows and volumes (Richey and Costa-Cabral, 2006).

The results of these climatic changes are likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to

the ocean, c) increasingly An outcome of these climatic patterns is that during the past 140 years, an increase in sea levels has been observed (Bloetscher, 2012), a worrying pattern since sea level rise is a permanent phenomenon, that can be catastrophic to low lying areas in the long-term. The question is how much and how soon? Various studies (Bindoff et al., 2007; Domingues et al., 2008; Edwards, 2007; Gregory, 2008; Vermeer and Rahmstorf, 2009; Jevrejeva, Moore and Grinsted, 2010; Bloetscher, 2010, 2011; IPCC, 2007; Heimlich et al., 2009) indicate large uncertainty in projections of sea level rise by 2100. Gregory et al. (2012) note that during the last two decades, the global rate of sea level rise has been larger than the 20th-century time-mean, and Church et al. (2011) suggested that the cause was increased rates of thermal expansion, glacier mass loss, and ice discharge from icesheets. Gregory et al. (2012) suggested that there may also be increasing contributions to global sea level rise from the effects of groundwater depletion, reservoir impoundment, and loss of storage capacity in surface waters due to siltation. Measurements of Florida's east coast (Maul, 2008) show an average rate of sea level rise of 2.27 ± 0.04 mm per year from 1915 to 1992 based on tide gauge readings. Analyzing the tidal gauge readings for Florida shows that:

1. Florida average sea level rise is 2.10 ± 0.49 mm/yr
2. All but one location is within the 95% confidence limit range (the exception is Panama City where there is evidence of submergence and other land-based issues)
3. None of the Florida sea level rise rates differ statistically
4. Average global sea level rise for 1920-2000 was 2.0 mm/yr – within 95% confidence limit for Florida locations

From 1929 to 1992, over eight inches of sea, with another 6 inches added since 1992, which is already having significant impacts on coastal communities where population growth has increased the need for improved flood management strategies (Bloetscher, 2008; Parkinson, 2010; Zhang et al., 2011, 2011a; NFIP, 2011; Schmidt et al., 2011; Warner et al., 2012).

As a result, the SFRCCC (2015) adopted USACE's methodology to derive scenarios of sea level change intermediate to high rates of sea level rise for years 2030 (3" to 7") and 2060 (9" to 24") as the consensus projection to guide future planning. The path keeps increasing – now 14 inches since 1929 (**Error! Reference source not found.**) caused by thermal expansion of the ocean and melting ice caps (Jevrejeva et al., 2010; Vermeer and Rahmstorf, 2009). Sea level rise is a major concern in Florida, including Walton County, since the majority of the state's population live on the coast, involving most major commercial, residential, and economic enterprises. **Error! Reference source not found.** demonstrate the estimated sea level change for Panama City, considering the predictions of NOAA 2017. For NOAA high scenario SLR change scenario, the estimated level change is higher than 8 ft., while for the intermediate and low scenarios are about 3.9 feet and 1.7 feet respectively.

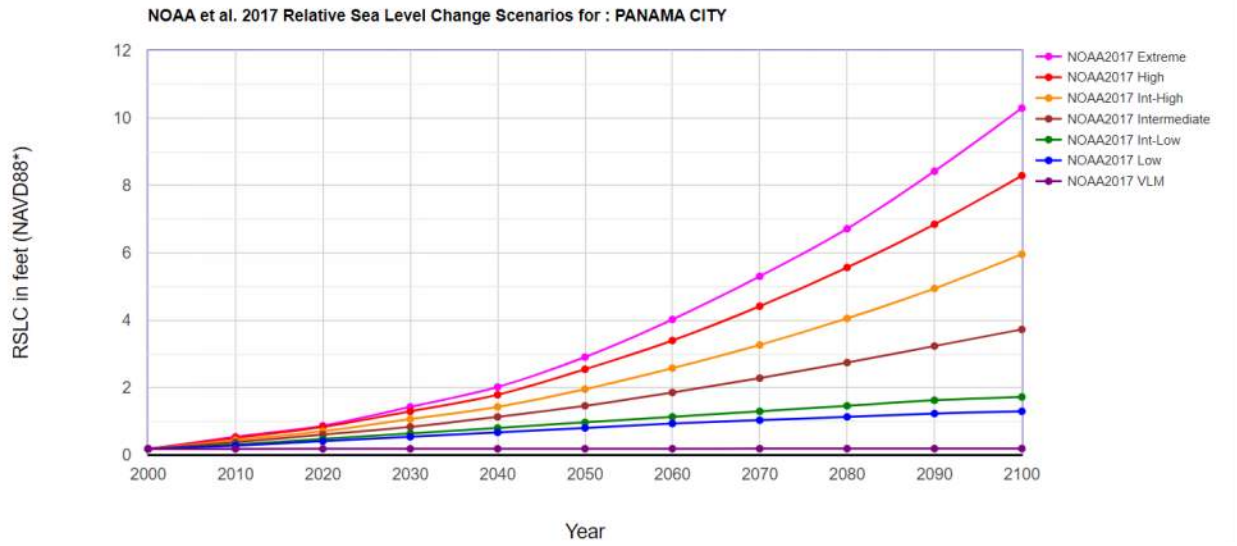

Figure 32. Relative Sea Level Change Scenarios for gauge 8729108, Panama City, FL. (Source: NOAA, 2017 available at https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html)

NOAA (2017) outlines five scenarios for sea level rise. The NFIP proposes the use of the intermediate high projection, which is 1.2 meters or 4 ft globally from current sea level elevations (**Error! Reference source not found.**).

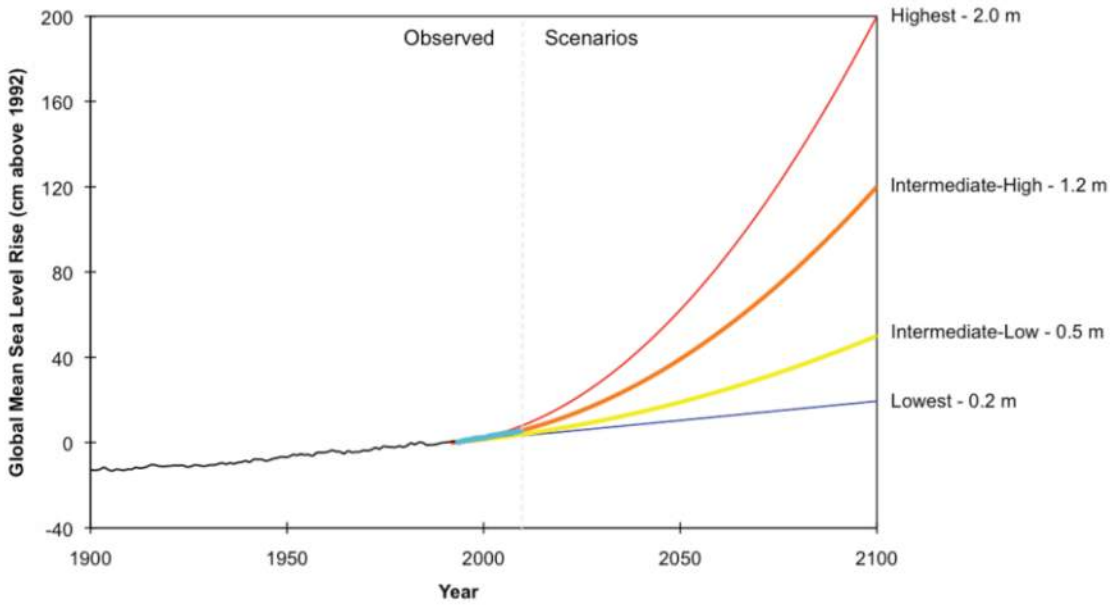

Figure 33. Graphic of global sea level rise projections from NOAA (2017). (Source: NOAA, 2017 available at https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf)

As sea level rises, access to roads, bridges, rail, and transit could be at risk of flooding, causing the effects of sea level rise to spread indirectly throughout the entire transportation network, affecting the overall system performance. For example, the flooding of a critical road or facility access can cause a shifting of traffic flow causing congested conditions in other roadways that are not actually flooded. Since the roadway network would be unable to carry the traffic demand, the system would experience operational failure; as a result, causing travel times and delays. Moreover, the inundation of a critical access could cause transportation connectivity problems to essential infrastructure like ports or airports. Transportation infrastructure relies on the effectiveness of flood control and stormwater drainage systems for the transportation corridors. Road integrity relies on adequate drainage. The increased risk of severe flooding in Florida's low-lying terrain can adversely affect transportation infrastructure along the coastline; roads can be inundated, and roadway beds can be damaged. Sea level rise will cause increased water Table levels (FDOT, 2012), as regional water tables cannot exist naturally below mean high tide (2 feet in Florida). Adding 3 feet of sea level rise on top of groundwater would compound the risk of flooding in low-lying areas. Road bases below 5 feet NVGD would become saturated under this scenario, likely causing premature base failure. As soil storage capacity is diminished due to rising groundwater elevations associated with sea level rise, the potential for more frequently flooded roadways would likely damage pavements (FDOT, 2012). Hence sea level rise must be accounted for in WMPs in coastal areas. To allow flexibility in the analysis due to the range of increases within the different time periods, an approach that uses incremental increases of 1, 2, and 3 feet of sea level rise is suggested for modeling. The increments can work as threshold values in planning considerations in terms of allowing planners the ability to know ahead of time where the next set of vulnerable areas will be, to allow for a proactive response approach that can be matched to the observed future rates. Sea level rise is a major concern since nearly half the US population lives within 50 miles of the coast, involving most major commercial, residential, and economic enterprises. The effects of 5 ft sea level rise, King tide, and 1-day 100-year storm event are shown in Figure 34.

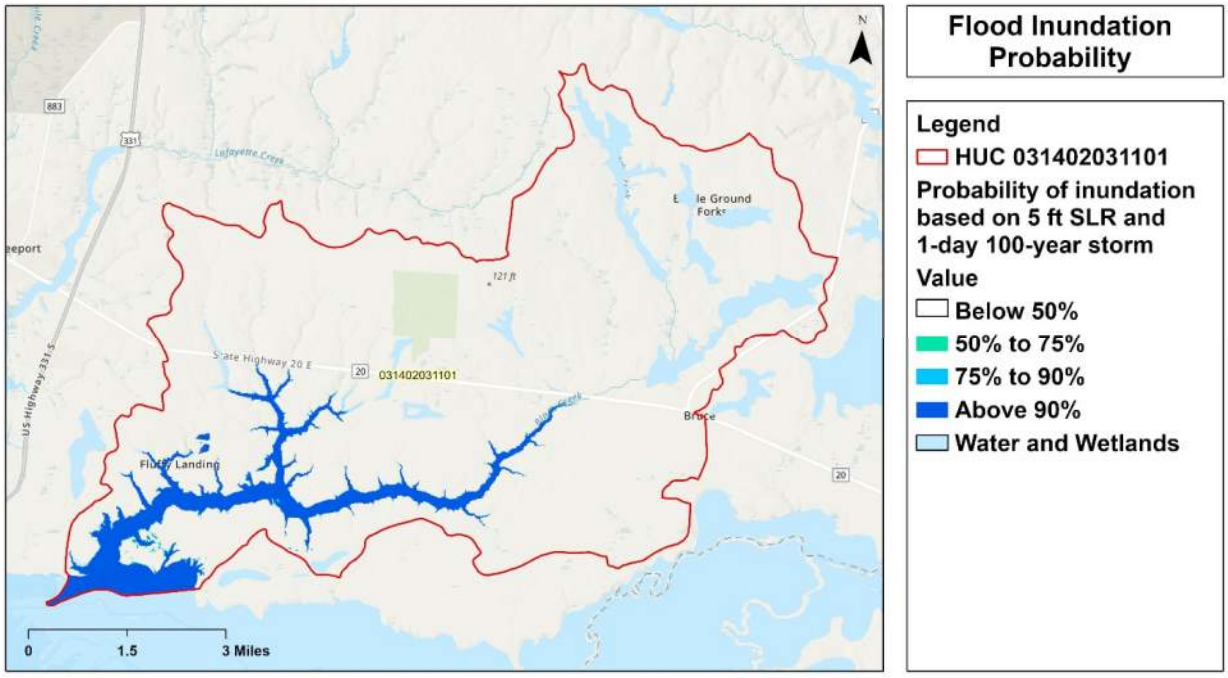

Figure 34. Flood Inundation Probability for a Sea level rise of 5 ft + 1-day 100-year storm event for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Dark blue is area under 5 ft NAVD8

2.4 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. **3-day 25-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 35)
2. **1-day 100-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 36)
3. **1-day 10-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 37)
4. **1-day 5-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 38)
5. **Sea level rise of 1 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 39)
6. **Sea level rise of 1 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations storm (Figure 40)

7. **Sea level rise of 1 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 41)
8. **Sea level rise of 1 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 42)
9. **Sea level rise of 2 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 43)
10. **Sea level rise of 2 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 44)
11. **Sea level rise of 2 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 45)
12. **Sea level rise of 2 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 46)
13. **Sea level rise of 3 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 47)
14. **Sea level rise of 3 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 48)
15. **Sea level rise of 3 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 49)
16. **Sea level rise of 3 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 50)
17. **Sea level rise of 4 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 51)
18. **Sea level rise of 4 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 52)
19. **Sea level rise of 4 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 53)

20. **Sea level rise of 4 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 54)
21. **Sea level rise of 5 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 55)
22. **Sea level rise of 5 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 56)
23. **Sea level rise of 5 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 57)
24. **Sea level rise of 5 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 58)

In all scenarios, a considerable amount of flooding is noted at the river entrance to the HUC, extending to the wetland areas. As this basin connects to the ocean though Choctawhatchee Bay, SLR scenarios plays an important hole, implying a considered growth as the projected scenario of rising tides rises.

The design storm simulation determined that approximately 4.9% of the HUC total area or 2.53 mi² has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 5% of the HUC's total area, or 2.58 mi² would be expected to be inundated during a 1-day 100-year design storm. Approximately 4.7% of the HUC's total area, or 2.43 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 4.6% of the HUC's total area, or 2.38 mi², would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031402031101 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	49.45	2.53	95.1%	4.9%
1-day 100-year	49.40	2.58	95.0%	5.0%
1-day 10-year	49.55	2.43	95.3%	4.7%
1-day 5-year	49.60	2.38	95.4%	4.6%

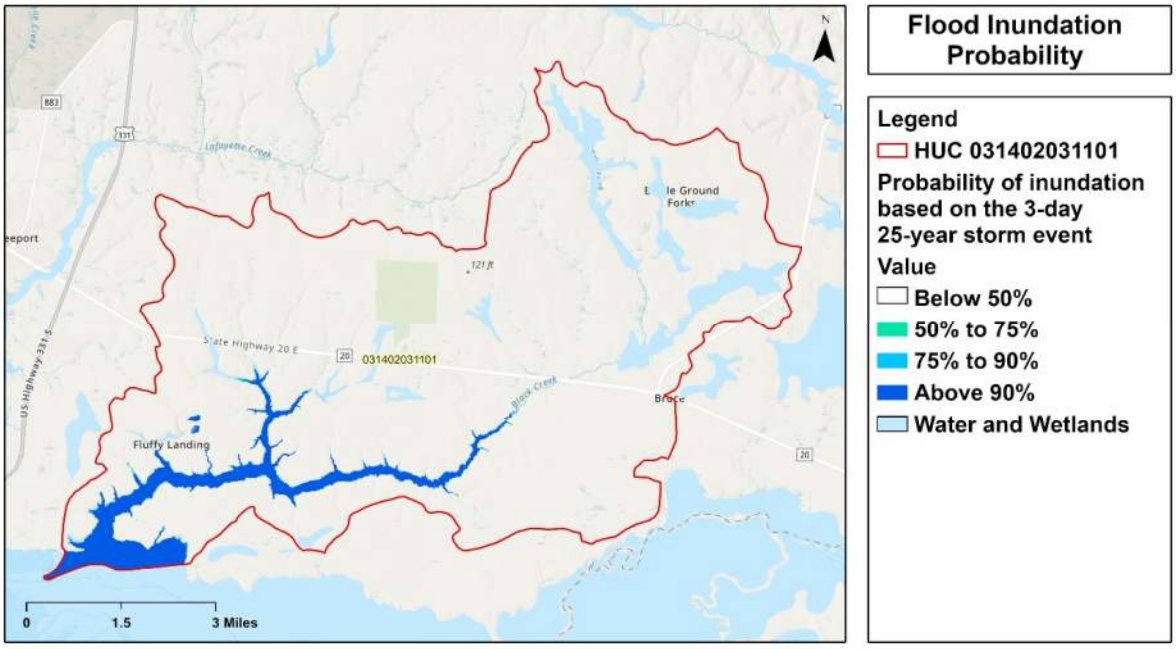

Figure 35. 3-day 25-year storm event for HUC 031402031101 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

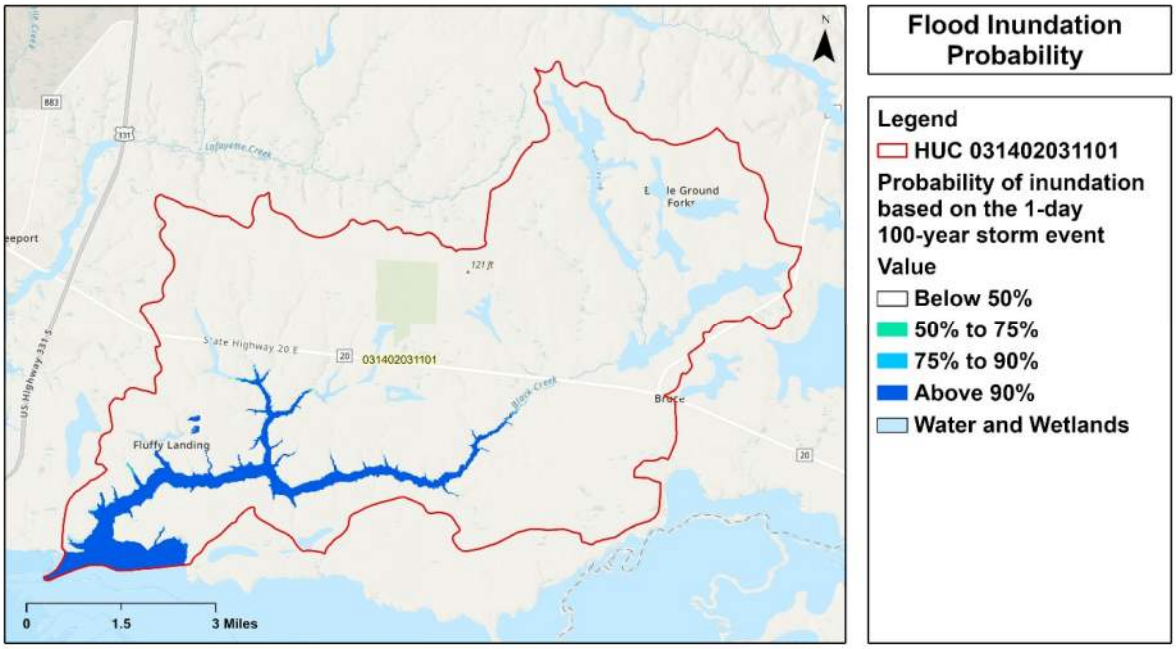

Figure 36. 1-day 100-year storm event for HUC 031402031101 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

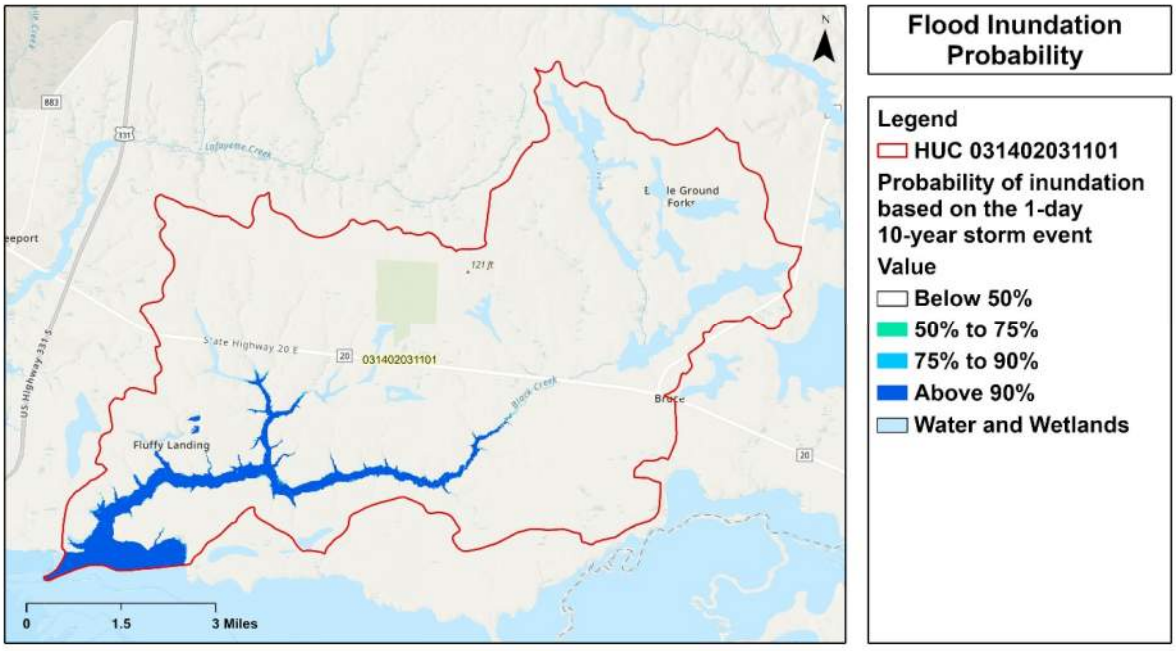

Figure 37. 1-day 10-year storm event for HUC 031402031101 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

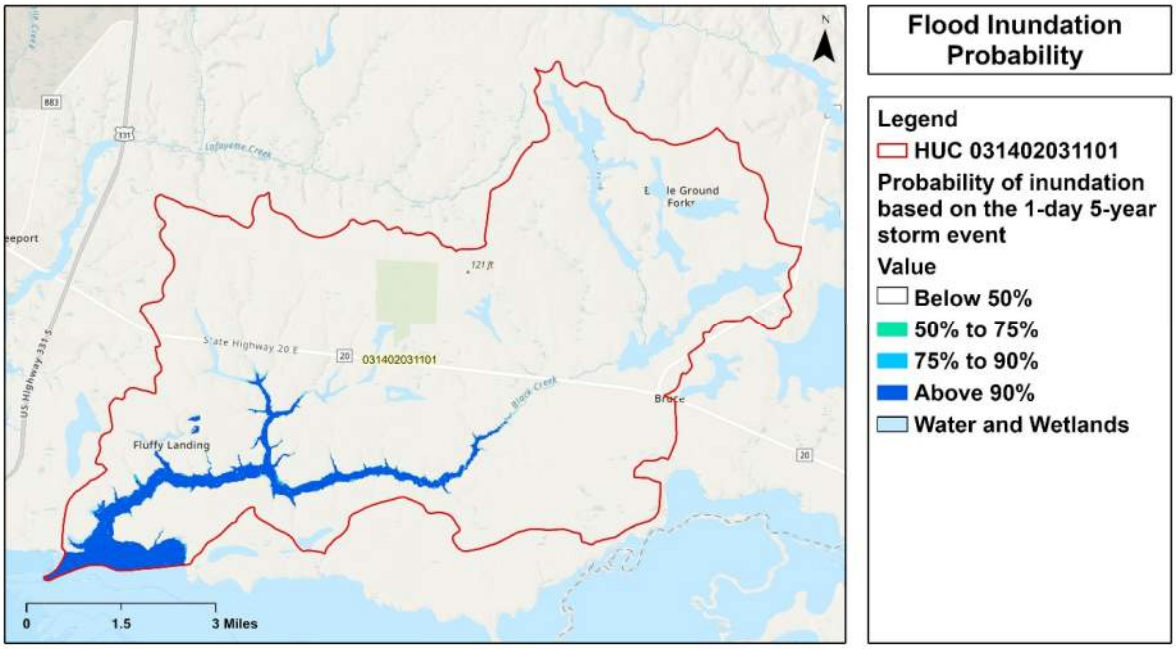

Figure 38. 1-day 5-year storm event for HUC 031402031101 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

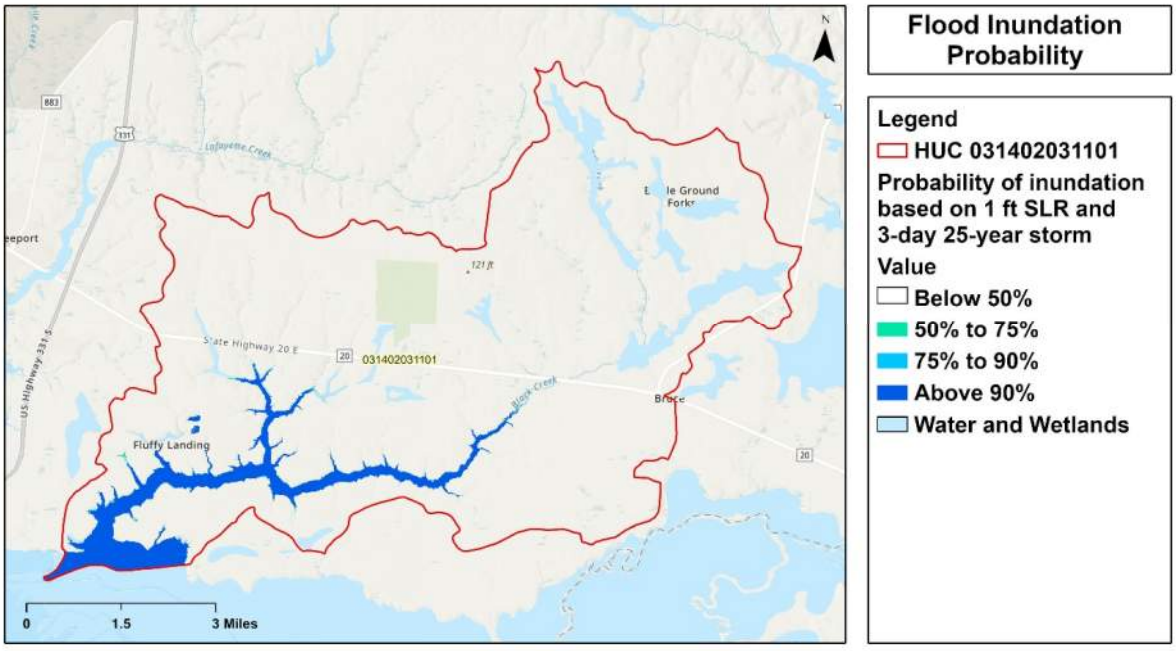

Figure 39. Sea level rise of 1 ft + 3-day 25-year storm for HUC 031402031101 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

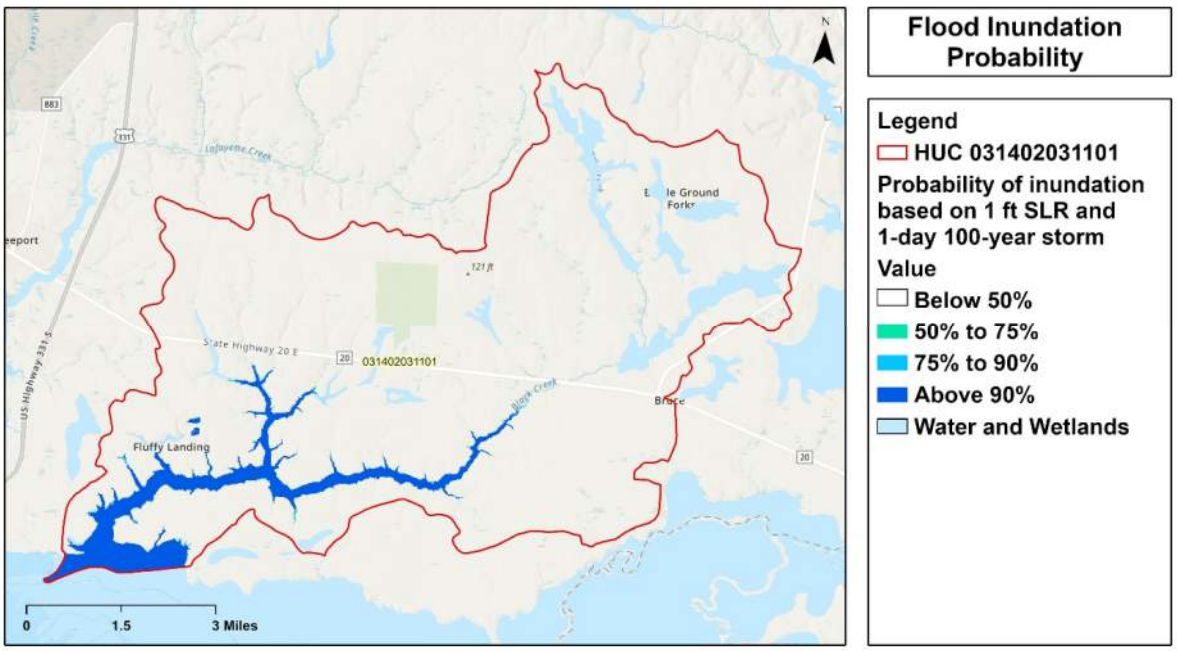

Figure 40. Sea level rise of 1 ft + 1-day 100-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

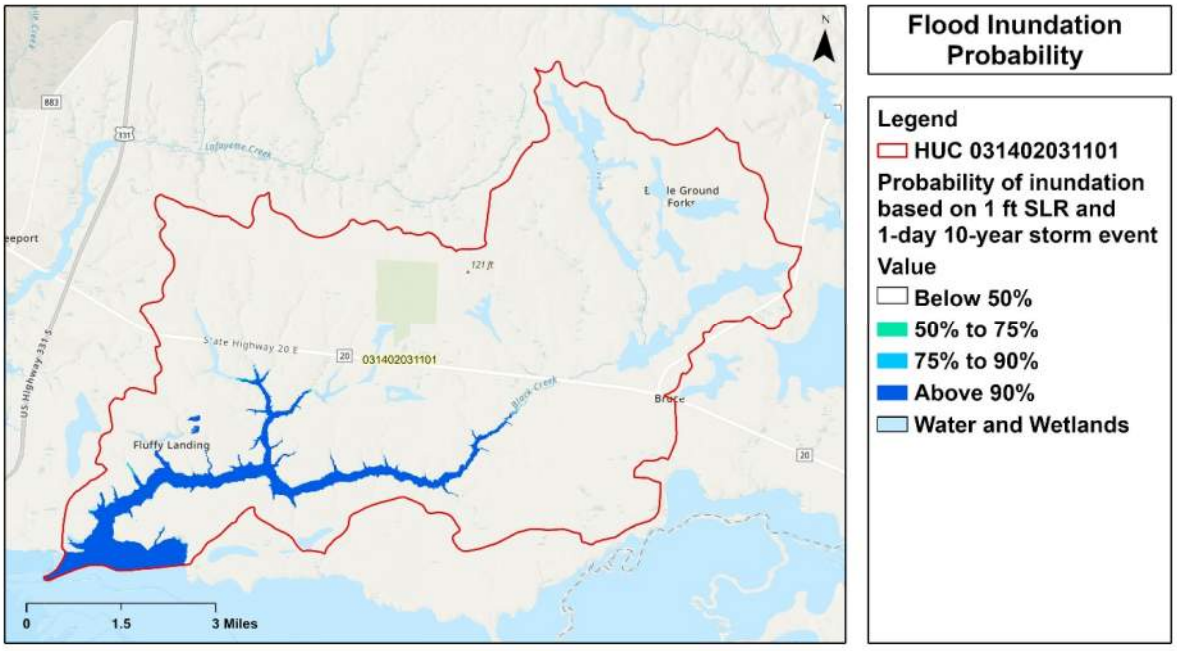

Figure 41. Sea level rise of 1 ft + 1-day 10-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

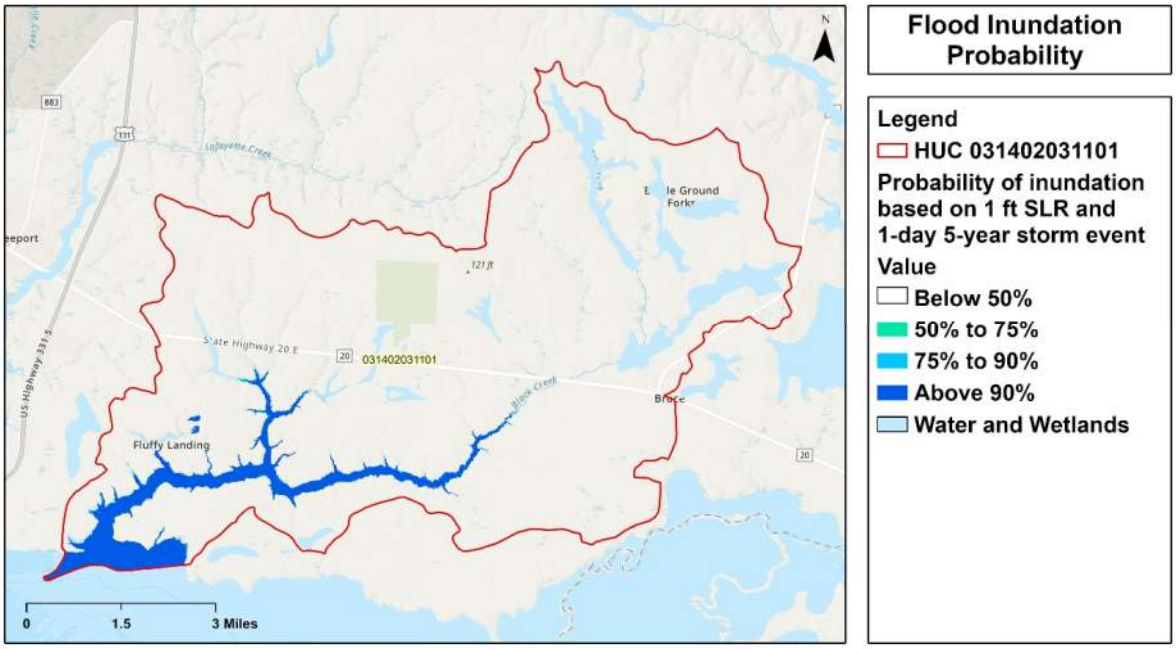

Figure 42. Sea level rise of 1 ft + 1-day 5-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

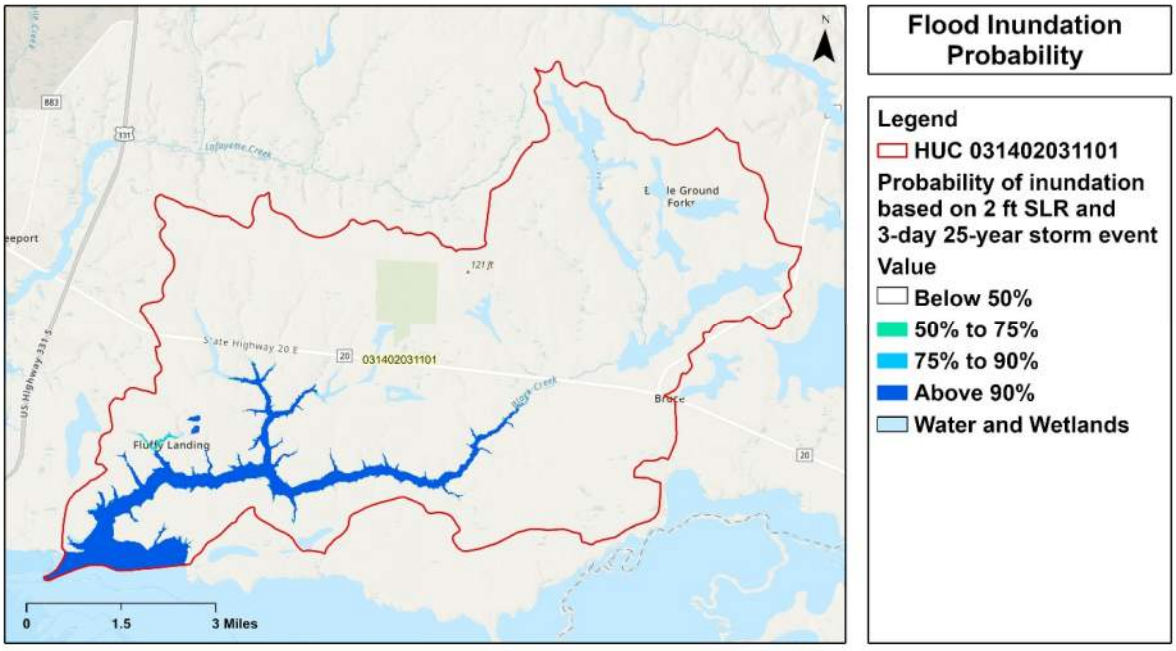

Figure 43. Sea level rise of 2 ft + 3-day 25-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

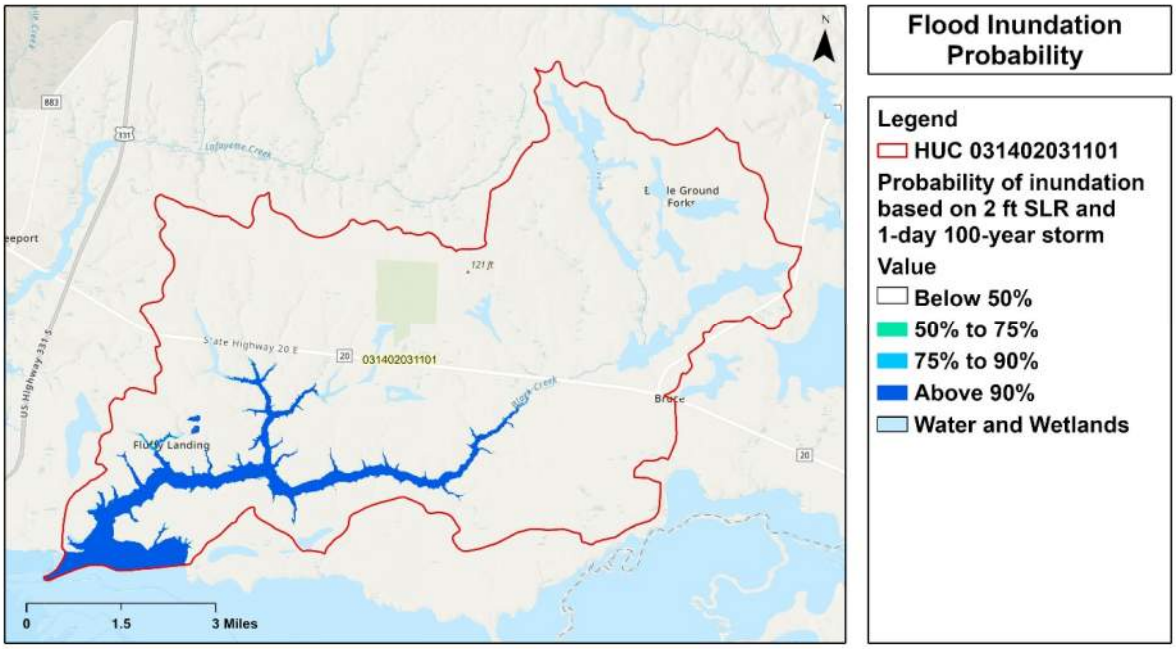

Figure 44. Sea level rise of 2 ft + 1-day 100-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

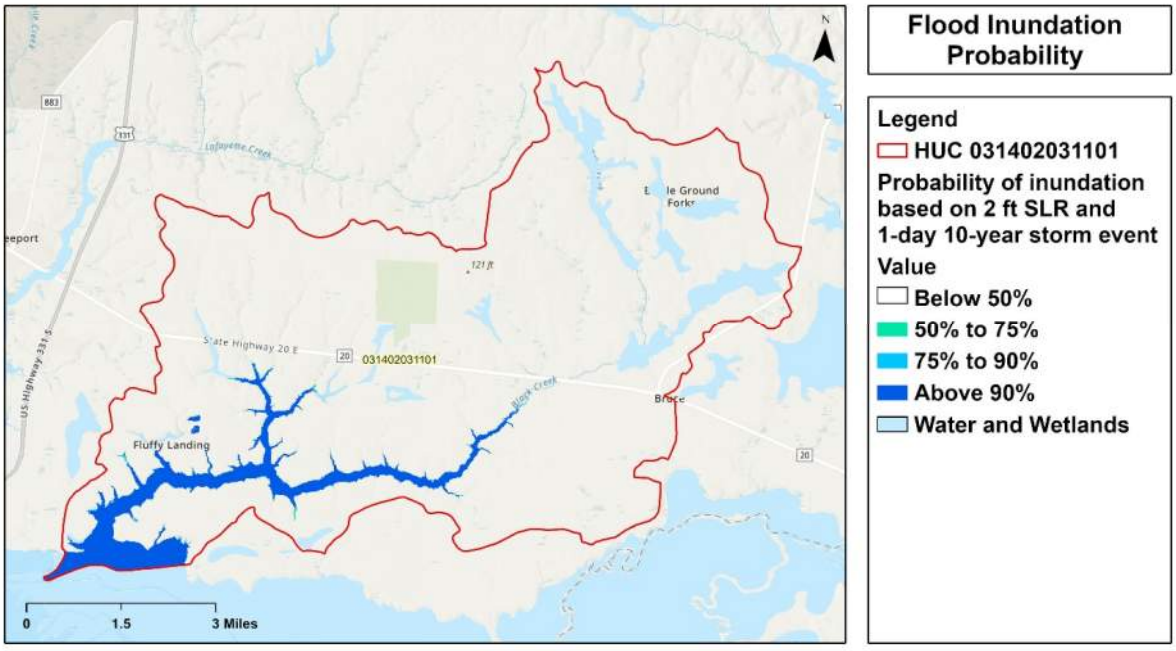

Figure 45. Sea level rise of 2 ft + 1-day 10-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

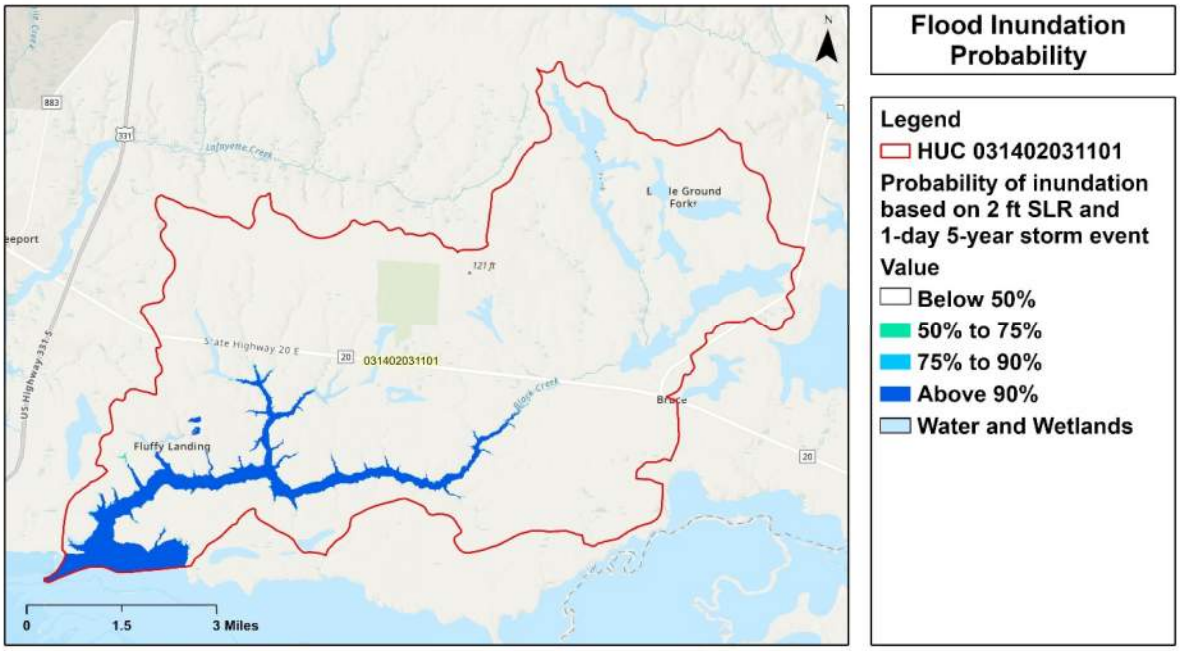

Figure 46. Sea level rise of 2 ft + 1-day 5-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

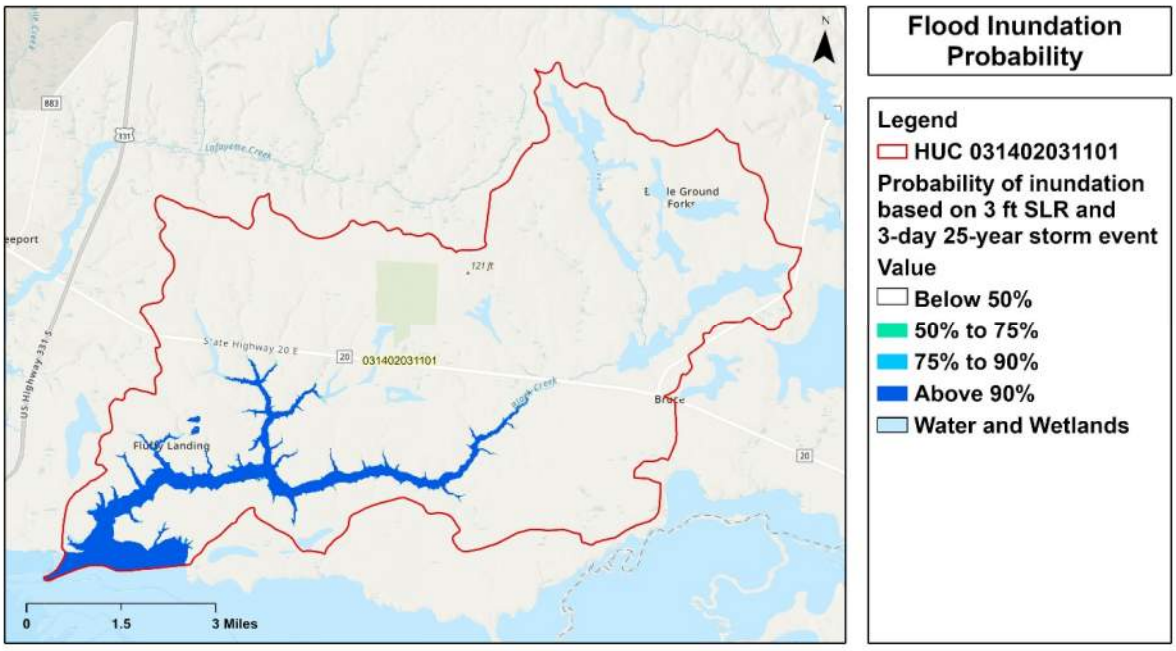

Figure 47. Sea level rise of 3 ft + 3-day 25-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

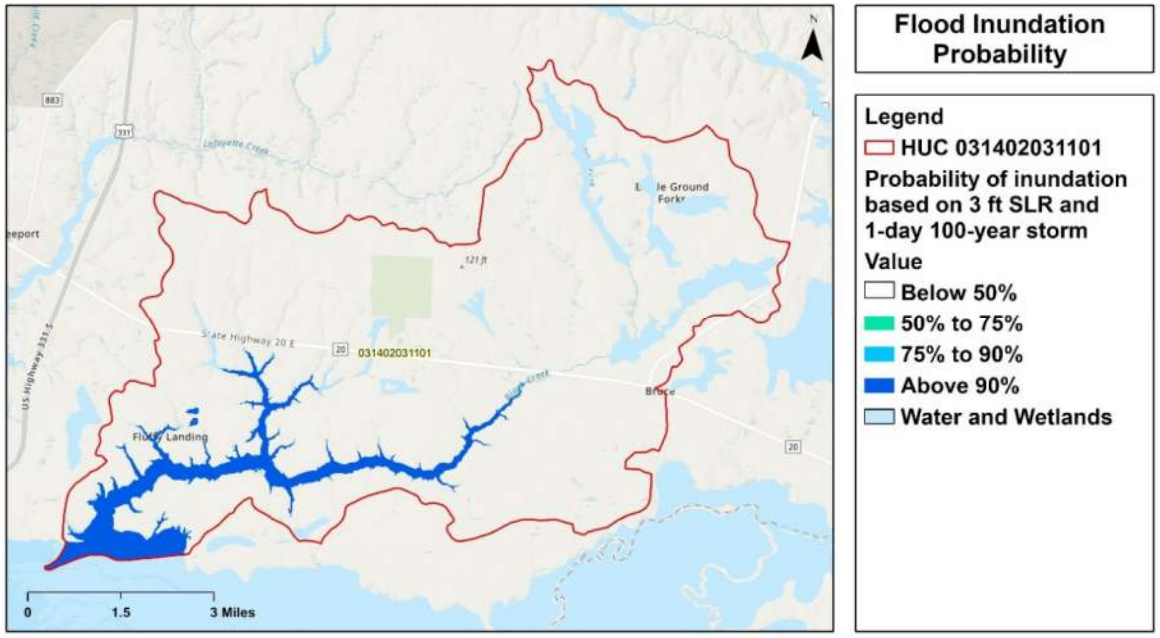

Figure 48. Sea level rise of 3 ft + 1-day 100-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

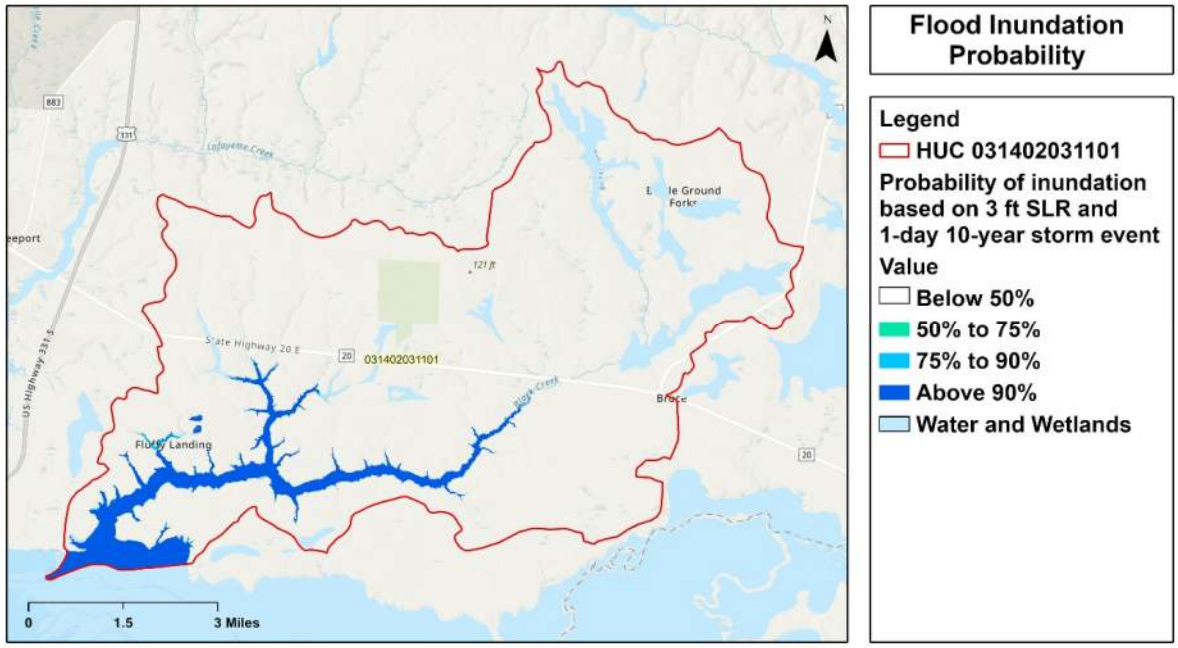

Figure 49. Sea level rise of 3 ft + 1-day 10-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

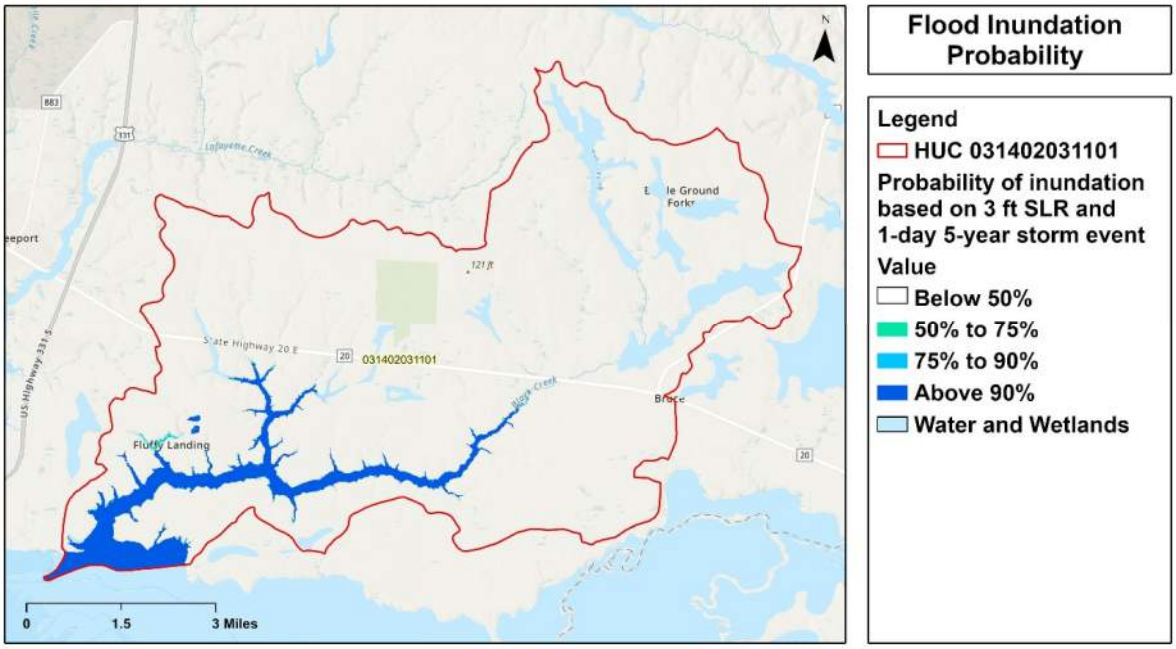

Figure 50. Sea level rise of 3 ft + 1-day 5-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

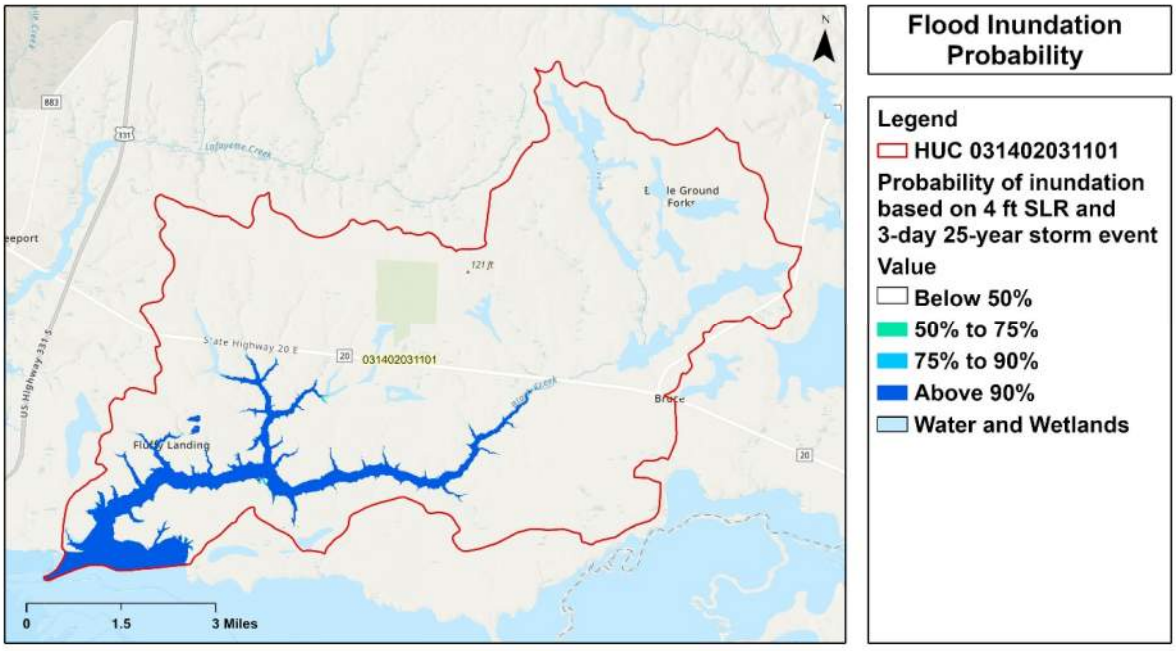

Figure 51. Sea level rise of 4 ft + 3-day 25-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

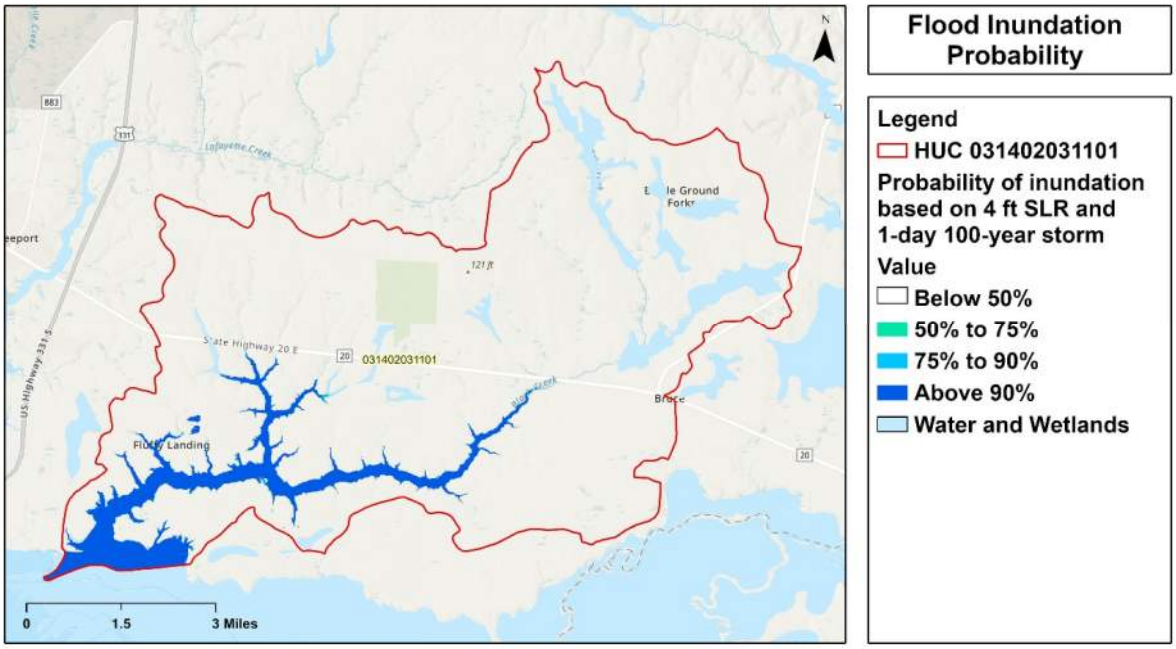

Figure 52. Sea level rise of 4 ft + 1-day 100-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

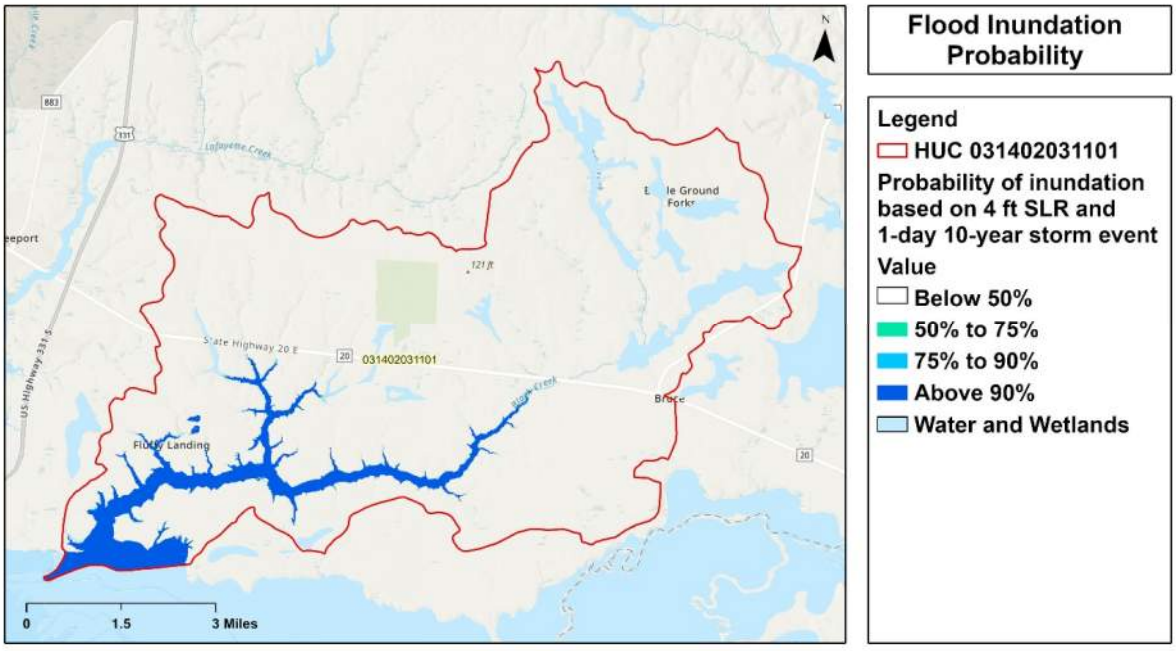

Figure 53. Sea level rise of 4 ft + 1-day 10-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

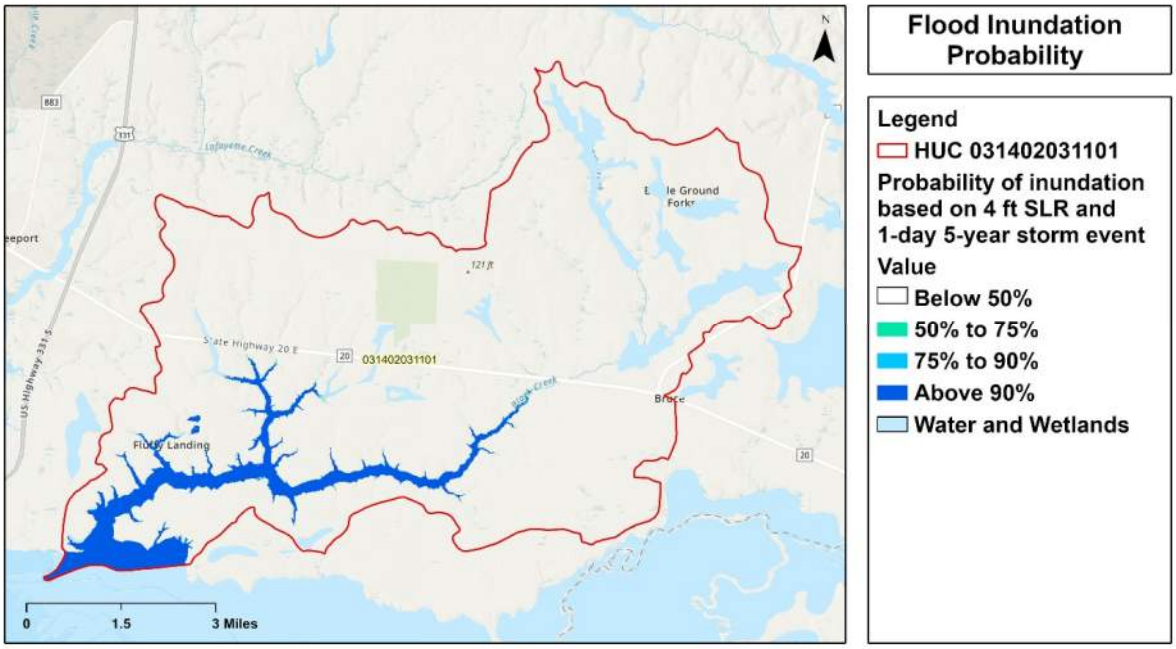

Figure 54. Sea level rise of 4 ft + 1-day 5-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

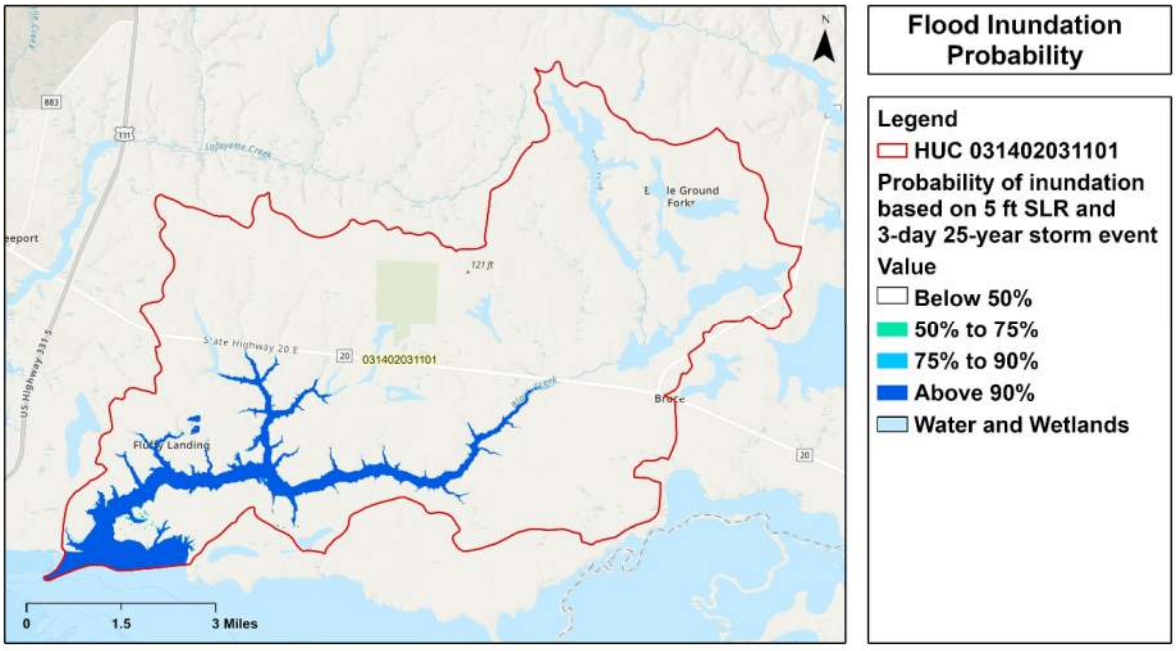

Figure 55. Sea level rise of 5 ft + 3-day 25-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

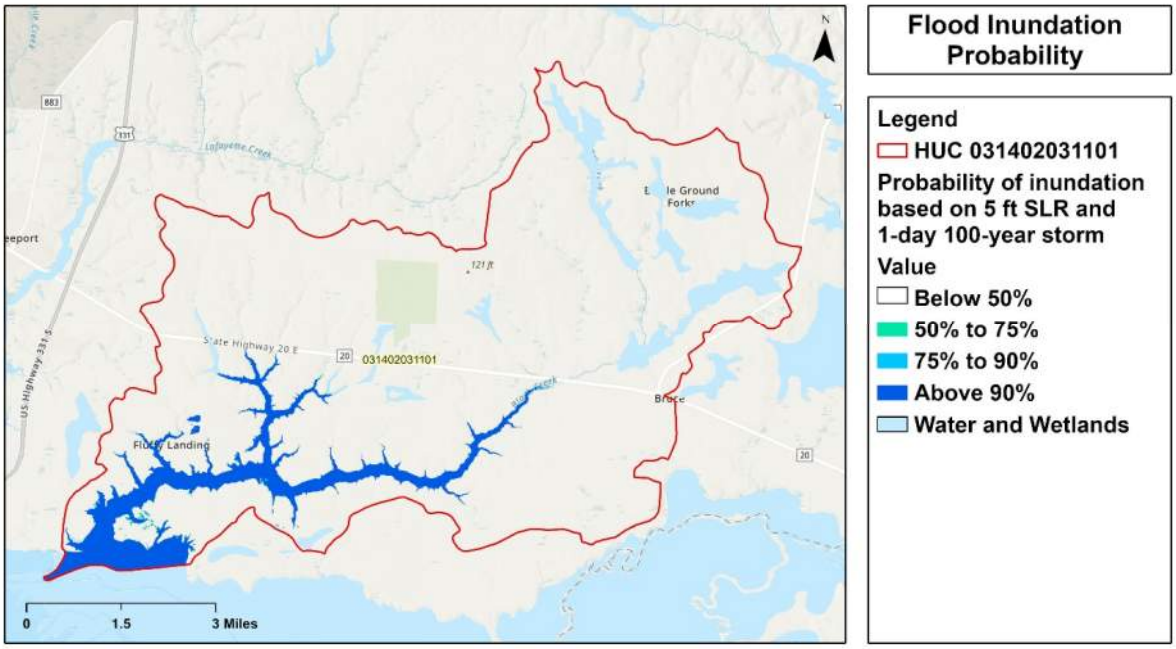

Figure 56. Sea level rise of 5 ft + 1-day 100-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

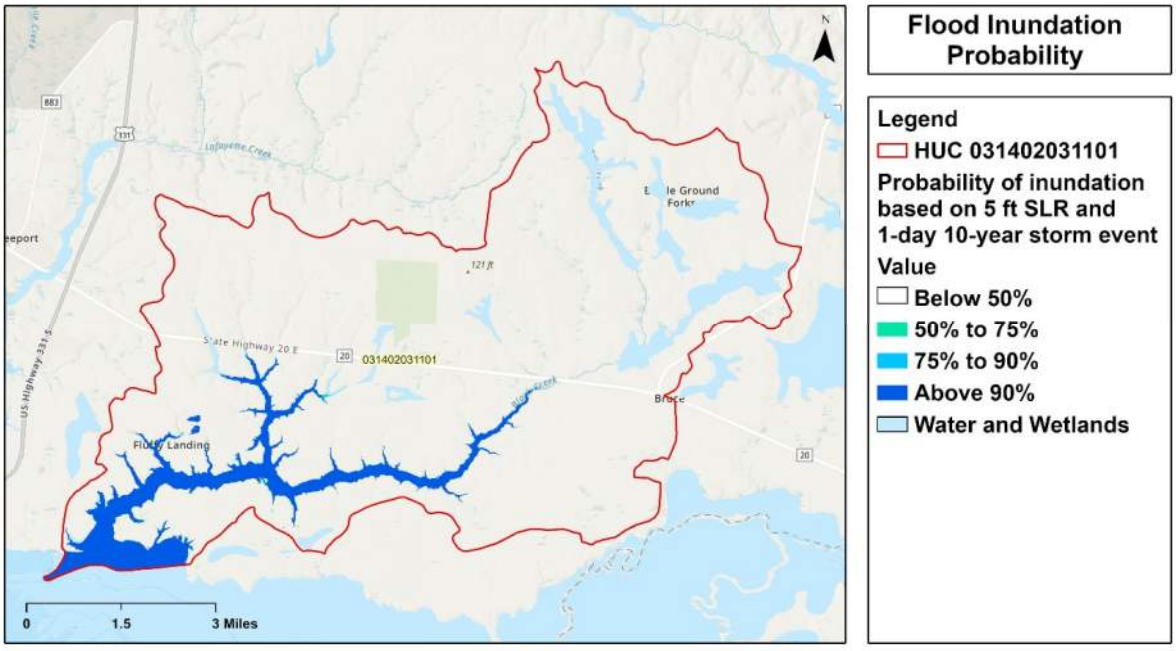

Figure 57. Sea level rise of 5 ft + 1-day 10-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

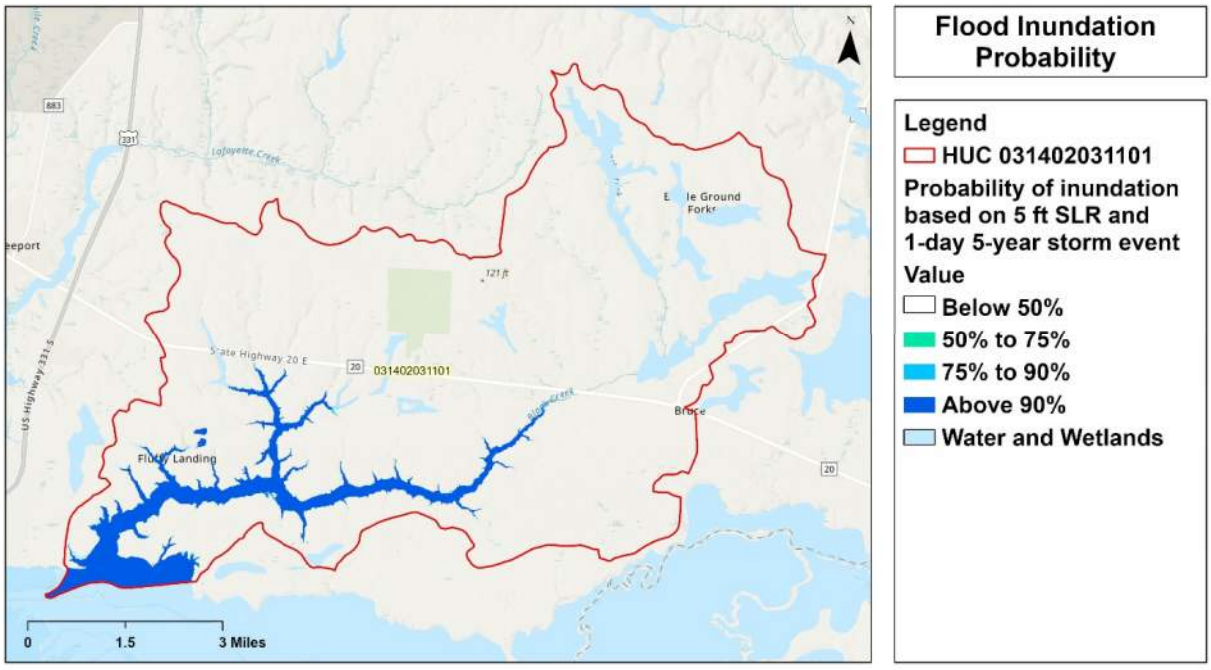

Figure 58. Sea level rise of 5 ft + 1-day 5-year storm for HUC 031402031101 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.5 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health)

requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5

27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6

62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6

101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.5.1 Results

The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 60) overlays critical facilities onto the 1-day 100-year storm event scenario, while the third map (**Error! Reference source not found.**) represents the same overlay within the context of 5 feet of sea level rise (SLR) combined with the 1-day 100-year storm event. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 5 feet SLR + 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** and **Error! Reference source not found.** illustrate the composite score for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. **Error! Reference source not found.** represents the calculation for composite score based on 1-day 100-year storm event, while **Error! Reference source not found.** shows the calculation for composite score for the same storm event, but including a 5 feet of Sea Level Rise scenario. **Error! Reference source not found.** shows the same area zoomed out.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

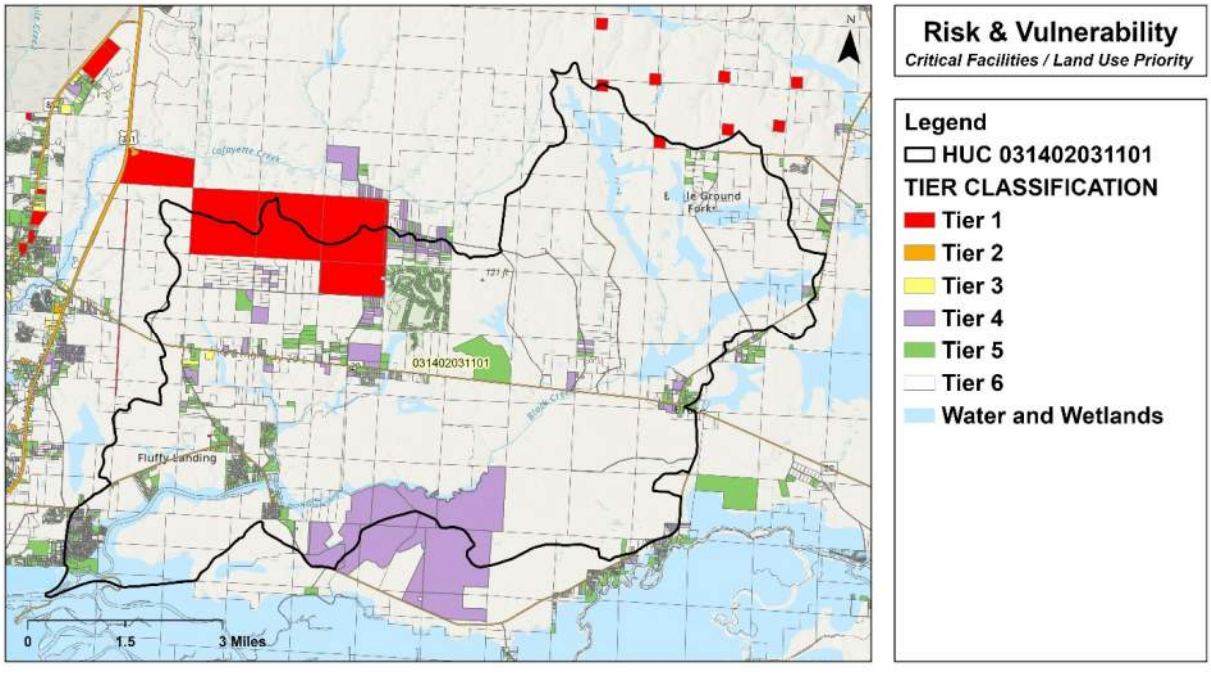

Figure 59. HUC 031402031101 sub-watershed Critical Facilities (priority of land uses) map.

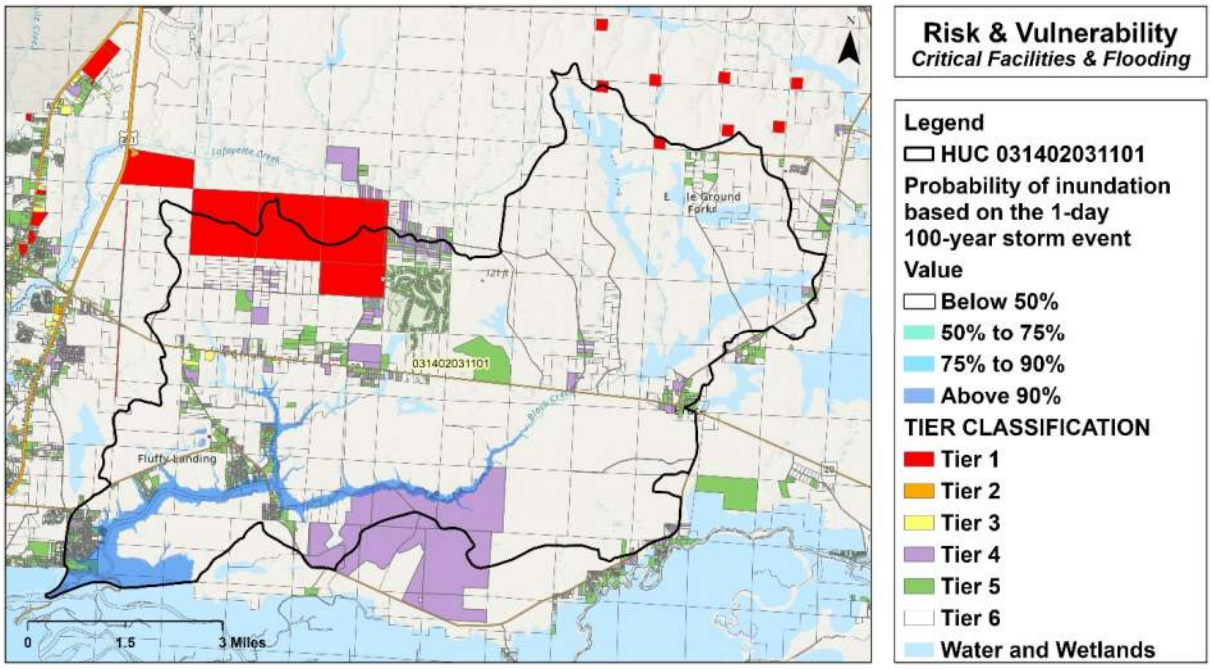

Figure 60. HUC 031402031101 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation.
Processed by FAU.

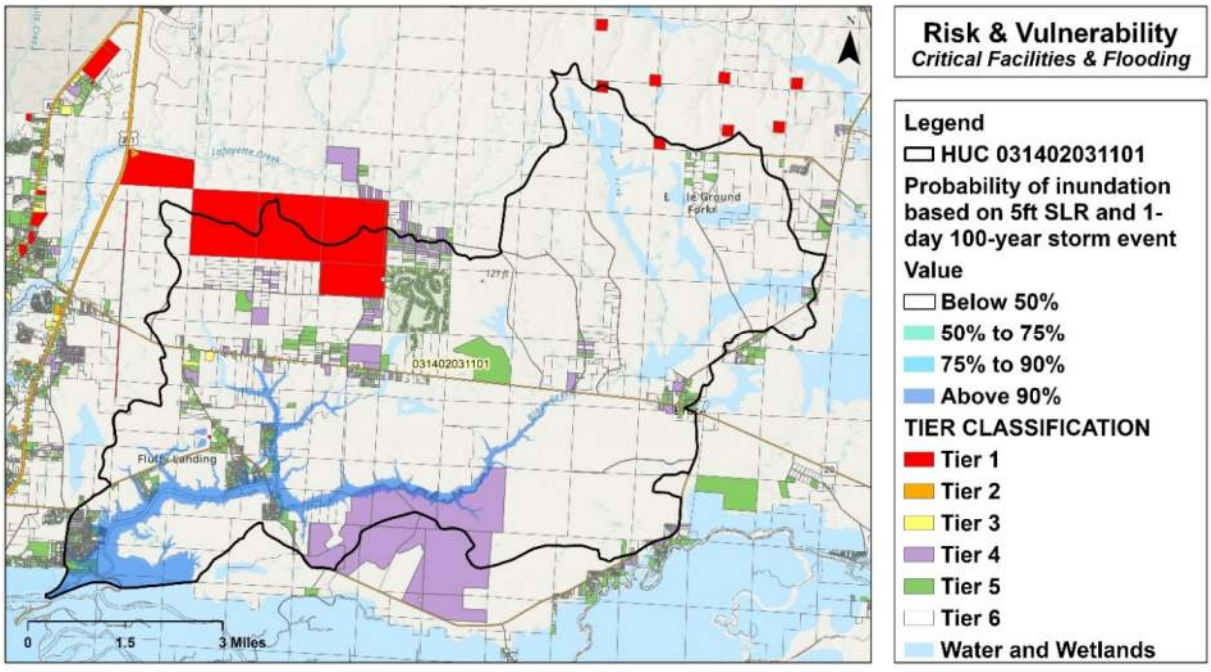

Figure 61. HUC 031402031101 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation.
Processed by FAU.

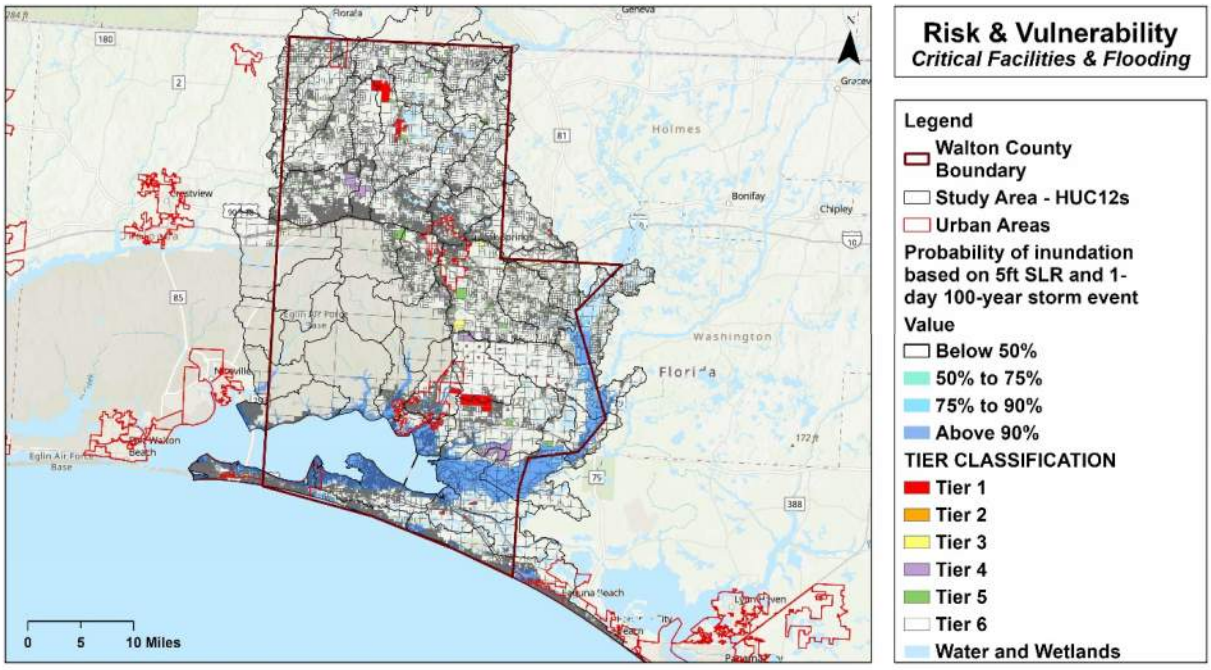

Figure 62. Walton County (mosaic) - Critical Facilities (priority of land uses) map, overlaid on the 1-day 100-year storm event + 5 ft. SLR probability of inundation for Walton County. Processed by FAU.

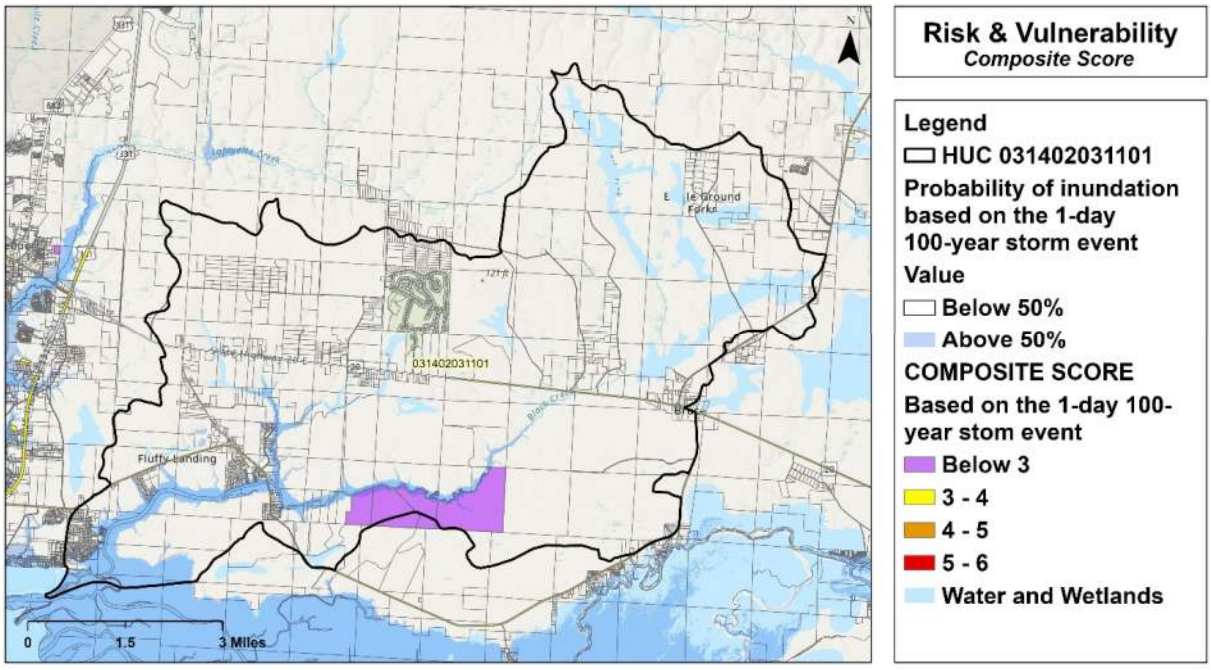

Figure 63. HUC 031402031101 sub-watershed Composite Score Risk map based on the 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation. Processed by FAU.

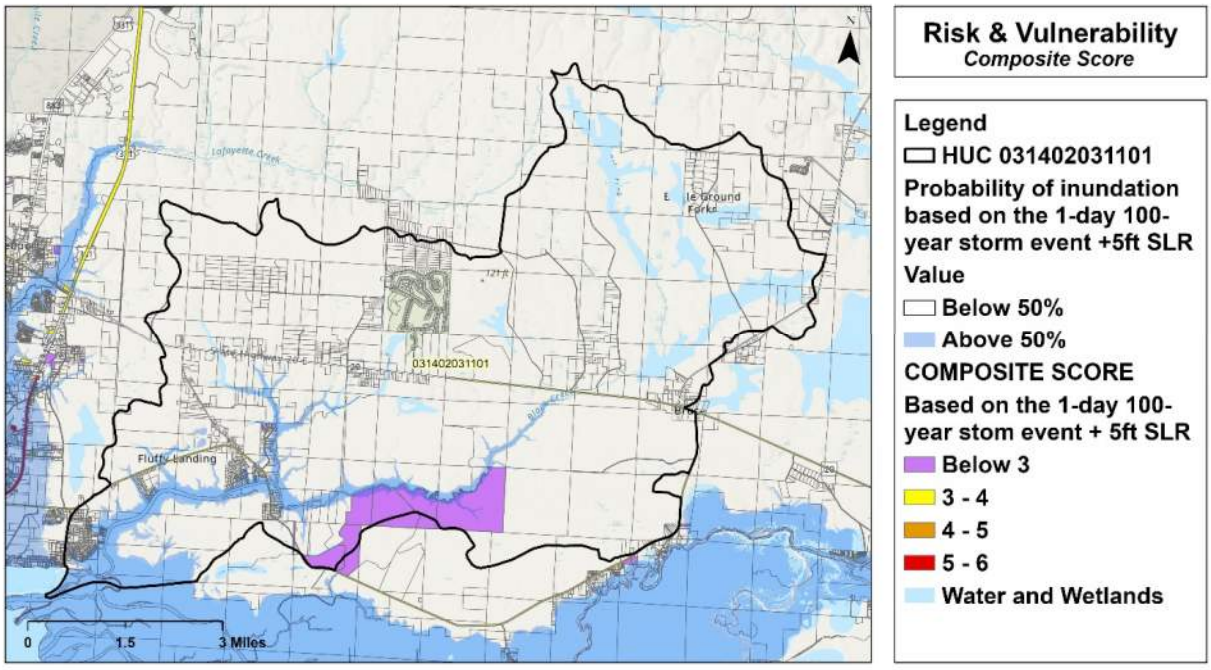

Figure 64. HUC 031402031101 sub-watershed Composite Score Risk map based on 1-day 100-year storm event + 5 ft. SRL, overlaid on the 1-day 100-year + 5 ft. SLR probability of inundation. Processed by FAU.

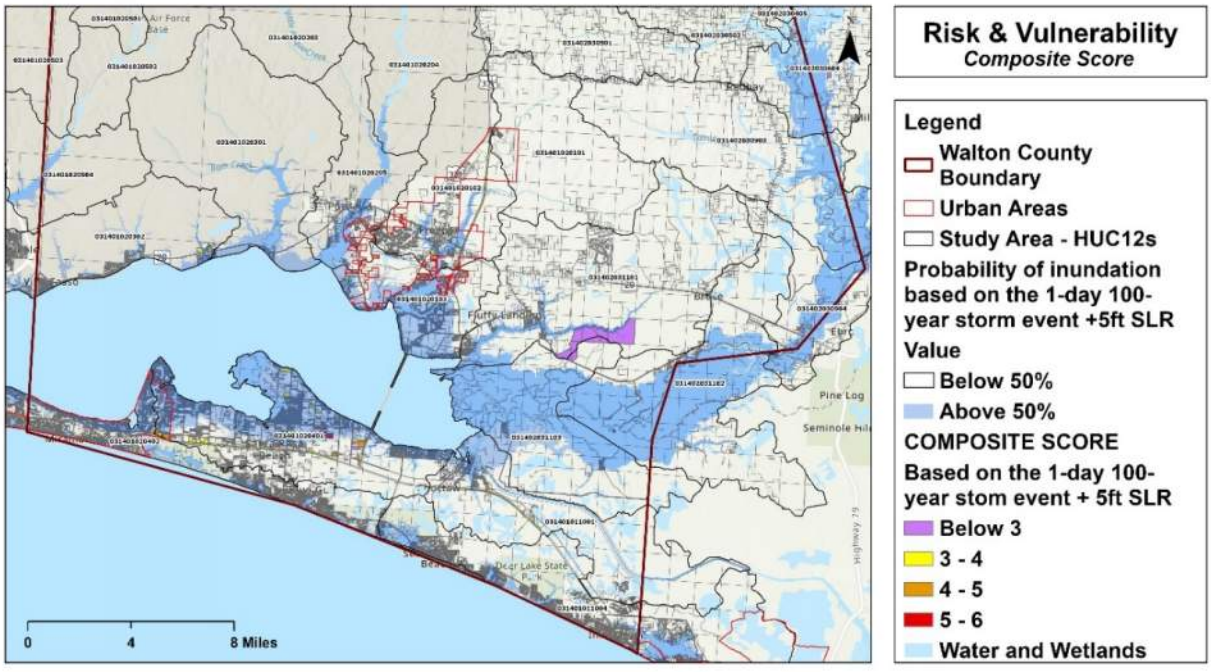

Figure 65. Coastal Area of Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

2.5.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031402031101. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.5.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It's important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031402031101. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031402031101	33266.17
All of the 1-day 100-year storm event inundation	**1652.17**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	1106.58
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	130.52
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	53.71
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	545.59
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	361.36

2.5.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

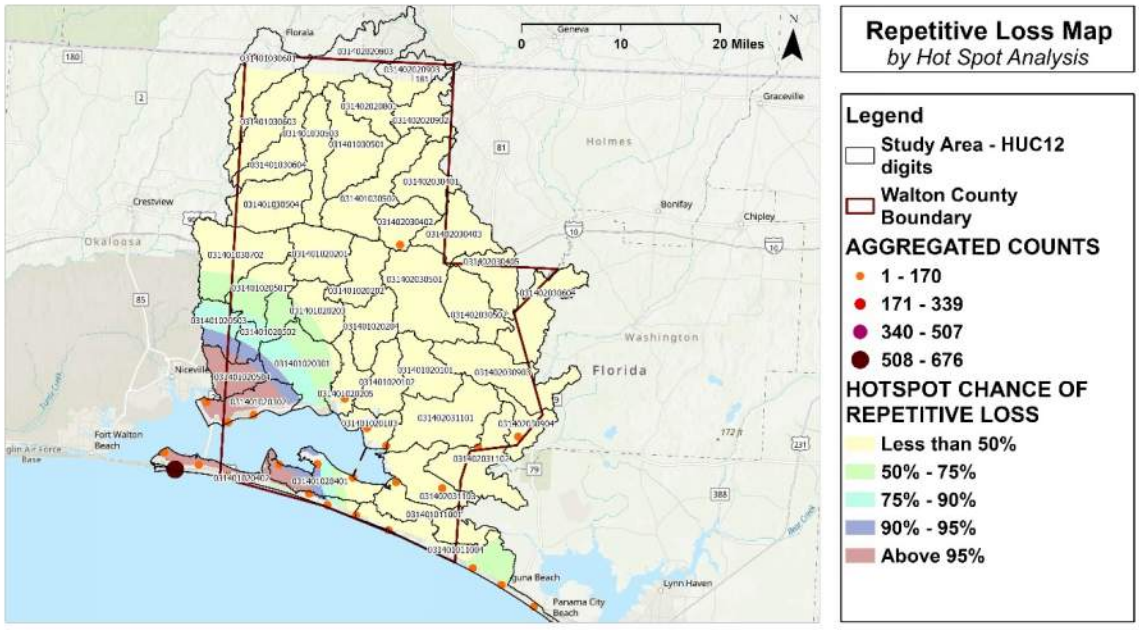

Figure 66. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU. (Source Data: FEMA)

2.5.5 Priority Projects

While the basin does not have a significant amount of developed land, some parcels fall within the flood zone due to the area's susceptibility to a medium-to-significant flooding in both 1-day 100-

year storm events and 1-day 100-year + 5 feet sea level rise scenarios. In terms of land use priority, there are some parcels in tiers 2 (roads), 4, and 5 within the flooding zone. There are four parcels in Tier 1 of priority of land use, but fortunately, they are not in the flooding zone.

Examining the composite score, there are a total of 99 parcels within the flood zone that require attention. Among them, only one parcel is in the score range of 5-6, and it is a road (Rushing Cutoff), representing the highest priority for intervention. Additionally, there are 52 parcels with scores in the range of 3-4, which 41 are mobile homes, and 11 are roads, such as Co Highway 3280, Phillips Dr, Creekside Waterview Ct, Us Hwy 20, Creek View Ave, Black Creek Lodge Rd, E Edgewater Drive, and Mcdaniels Fishcamp Rd. Finally, there are 46 parcels with scores below 3, including 40 mobile homes and six orphanages or other non-profit organizations.

APPENDIX AP

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031402031102

EAST RIVER-CHOCTAWHATCHEE RIVER

Principal Investigator: Frederick Bloetscher, Ph.D., P.E.

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Research Assistant: Leticia Sabio

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 sub-watershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 (031402031102) is highlighted among all the HUCs to help identifying its location. (Figure 3).

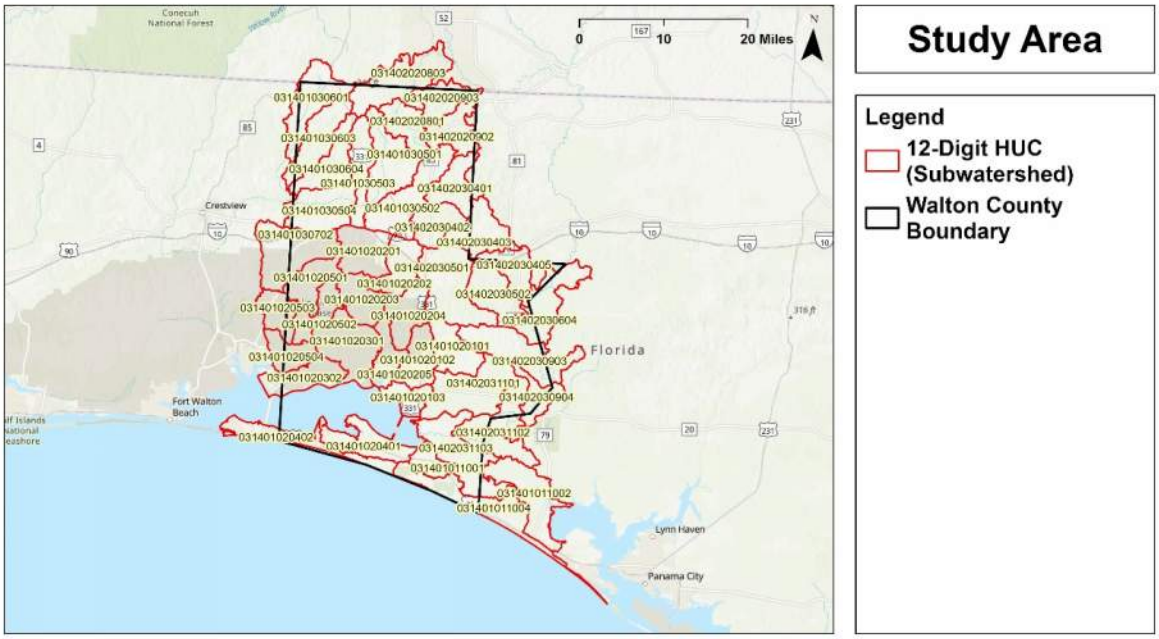

Figure 1. Walton County and all HUCs 12-digit sub-watershed, processed by FAU.

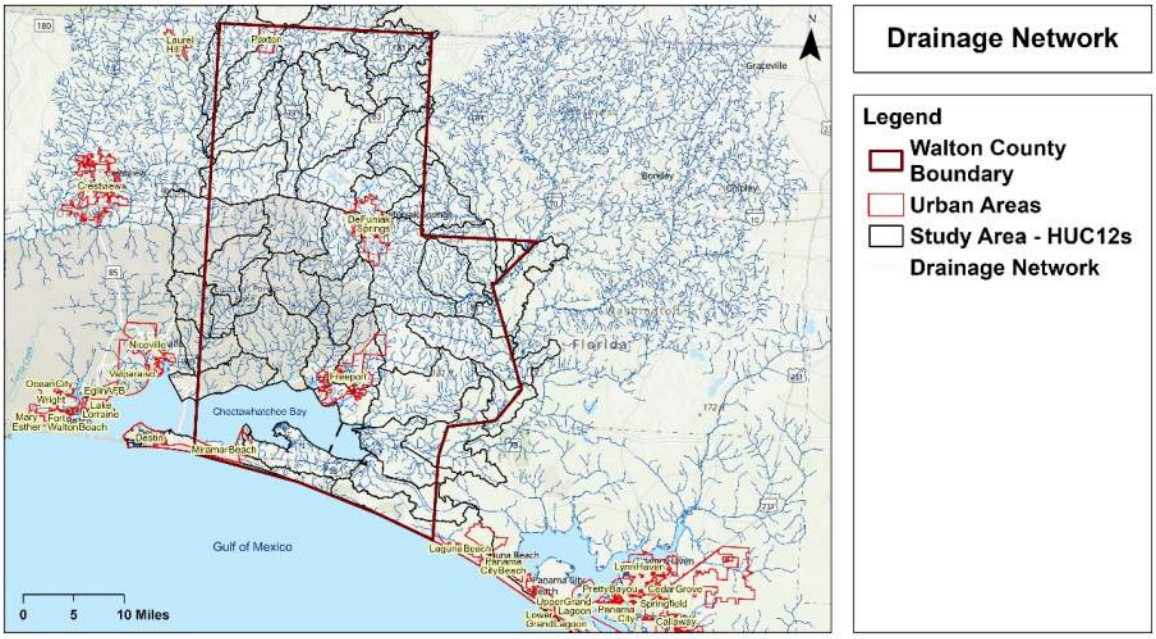

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

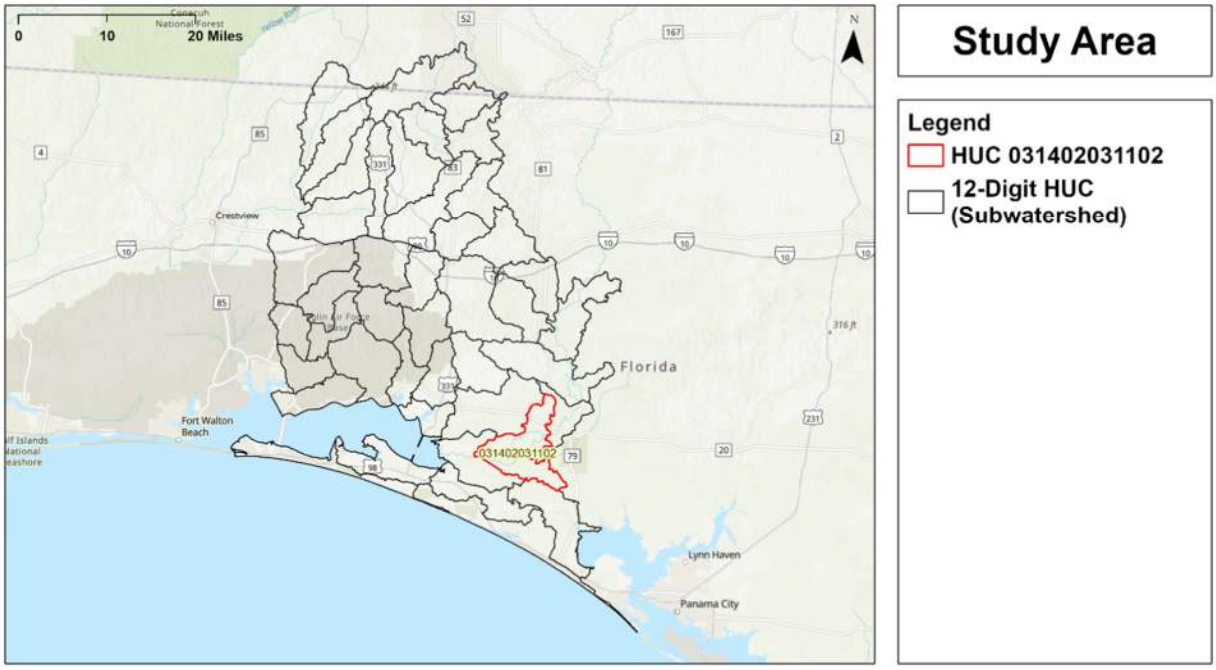

Figure 3. HUC 031402031102 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state,

with a height of 345 feet in its northern end. With a population of 75,305 residents according to the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development, tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife

management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers)

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1. Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

(Source Data: FEMA)

Figures 12 and 13 is the county-wide report show the current and projected land use for the County. Based on the 2017 future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**.

Table 2. Land Use in Walton County (Prepared by FAU from future land use map) versus land use in the entire watershed

Level 1 Land Use-Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

(Source Data: (NWFWMD 2017)

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 1.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (**Error! Reference source not found.**). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

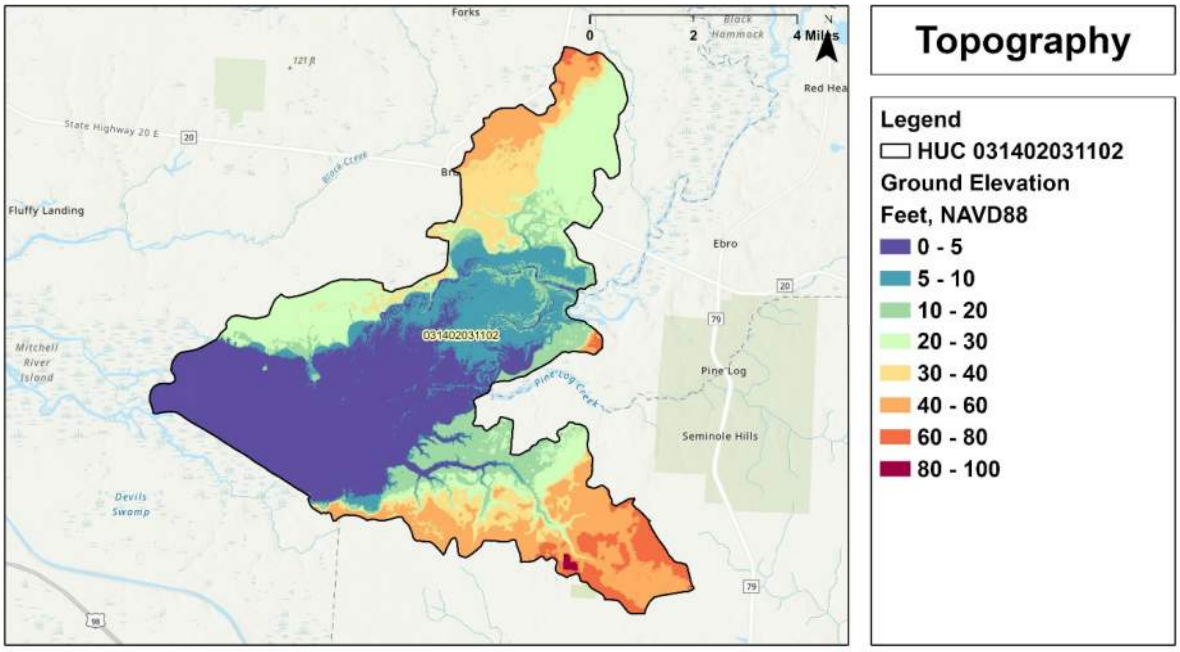

Figure 4. Topographic map of the HUC 031402031102 sub-watershed, processed by FAU. (Data Source: USGS)

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology. Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031402031102 sub-watershed is shown in **Error! Reference source not found.**.

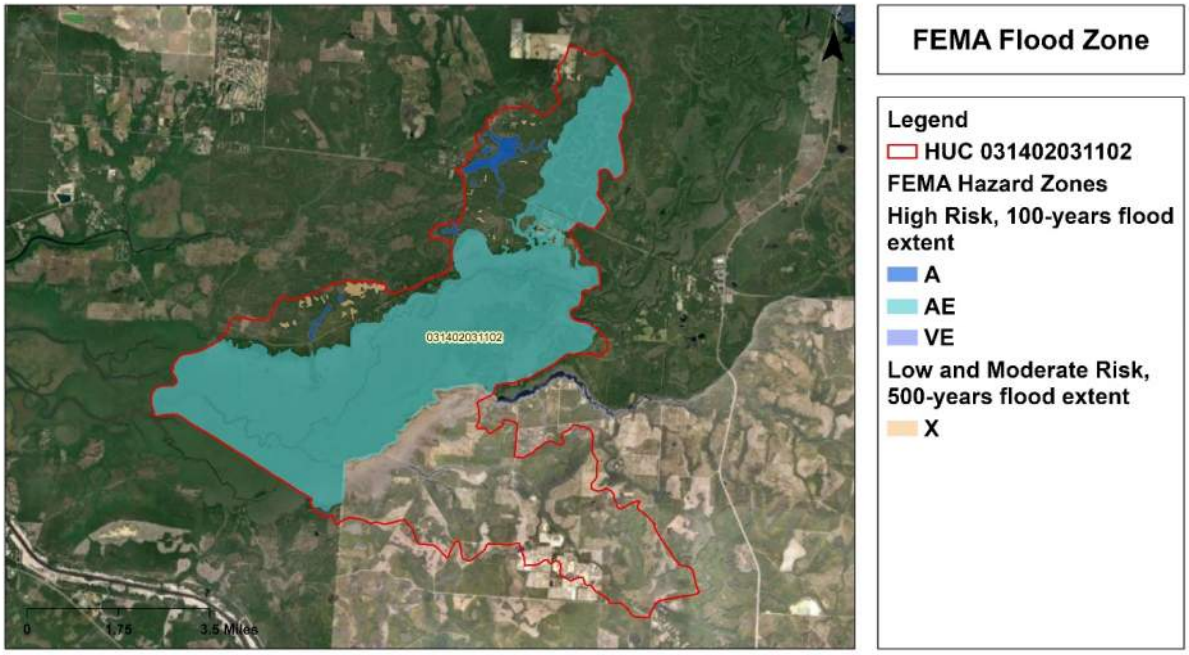

Figure 5. FEMA Flood Zone map (2020) for HUC 031402031102 sub-watershed, processed by FAU.
(Data Source: FEMA)

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031402031102 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem.

This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

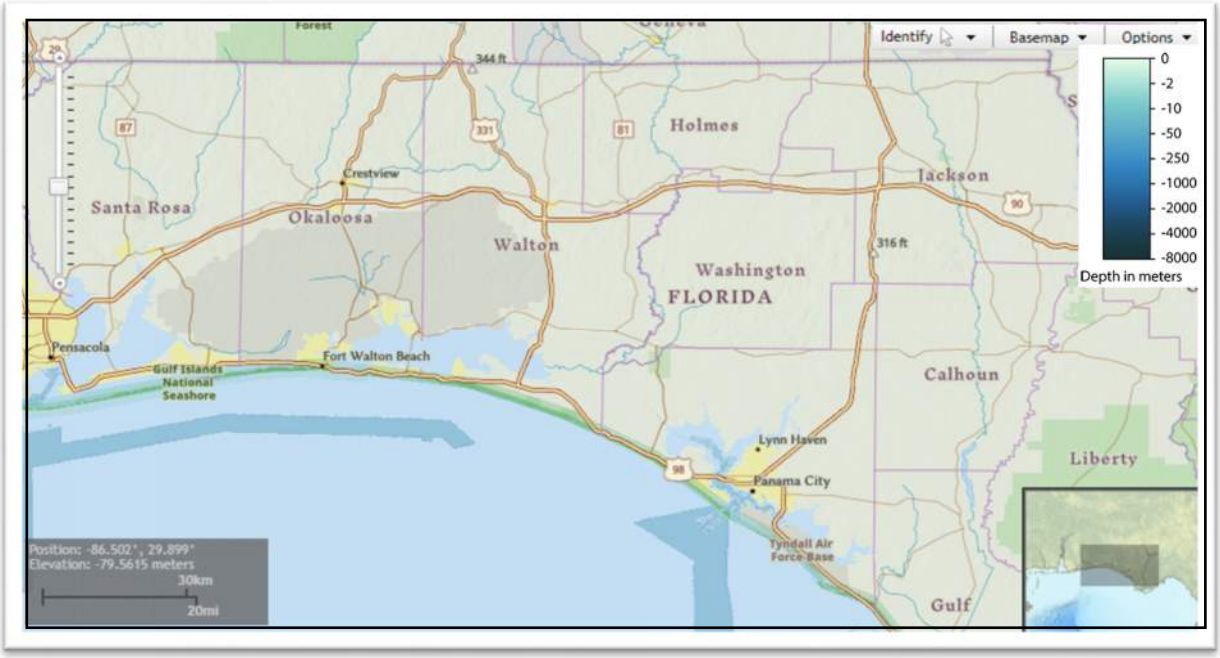

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
(Source: ncei.noaa.gov/maps/bathymetry/)

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

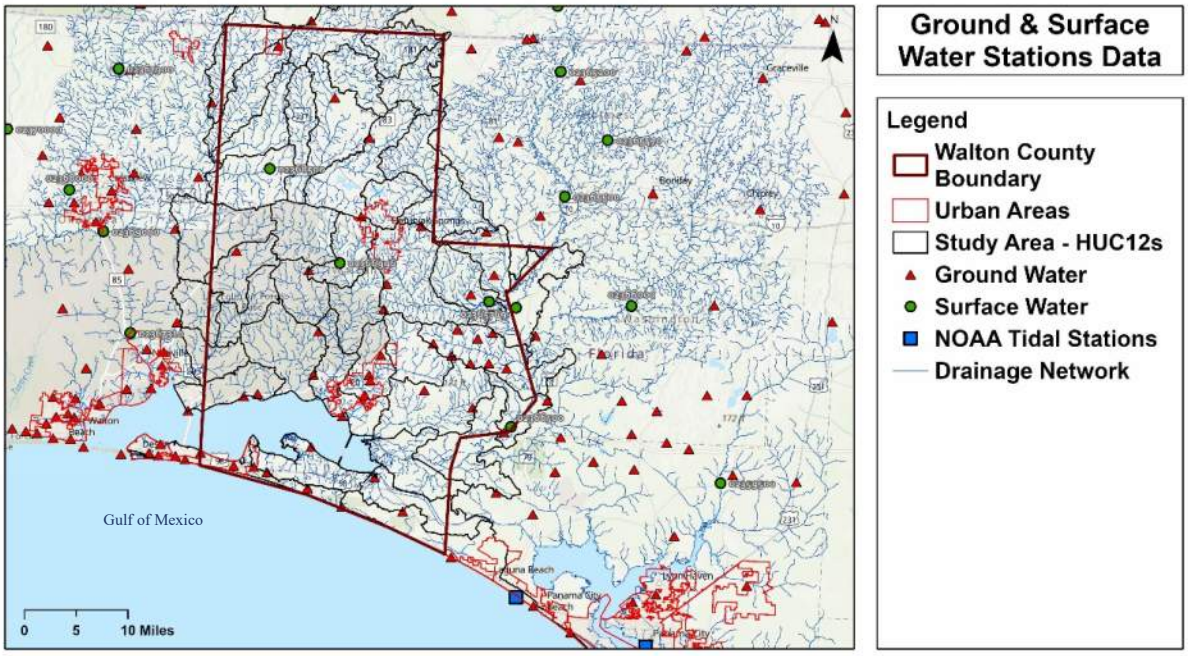

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.
(Data Source: USEPA – National Hydrographic Dataset (NHD) and NOAA's Tides)

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The major water bodies in the HUC 031402031102 sub-watershed include:

- Choctawhatchee River

- East River
- Otter Creek
- Sewell Branch
- Boutwell Branch
- Dismal Creek

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031402031102, which is USGS 02366500 Choctawhatchee River NR Bruce FLA.

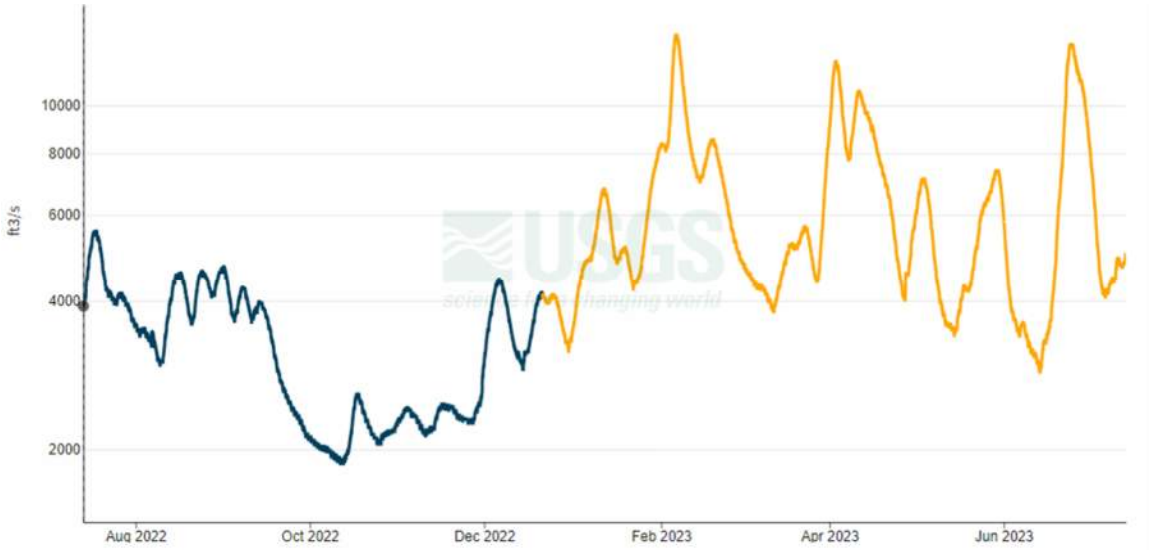

Figure 8. Average streamflow for Choctawhatchee River NR Bruce FLA (USGS 02366500 Surface-Water, June 2022 to July 2023).
(Source: USGS Water Data Services, available at https://waterdata.usgs.gov/monitoring-location/02366500/#parameterCode=00065&period=P365D)

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99th- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending

order to determine the 98th - 100th percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031402031102 and points out the location of the ground water stations in the surroundings. A groundwater-surface layer for the HUC 031402031102 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

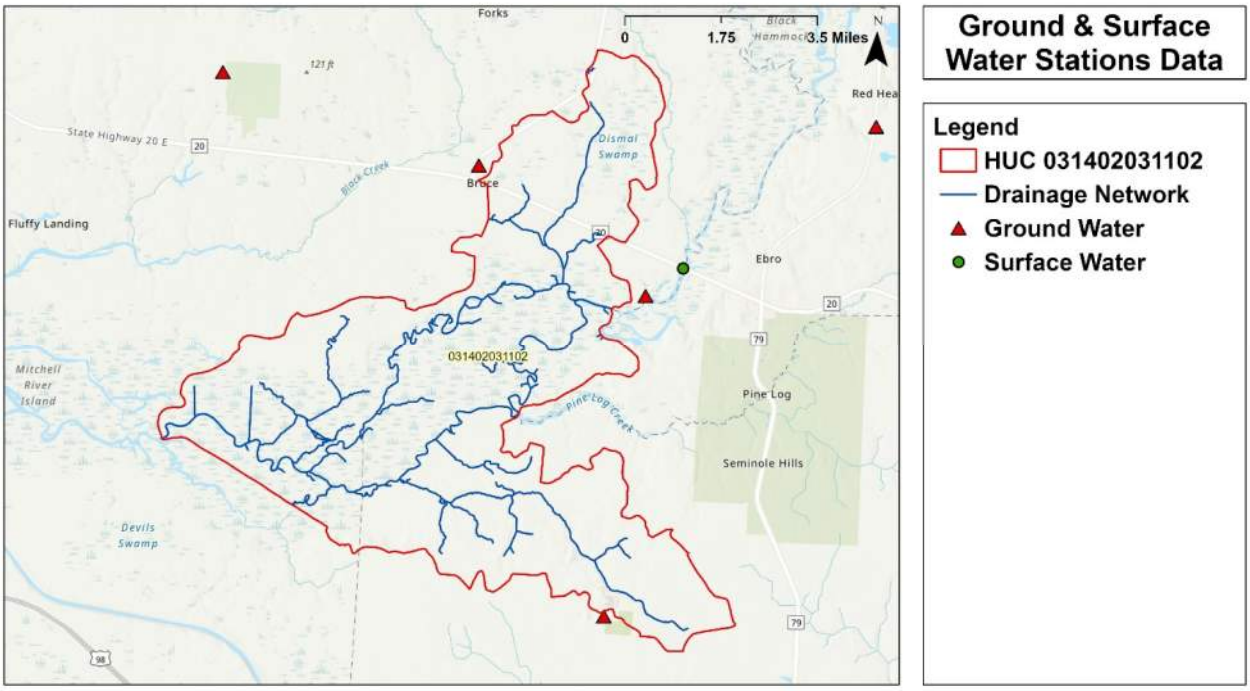

Figure 9. Ground and Surface Water Stations in the HUC 031402031102 sub-watershed, processed by FAU.
(Data Source: USEPA – National Hydrographic Dataset (NHD)

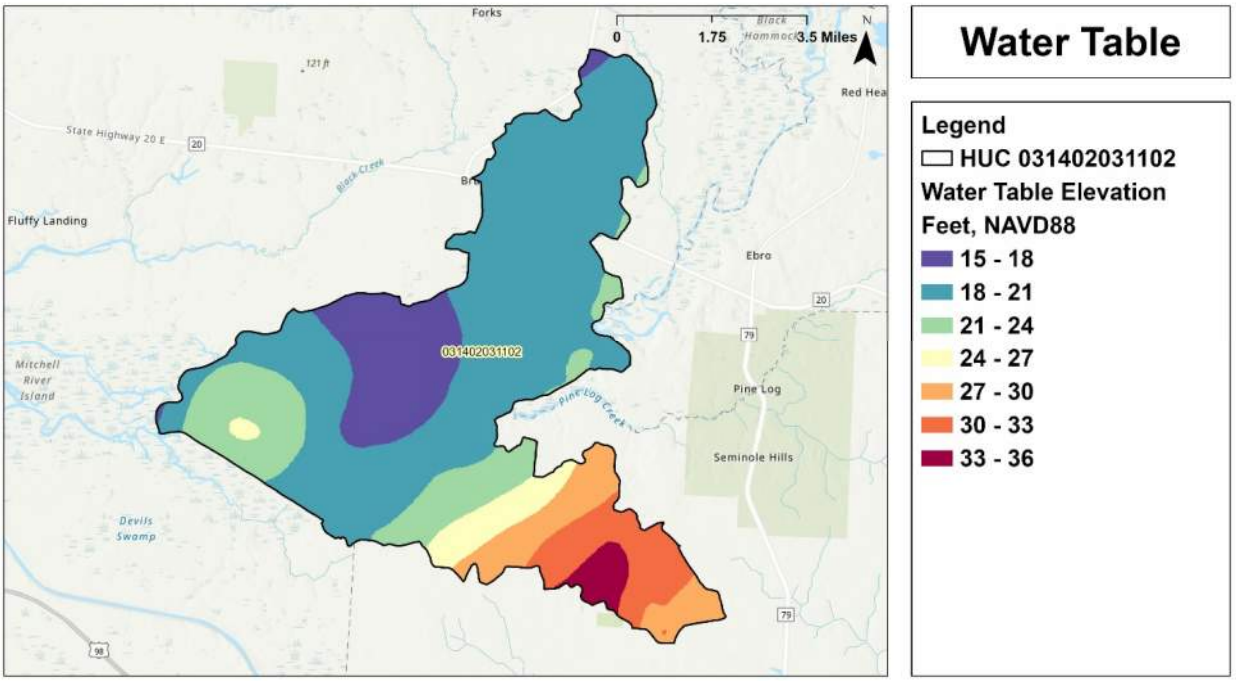

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031402031102 sub-watershed, created by multiple linear regression analysis – elevation NAVD88, processed by FAU.
(Data Source: USGS and NWFWMD)

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the average precipitation over Walton County for every month of the year between 2011 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches for the entire county.

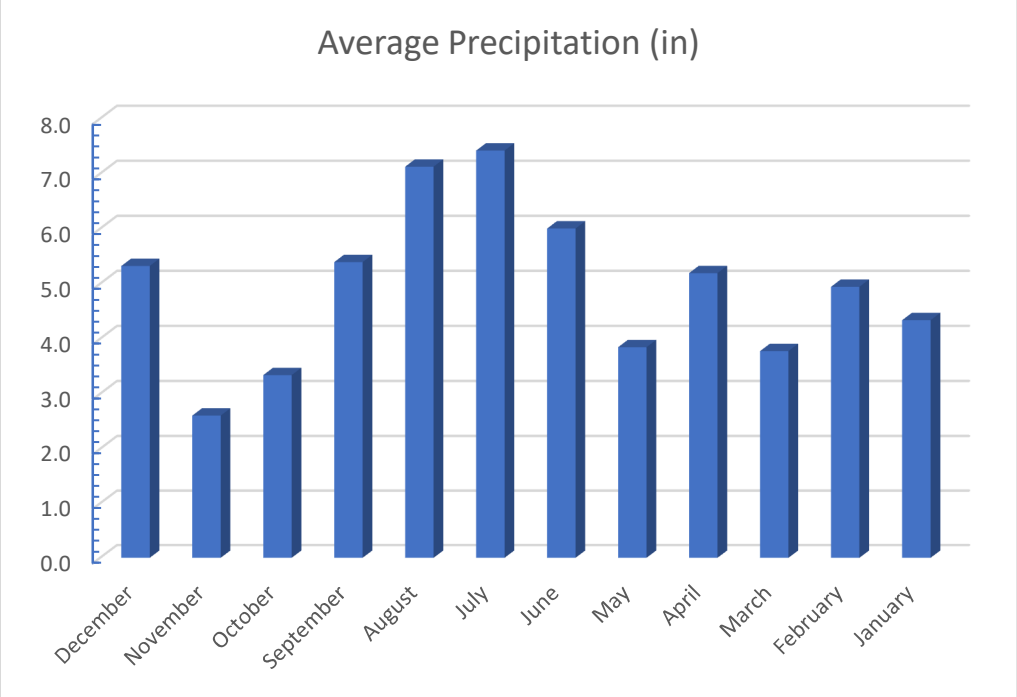

Figure 11. Monthly precipitation in Walton County, FL (2011-2023).
(Data Source: Florida Weather Data, available at https://data.usatoday.com/weather-data/walton-county/12131/1975-04-01/table/)

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is none NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

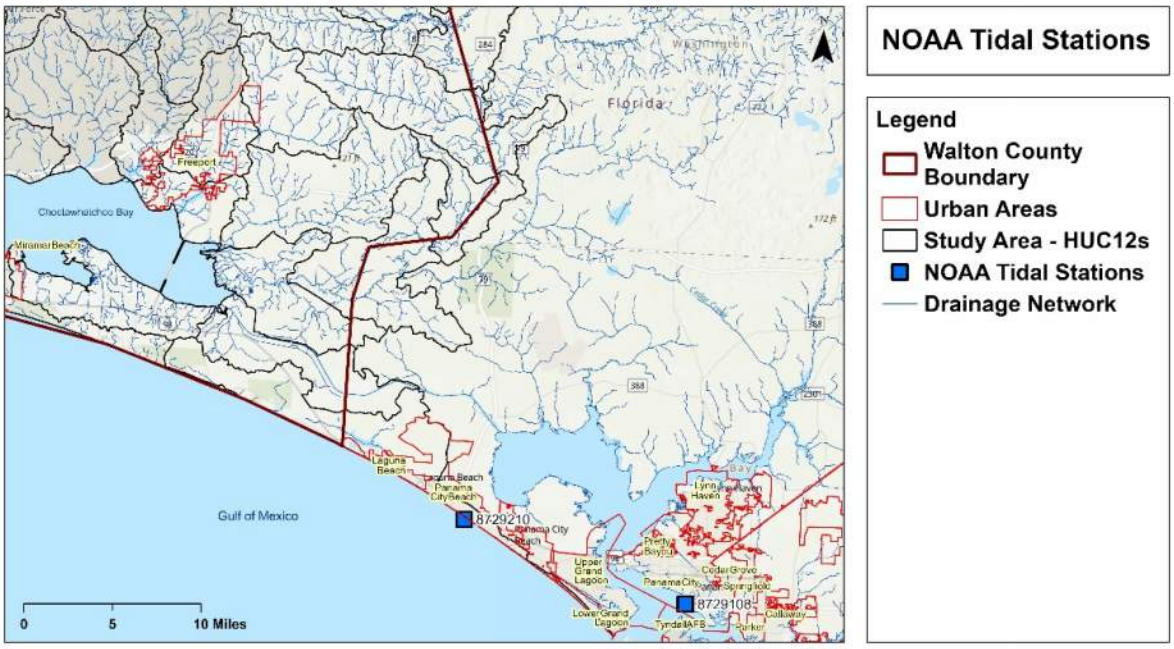

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.
(Data Source: USEPA – National Hydrographic Dataset (NHD) and NOAA's Tides)

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in Figure 13.

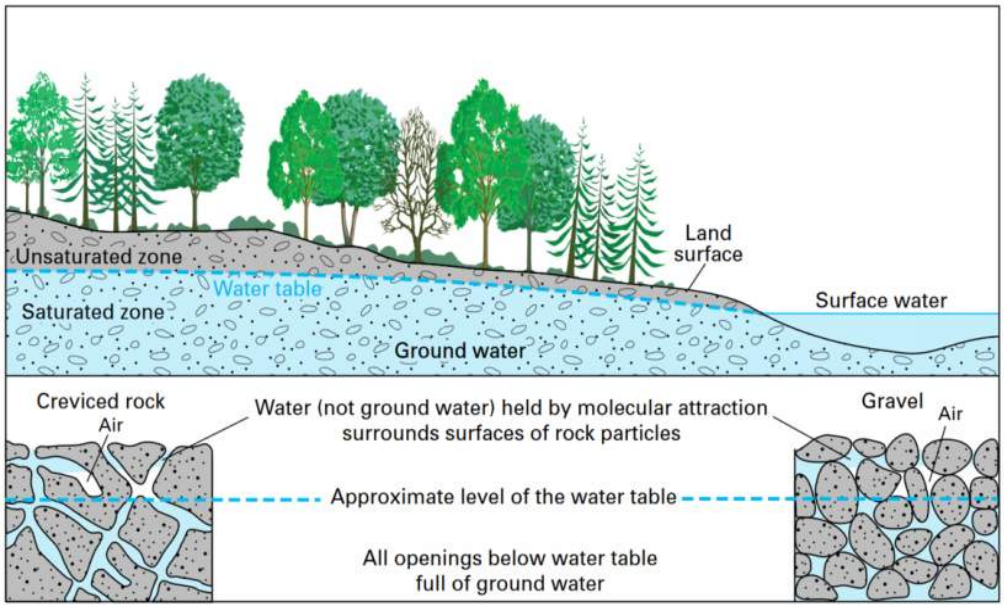

Figure 13. Zones where underground water exists.
(Source: USGS, 2020)

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in Figure 14. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

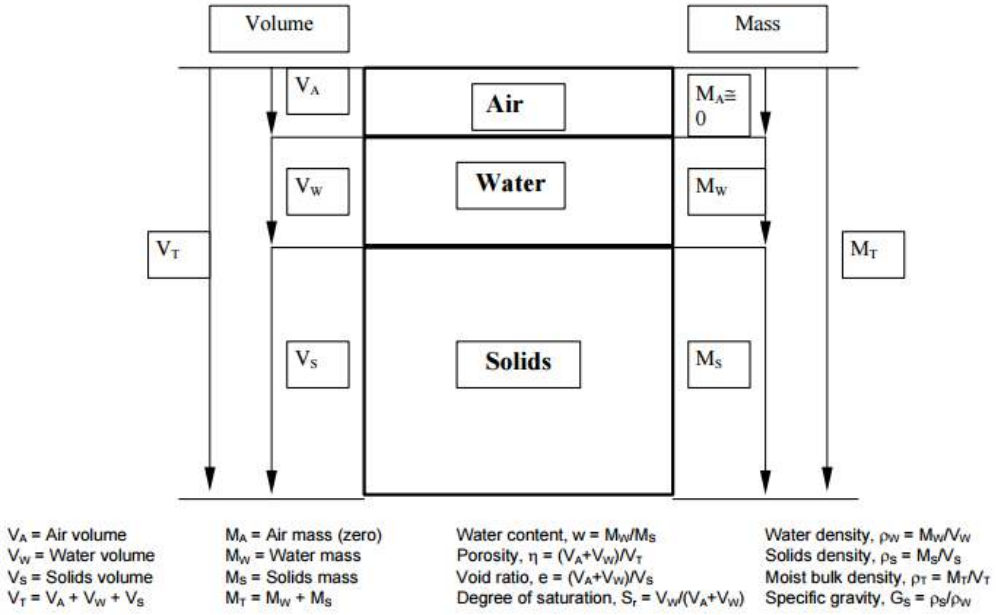

Figure 14. Saturated zone soil phase diagram and definitions.
(Source: Gregory et al., 1998)

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

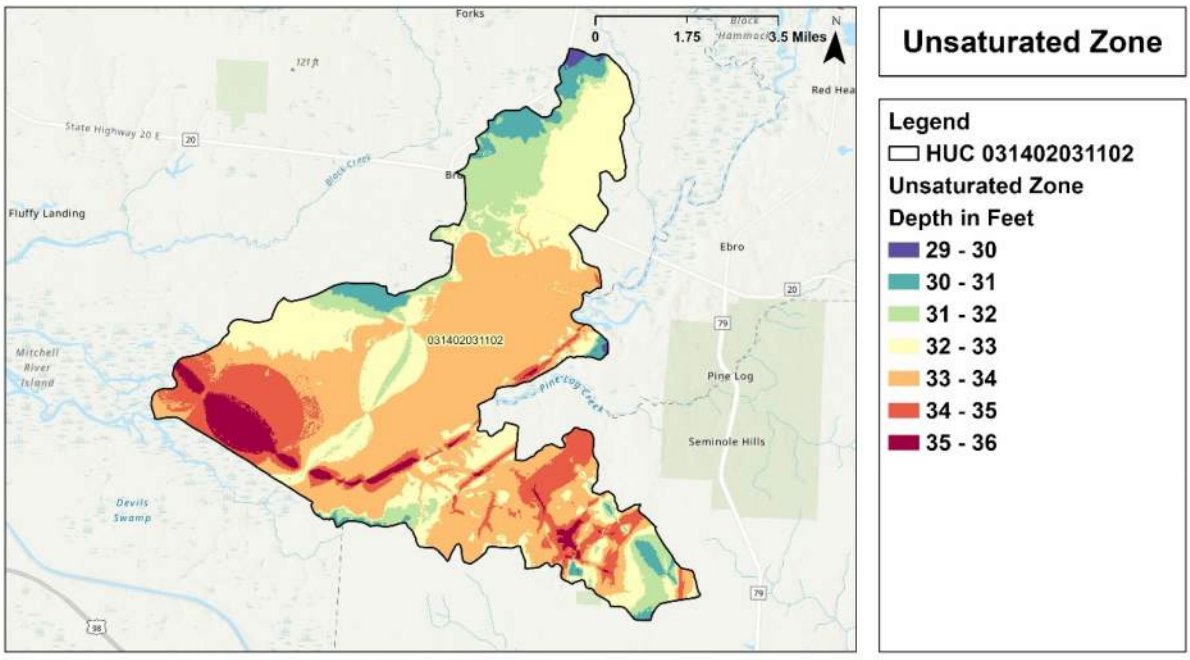

Figure 15. Unsaturated zone map for HUC 031402031102, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately favorable soil storage capacity, falling within the range of 31 to 35 feet of remaining capacity.

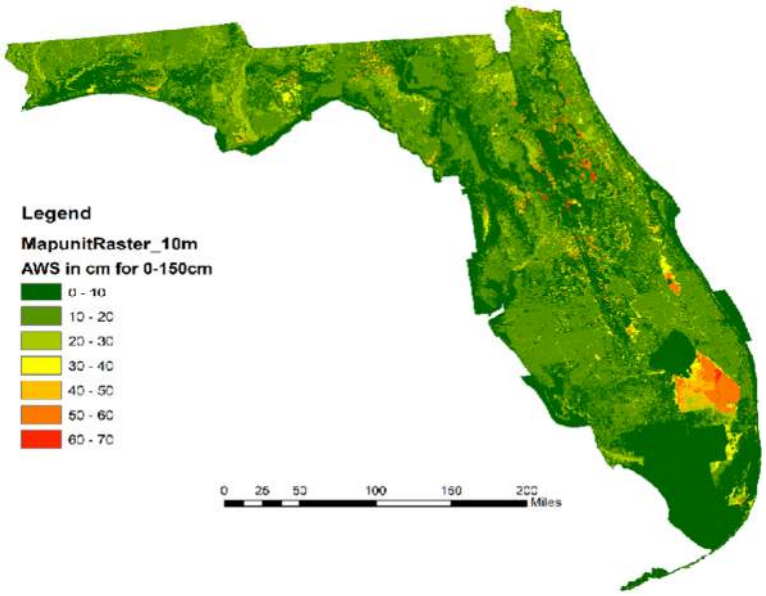

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.
(Data Source: USDA - SSURGO)

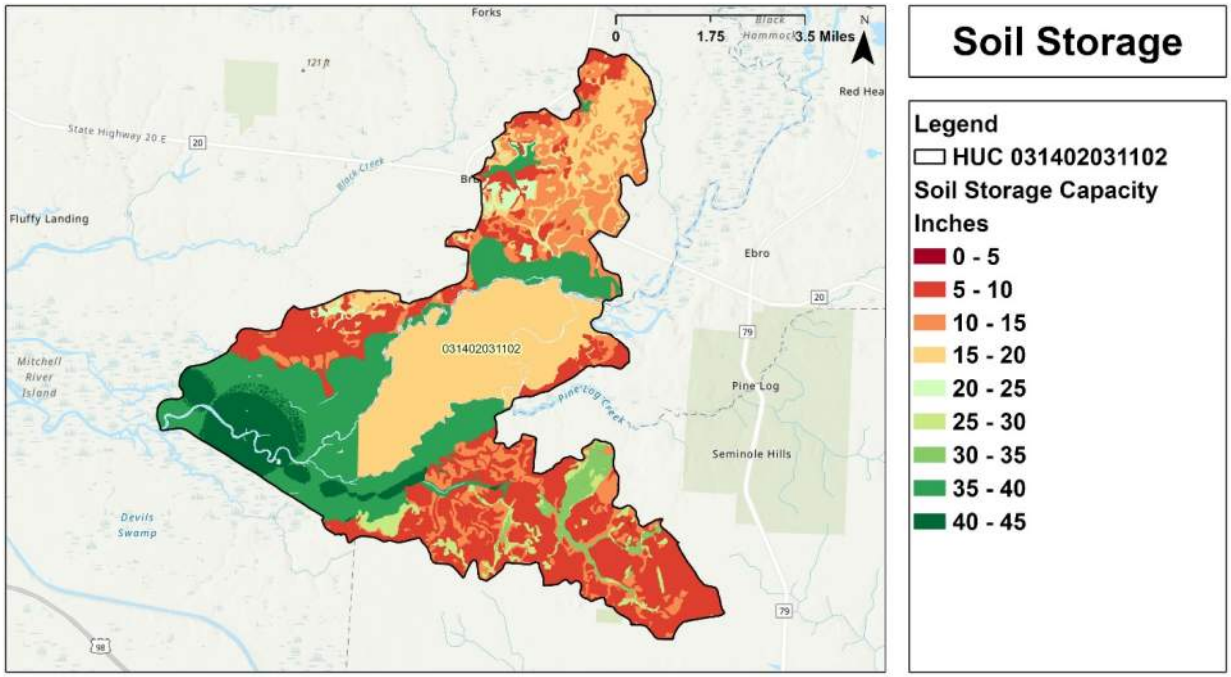

Figure 17. Water storage capacity of soil for the HUC 031402031102, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

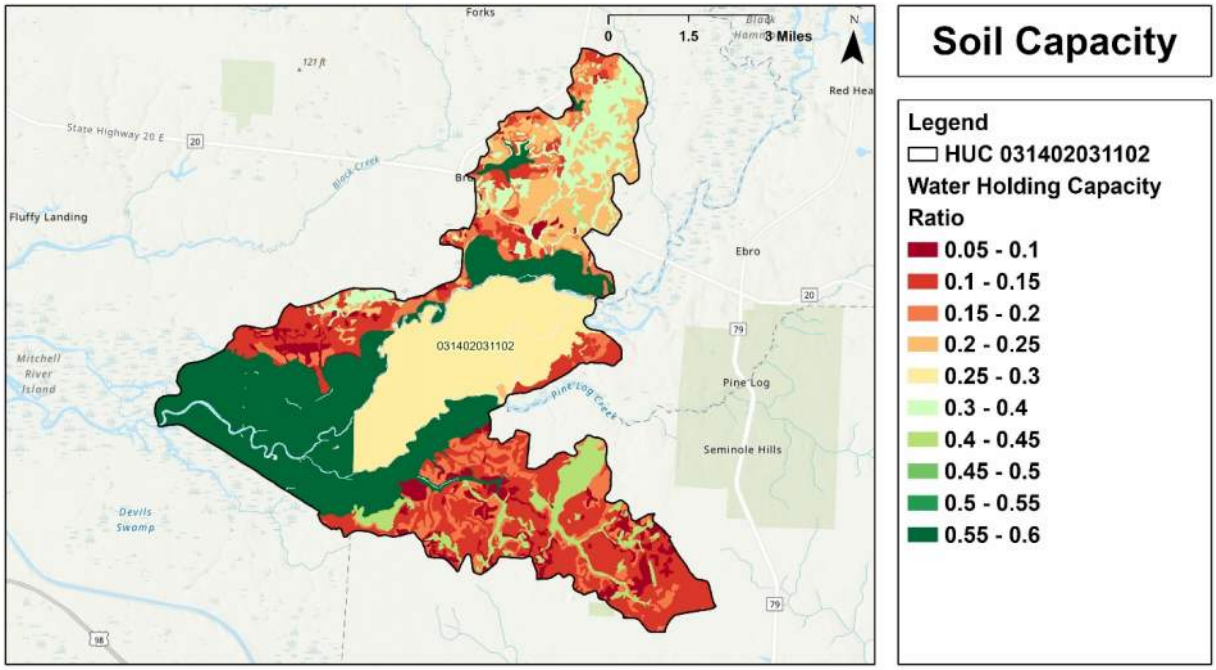

Figure 18: Water Holding Capacity (ratio) for the HUC 031402031102, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

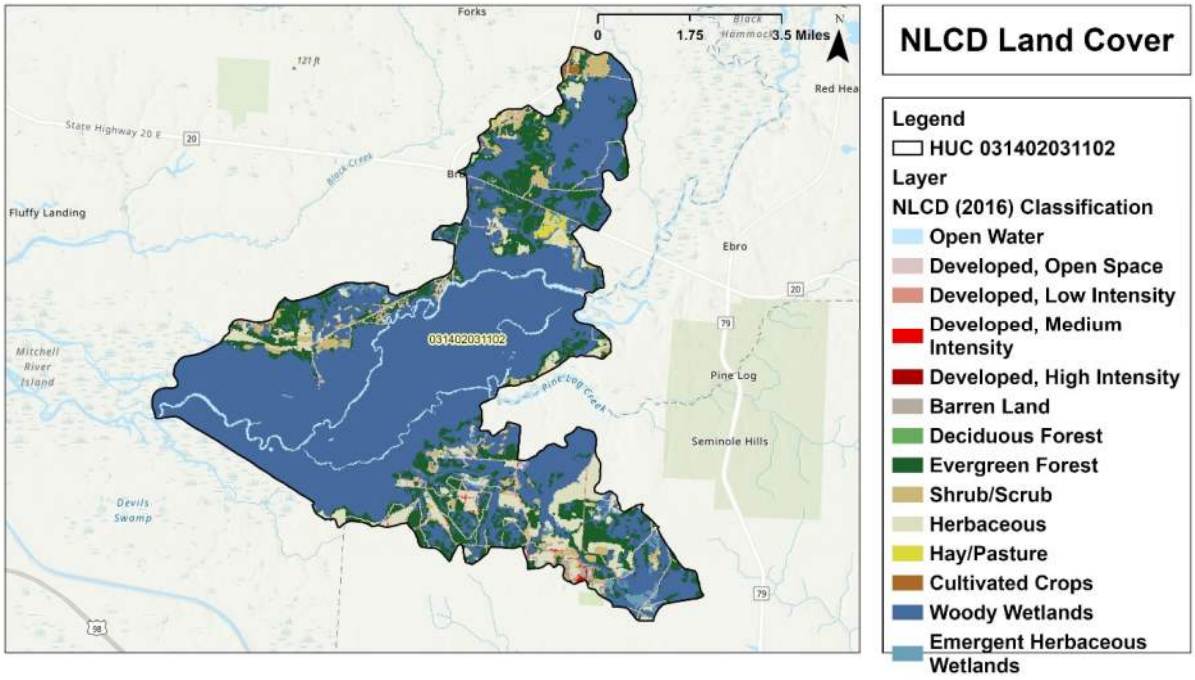

Figure 19. Land use in the HUC 031402031102 (from the NLCD 2016 database), processed by FAU.
(Source Data: NLCD, 2016)

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

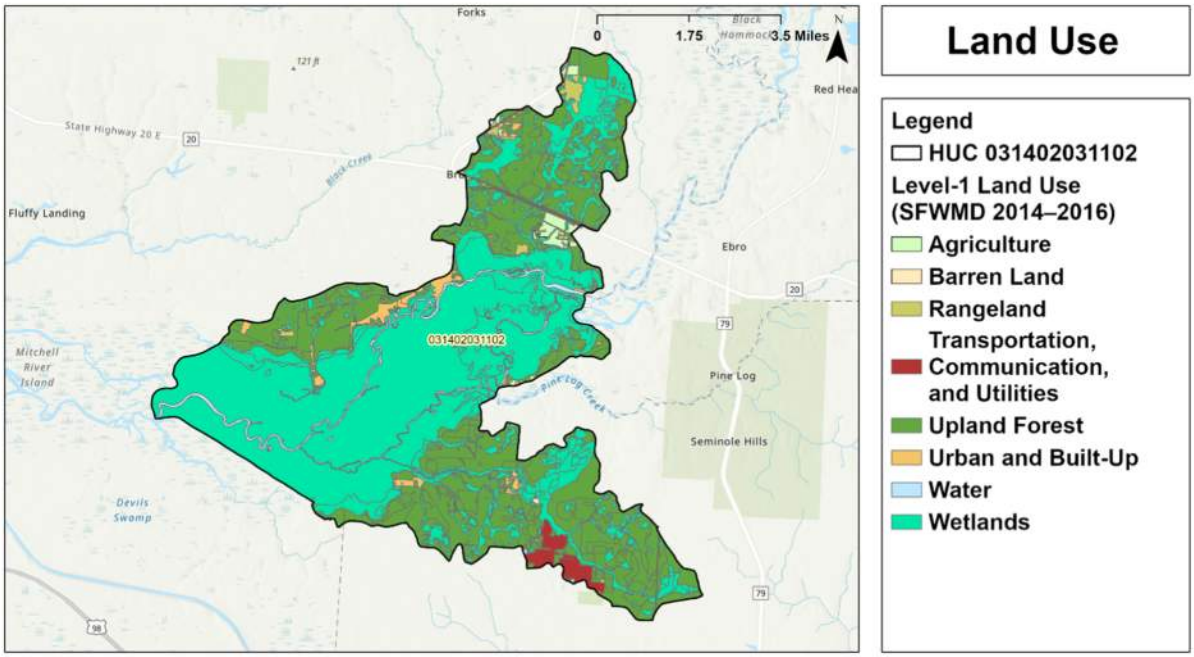

Figure 20. Land use in the HUC 031402031102, processed by FAU.
(Source Data: 2023 Florida Geographic Data Library (FGDL) database))

In the HUC 031402031102 sub-watershed, the predominant land cover is wetlands, accounting for 48.82% of the area. Upland forest comes in second at 32.99%, followed by Transportation, Communication, and Utilities at 8.05%. Developed land constitutes a minor portion, with only 1.20% categorized as urban and built-up, as indicated in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031402031102 sub-watershed

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	377.88	0.94%
Barren Land	6.83	0.02%
Rangeland	237.74	0.59%
Transportation, Communication, and Utilities	3236.46	8.05%
Upland Forest	13272.02	32.99%
Urban and Built-Up	483.61	1.20%
Water	2973.10	7.39%
Wetlands	19639.53	48.82%
Grand Total:	**40227.19**	**100.00%**

(Source Data: 2023 Florida Geographic Data Library (FGDL) database))

Table 4. Roughness and CN Values for Each Land Use Code

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

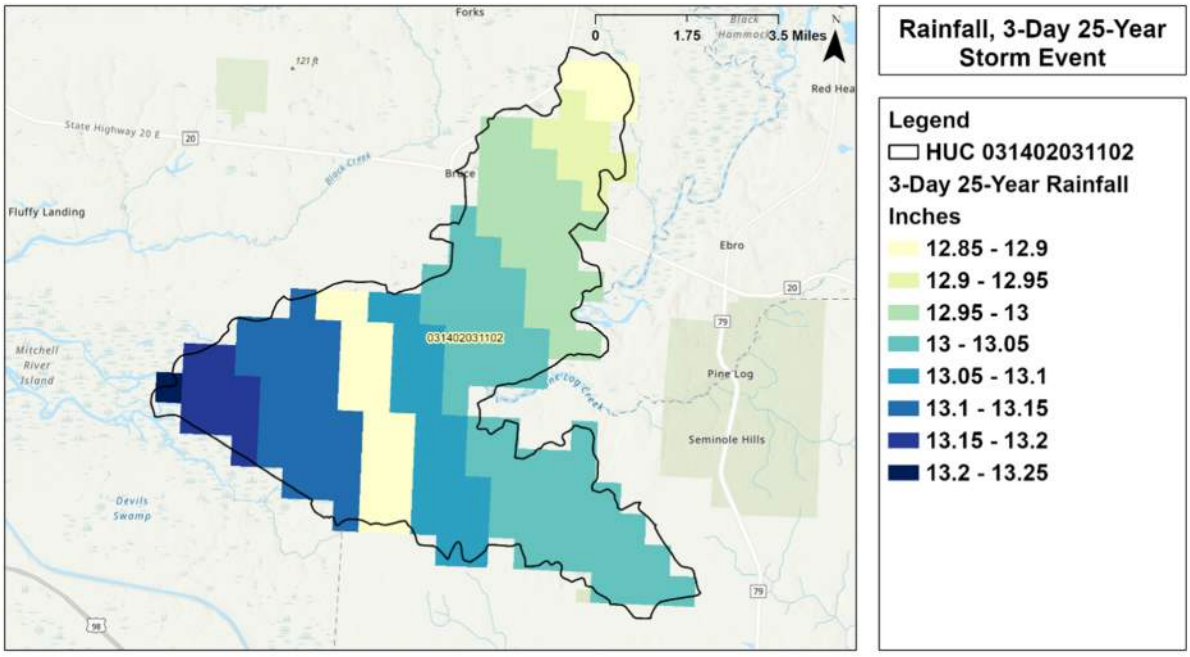

Figure 21. Rainfall distribution map across HUC 031402031102 sub-watershed, for 3-day 25-year storm event, processed by FAU.
(Source Data: NOAA Atlas 14 Database)

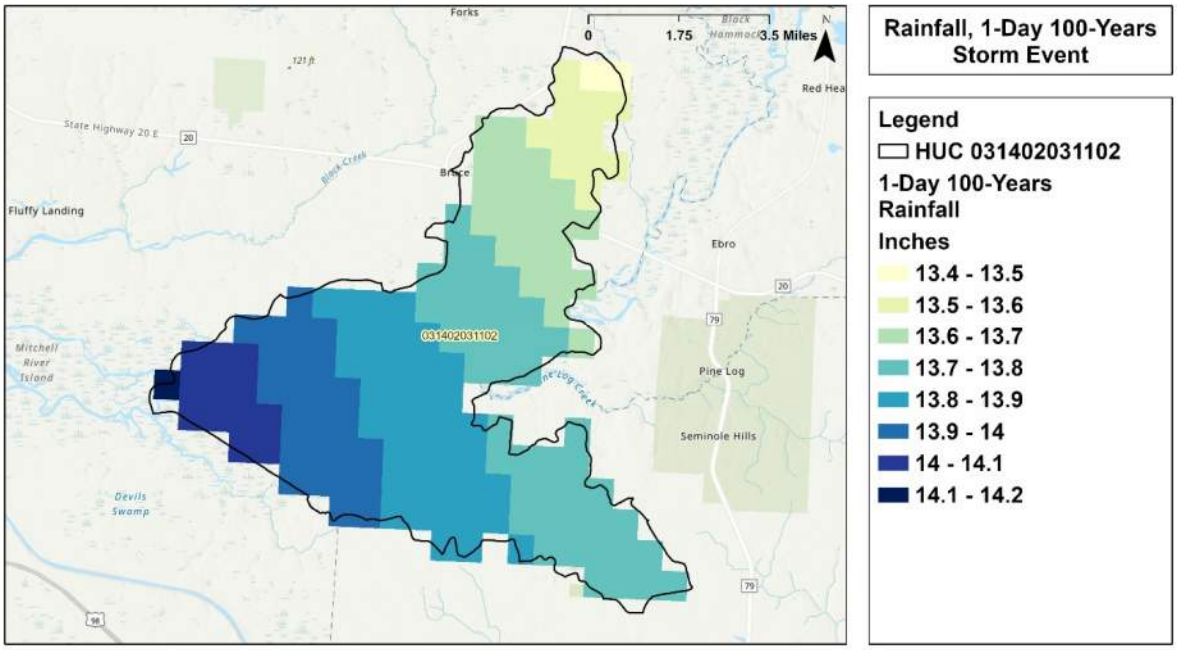

Figure 22. Rainfall distribution map across HUC 031402031102 sub-watershed, for 1-day 100-year storm event, processed by FAU.
(Source Data: NOAA Atlas 14 Database)

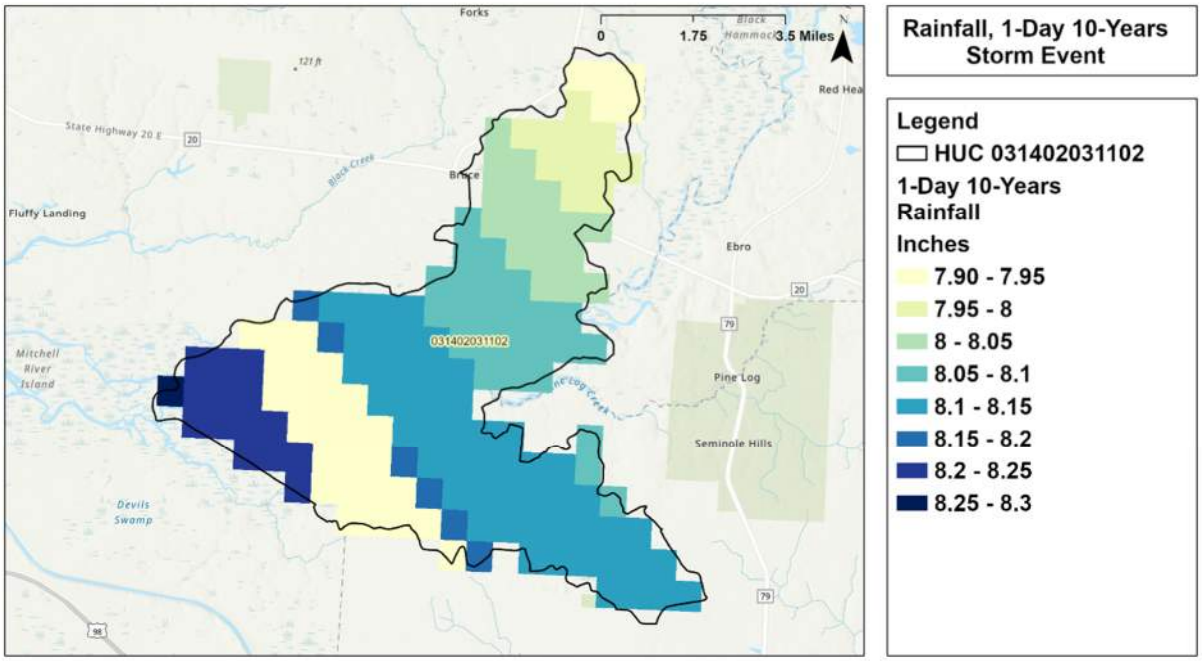

Figure 23. Rainfall distribution map across HUC 031402031102 sub-watershed, for 1-day 10-year storm event, processed by FAU.
(Source Data: NOAA Atlas 14 Database)

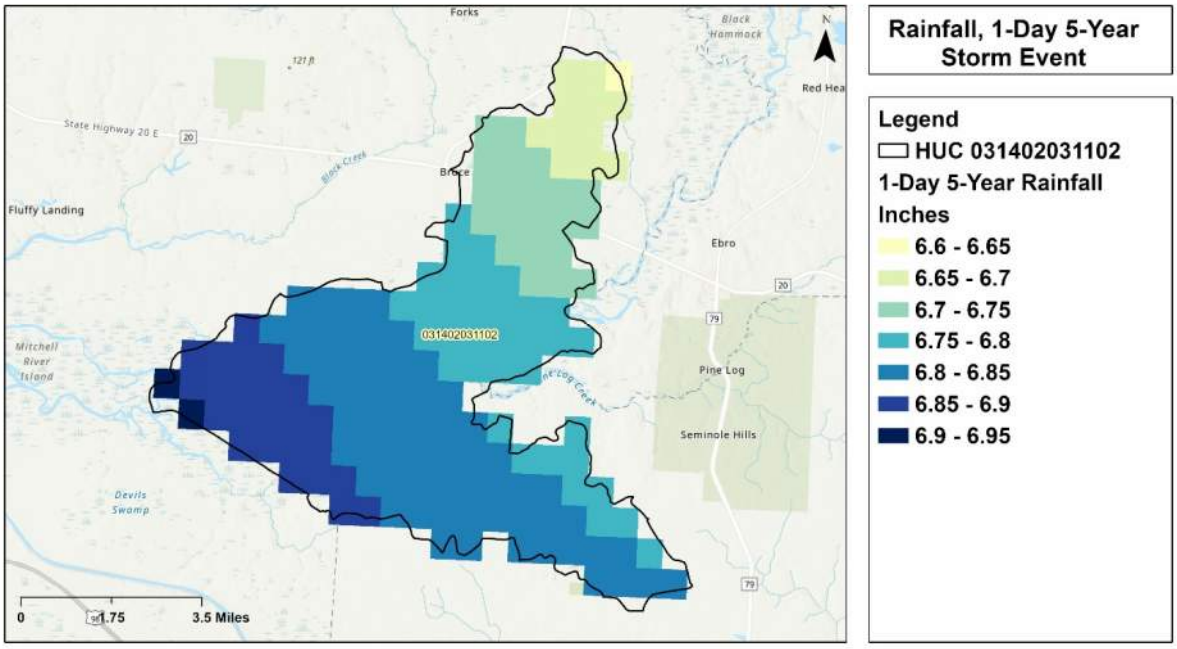

Figure 24. Rainfall distribution map across HUC 031402031102 sub-watershed, for 1-day 5-year storm event, processed by FAU.
(Source Data: NOAA Atlas 14 Database)

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

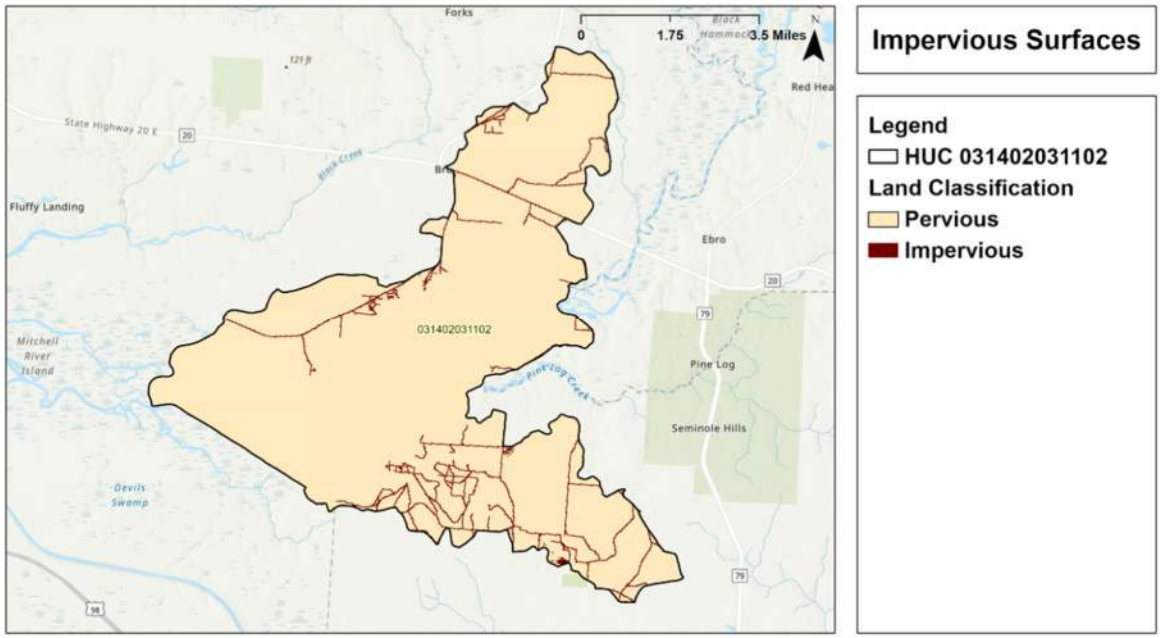

Figure 25. Impervious area map for the HUC 031402031102 sub-watershed, processed by FAU. (Source Data: NLCD, 2016)

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

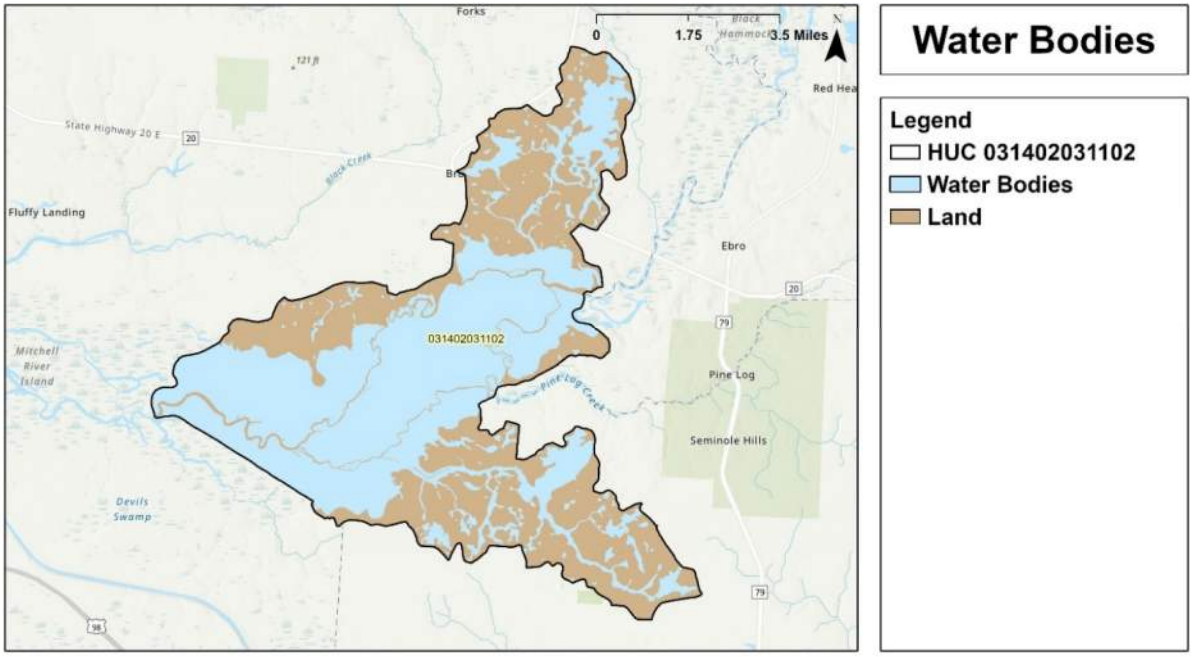

Figure 26. Water bodies map for the HUC 031402031102 sub-watershed, processed by FAU. (Source Data: USEPA – National Hydrographic Dataset (NHD))

1.10. Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

(Source: US Census Bureau 2020, and Zip-codes.com)

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.

- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

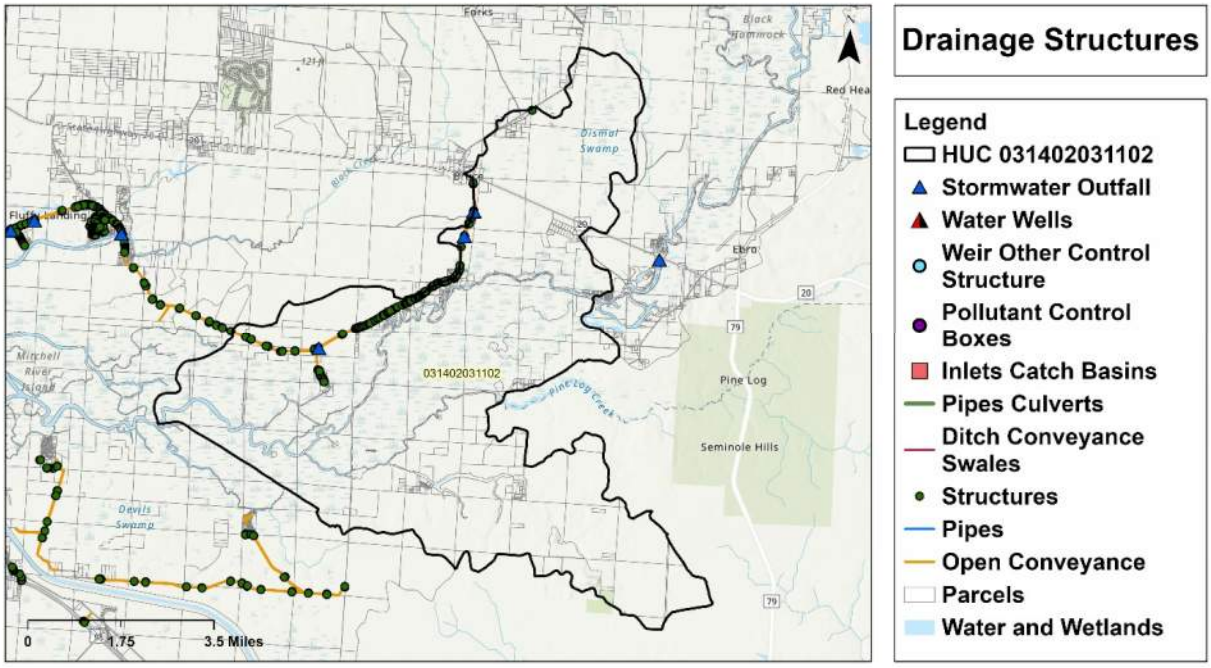

Figure 27. Stormwater Infrastructure for the HUC 031402031102. Processed by FAU.
(Source Data: Walton County Storm Asset Inventory and Stormwater Inventory)

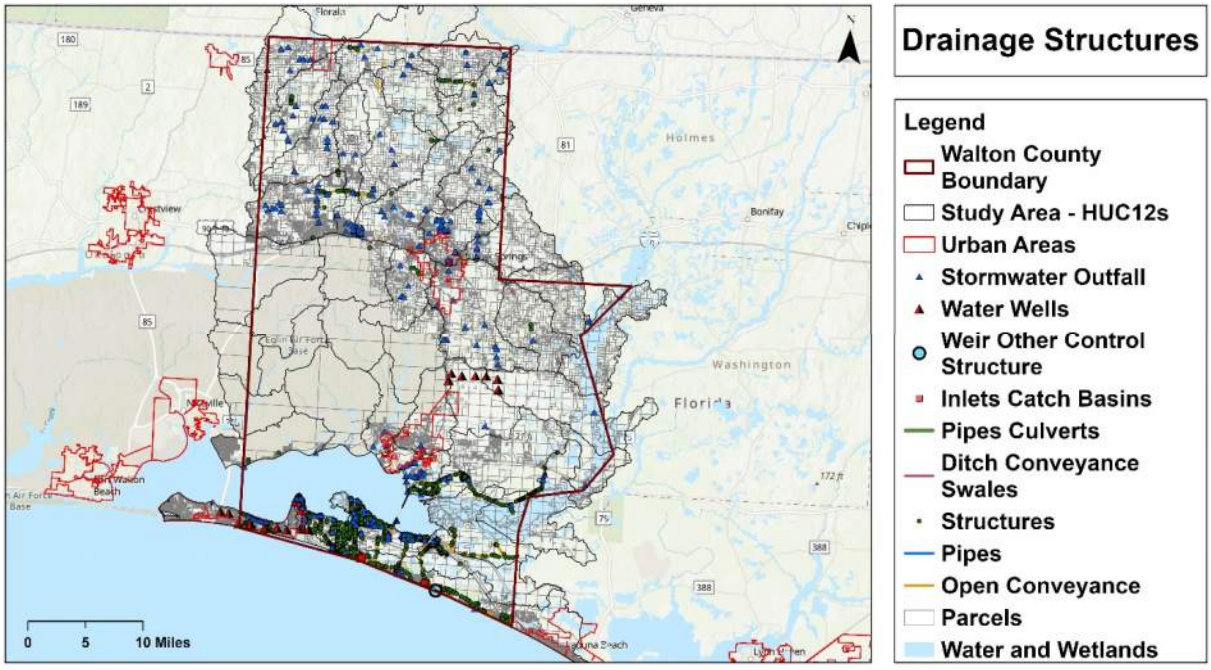

Figure 28.Stormwater Infrastructure for Walton County. Processed by FAU.
(Source Data: Walton County Storm Asset Inventory and Stormwater Inventory)

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in Table 5. The data can be used to model the impacts

of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1, analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031402031102 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the

coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD DBHYDRO website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

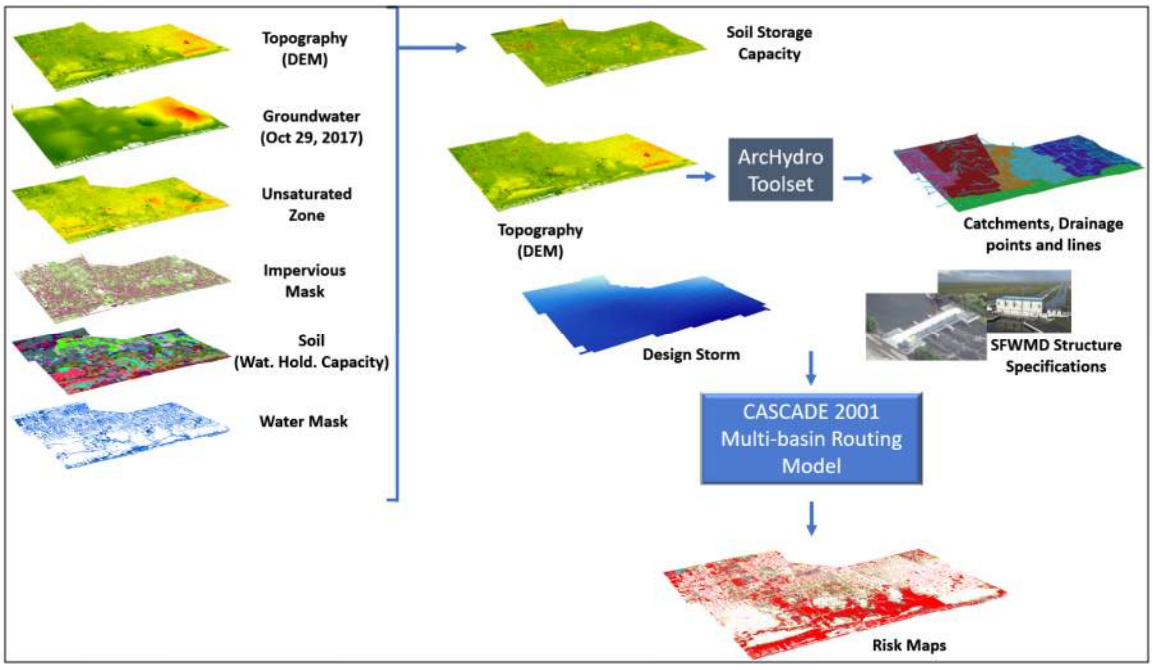

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the

investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

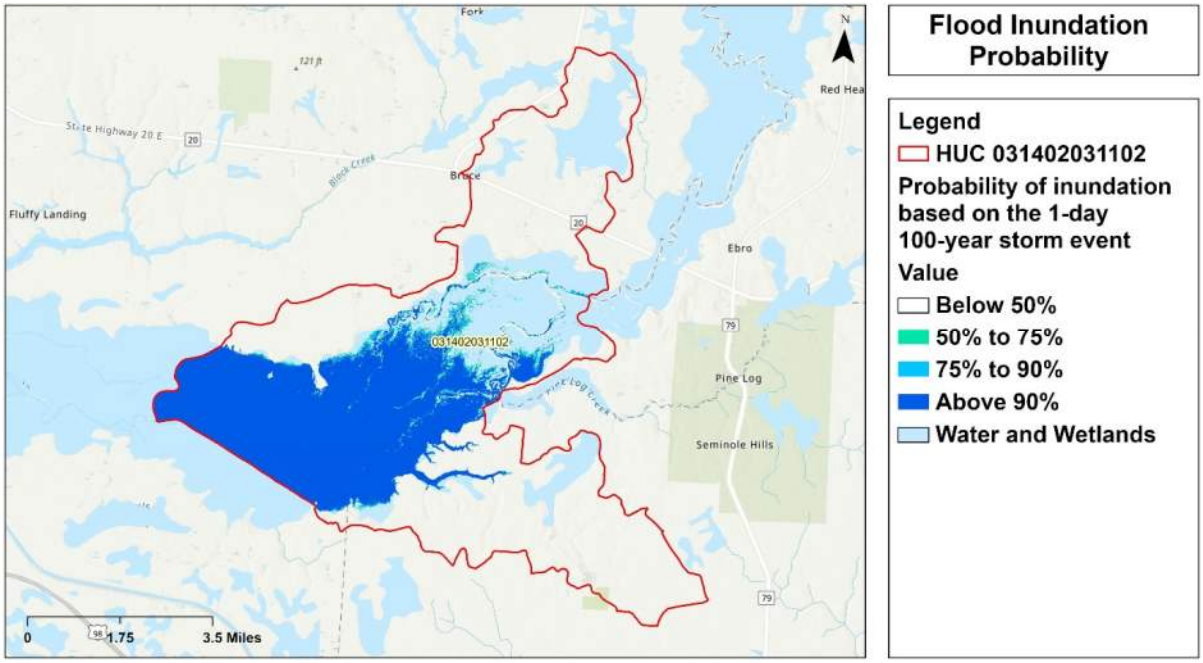

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031402031102, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate

the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 2.5 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not

eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Future Challenges of Sea Level Rise and Climate Change

Global observations from satellites and long-term data collection have made it possible to document and analyze patterns in the Earth's climate. Scientific analysis of the impact of these changes has helped to improve the understanding of future flood hazard driving forces and long-term impacts on human activities and watershed master planning (http://www.research.noaa.gov/climate/t_observing.html). Examples of impacts are rising global average air and ocean temperatures, increased and earlier snow and ice melt, shorter subtropical rainy seasons, shifted seasons, sea level rise and greater variations in temperature and precipitation (IPCC, 2013; Freas et al., 2008; Marshall et al., 2004; Bloetscher et al., 2010). Marshall et al. (2004) specifically focused on the Florida peninsula to predict changes in rainfall and warmer temperatures but interspersed lower low temperatures due to the potential loss of wetlands.

Future changes in climate will add to the existing impacts, at a time when the population of the state is expected to nearly double by 2030. Additional research and high-resolution climate modeling for the Florida peninsula and local jurisdictions is needed to help guide long-term plans like WMPs. Rainfall appears to be decreasing and temperatures rising (see **Error! Reference source not found.**).

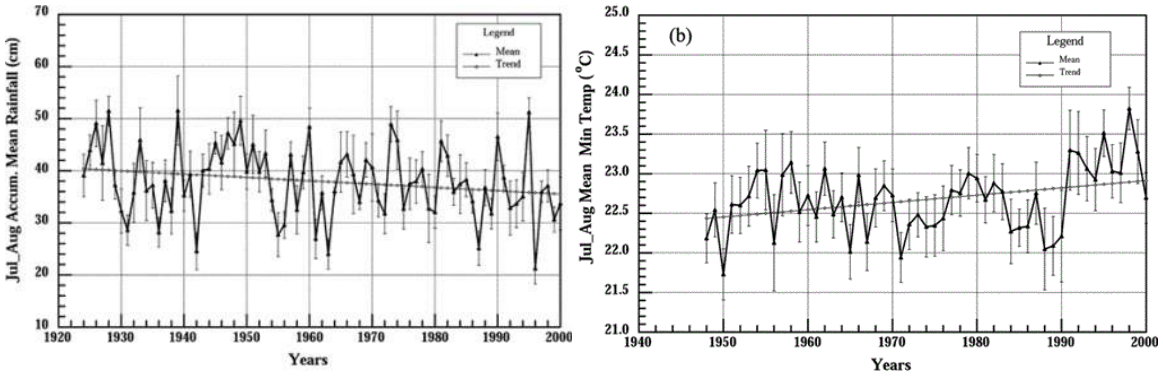

Figure 31. Change in average rainfall and change in average temp 1924 to 2000.
Note the reversed trend, which means groundwater input variability is lessened.
(Source: Marshall et al., 2004)

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to

flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3 feet. Accompanying these drivers are potential changes in storm frequency and intensity, desertification, population migration, ocean acidification and coastal flooding (IPCC, 2007), exacerbated by the land cover and land use changes, which are substantially impacted by the fluxes, timing and quality of precipitation (Adrians et al., 2003; Scanlon et al., 2005; Marshall et al., 2004; Salmun and Molod, 2006), and leading to changes in the timing of peak flows and volumes (Richey and Costa-Cabral, 2006).

The results of these climatic changes are likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly An outcome of these climatic patterns is that during the past 140 years, an increase in sea levels has been observed (Bloetscher, 2012), a worrying pattern since sea level rise is a permanent phenomenon, that can be catastrophic to low lying areas in the long-term. The question is how much and how soon? Various studies (Bindoff et al., 2007; Domingues et al., 2008; Edwards, 2007; Gregory, 2008; Vermeer and Rahmstorf, 2009; Jevrejeva, Moore and Grinsted, 2010; Bloetscher, 2010, 2011; IPCC, 2007; Heimlich et al., 2009) indicate large uncertainty in projections of sea level rise by 2100. Gregory et al. (2012) note that during the last two decades, the global rate of sea level rise has been larger than the 20th-century time-mean, and Church et al. (2011) suggested that the cause was increased rates of thermal expansion, glacier mass loss, and ice discharge from icesheets. Gregory et al. (2012) suggested that there may also be increasing contributions to global sea level rise from the effects of groundwater depletion, reservoir impoundment, and loss of storage capacity in surface waters due to siltation. Measurements of Florida's east coast (Maul, 2008) show an average rate of sea level rise of 2.27 ± 0.04 mm per year from 1915 to 1992 based on tide gauge readings. Analyzing the tidal gauge readings for Florida shows that:

1. Florida average sea level rise is 2.10 ± 0.49 mm/yr

2. All but one location is within the 95% confidence limit range (the exception is Panama City where there is evidence of submergence and other land-based issues)
3. None of the Florida sea level rise rates differ statistically
4. Average global sea level rise for 1920-2000 was 2.0 mm/yr – within 95% confidence limit for Florida locations

From 1929 to 1992, over eight inches of sea, with another 6 inches added since 1992, which is already having significant impacts on coastal communities where population growth has increased the need for improved flood management strategies (Bloetscher, 2008; Parkinson, 2010; Zhang et al., 2011, 2011a; NFIP, 2011; Schmidt et al., 2011; Warner et al., 2012).

As a result, the SFRCCC (2015) adopted USACE's methodology to derive scenarios of sea level change intermediate to high rates of sea level rise for years 2030 (3" to 7") and 2060 (9" to 24") as the consensus projection to guide future planning. The path keeps increasing – now 14 inches since 1929 (**Error! Reference source not found.**) caused by thermal expansion of the ocean and melting ice caps (Jevrejeva et al., 2010; Vermeer and Rahmstorf, 2009). Sea level rise is a major concern in Florida, including Walton County, since the majority of the state's population live on the coast, involving most major commercial, residential, and economic enterprises. **Error! Reference source not found.** demonstrate the estimated sea level change for Panama City, considering the predictions of NOAA 2017. For NOAA high scenario SLR change scenario, the estimated level change is higher than 8 ft., while for the intermediate and low scenarios are about 3.9 feet and 1.7 feet respectively.

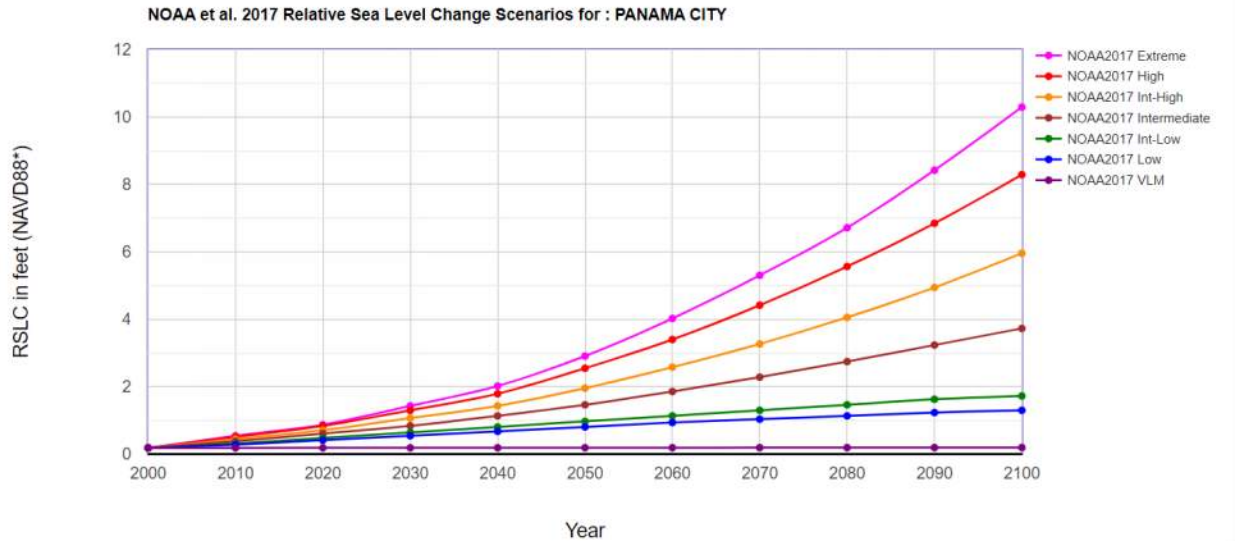

Figure 32. Relative Sea Level Change Scenarios for gauge 8729108, Panama City, FL. (Source: NOAA, 2017 available at https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html)

NOAA (2017) outlines five scenarios for sea level rise. The NFIP proposes the use of the intermediate high projection, which is 1.2 meters or 4 ft globally from current sea level elevations (**Error! Reference source not found.**).

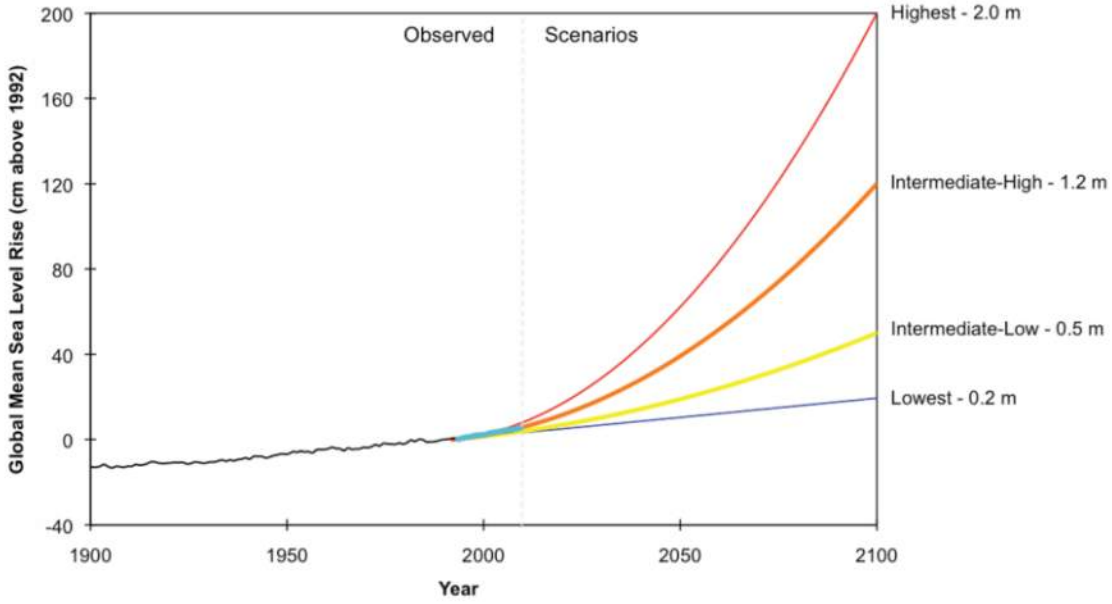

Figure 33. Graphic of global sea level rise projections from NOAA (2017).
(Source: NOAA, 2017 available at https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf)

As sea level rises, access to roads, bridges, rail, and transit could be at risk of flooding, causing the effects of sea level rise to spread indirectly throughout the entire transportation network, affecting the overall system performance. For example, the flooding of a critical road or facility access can cause a shifting of traffic flow causing congested conditions in other roadways that are not actually flooded. Since the roadway network would be unable to carry the traffic demand, the system would experience operational failure; as a result, causing travel times and delays. Moreover, the inundation of a critical access could cause transportation connectivity problems to essential infrastructure like ports or airports. Transportation infrastructure relies on the effectiveness of flood control and stormwater drainage systems for the transportation corridors. Road integrity relies on adequate drainage. The increased risk of severe flooding in Florida's low-lying terrain can adversely affect transportation infrastructure along the coastline; roads can be inundated, and roadway beds can be damaged. Sea level rise will cause increased water table levels (FDOT, 2012), as regional water tables cannot exist naturally below mean high tide (2 feet in Florida). Adding 3 feet of sea level rise on top of groundwater would compound the risk of flooding in low-lying areas. Road bases below 5 feet NVGD would become saturated under this scenario, likely causing premature base failure. As soil storage capacity is diminished due to rising groundwater elevations associated with sea level rise, the potential for more frequently flooded

roadways would likely damage pavements (FDOT, 2012). Hence sea level rise must be accounted for in WMPs in coastal areas. To allow flexibility in the analysis due to the range of increases within the different time periods, an approach that uses incremental increases of 1, 2, and 3 feet of sea level rise is suggested for modeling. The increments can work as threshold values in planning considerations in terms of allowing planners the ability to know ahead of time where the next set of vulnerable areas will be, to allow for a proactive response approach that can be matched to the observed future rates. Sea level rise is a major concern since nearly half the US population lives within 50 miles of the coast, involving most major commercial, residential, and economic enterprises. The effects of 5 ft sea level rise, King tide, and 1-day 100-year storm event are shown in in Figure 34.

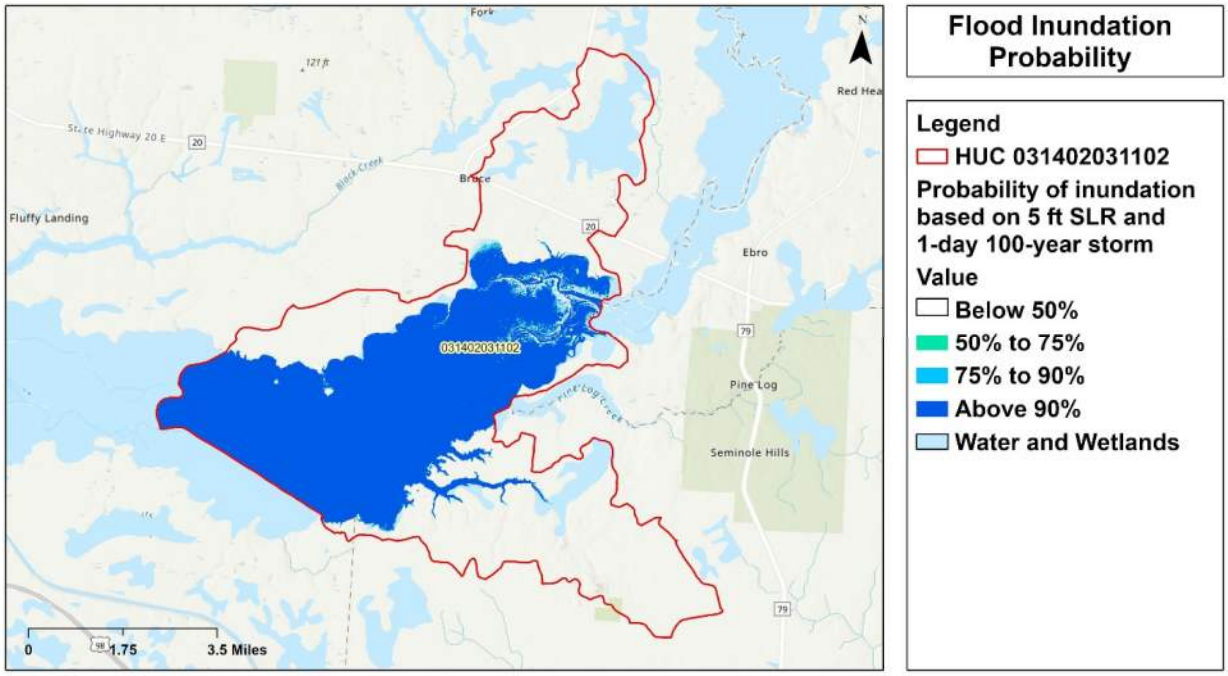

Figure 34. Flood Inundation Probability for a Sea level rise of 5 ft + 1-day 100-year storm event for HUC 031402031102 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Dark blue is area under 5 ft NAVD88 and potentially inundated at the 99th percentile tidal conditions. Processed by FAU.

2.4 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. **3-day 25-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 35)
2. **1-day 100-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 36)
3. **1-day 10-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 37)
4. **1-day 5-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 38)
5. **Sea level rise of 1 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 39)
6. **Sea level rise of 1 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations storm (Figure 40)
7. **Sea level rise of 1 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 41)
8. **Sea level rise of 1 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 42)
9. **Sea level rise of 2 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 43)
10. **Sea level rise of 2 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 44)
11. **Sea level rise of 2 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 45)
12. **Sea level rise of 2 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 46)
13. **Sea level rise of 3 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 47)
14. **Sea level rise of 3 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 48)

15. **Sea level rise of 3 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 49)
16. **Sea level rise of 3 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 50)
17. **Sea level rise of 4 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 51)
18. **Sea level rise of 4 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 52)
19. **Sea level rise of 4 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 53)
20. **Sea level rise of 4 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 54)
21. **Sea level rise of 5 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 55)
22. **Sea level rise of 5 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 56)
23. **Sea level rise of 5 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 57)
24. **Sea level rise of 5 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 58)

In all scenarios, a great amount of flooding is noted at the river entrance to the HUC, extending to the wetland areas. As this basin connects to the ocean though Choctawhatchee River, SLR scenarios plays an important hole, implying a considered growth as the projected scenario of rising tides rises.

The design storm simulation determined that approximately 32% of the HUC total area or 14.13 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 32.2% of the HUC's total area, or 14.24 mi^2 would be expected to be inundated during a 1-day 100-year design storm. Approximately 31.7% of the HUC's total area,

or 14.01 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 31.7% of the HUC's total area, or 14.01 mi², would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031402031102 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	30.07	14.13	68.0%	32.0%
1-day 100-year	29.96	14.24	67.8%	32.2%
1-day 10-year	30.19	14.01	68.3%	31.7%
1-day 5-year	30.19	14.01	68.3%	31.7%

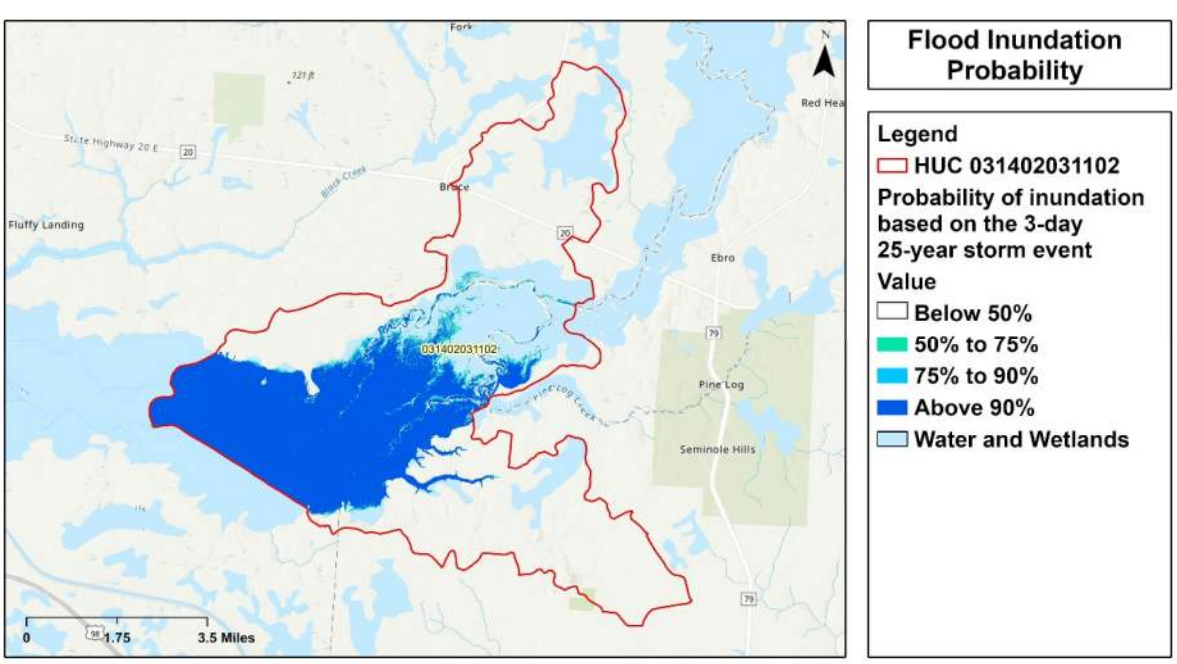

Figure 35. 3-day 25-year storm event for HUC 031402031102 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

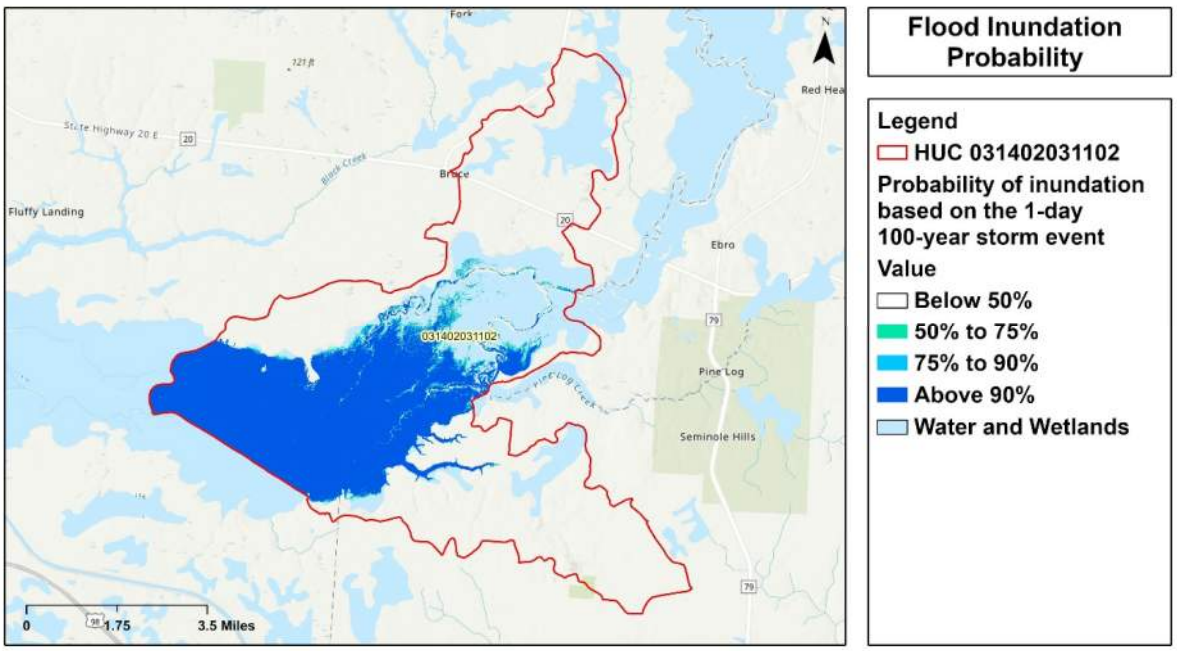

Figure 36. 1-day 100-year storm event for HUC 031402031102 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

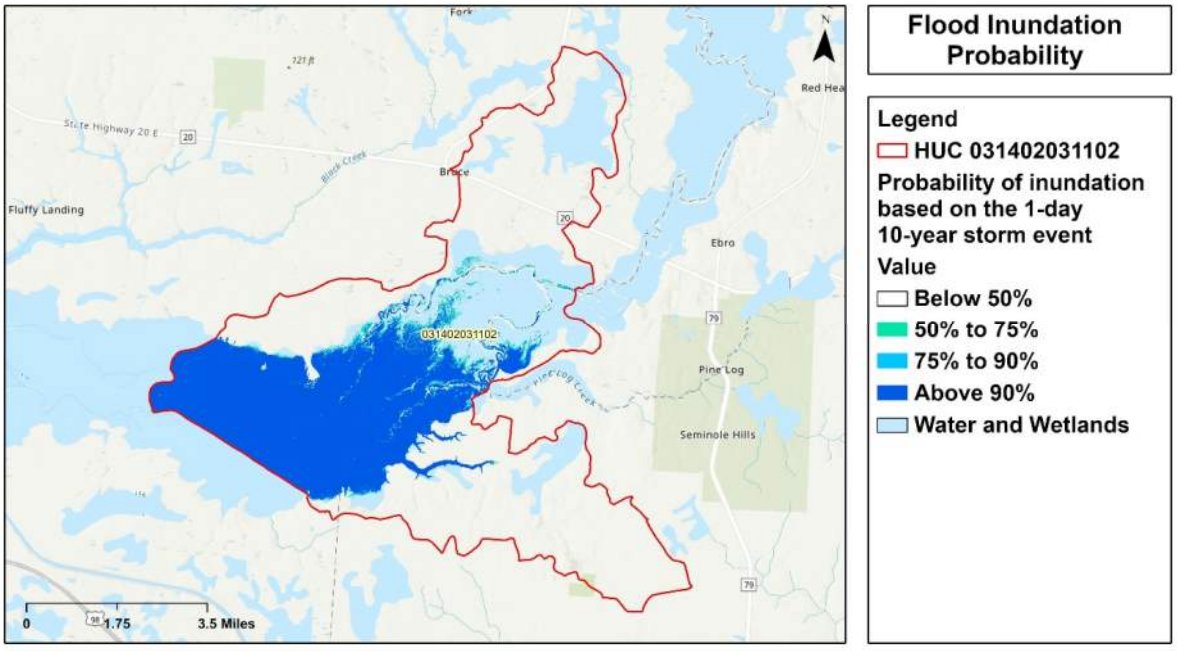

Figure 37. 1-day 10-year storm event for HUC 031402031102 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

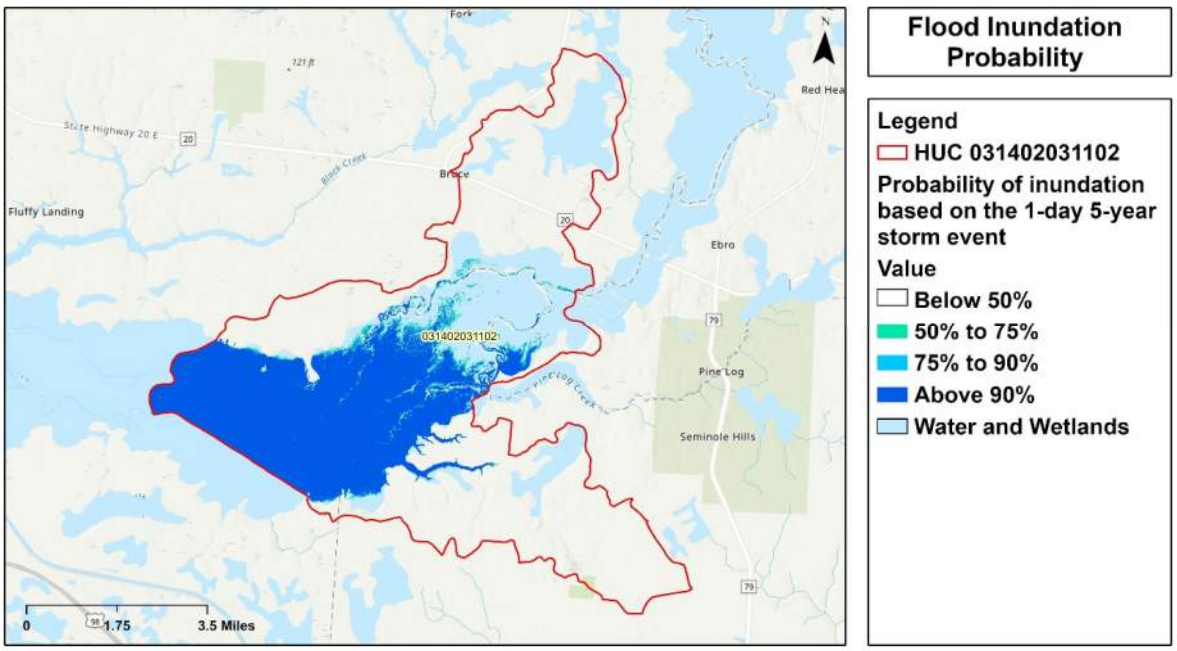

Figure 38. 1-day 5-year storm event for HUC 031402031102 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

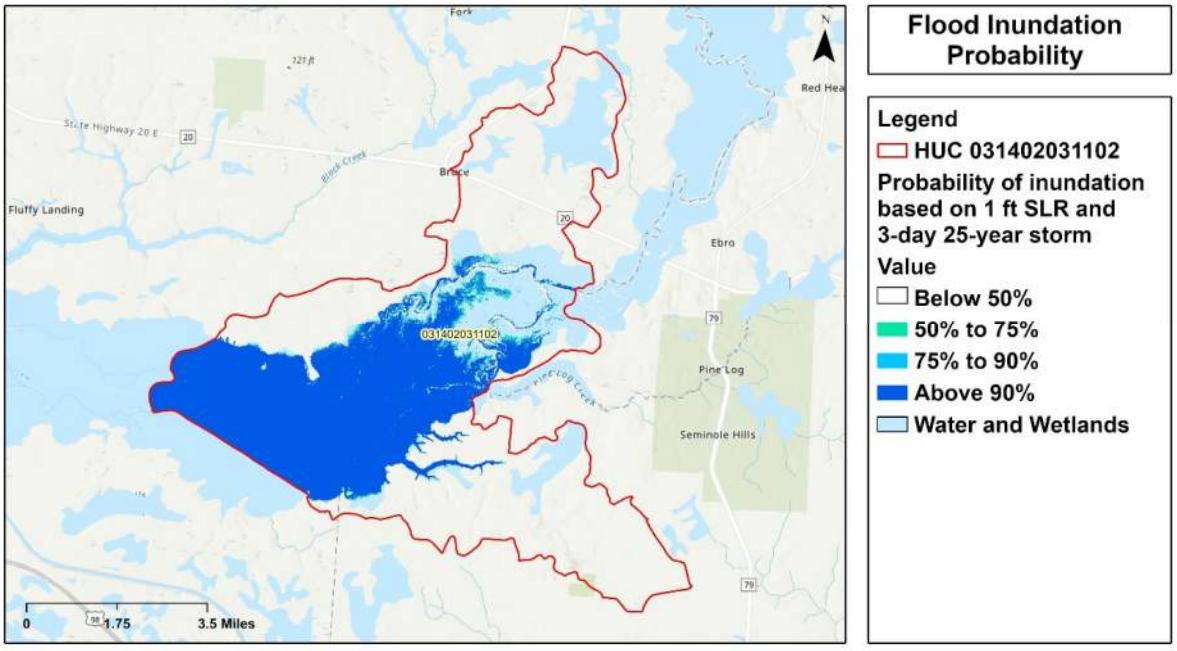

Figure 39. Sea level rise of 1 ft + 3-day 25-year storm for HUC 031402031102 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

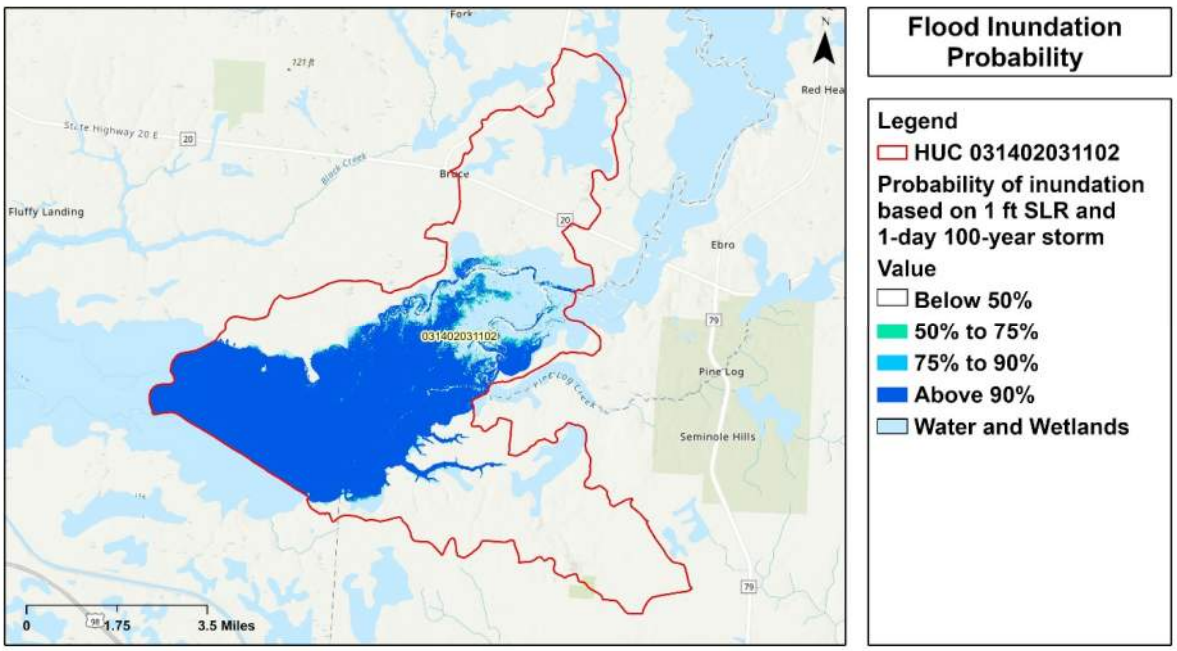

Figure 40. Sea level rise of 1 ft + 1-day 100-year storm for HUC 031402031102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

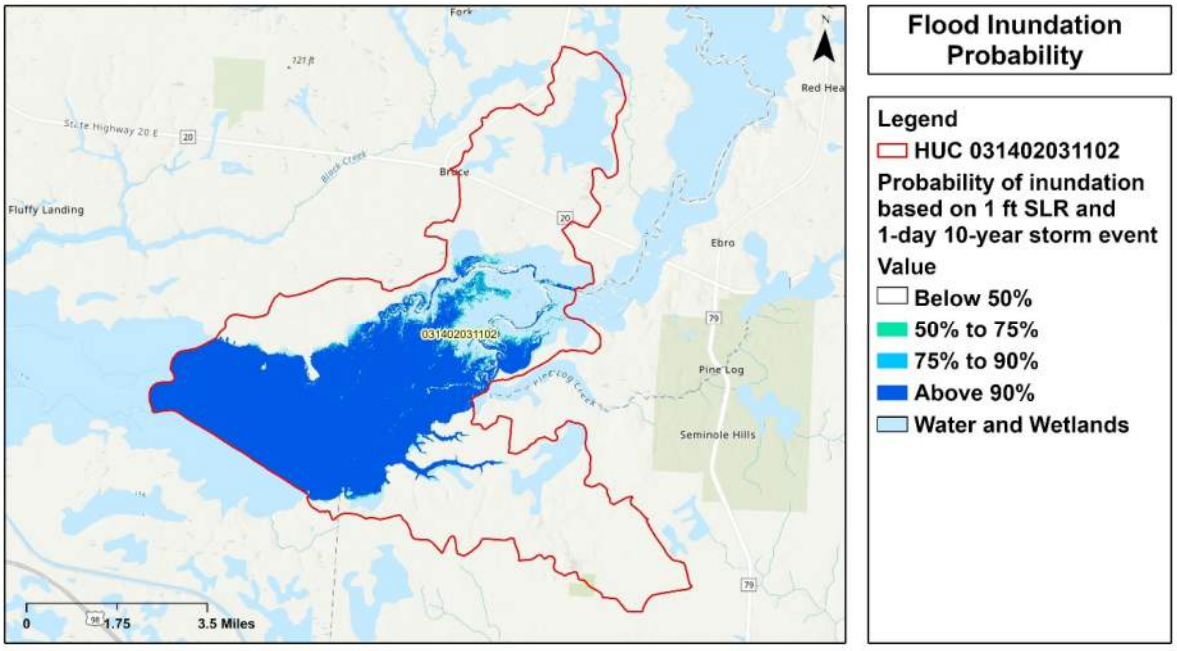

Figure 41. Sea level rise of 1 ft + 1-day 10-year storm for HUC 031402031102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

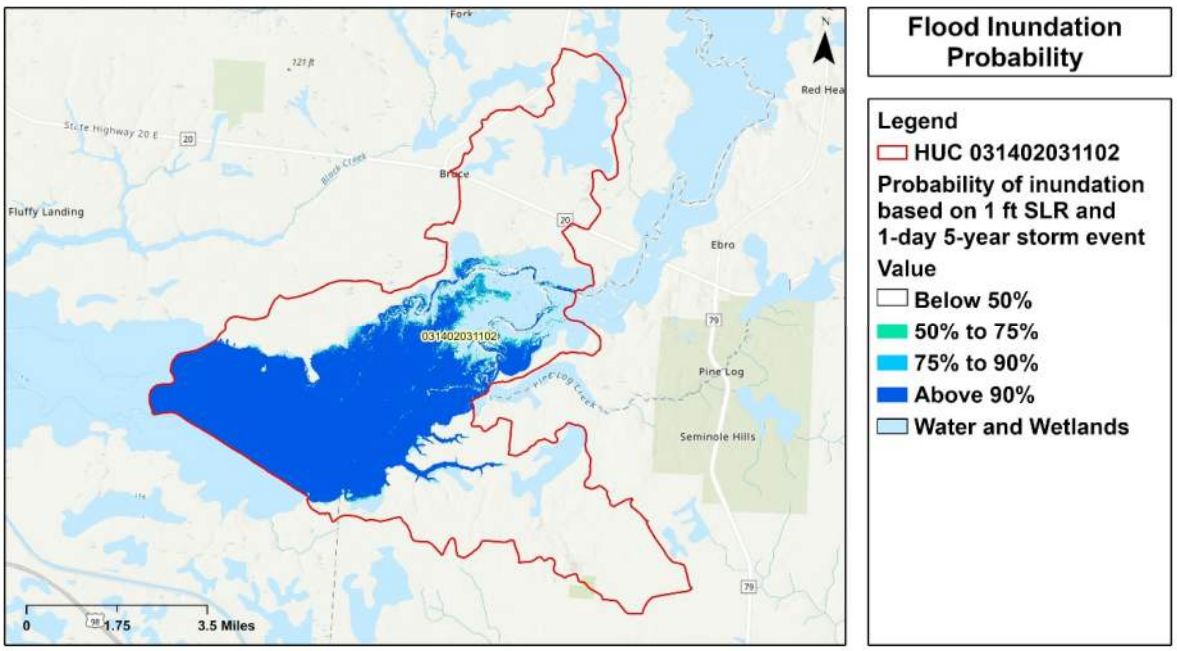

Figure 42. Sea level rise of 1 ft + 1-day 5-year storm for HUC 031402031102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

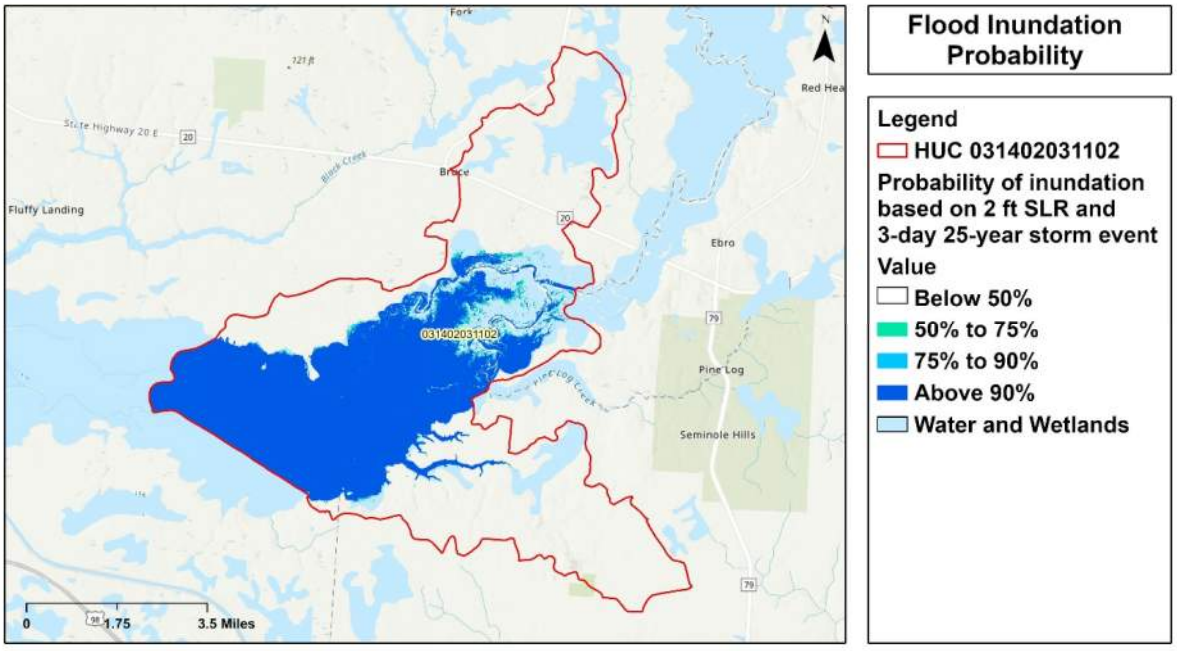

Figure 43. Sea level rise of 2 ft + 3-day 25-year storm for HUC 031402031102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

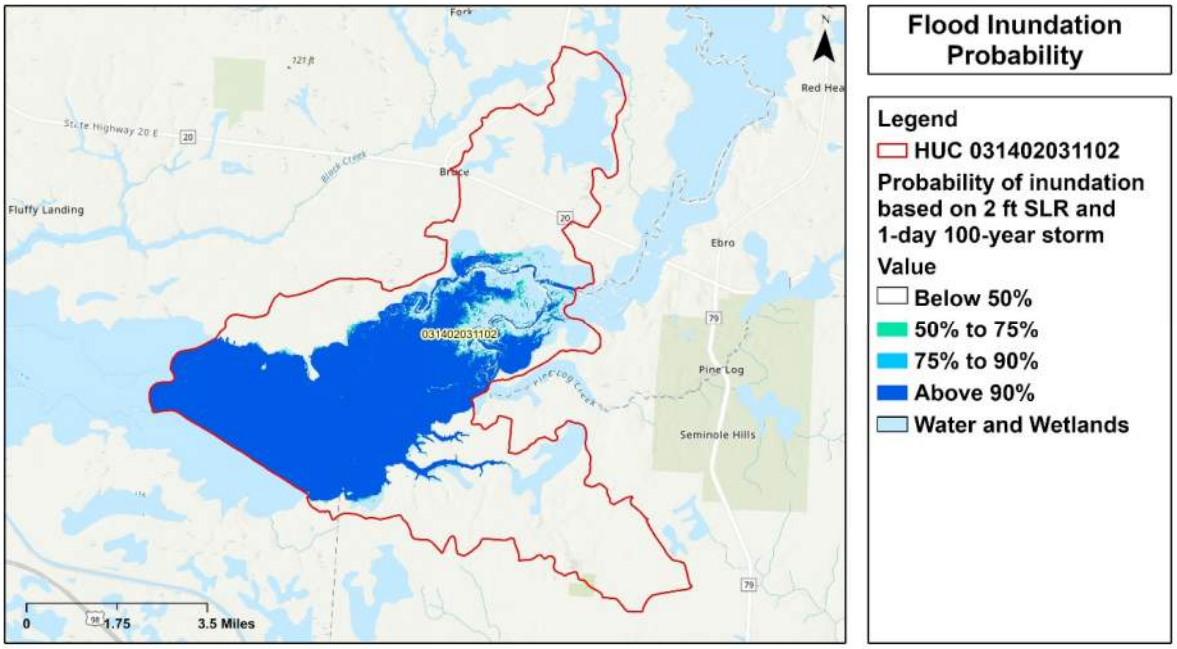

Figure 44. Sea level rise of 2 ft + 1-day 100-year storm for HUC 031402031102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

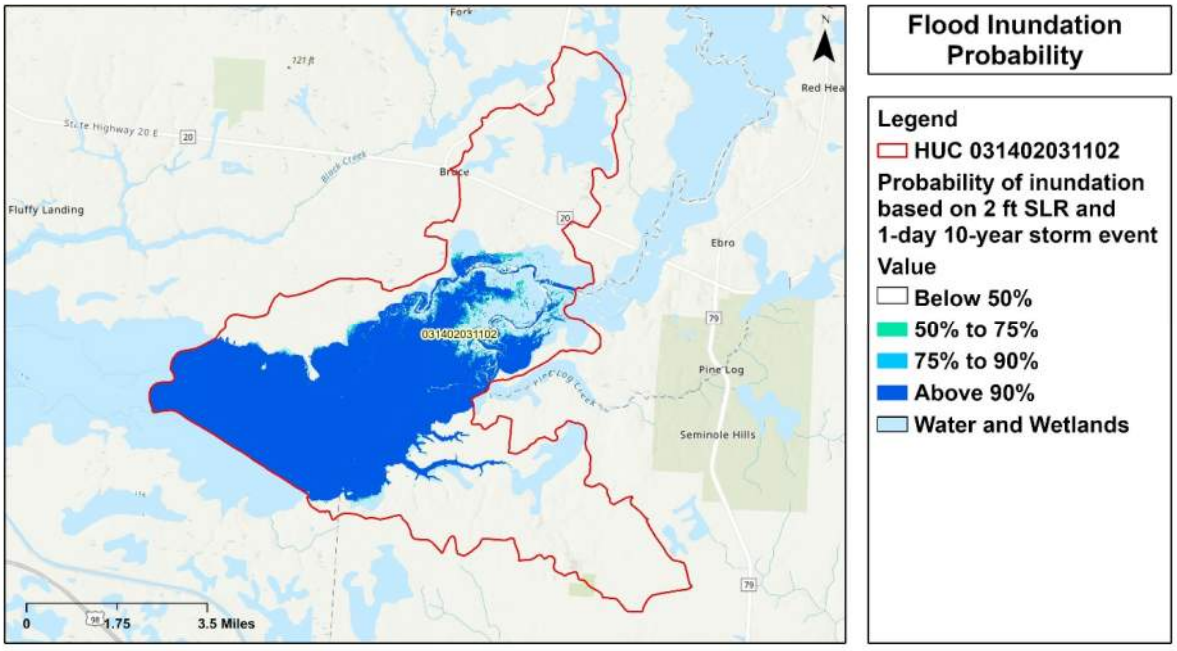

Figure 45. Sea level rise of 2 ft + 1-day 10-year storm for HUC 031402031102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

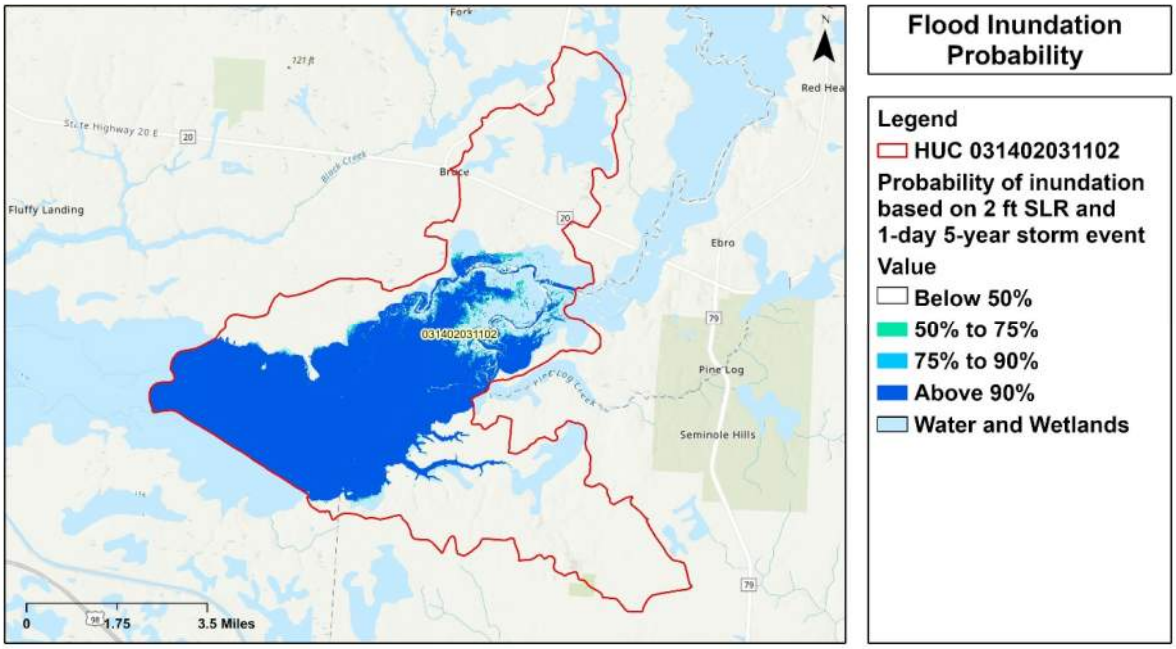

Figure 46. Sea level rise of 2 ft + 1-day 5-year storm for HUC 031402031102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

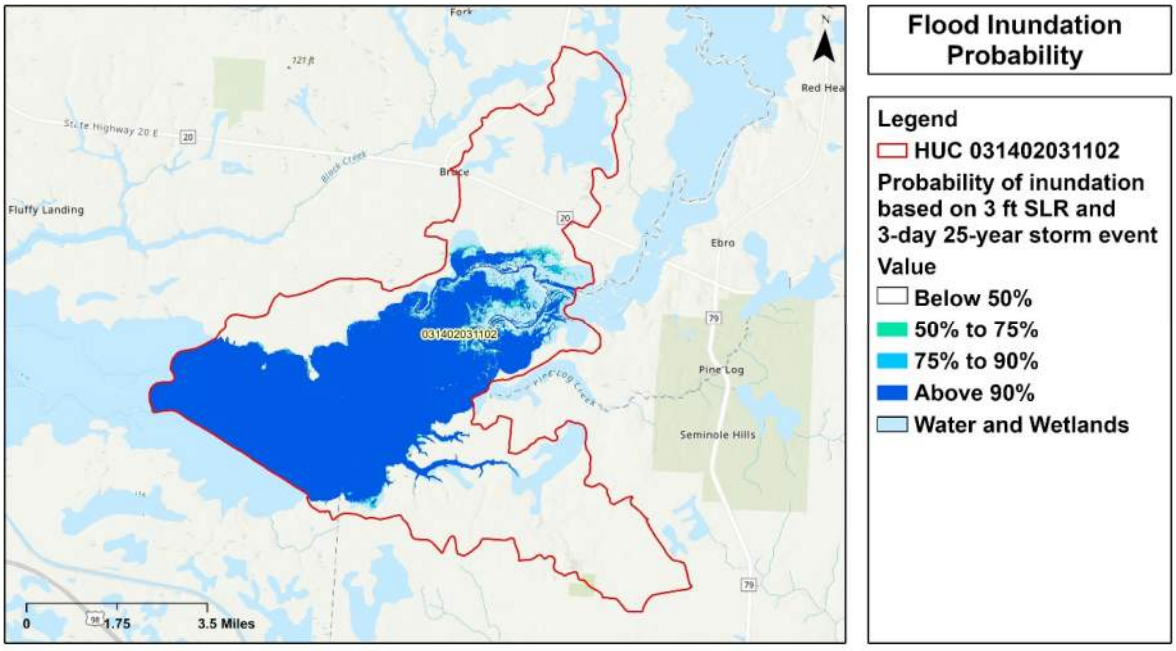

Figure 47. Sea level rise of 3 ft + 3-day 25-year storm for HUC 031402031102 sub-watershed.. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

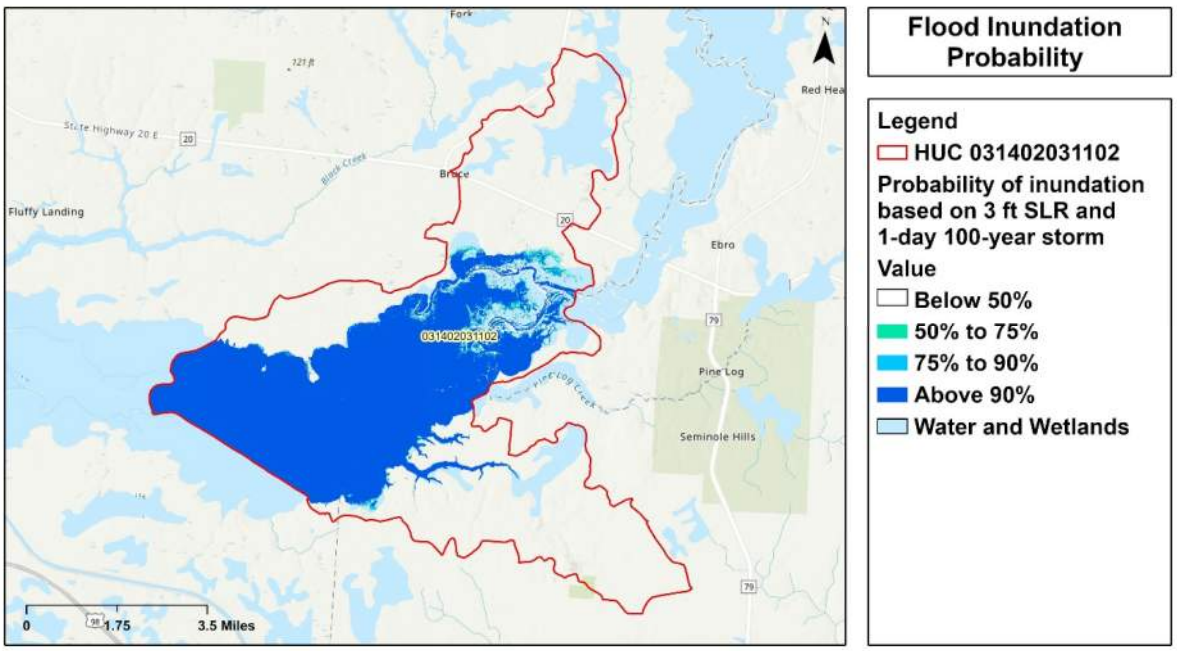

Figure 48. Sea level rise of 3 ft + 1-day 100-year storm for HUC 031402031102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

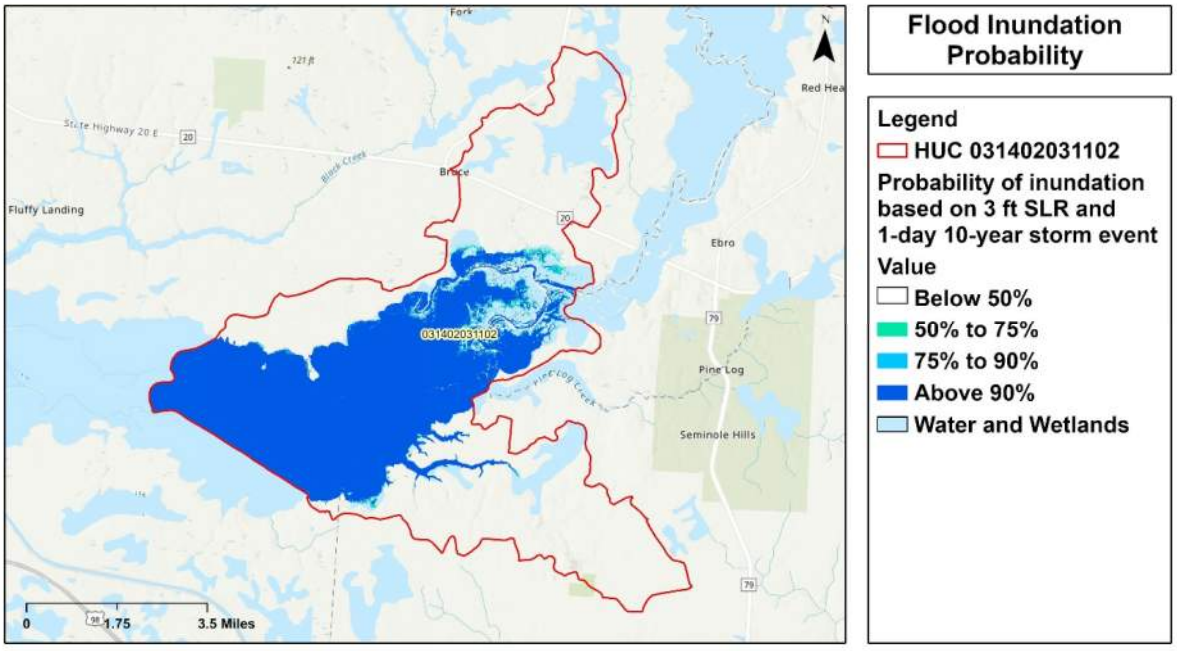

Figure 49. Sea level rise of 3 ft + 1-day 10-year storm for HUC 031402031102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

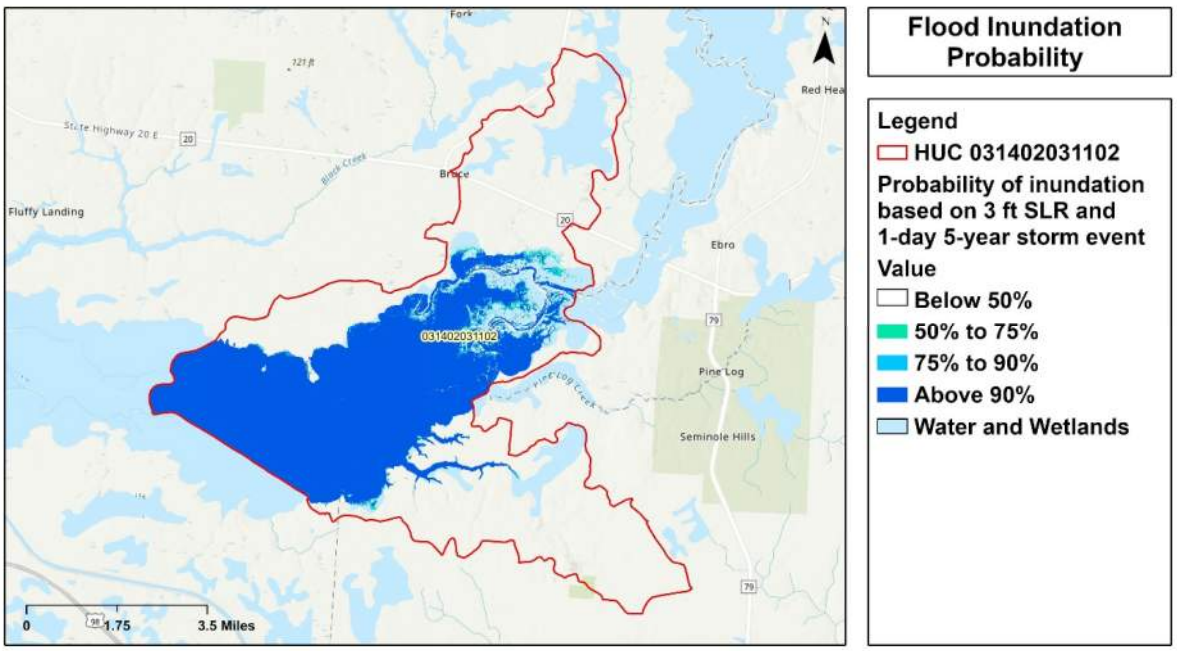

Figure 50. Sea level rise of 3 ft + 1-day 5-year storm for HUC 031402031102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

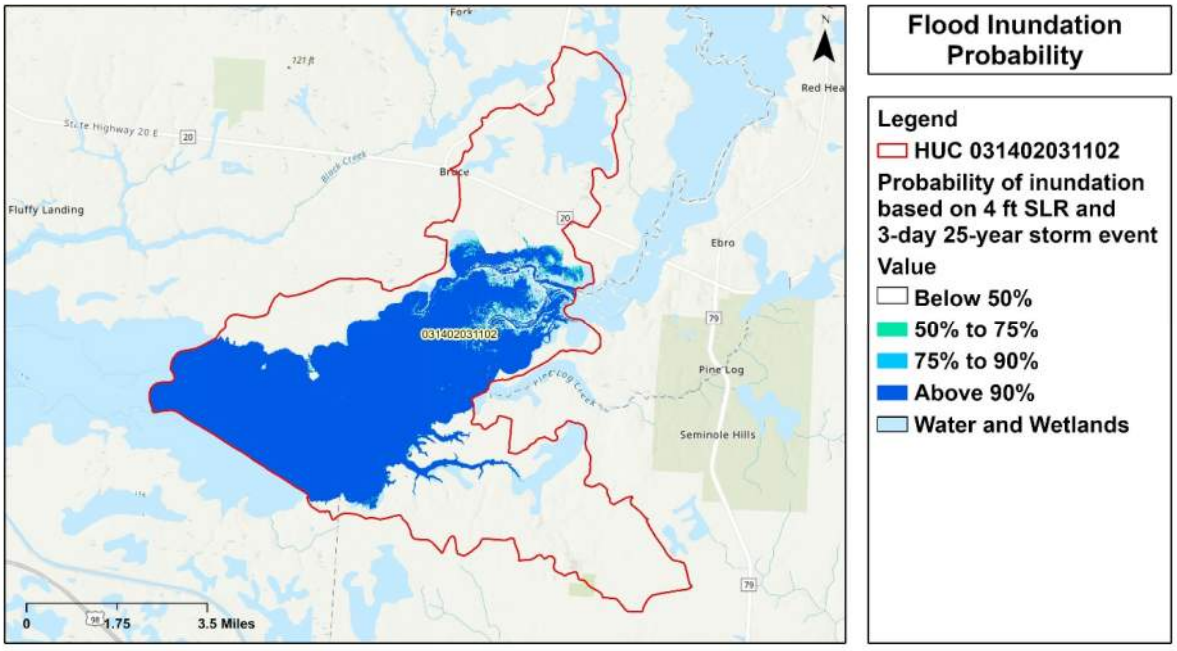

Figure 51. Sea level rise of 4 ft + 3-day 25-year storm for HUC 031402031102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

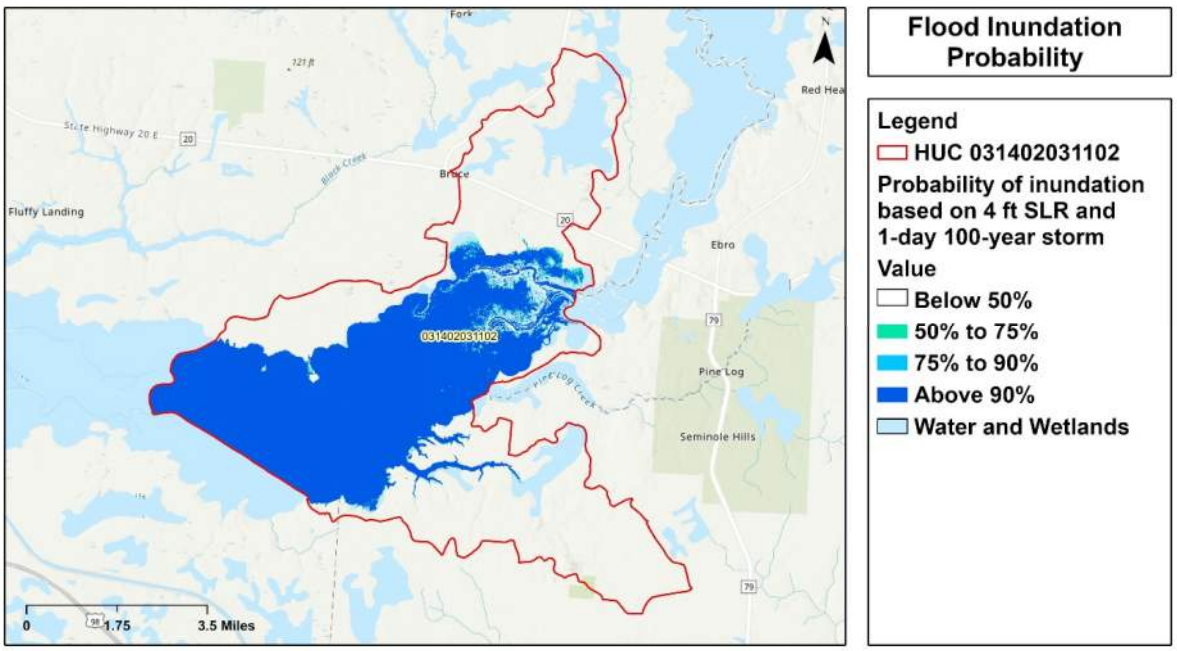

Figure 52. Sea level rise of 4 ft + 1-day 100-year storm for HUC 031402031102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

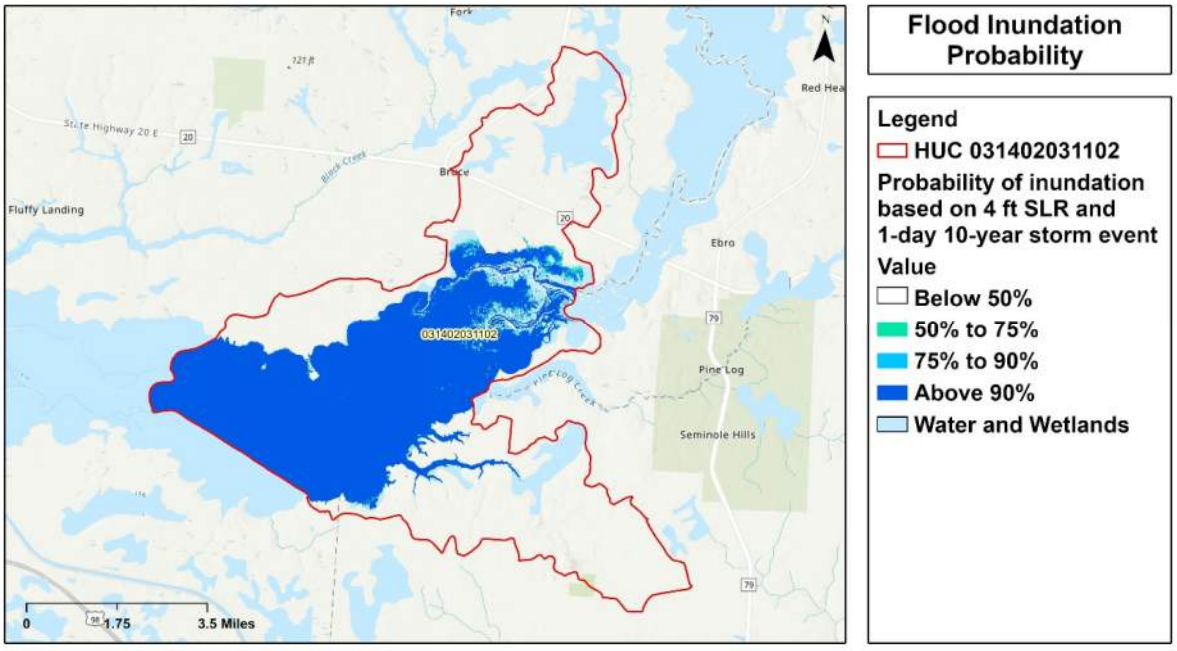

Figure 53. Sea level rise of 4 ft + 1-day 10-year storm for HUC 031402031102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

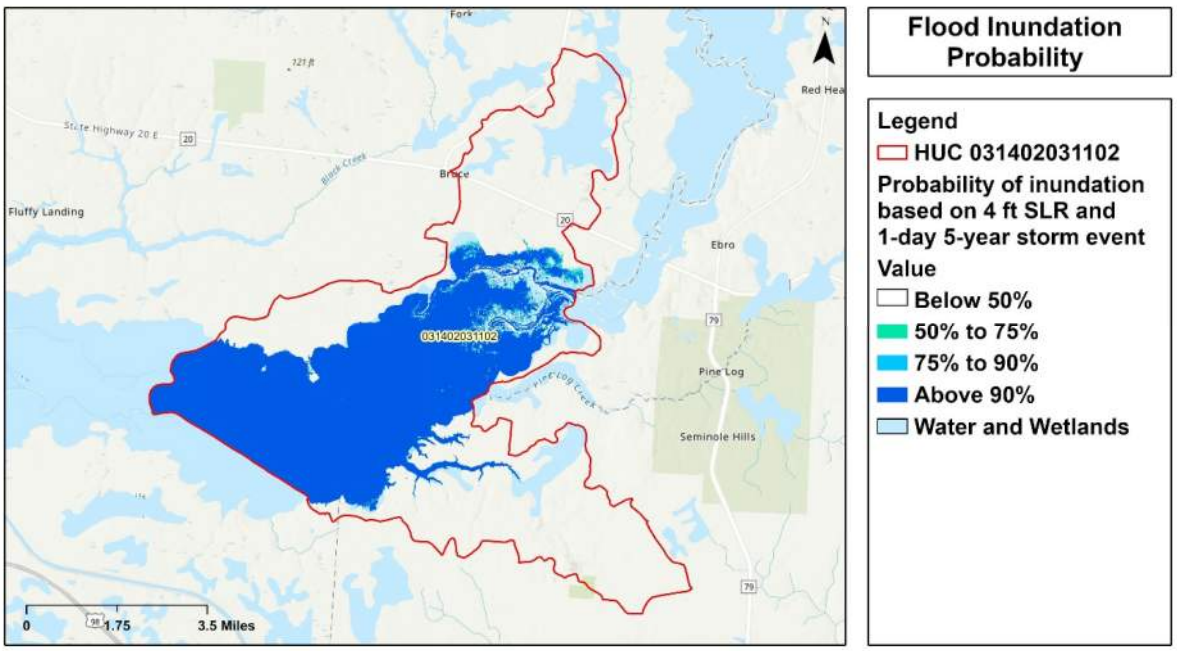

Figure 54. Sea level rise of 4 ft + 1-day 5-year storm for HUC 031402031102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

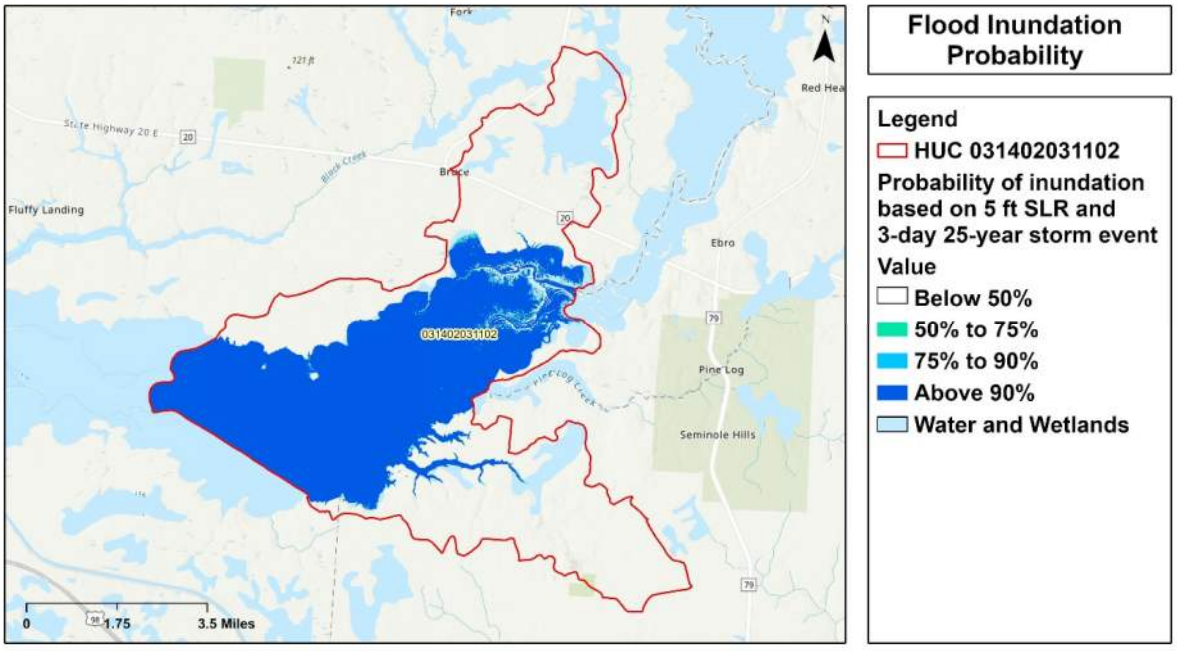

Figure 55. Sea level rise of 5 ft + 3-day 25-year storm for HUC 031402031102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

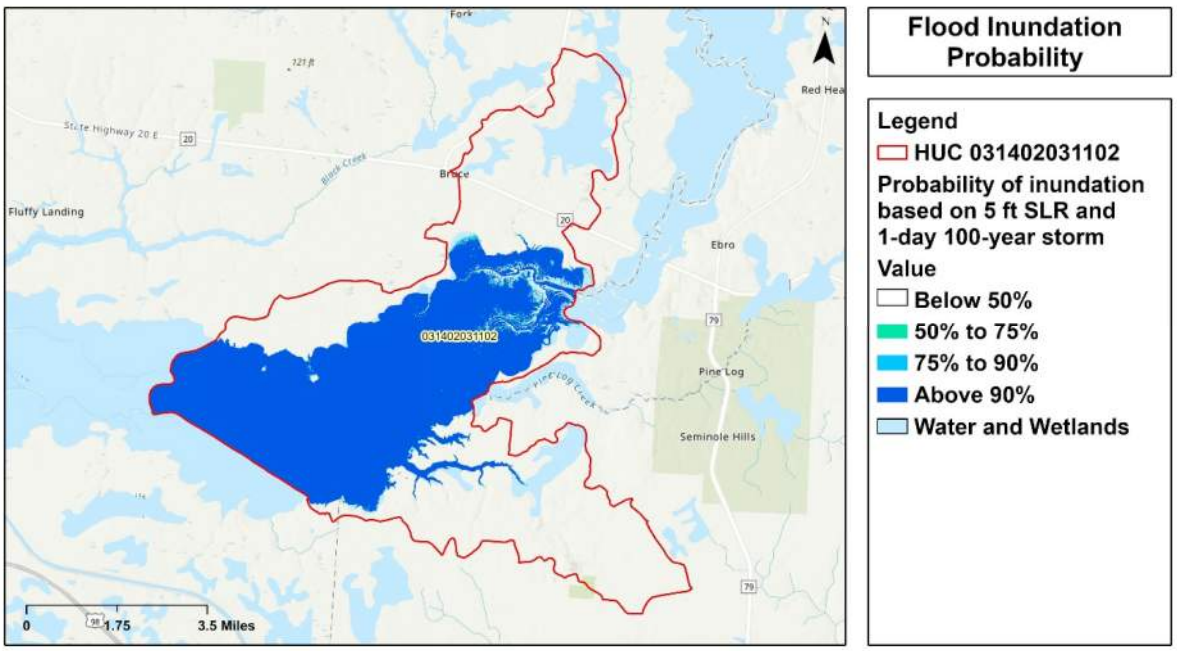

Figure 56. Sea level rise of 5 ft + 1-day 100-year storm for HUC 031402031102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

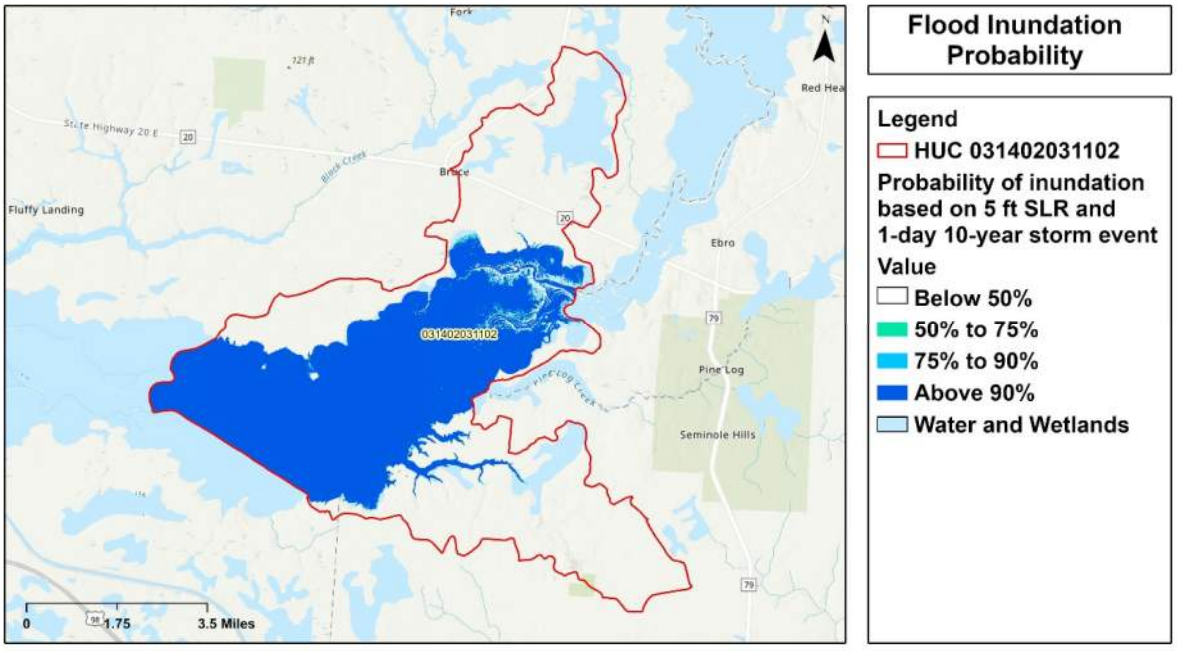

Figure 57. Sea level rise of 5 ft + 1-day 10-year storm for HUC 031402031102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

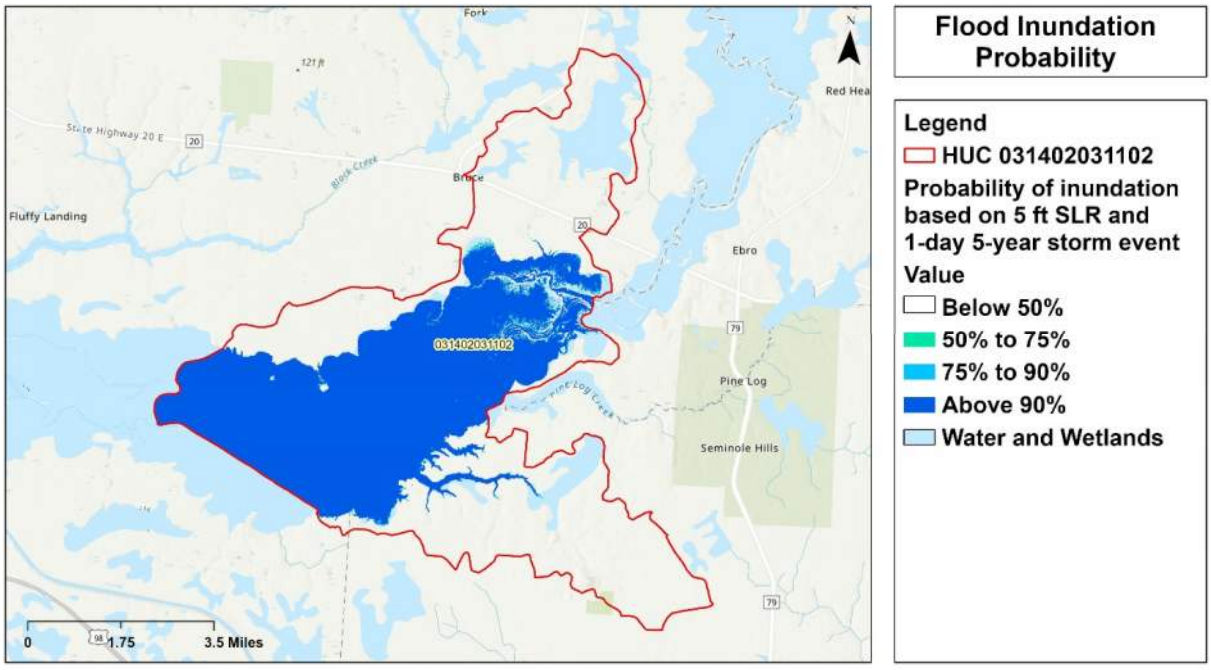

Figure 58. Sea level rise of 5 ft + 1-day 5-year storm for HUC 031402031102 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.5 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health)

requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3
25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3

26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6
51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6

60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6
87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6

98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.5.1 Results

Error! Reference source not found. to **Error! Reference source not found.** depict the HUC 031402031102 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (Figure 59) exclusively displays critical facility parcels within the HUC without any flooding. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 60) overlays critical facilities onto the 1-day 100-year storm event scenario, while the third map (**Error! Reference source not found.**) represents the same overlay within the context of 5 feet of sea level rise (SLR) combined with the 1-day 100-year storm event. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 5 feet SLR + 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** and **Error! Reference source not found.** illustrate the composite score for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. **Error! Reference source not found.** represents the calculation for composite score based on 1-day 100-year storm event, while **Error! Reference source not found.** shows the calculation for composite score for the same storm event, but including a 5 feet of Sea Level Rise scenario. **Error! Reference source not found.** shows the same area zoomed out.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

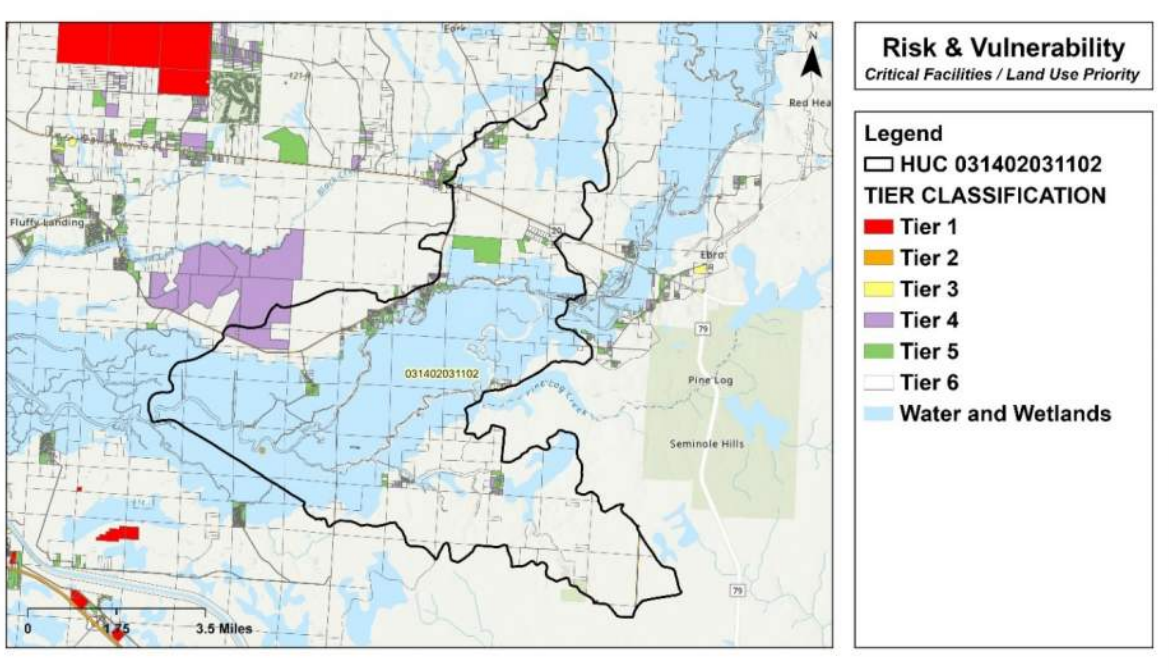

Figure 59. HUC 031402031102 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

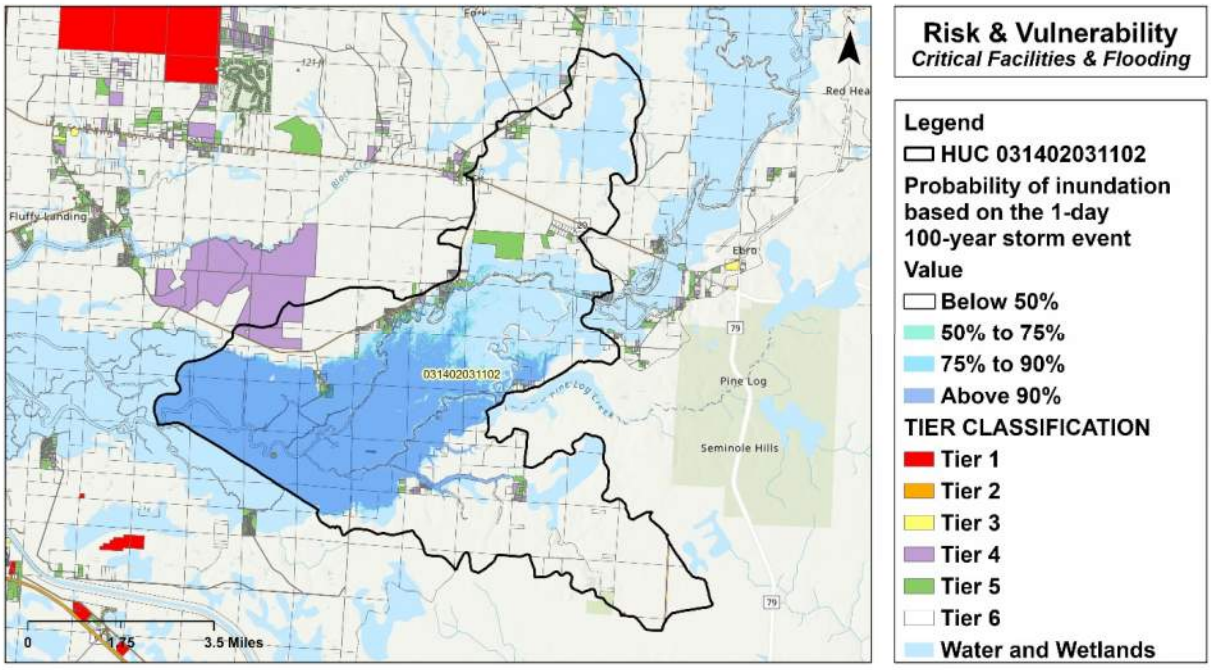

Figure 60. HUC 031402031102 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

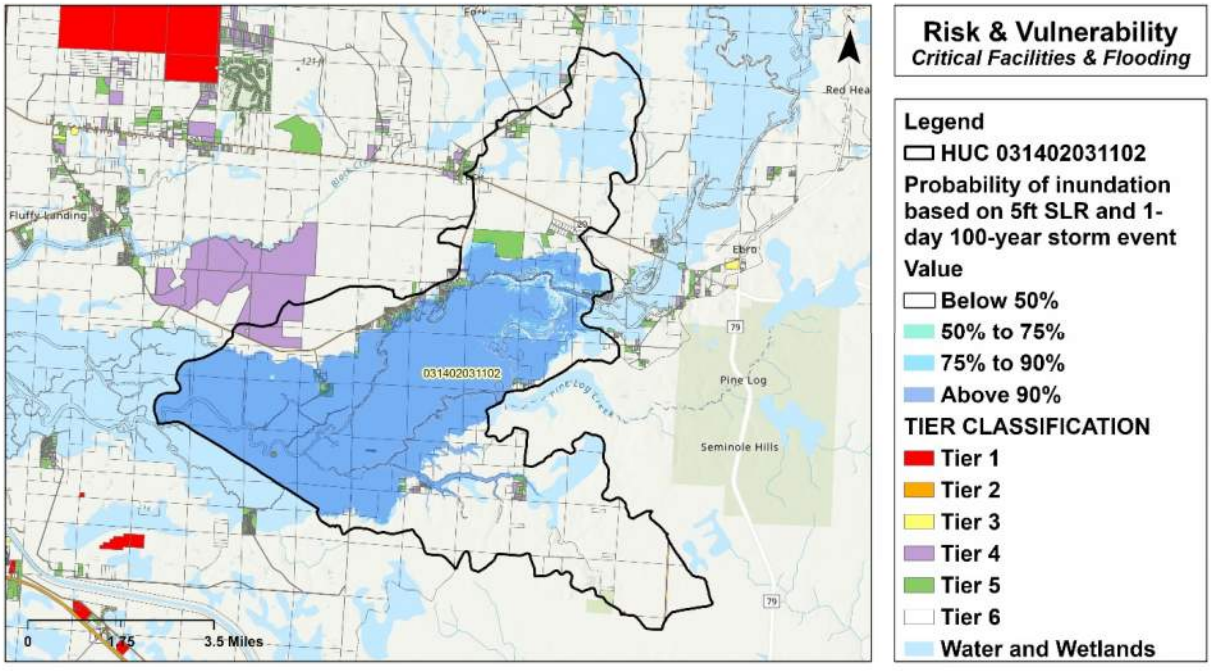

Figure 61. HUC 031402031102 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

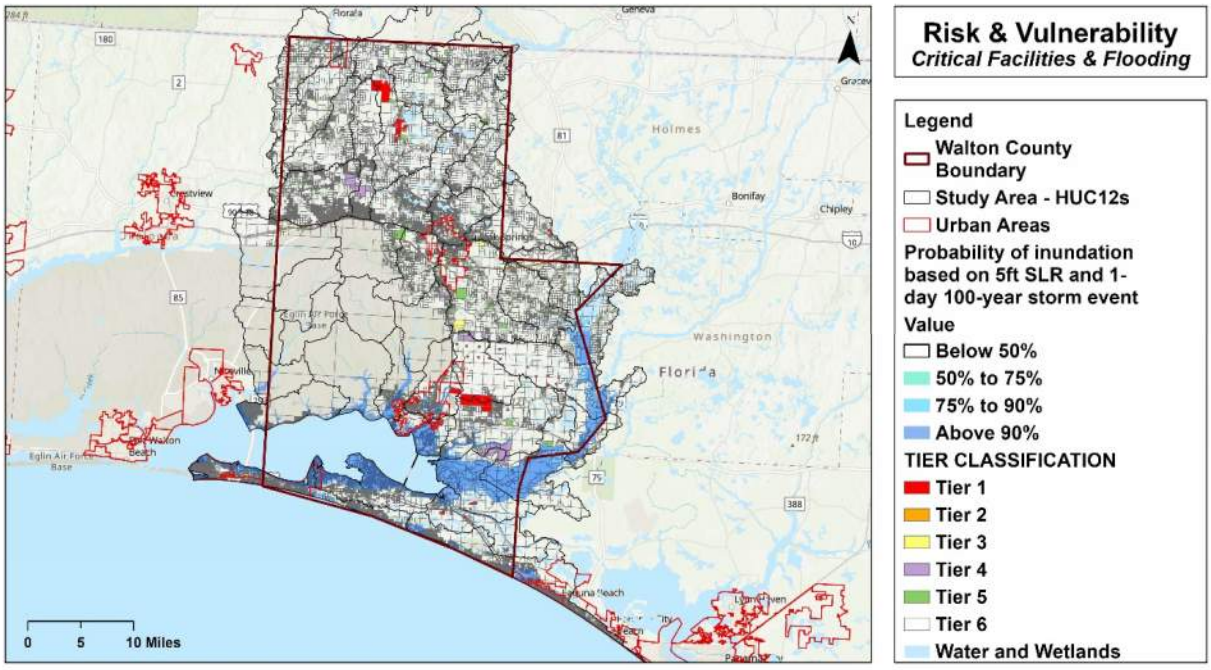

Figure 62. Walton County (mosaic) - Critical Facilities (priority of land uses) map, overlaid on the 1-day 100-year storm event + 5 ft. SLR probability of inundation for Walton County. Processed by FAU.

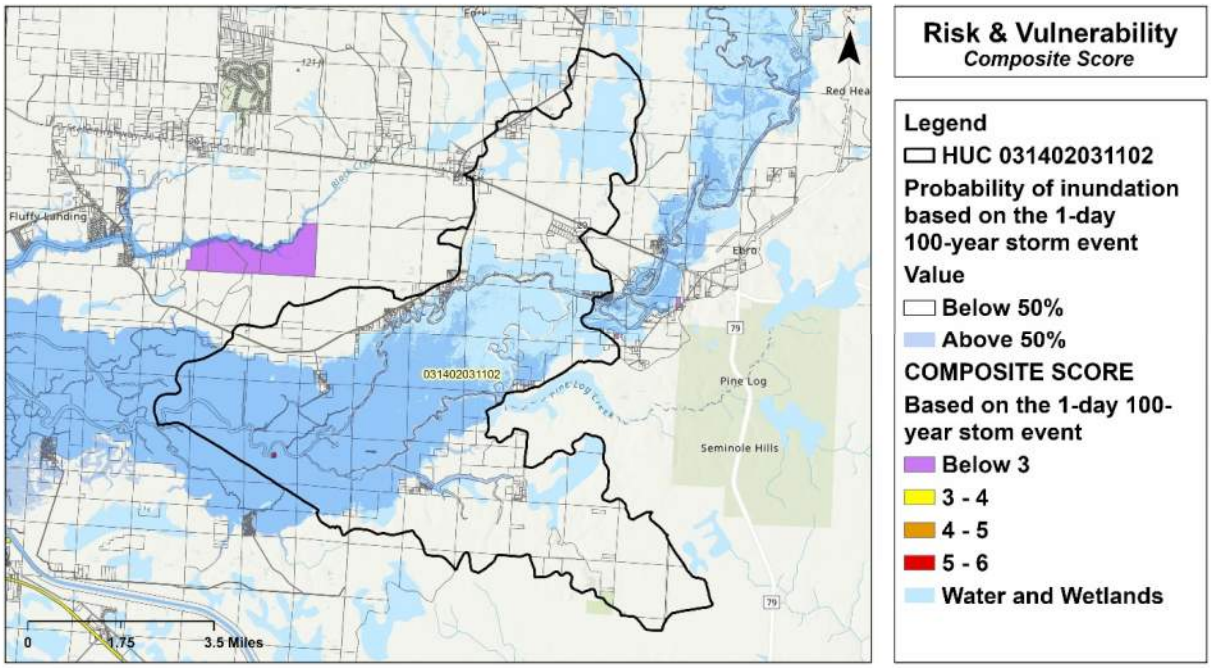

Figure 63. HUC 031402031102 sub-watershed Composite Score Risk map based on the 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation. Processed by FAU.

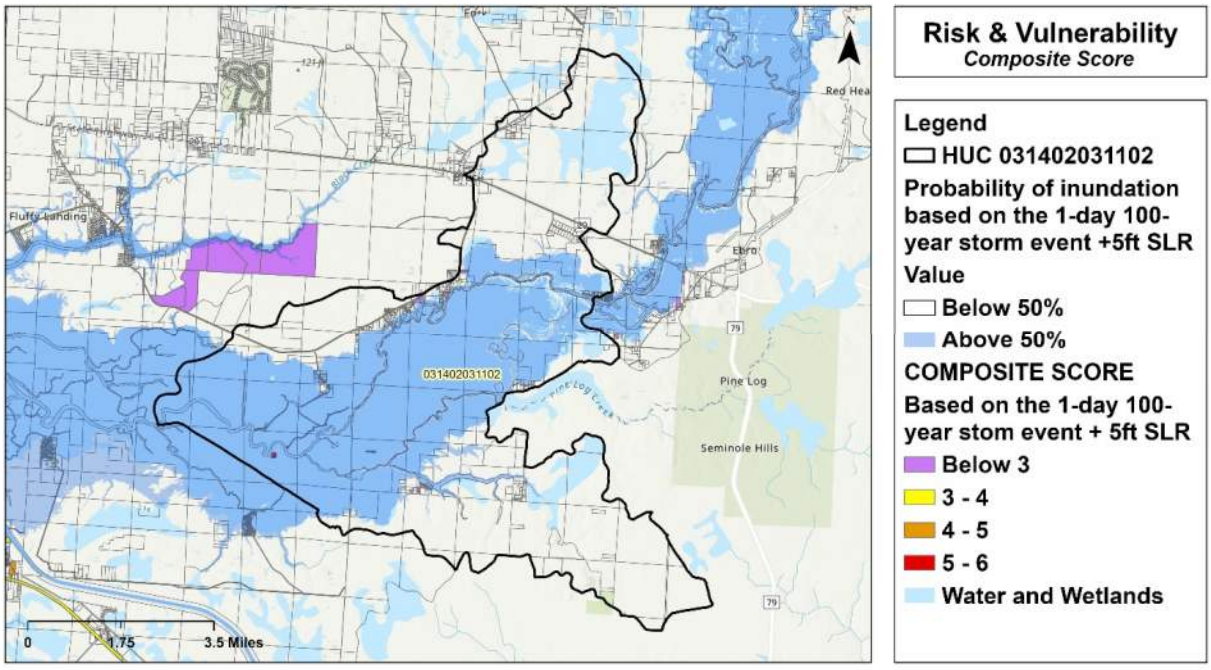

Figure 64. HUC 031402031102 sub-watershed Composite Score Risk map based on 1-day 100-year storm event + 5 ft. SRL, overlaid on the 1-day 100-year + 5 ft. SLR probability of inundation. Processed by FAU.

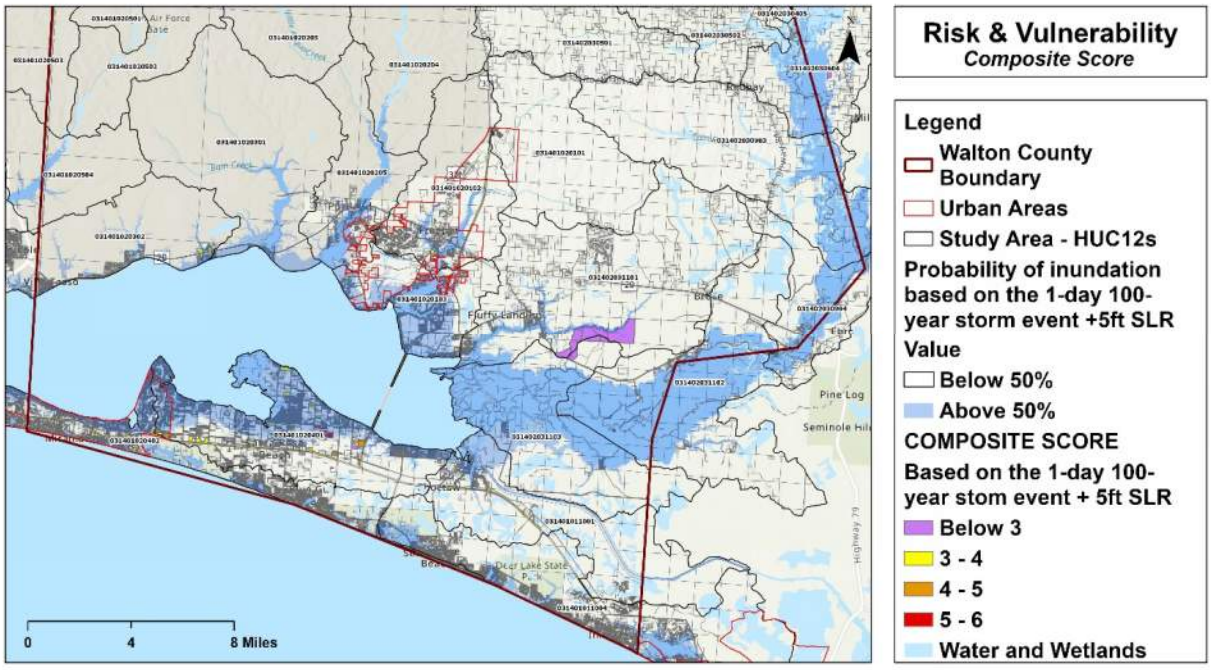

Figure 65. Coastal Area of Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

2.5.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031402031102. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.5.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It is important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031402031102. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031402031102	28288.77
All of the 1-day 100-year storm event inundation	**9114.77**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	8256.64
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	636.99
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	1.75
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	858.13
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	219.39

2.5.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

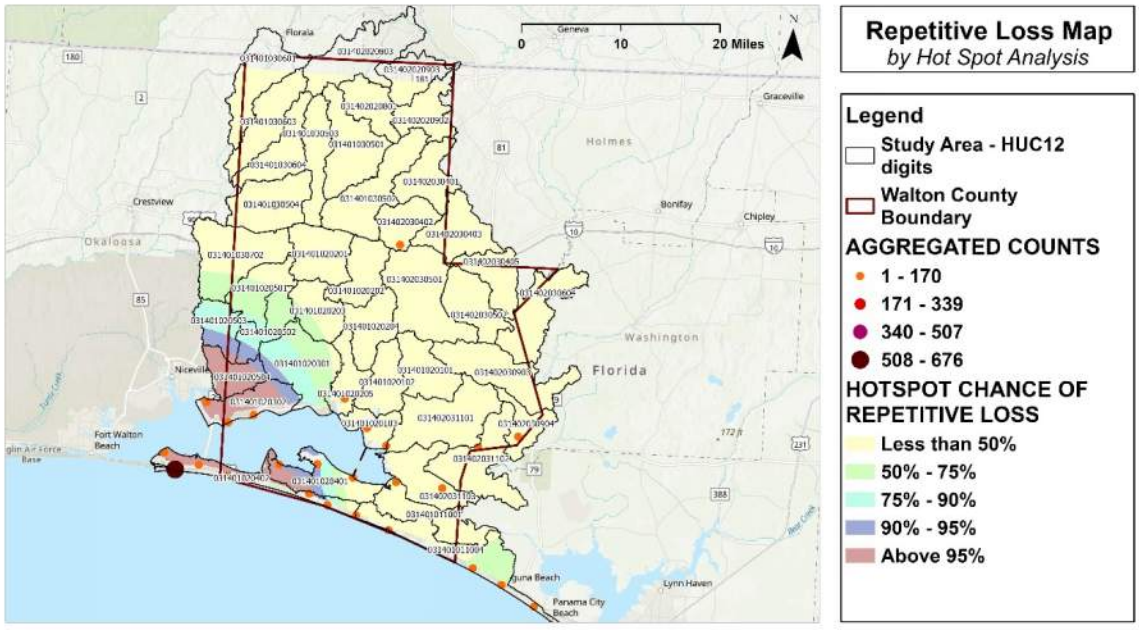

Figure 66. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU. (Source Data: FEMA)

2.5.5 Priority Projects

While the basin does not have a significant amount of developed land, some parcels fall within the flood zone due to the area's susceptibility to significant flooding in both 1-day 100-year storm

events and 1-day 100-year + 5 feet sea level rise scenarios. In terms of land use priority, there are some parcels in tiers 2 (roads), 4, and 5 within the flooding zone. There is only one Tier 1 priority parcels, that fortunately is not in the flooding zone.

Examining the composite score, there are a total of 38 parcels within the flood zone that require attention. Among them, five are in the score range of 5-6, all of which are roads (Smokehouse Run, East Pocket, Smokehouse Run, Buzzards Roost, and River Shannon), representing the highest priority for intervention. Additionally, there are 13 parcels, which 5 of them are mobile homes, and 8 are also roads (B H Reddick Rd, Us Hwy 20, Choctawhatchee River Rd, Cowford Rd, Co Highway 3280, Smokehouse Lake Road, Herring Rd, and one more with no name), with scores in the range of 3-4. Finally, there are 20 parcels with scores below 3, all of which are mobile homes.

APPENDIX AQ

Watershed Master Planning Initiative

Walton County

HUC 12 digit: 031402031103

MITCHELL RIVER-CHOCTAWHATCHEE RIVER FRONTAL

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Research Assistant: Leticia Sabio

This resource was funded in part, through a grant agreement from the Florida Division of Emergency Management's (FDEM) Bureau of Mitigation, by a grant provided by through the Hazard Mitigation Grant Program (HMGP) DR-4337-004-P, as approved by FDEM and the Federal Emergency Management Agency (FEMA) to create and update Watershed Master Plans (WMP) throughout the state of Florida. The views, statements, findings, conclusions, and recommendations expressed herein are those of the authors and do not necessarily reflect the views of the State of Florida, FEMA, or any of their sub-agencies.

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X.0 EXECUTIVE SUMMARY

The goal of the appendices to the watershed plan are to outline the issues associated with the individual HUC12s that contribute or impact the community's flood vulnerability and there for its flood protection efforts. Floodplain analysis includes developing a watershed model and identifying associated inundation polygons. It builds upon information generated from the watershed evaluation so that planning and management decisions can be formulated.

This appendix describes the issues and modeling associated with one of the HUC12s that affects Walton County. In developing the County-wide plan, this HUC 12 was analyzed so as to determine how it brings or removes floodwaters from the County. For the NFIP process the goal is to analyze all communities at the HUC12 level. From a community perspective the HUC12 is less useful to residents than a community-wide plan. Hence in all cases the HUC12 results were mosaicked into the community-wide plan. Details can be found in the HUC12 appendices, some of which were brought into the community plan.

To reduce redundancy, information of the plans, ordinances, policies and regulations were rolled up to the community-wide plan and will not be repeated in the appendices. Likewise, the community wide mapping was parced for HUC12 use.

1.0 WATERSHED CHARACTERIZATION

In this section, key aspects of the watershed are characterized. This is important for later being able to identify the most vulnerable areas and to mobilize resources to implement an action plan. Understanding the characteristics of the watershed involves gathering existing information and data sets from previous planning efforts. It is important to note that this step is iterative and ongoing as new data are generated and projects are implemented and monitored.

To assess the historical and current conditions of the study area, the following existing data sets that characterize the physical and natural features of the watershed were obtained for each HUC-12 subwatershed in the study area:

- Topographic data (LiDAR)
- Relevant waterway locations
- Groundwater levels
- Soils data
- Land uses including vacant land, wetlands, impervious, etc.
- Precipitation records
- Catchment delineations for flood routing

In addition, the FEMA flood maps must be obtained, and the storm of interest must be identified for screening purposes (1-day, 2-year, 5-year, and 100-year events as well as the 3-day 25-year storm event to achieve class 4 in the CRS Manual). In developed areas, many sources of data are already available – the key is putting the key datasets in a format that can queried for screening to identify the priority areas of the watershed. Table 6 is a summary of datasets available at cwr3.fau.edu that were used to construct this plan.

This watershed master plan is a drilldown of the larger Walton County TMDL region, which involves 42 HUC 12-digit sub-(watersheds (**Error! Reference source not found.**). **Error! Reference source not found.** shows Walton County Drainage Network and the location of urban areas (cities and towns). In **Error! Reference source not found.**, the HUC-12 (031402031103) is highlighted among all the HUCs to help identifying its location (Figure3).

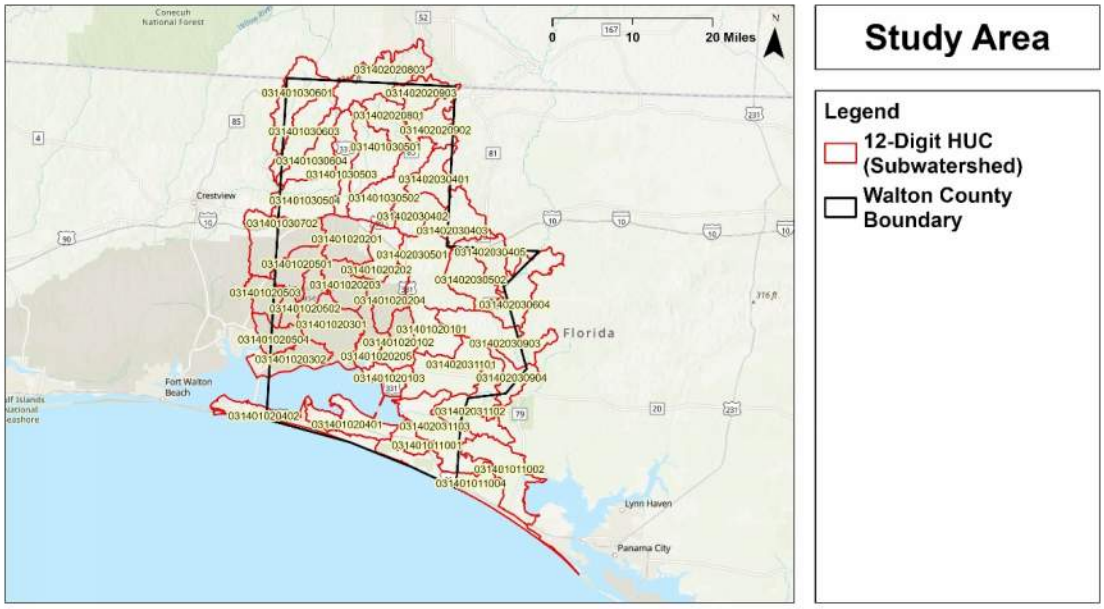

Figure 1. Walton County and all HUCs 12-digit subwatershed, processed by FAU.

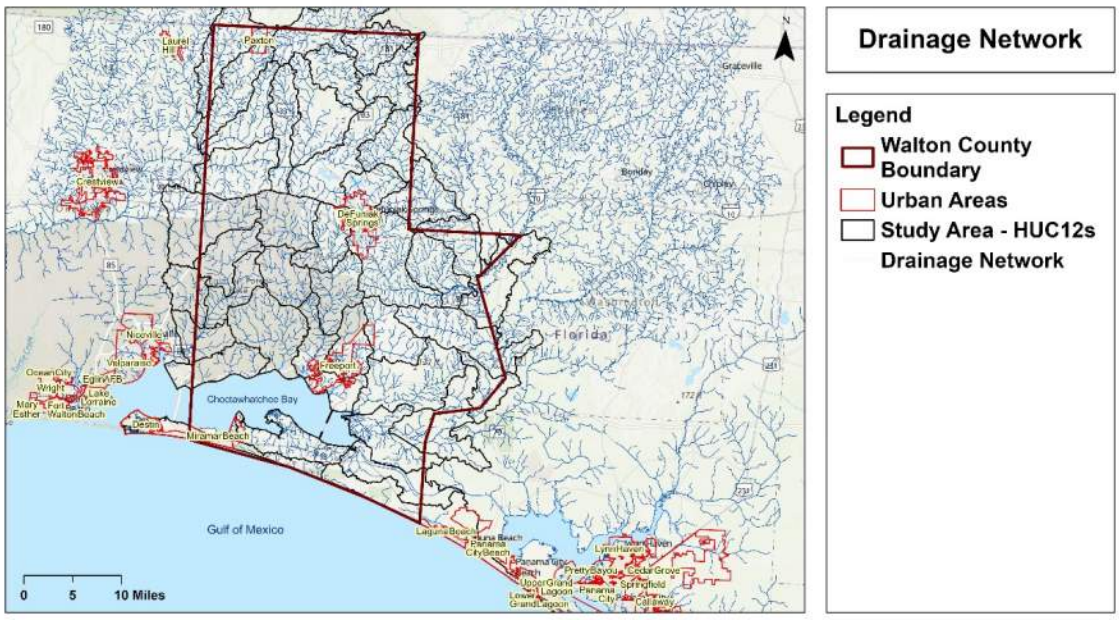

Figure 2. Walton County Drainage Network and urban areas (cities and towns), processed by FAU.

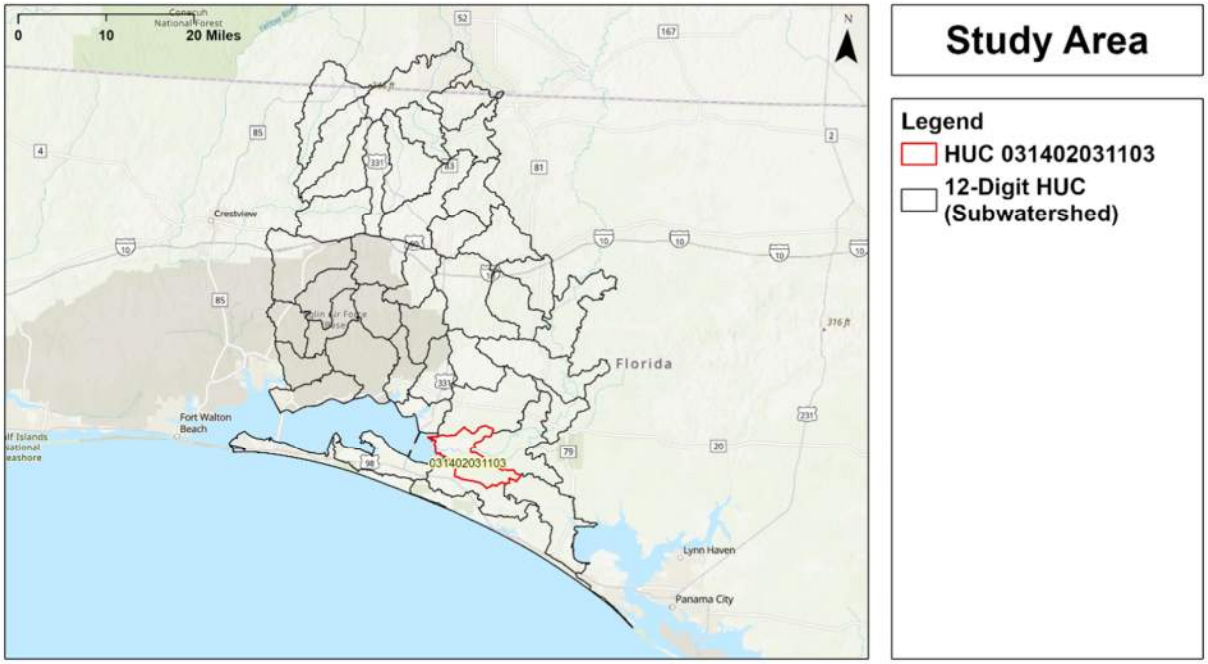

Figure 3. HUC 031402031103 sub-watershed location.

Located in the northwestern region of Florida, Walton County has 1,037.7 square miles of land and it is the 12th largest county in Florida by area, while also sits the highest point in the state,

with a height of 345 feet in its northern end. With a population of 75,305 residents according to the 2020 census and an estimate population in July of 2022 of 83,304, the county has experienced consistent growth within the past several years, driven by factors such as tourism, retirement migration, and regional population dynamics. The county was the residence for 55,043 people according to Census 2010, which leads to a percent change of 36.8% in 10 years, between 2010 and 2020, and a percentage change of 10.6% in two years, between 2020 and 2022 (United States Census Bureau).

The surge in population, particularly in the southern part of Walton County, has resulted in a corresponding expansion of infrastructure to cater to the growing needs. Essential facilities such as potable water systems, wastewater treatment plants, electrical utilities, roads, and schools have been developed to support this increasing population. However, the infrastructure expansion has brought about a significant change in the natural environment. Prior to the existing development , tropical cyclone impacts would be mitigated by natural barriers such as vegetated sand dunes, wetlands, and deserted beaches, which would absorb some of the destructive forces. Now, with the proliferation of costly infrastructure and residential dwellings in coastal areas, these storms pose a higher risk of potential damage. The very areas where development is occurring are becoming more vulnerable to the impact of severe storms, highlighting the importance of considering and implementing adequate measures to address potential storm damage in these coastal regions (Walton County Local Mitigation Strategy Plan, 2015).

Demographically, Walton County presents a heterogeneous age distribution, encompassing a blend of younger and elderly cohorts. The median age of approximately 44 years reflects the presence of both younger families and retirees seeking a serene and picturesque environment. Ethnically, the county' population is predominantly White with smaller yet notable populations of Hispanic/Latino, African American, and other racial/ ethnic groups.

Economically, the tourism sector stands as a dominant force in Walton County, constituting 23.4 percent of the workforce, according to Walton County Economic Development Alliance in 2011, due to its renowned beach destinations, such as Santa Rosa Beach, Miramar Beach, and the New Urbanist Communities of Seaside and Rosemary Beach. Following closely behind is the trade, transportation & utilities sector, accounting for 20.3 percent of employment, while construction stands at 10.0 percent in third place. Education, health care services, and public administration also play significant roles within the top five employment sectors, reflecting the diversified economic landscape of the county (Walton County Local Mitigation Strategy Plan, 2015).

The natural environment in Walton County contributes to its distinctive appeal to visitors and tourists. The county's coastal environment along the Gulf of Mexico showcases picturesque vistas, including white sand beaches, undulating dunes, and coastal dune lakes. These lakes, a rarity worldwide, provide unique ecological habitats. Walton County is also committed to environmental conservation, with designated protected areas comprising state parks, forests, and wildlife

management zones. These preserved landscapes offer abundant opportunities for recreational activities, including hiking, fishing, and birdwatching.

The presence of wetlands and waterways further enhances the natural attributes of Walton County. Various rivers and creeks alongside Choctawhatchee Bay permeate the landscape, fostering diverse ecosystems and serving as crucial habitats for a wide range of wildlife species. This rich natural heritage encourages exploration and nurtures an appreciation for the environment.

DeFuniak Springs serves as the county seat and boasts a diverse economy. Anchored by sectors such as healthcare, education, retail, government services, and a thriving small business community, DeFuniak Springs offers a range of employment opportunities. Surrounded by the natural beauty of forests, lakes, and wetlands, the city enjoys the presence of Lake DeFuniak, a noteworthy natural resource. With a population of approximately 5,100 residents, DeFuniak Springs is a vibrant city featuring a mix of economic activities. The land area of DeFuniak Springs is approximately 12.6 square miles (32.7 square kilometers).

Freeport boasts a diverse demographic profile, and a developing economy. The city is situated along the shores of Choctawhatchee Bay, which provides opportunities for recreational opportunities and supports local ecosystems. Surrounded by lush forests and intersected by waterways, Freeport enjoys a rich environmental setting. In terms of economics, Freeport's economy is in a phase of growth and diversification, with sectors including healthcare, education, retail, and small businesses. The city is also strategically positioned for future economic expansion due to its proximity to major transportation corridors. Demographically, Freeport is a close-knit community with a population of approximately 2,600 residents, comprising a mix of permanent residents, retirees, and individuals seeking a suburban or rural lifestyle. The city reflects a diverse demographic composition, showcasing a variety of cultures, and backgrounds. Freeport occupies a land area of about 13.6 square miles (35.3 square kilometers).

Further along the coast, Miramar Beach stands as a coastal gem known for its tourism and hospitality industry. Luxury resorts, vacation rentals, gourmet restaurants, high-end retail shops, and entertainment venues thrive within this bustling city. Miramar Beach's main attraction lies in its stunning white sand beaches along the Gulf of Mexico, providing endless opportunities for beach activities and water sports. Its boundaries extend into neighboring Okaloosa County, attracting a blend of permanent residents, vacation homeowners, and rental property occupants. Miramar Beach, including its neighboring areas, covers an estimated land area of around 4.7 square miles (12.2 square kilometers).

Continuing along the Gulf Coast, we encounter Santa Rosa Beach. This coastal community is renowned for its vibrant tourism industry, offering a plethora of accommodations ranging from upscale resorts to charming vacation rentals. Its demography reflects a mix of permanent residents, seasonal visitors, and individuals seeking a coastal lifestyle, resulting in a diverse and dynamic

community. Santa Rosa Beach spans a larger area compared to other cities in Walton County, with an estimated land area of approximately 31.2 square miles (80.8 square kilometers).

A summary of the existing CRS classifications for the communities in the study area is listed in **Error! Reference source not found.**. No cities in Walton County are listed in the FEMA Community Rating System Eligible Communities.

Table 1: Community Rating System for Walton County. Effective April 1, 2023.

Community #	**Community Name**	**CRS Class Rating**	**Premium Discount for SFHA**	**% Discount for Non- SFHA**	**Status**
120317	Walton County	6	20%	10	Cycle

(Source Data: FEMA)

Figures 12 and 13 is the county-wide report show the current and projected land use for the County. Based on the 2017 future land use for Walton County, only 7.07% of the land use in the county is urban and built up, and water/wetlands makes up 29.16% of the land use. The majority of land is upland forest, with 48.3%, as shown in **Error! Reference source not found.**

Table 2. Land Use in Walton County (Prepared by FAU from future land use map) versus land use in the entire watershed

Level 1 Land Use-Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	52958.94669	7.17%
Barren Land	9242.05986	1.25%
Rangeland	40326.66002	5.46%
Transportation, Communication, and Utilities	11815.69287	1.60%
Upland Forest	356796.0541	48.30%
Urban and Built-Up	52194.79061	7.07%
Water	61593.80508	8.34%
Wetlands	153759.9055	20.82%
Total	**738687.9147**	**100.00%**

(Source Data: (NWFWMD 2017)

Walton County has a history of flooding and has implemented various measures for flooding mitigation over the years (see section 1.12 for more details). The County has experienced flooding primarily due to heavy rainfall events and proximity to large water bodies such as the Gulf of Mexico, Choctawhatchee Bay, and numerous rivers and creeks. The topography of the region, with low-lying areas in the coastal areas and wetlands, also contributes to flood vulnerability. The

proximity to the ocean (Gulf of Mexico) makes the county vulnerable to sea level rise. Over the years, Walton County has faced multiple flooding incidents, including:

- March 1997: Heavy rainfall led to significant flooding throughout the county, resulting in property damage and road closures.
- April 2009: Intense storms caused widespread flooding, damaging homes and infrastructure and resulting in the declaration of a state of emergency.
- April 2014: Heavy rainfall caused severe flooding, leading to the evacuation of some residents and the closure of roads.

Today,, the goal of a stormwater management system in many communities is to keep the community as a place to live and do business while limiting risk from damage due to flooding. The short-term impacts from stormwater include flooding in low-lying areas and standing water in areas with limited soil storage capacity. Less common, but of increasing frequency, is the potential for extensive inundation of some areas, especially low-lying areas, during periods with high groundwater levels and groundwater impacted by sea level rise. As a result, there is a need to understand the economic impact of flooding events and to create cost-effective stormwater infrastructure and policy solutions to protect property. This means preserving as much property and economic activity as possible without disrupting current activity or expending funds on inappropriate projects with limited long-term or social value.

1.1 Surface Topography

Topography is a key parameter that influences many of the processes involved in flood risk assessment, and thus, up-to-date, high-resolution, high-accuracy elevation data are required. In order to meet the requirements for FEMA Risk Mapping, Assessment, and Planning (RiskMAP), 1-meter (2015 to present) and 1/9 arc-second (~ 3-meter) (2010 -2015) LiDAR DEMs were acquired. The 1 m × 1 m LiDAR tiles were kriged to create a topographic map of the study area (Figure4). This accuracy meets the 3DEP Quality Level 2 vertical root mean square error accuracy threshold of ±10 cm for FEMA (Arundel et al., 2015). The LiDAR used for this basin was 2016.

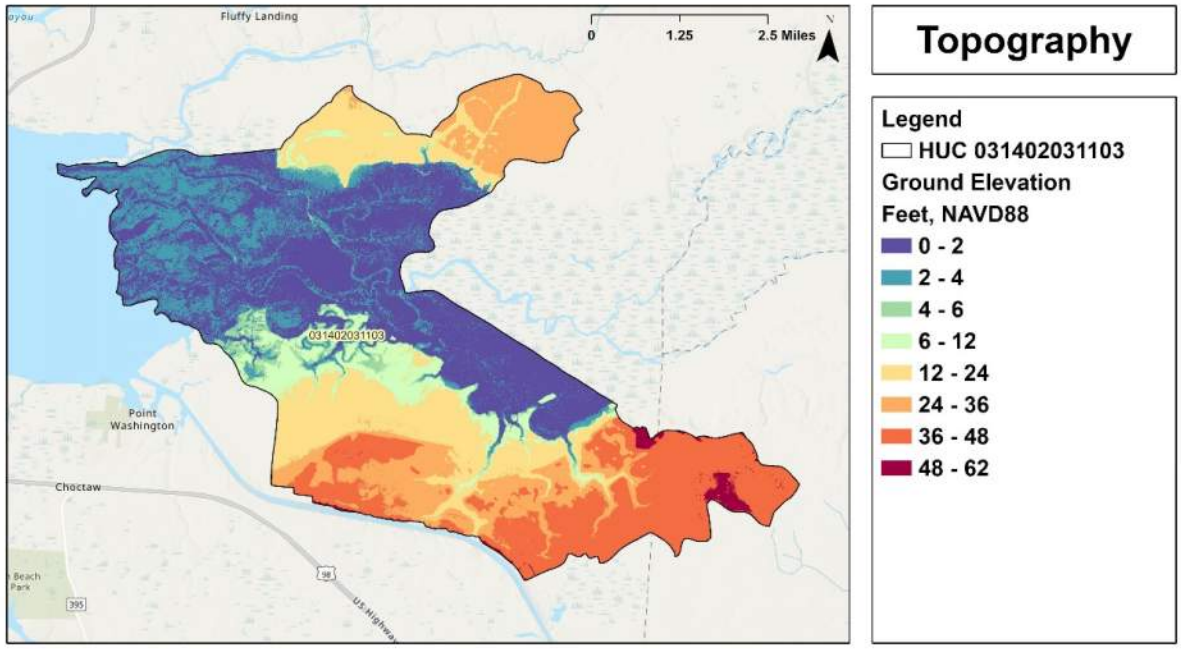

Figure 4. Topographic map of the HUC 031402031103 sub-watershed, processed by FAU. (Data Source: USGS)

1.1.1 Geomorphological Considerations

Walton County's coastal area is characterized by the presence of barrier islands, extensive sandy beaches, and coastal dune systems. These features are influenced by the dynamic processes of wave action, tidal currents, and wind-driven sediment transport. The shoreline is subject to natural changes, including erosion and accretion, which significantly shape the coastal geomorphology.

Inland Walton County exhibits a mix of wetlands, forests, rolling hills, and rivers. These landforms are influenced by a combination of factors, including underlying geology, fluvial processes, and the region's hydrological regime.

Like many areas in Florida, Walton County is underlain by limestone formations. The specific composition and properties of these limestone formations in Walton County may vary. However, limestone is generally known for its porous nature, which allows for the absorption and storage of water. Underground aquifers within the limestone formations can hold significant volumes of freshwater, contributing to the region's water resources.

For context, the FIRM panel index of HUC 031402031103 sub-watershed is shown in Figure5.

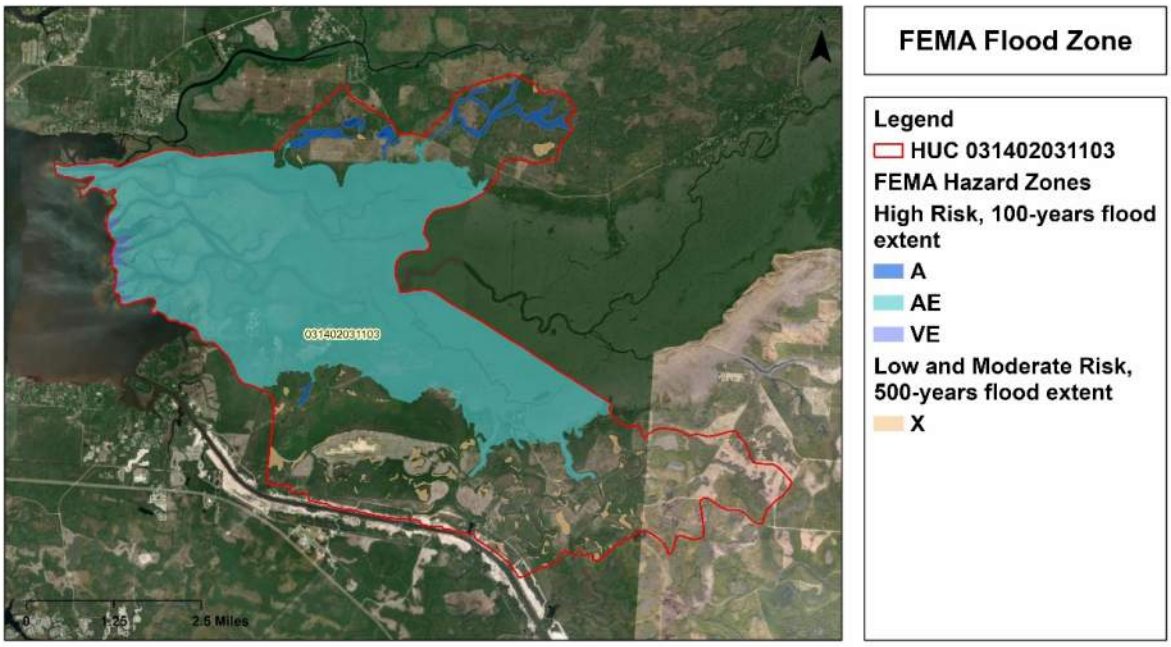

Figure 5. FEMA Flood Zone map (2020) for HUC 031402031103 sub-watershed, processed by FAU.
(Data Source: FEMA)

1.1.2 Waterway Features

In Walton County, Florida, the waterway features are primarily influenced by the presence of rivers, creeks, bayous, and the proximity to the Gulf of Mexico. To the south of Walton County lies the Gulf of Mexico. Sandy beaches, barrier islands, and the open waters of the Gulf itself characterize the coastline along the Gulf. The Gulf of Mexico influences the coastal processes, including wave action, tidal currents, and sediment transport along the shoreline. The combination between sea level rise and King tide would have detrimental consequences for the county costal area, including the sub-watershed 031402031103 as it will reach the area thought Choctawhatchee Bay.

Walton County is home to several rivers and creeks that meander through its landscape. These waterways provide drainage for the inland areas and contribute to the overall hydrological system. Examples of significant rivers in the county include the Choctawhatchee River and the Shoal River. In addition, Walton County features bayous and estuaries that connect inland water systems to the Gulf of Mexico.

Choctawhatchee Bay serves as a vital estuarine ecosystem, where freshwater from rivers and creeks mixes with the saltwater from the Gulf of Mexico, serving as a vital estuarine ecosystem. This unique brackish water environment supports a rich diversity of flora and fauna, including various fish species, shellfish, migratory birds, and wetland vegetation, contributing to the overall biodiversity of the region. It also plays a significant role in the local economy of Walton County as it supports commercial and recreational fishing industries, providing livelihoods for local fishermen and contributing to the seafood industry, while also offering a range of recreational opportunities for residents and visitors alike, such as boating, kayaking, paddle boarding, and sailing. **Error! Reference source not found.** shows the bathymetry offshore.

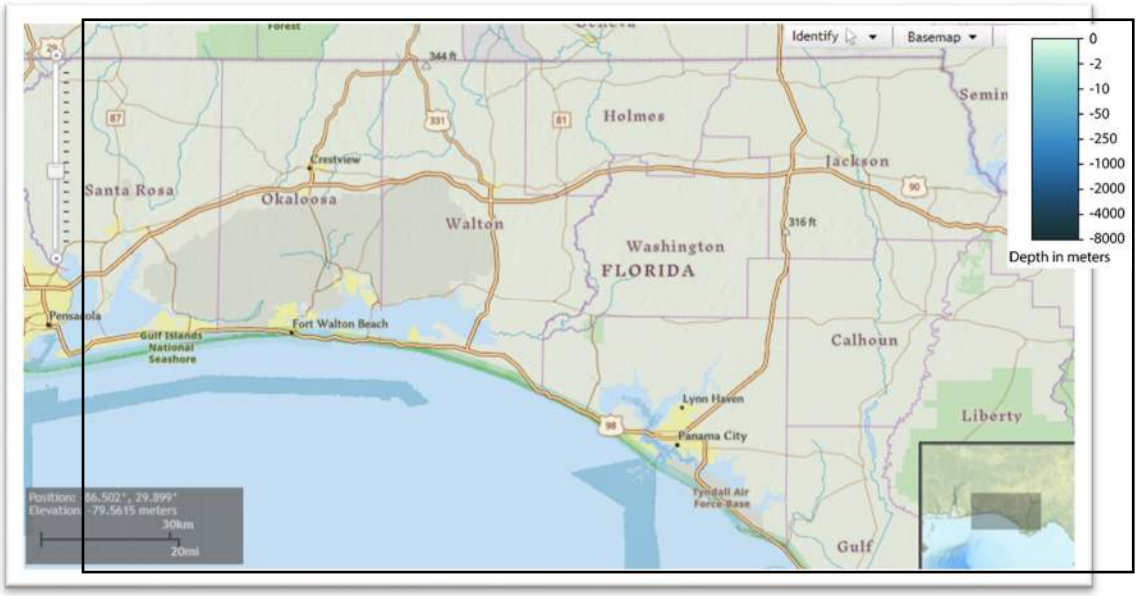

Figure 6. Bathymetry map of the shore of Walton County and surrounding counties of Florida Panhandle.
(Source: ncei.noaa.gov/maps/bathymetry/)

Numerous tributaries exist throughout both the freshwater and estuarine portions of the watershed and can influence the overall hydrology of the area depending on rainfall and regional hydrological conditions. **Error! Reference source not found.** shows the location of all four surface water stations along with ground water stations (wells) and the drainage network of Walton County.

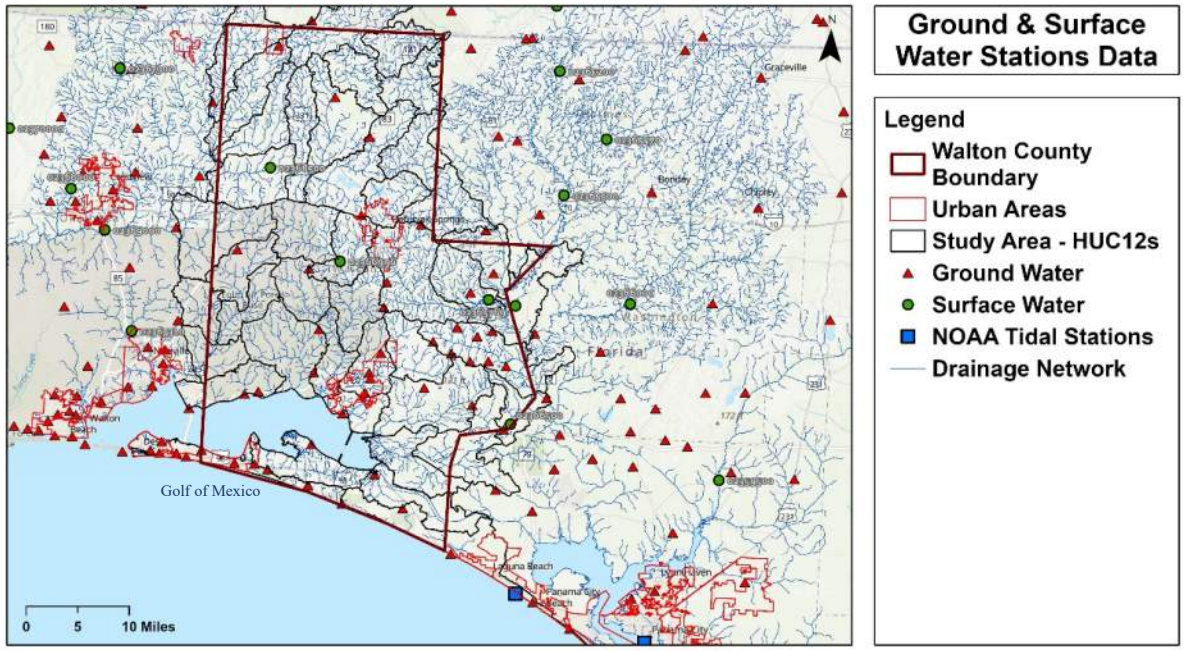

Figure 7. Ground & Surface Water Stations with drainage network for Walton County, processed by FAU.
(Data Source: USEPA – National Hydrographic Dataset (NHD) and NOAA's Tides)

1.1.3 Hydrologic Boundaries

The geographic area of the subject sub-watershed should be clearly defined to ensure that implementing the WMP will address all the major sources and causes of impairments and threats. Although there is no rigorous definition or delineation of this concept, one way to identify the geographic extent of the watershed master planning effort is to consult the United States Geological Survey (USGS) map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as sub-watersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Region>>Subregion>>Basin>>Sub-basin>>Watershed>>Sub-watershed

The major water bodies in the sub-watershed are the Choctawhatchee Bay at the west side of the HUC-12 with the associated rivers and canals:

- Choctawhatchee River
- Mitchell River
- Indian River
- Cypress River
- Williams Lake
- Sister River
- Reedy Branch
- Tenmile Branch
- Ninemile Branch
- Roaring Creek

Given that stream flow data are critical for estimating flooding, **Error! Reference source not found.** shows the historical streamflow during June 2022 to July 2023 for USGS 02366500. However, as there are only four surface water station within Walton County, it was necessary to use the nearest station to the sub-watershed 031402031103, which is USGS 02366500 Choctawhatchee River NR Bruce FLA.

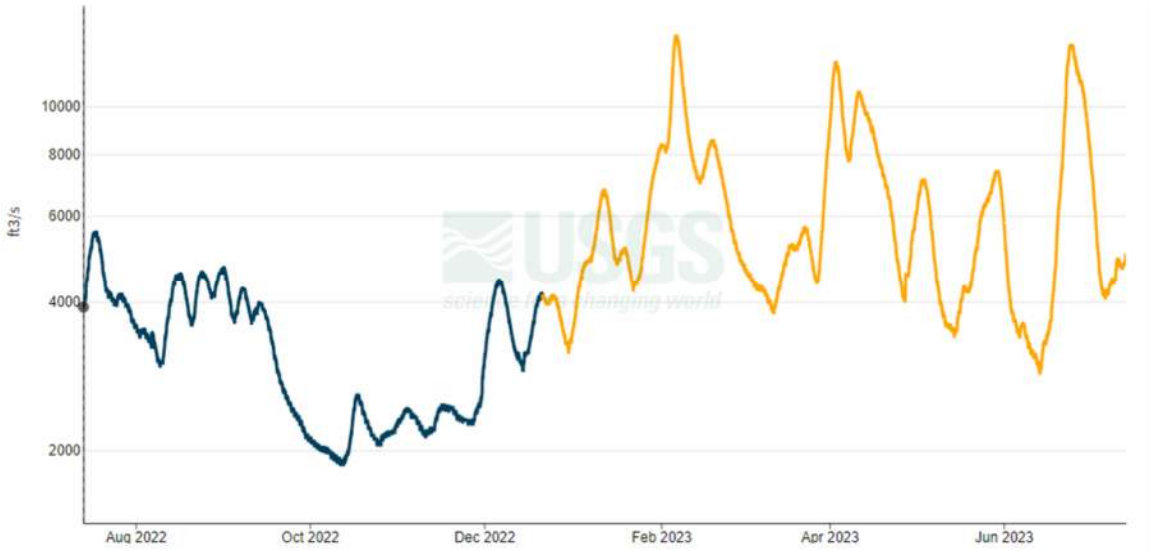

Figure 8. Average streamflow for Choctawhatchee River NR Bruce FLA (USGS 02366500 Surface-Water, June 2022 to July 2023).
(Source: USGS Water Data Services, available at https://waterdata.usgs.gov/monitoring-location/02366500/#parameterCode=00065&period=P365D)

1.2 Groundwater

In this region of Florida, there is a direct interaction between groundwater and surface water. In addition to low land elevations and topographic relief, the groundwater and surface water are controlled by the canals, rivers, and tides. Since there is a limited number of groundwater monitoring stations, the strong relationship between groundwater and surface water was leveraged to develop a 99^{th}- percentile surface of the water table elevation for mapping purposes. To establish a common date for modeling, the recorded groundwater table elevations were sorted in ascending order to determine the 98^{th} - 100^{th} percentile date of occurrence in Excel®, following the procedure detailed in Romah (2011). This procedure was automated for this effort using a python code to process the groundwater data more efficiently. Outliers and anomalous groundwater levels in the database are initially identified (e.g. catastrophic storm events) and replaced by region-specific mean values based on observations available from the nearest well. Missing date-specific data are estimated using simple temporal interpolation based on observations available in time. If a station (or monitoring well) data contains large amounts of missing data, it is not used in the generation of the groundwater surface.

In Walton County, the average annual rainfall is abundant, reaching 65 inches at DeFuniak Springs. This rainfall predominantly infiltrates the sand-and-gravel aquifer and eventually seeps into streams or the underlying artesian Floridan aquifer. The county's two major aquifers are the sand-and-gravel aquifer and the Floridan aquifer. While the sand-and-gravel aquifer provides water for rural domestic use and plays a crucial role in water storage and streamflow maintenance, it also serves as a recharge source for the Floridan aquifer. Water from the sand-and-gravel aquifer contains varying levels of dissolved solids, pH, and iron content. The Floridan aquifer, being the primary water supply source, underlies the entire county and yields around 500 to 1,000 gallons per minute from wells, except along the Gulf Coast where the permeability is lower. Recharged by leakage from the sand-and-gravel aquifer, the Floridan aquifer's movement is predominantly southward away from the potentiometric high in northwestern Walton County. It discharges through springs, seeps along the Choctawhatchee River, and by wells. In southern Alabama, the Floridan aquifer is directly recharged by rainfall when it is exposed or close to the land surface. (Bureau of Ecology, 1974).

Once a common time period is determined across the majority of shallow groundwater wells, canal data can be gathered for that common date (and two days prior, in the event the canals were deliberately lowered). Data was obtained from the NWFWMD and processed by FAU at cwr3.fau.edu. Between stations, an ArcGIS tool permits a line to be drawn to replicate the canals and establish points in a gradient between stations. The same is true for the ocean, but it is a constant head boundary. The canals form boundary conditions for the screening tool on the edges of the basin and affect localized groundwater. The tide issue is resolved by using the common date for high tide.

Error! Reference source not found. shows the drainage network of HUC 031402031103 and points out the location of the only one ground water station in the surroundings. A groundwater-surface layer for the HUC 031402031103 sub-watershed was created using several datasets including water level data from USGS and NWFWMD and groundwater elevation contour maps. The datasets were used to generate a raster surface of the groundwater elevation (**Error! Reference source not found.**).

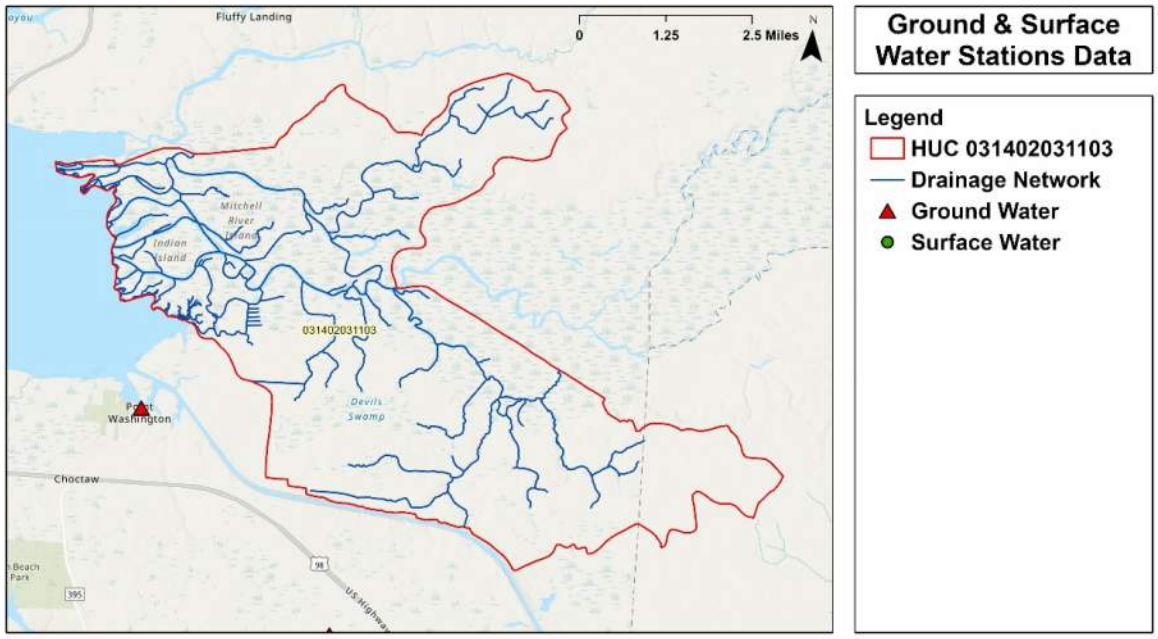

Figure 9. Ground and Surface Water Stations in the HUC 031402031103 sub-watershed, processed by FAU.

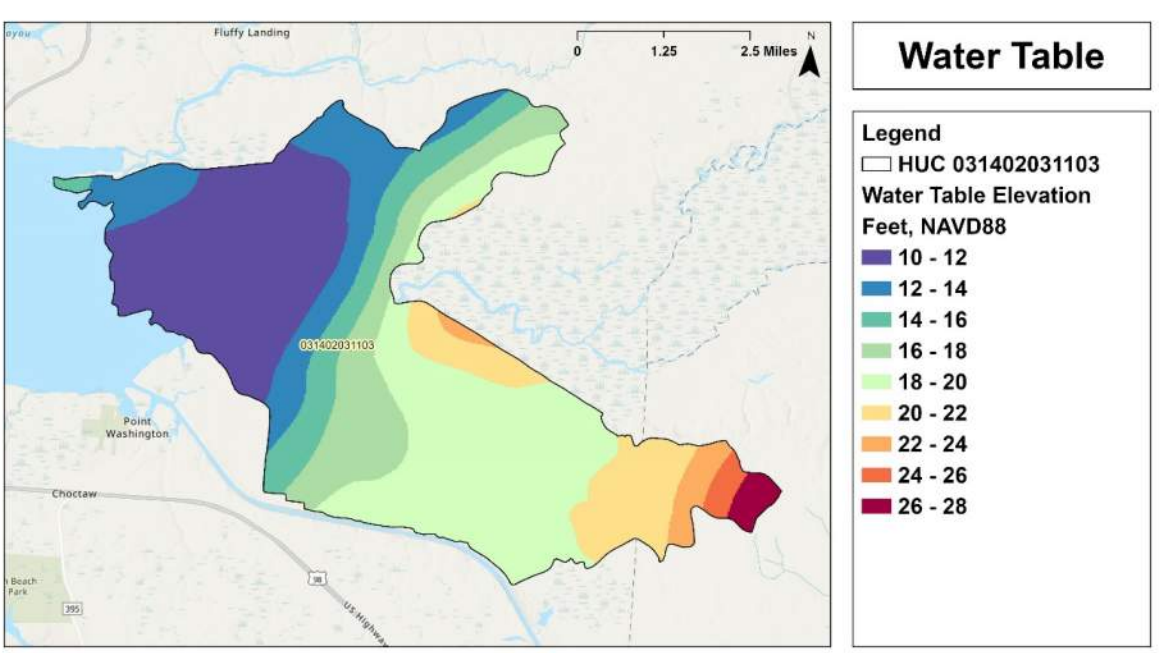

Figure 10. Elevation of the top of the surface groundwater layer for the HUC 031402031103. Created by multiple linear regression analysis – elevation NAVD88, processed by FAU. (Data Source: USGS and NWFWMD)

1.3 Surface Water/Tides

Historically, surface water and tides have been an important factor in determining how much freshwater is delivered, how fast this water enters wetlands and estuaries, and the quality of that water. Evapotranspiration and rainfall do not coincide in the study area, which makes water supply planning difficult. **Error! Reference source not found.** shows the average precipitation over Walton County for every month of the year between 2011 and 2023 - each rectangle is a month and each column is a year. The 12-month total precipitation decreased 7.5 inches from May 1900 to April 2023. From May 1900 to April 2023, the average 12-month total precipitation was 60.5 inches for the entire county.

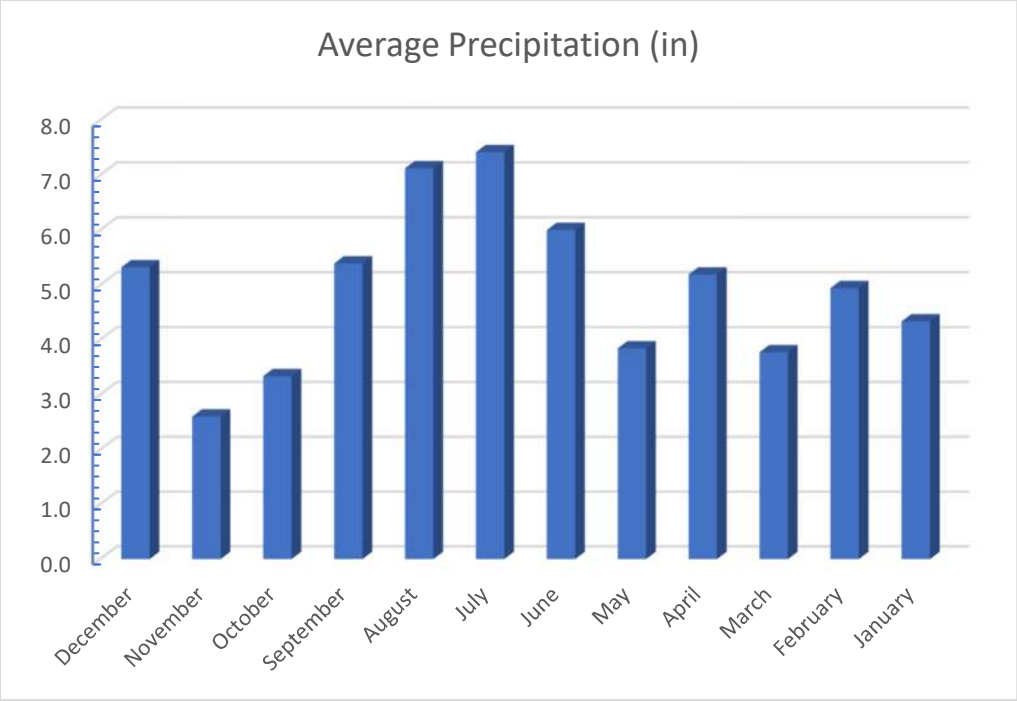

Figure 11. Monthly precipitation in Walton County, FL (2011-2023).
(Data Source: Florida Weather Data, available at https://data.usatoday.com/weather-data/walton-county/12131/1975-04-01/table/)

While the topography (Section 1.1) and native soil (Section 1.4) create an environment that is highly permeable and capable of infiltrating significant percolation into the soil, changes in land use and land cover have resulted in water falling on impervious areas, where the water collects in pools or runs off rapidly, in direct contrast to the natural condition. This runoff flowing over impermeable regions can lead to larger scale flooding.

Tidal data can be gathered from NOAA tidal gages and other gages monitored by local governments. The location of tide gages is important to ensure they accurately depict tides, as opposed to inland waters. To set a boundary for the coastal areas, the high tide on the common date from 12/03/2018 to 12/10/2018 was selected. **Error! Reference source not found.** shows the two closest tide stations to Walton County. Since there is none NOAA tide station in Walton County, the Panama City Beach station (8729210) was used.

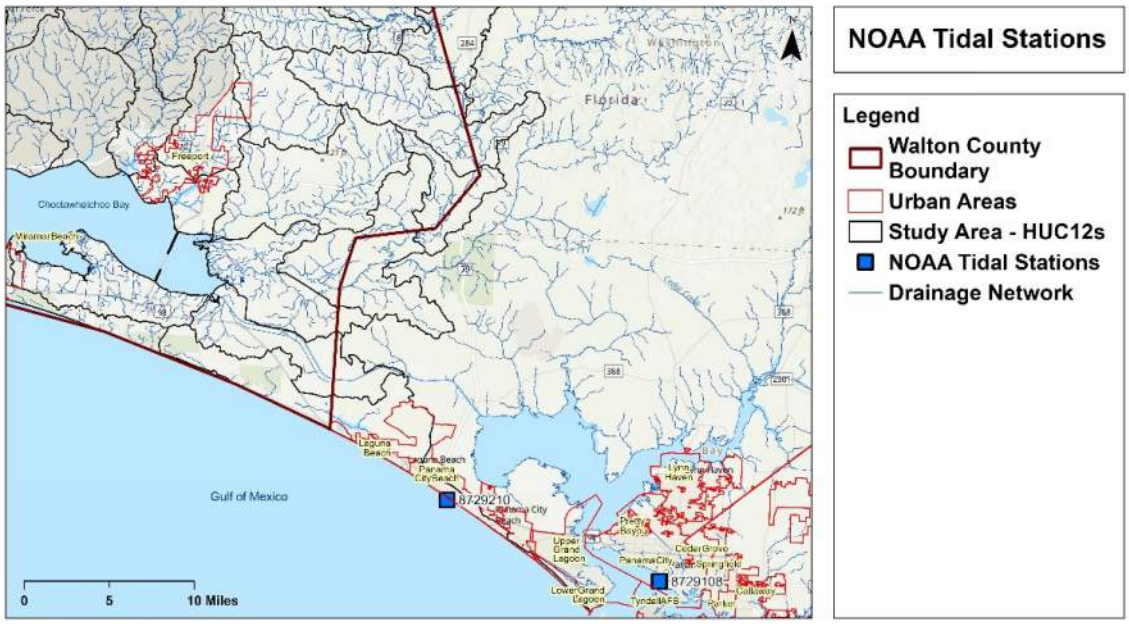

Figure 12. Locations of Florida tidal stations maintained by NOAA near to Walton County, processed by FAU.
(Data Source: USEPA – National Hydrographic Dataset (NHD) and NOAA's Tides)

1.4 Soils

Soil can store water if there is adequate distance between the topographic surface and the groundwater, and the soil types are capable of absorbing the water. Soil storage capacity is the volume of soil pores in the unsaturated zone that is available to store infiltrated stormwater (Gregory et al., 1998). Throughout Florida, it is common to have large volume storm events that fill the voids in the unsaturated zone as shown in Figure 13.

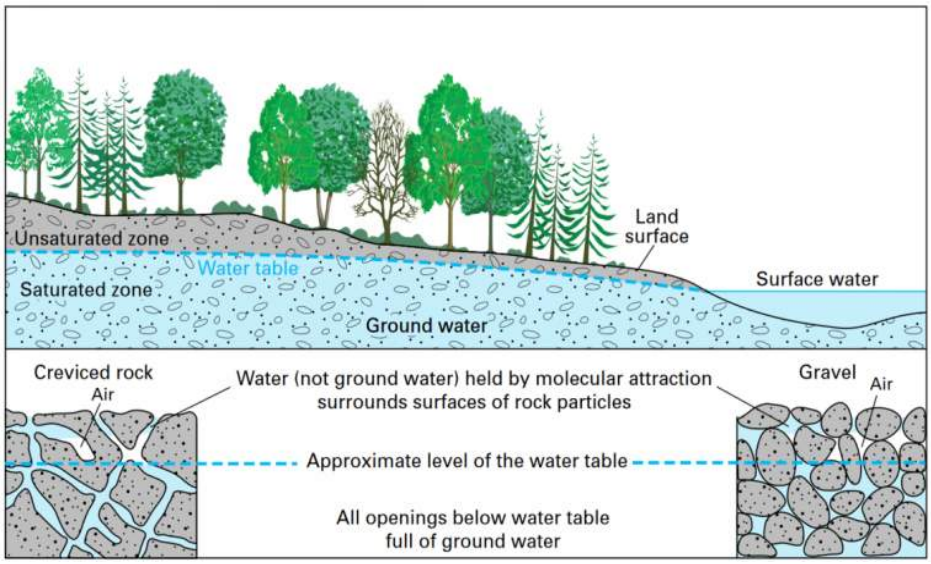

Figure 13. Zones where underground water exists.
(Source: USGS, 2020)

The unsaturated zone is the portion of the subsurface above the water table that contains soil/rock and air and water in its pores as shown in Figure 14. This zone affects the rate at which the aquifer is recharged by controlling water movement from the surface of the land downward towards the aquifer. During rain events, the soil voids fill up quickly resulting in the water table rising to the surface, and the surplus rainfall becomes runoff.

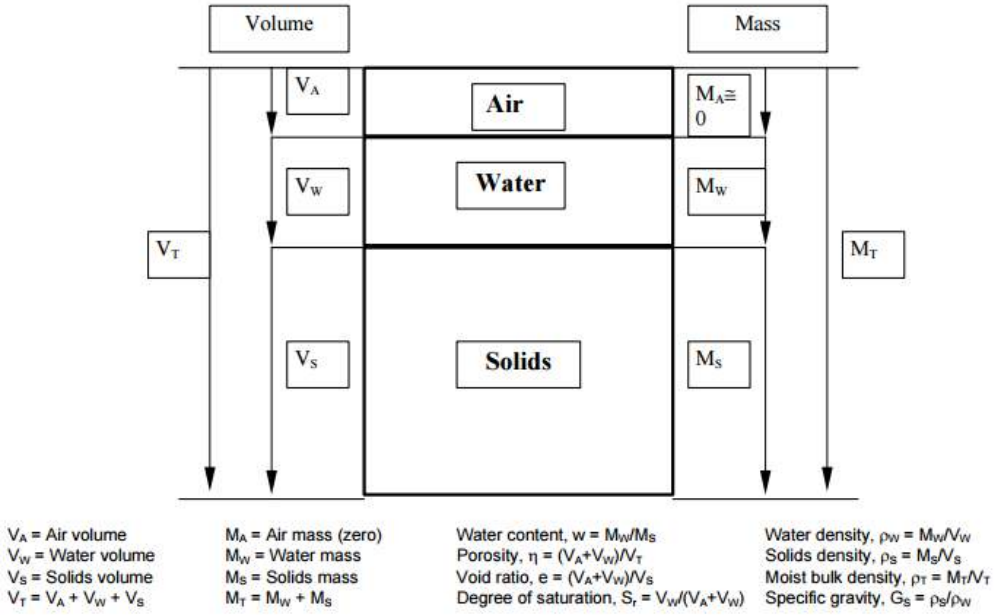

Figure 14. Saturated zone soil phase diagram and definitions.
(Source:Gregory et al., 1998)

Soil data is available from the United States Department of Agriculture (USDA) or other agencies in the form of maps that can be incorporated as a GIS layer. The Gridded SSURGO (gSSURGO) dataset from USDA is chosen. This dataset is similar to the standard product from USDA Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database, but is in the Environmental Systems Research Institute, Inc. (ESRI®) file geodatabase format. A file geodatabase allows for statewide or even Conterminous United States (CONUS) tiling of data. The gSSURGO dataset contains all of the original soil attribute tables in SSURGO. All spatial data are stored within the geodatabase instead of externally as separate shape files. Both SSURGO and gSSURGO are considered products of the National Cooperative Soil Survey (NCSS). **Error! Reference source not found.** shows the unsaturated zone found by the difference between the groundwater elevation layer and surface topography.

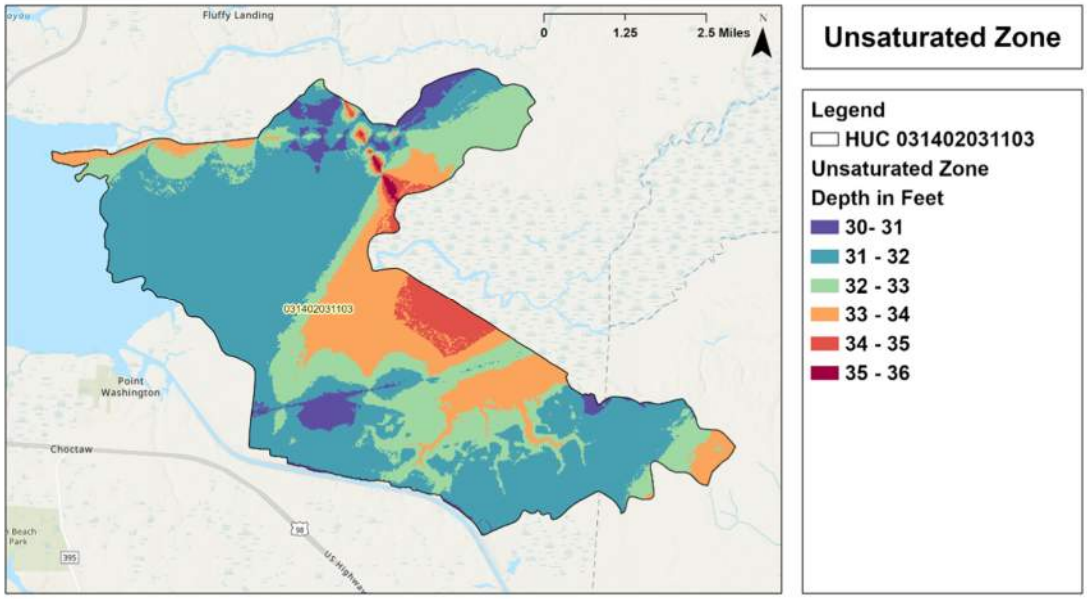

Figure 15. Unsaturated zone map for HUC 031402031103, processed by FAU.

The available water storage from USDA derived for the soil layer (0-150 cm or 0-5 ft) statewide is shown in **Error! Reference source not found.**, which covers most of Florida with a spatial resolution of 10 m. The unit is in cm. As a result of applying this layer to the study area (**Error! Reference source not found.**), the estimated soil storage capacity can be illustrated. A significant portion of the basin demonstrates a moderately favorable soil storage capacity, falling within the range of 31 to 35 feet of remaining capacity.

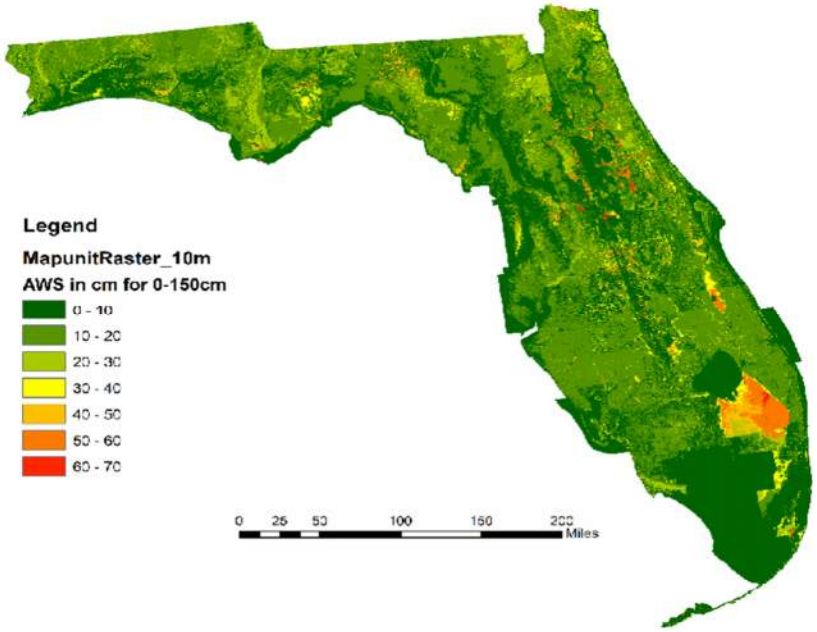

Figure 16. Available water storage derived from the gSSURGO soil database for all of Florida, as processed by FAU.
(Data Source: USDA - SSURGO)

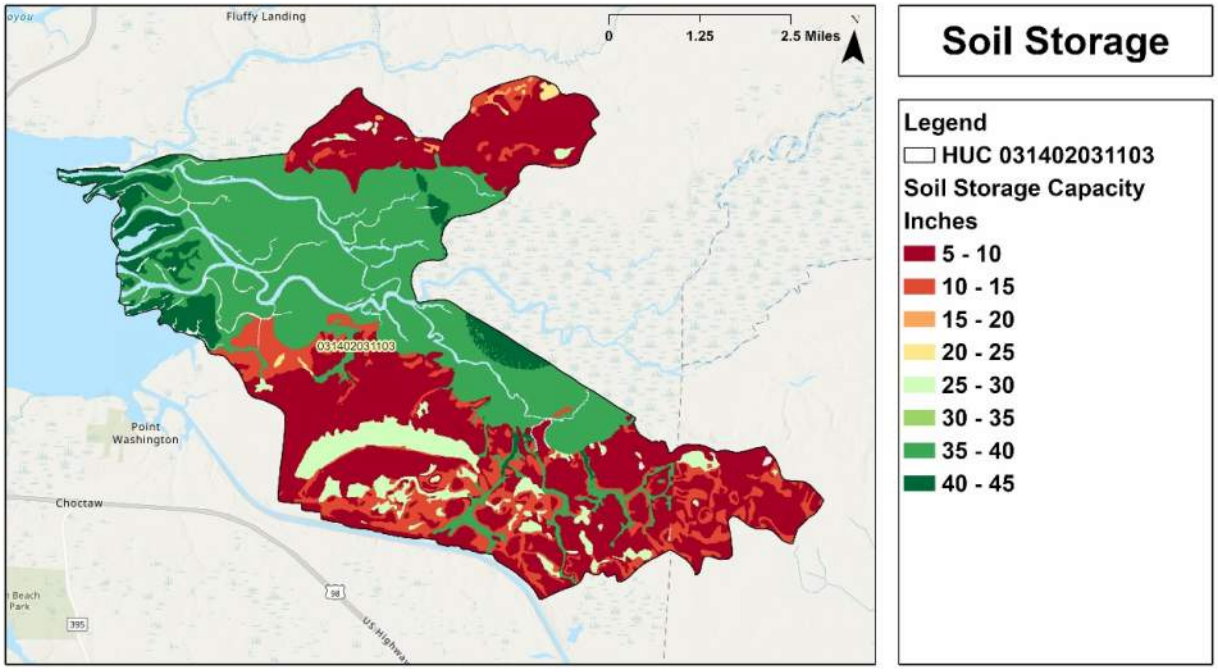

Figure 17. Water storage capacity of soil for the HUC 031402031103, processed by FAU.

Lastly, **Error! Reference source not found.** shows the water holding capacity for the basin, which refers to the capacity of a particular soil texture to retain water against the force of gravity.

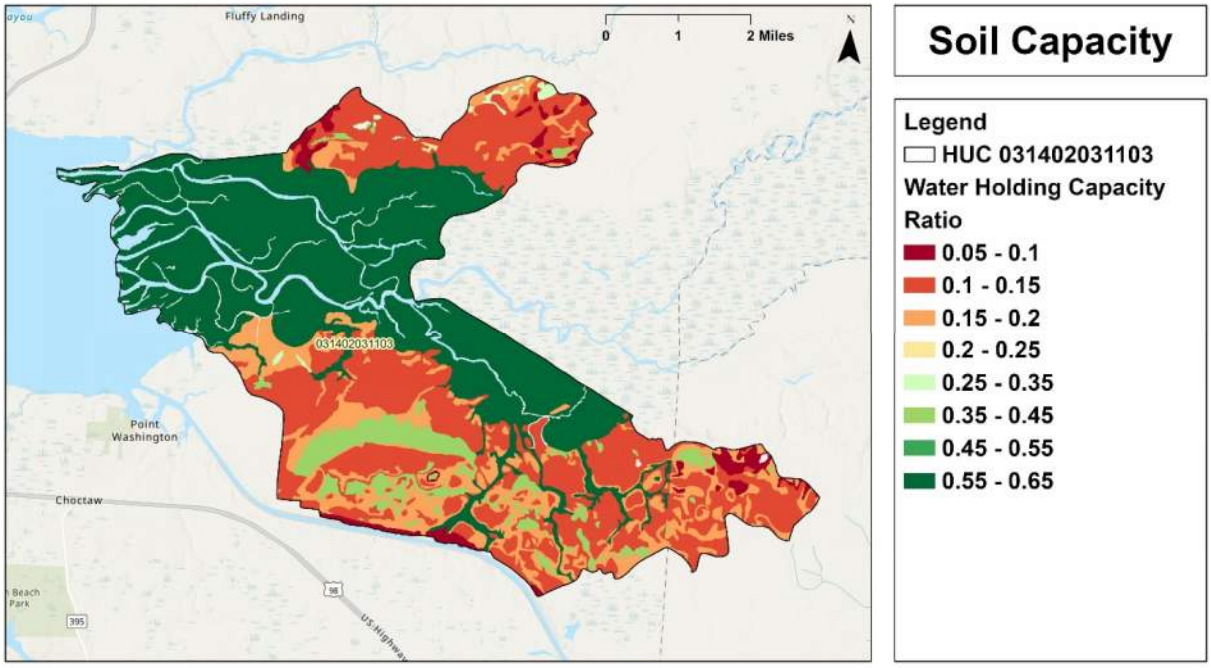

Figure 18. Water Holding Capacity (ratio) for the HUC 031402031103, processed by FAU.

1.5 Land Cover

The USGS produces the NLCD of nationwide data on land cover at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. NLCD is coordinated through the 10-member Multi-Resolution Land Characteristics Consortium (MRLC) to provide digital land cover information nationwide. For the conterminous United States, NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, urban imperviousness and urban imperviousness change across 4 epochs from 2001-2016, tree canopy and tree canopy change across 2 epochs from 2011-2016 and western U.S. shrub and grassland areas for 2016 (**Error! Reference source not found.**).

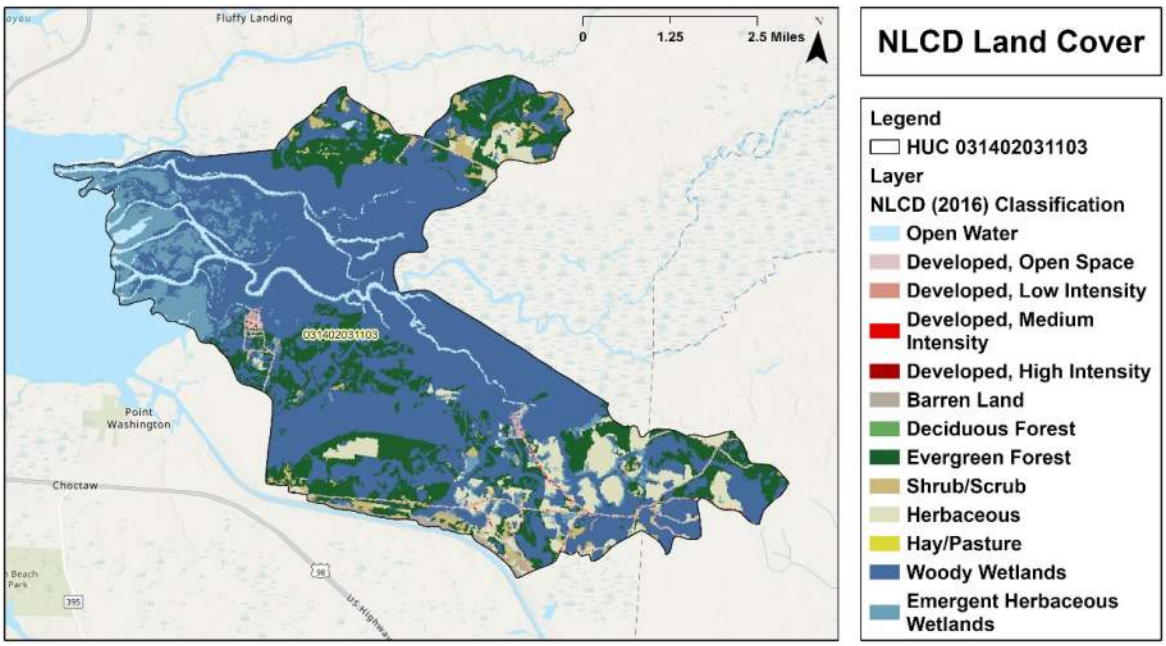

Figure 19. Land use in the HUC 031402031103 (from the NLCD 2016 database), processed by FAU.
(Source Data: NLCD, 2016)

The dataset is derived from the Florida Land Use Cover Classification System (FLUCCS), which is digitized by photo-interpretation on county-based aerial photography with varying resolution in the range of 4 in - 2 ft pixel. The NLCD2016 has a 30-meter resolution derived from Landsat imagery. Hence, the NLCD maps appear much coarser and pixelated compared to the 2023 Florida Geographic Data Library (FGDL) (https://fgdl.org/fgdlmap/) maps. A view of the latter is provided in **Error! Reference source not found.**. The future land use maps need to be used for the final land cover, as adjusted for future stormwater improvements set by regulatory standards.

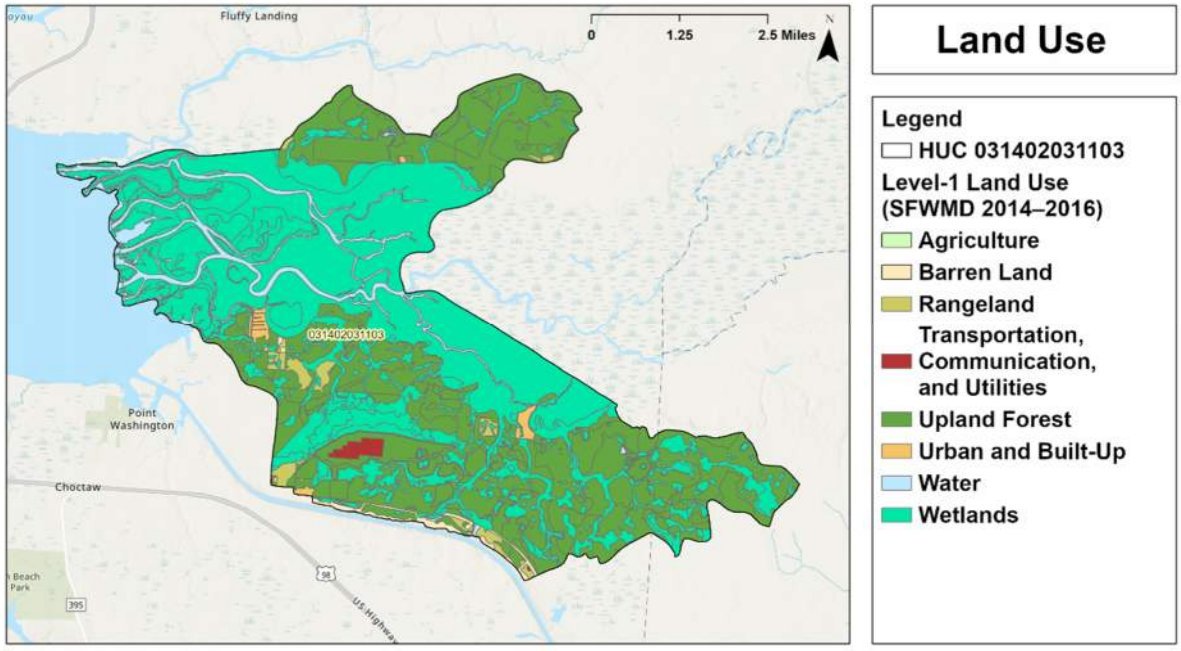

Figure 20. Land use in the HUC 031402031103, processed by FAU.
(Source Data: 2023 Florida Geographic Data Library (FGDL) database))

In the HUC 031402031103 sub-watershed, the predominant land cover is wetlands, accounting for 46.15% of the area. Upland forest comes in second at 36.84%, followed by water at 13.95. Developed land constitutes a minor portion, with only 0.48% categorized as urban and built-up, as indicated in **Error! Reference source not found.**. **Error! Reference source not found.** shows the roughness of the surface.

Table 3. Land use for HUC 031402031103 subwatershed

Level 1 Land Use Land Cover Type	**Area (Acres)**	**Percentage of Total**
Agriculture	8.36	0.02%
Barren Land	427.86	1.21%
Rangeland	375.30	1.06%
Transportation, Communication, and Utilities	101.47	0.29%
Upland Forest	13056.74	36.84%
Urban and Built-Up	171.80	0.48%
Water	4945.16	13.95%
Wetlands	16358.30	46.15%
Grand Total:	**35444.99**	**100.00%**

(Source Data: 2023 Florida Geographic Data Library (FGDL) database))

Table 4. Roughness and CN Values for Each Land Use Code.

DOR Code	Use	Impervious %	Roughness
0	Vacant	0	0.4
1	Single Family	29	0.25
2	Mobile homes	21	0.05
4	Condos	60	0.05
7	Vacant –to be developed	0	0.4
8	Multifamily	60	0.05
TH 101	Townhomes	91	0.025
94	Road Right-of-Ways	50	0.08
	Open water	100	n/a
All others	Commercial, etc.	50	0.07

1.6 Precipitation

Rainfall used in the screening tool is based on the SFWMD 3-day 25-year storm, but can be modified for any rainfall event using the accumulated rainfall table obtained from NOAA Atlas 14 Point Precipitation Frequency Estimates (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html). **Error! Reference source not found.** shows the 3-day 25-year rainfall map based on the NOAA Atlas 14 dataset for the whole state. **Error! Reference source not found.** to **Error! Reference source not found.** rainfall 1-day 100-year, 1-day 10-year, and 1-day 5-year storm event scenarios, in inches.

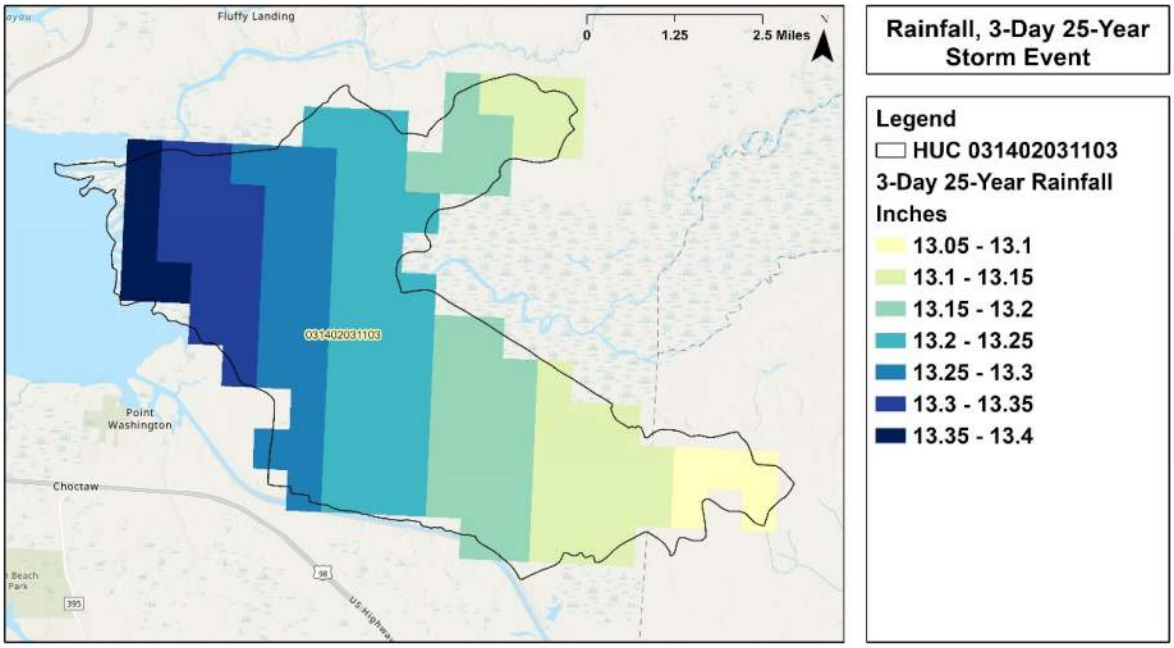

Figure 21. Rainfall distribution map across HUC 031402031103 sub-watershed, for 3-day 25-year storm event, processed by FAU.
(Source Data: NOAA Atlas 14 Database)

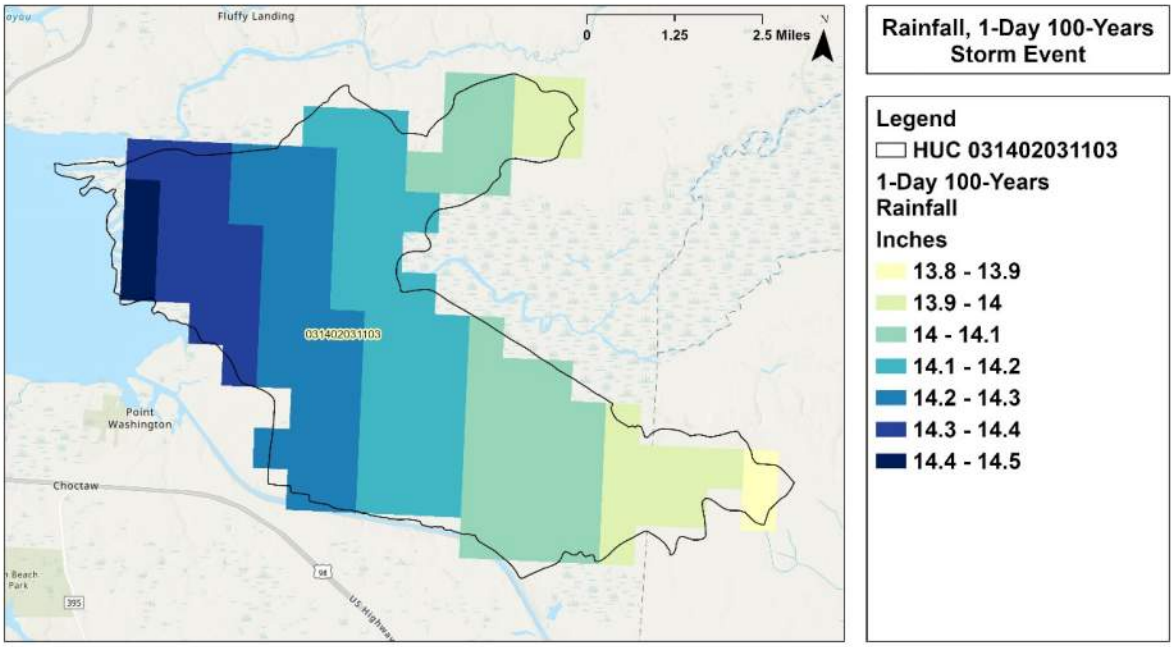

Figure 22. Rainfall distribution map across HUC 031402031103 sub-watershed, for 1-day 100-year storm event, processed by FAU.

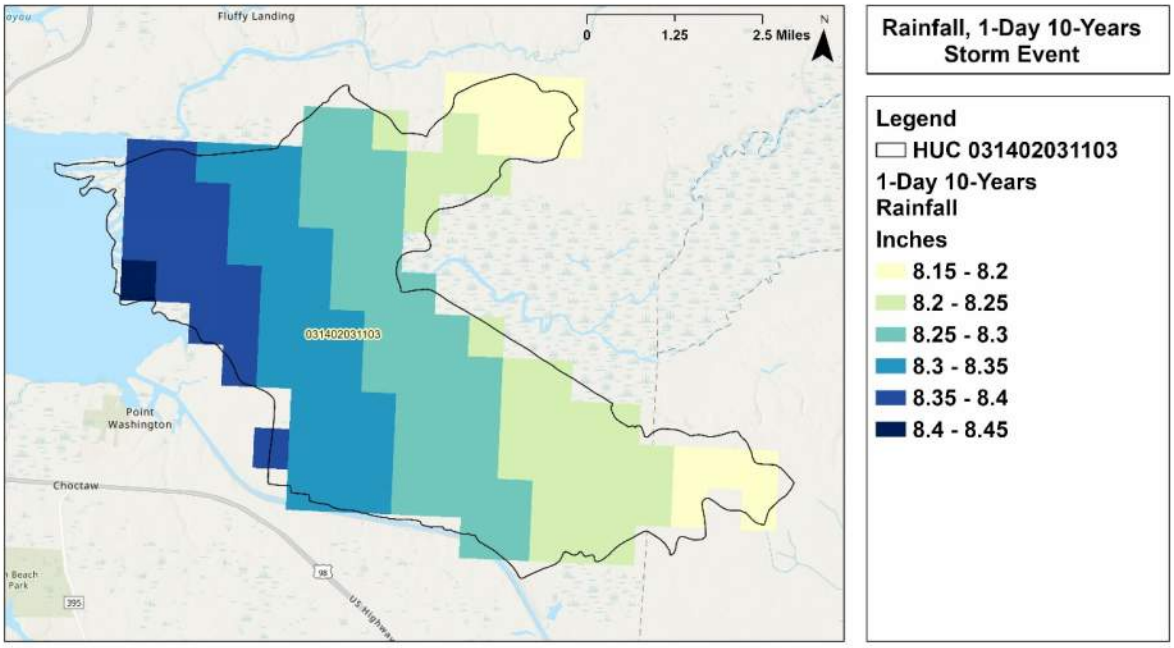

Figure 23. Rainfall distribution map across HUC 031402031103 sub-watershed, for 1-day 10-year storm event, processed by FAU.

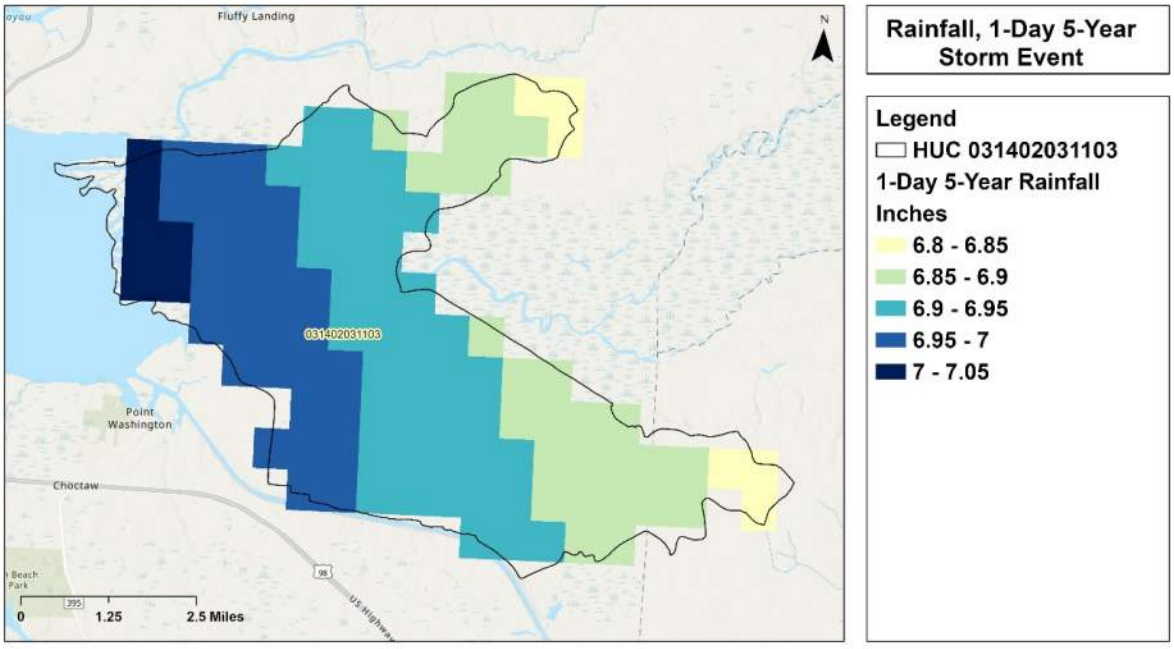

Figure 24. Rainfall distribution map across HUC 031402031103 sub-watershed, for 1-day 5-year storm event, processed by FAU.

1.7 Open Space

Open space is defined as areas that are exempted from development. Generally, this means one or more of the following qualifiers exist:

1. Land that is valuable for recreation, forestry, fishing, or conservation of wildlife or natural resources
2. Land that is a prime natural feature of the state's landscape, such as a shoreline or ridgeline
3. Land that is habitat for native plant or animal species listed as threatened, endangered, or of special concern
4. Land that is a relatively undisturbed example of an uncommon native ecological community
5. Land that is important for enhancing and conserving the water quality of lakes, rivers, and coastal water
6. Land that is valuable for preserving local agricultural heritage
7. Proximity to urban areas or areas with open space deficiencies and underserved populations
8. Vulnerability of land to development
9. Stewardship needs and management constraints
10. Preservation of forest land and water bodies that naturally absorb significant amounts of carbon dioxide

Permanent protection of sensitive areas can provide critical water quality protection and can be achieved through partnerships with landowners, municipalities, land trusts and state agencies. There is limited land in the study area that has been protected via acquisition by federal, state or local agencies, has conservation easements or is designated as wetlands or areas of critical concern. Agricultural land and other land cover will come from the land cover map (in Section 1.5). Added to this will be the water bodies discussed in Section 1.9, which serve a related condition to open space.

1.8 Impervious Areas

Impervious areas do not permit the infiltration of rainfall to groundwater, and because the water cannot infiltrate, it runs off faster. Faster runoff means that flows to water bodies and storm sewers occur faster and with higher peaks. The result is a disruption of the natural and potentially the planned hydrology. Impervious areas include pavement, buildings, and other areas that reduce runoff capacity. In other words, developed areas have much higher imperviousness than open spaces that are natural or agricultural.

The NLCD provides nationwide data on land cover and land cover change at a 30-m resolution with a 16-class legend based on a modified Anderson Level II classification system. Systematically aligned over time, the database offers the ability to understand both current and historical land cover and land cover change to enable assessment of trends. Using the NLCD 2016 dataset, a layer was created by using only three categories out of the 13 to identify impervious areas such as primary roads in urban areas, secondary roads in urban areas, and tertiary roads in urban areas. The new layer was then converted to match the 3-meter spatial resolution from the DEM and the standard State Plane Coordinate system. **Error! Reference source not found.** shows the impervious areas derived from the NLCD 2016 as updated by the future land use map.

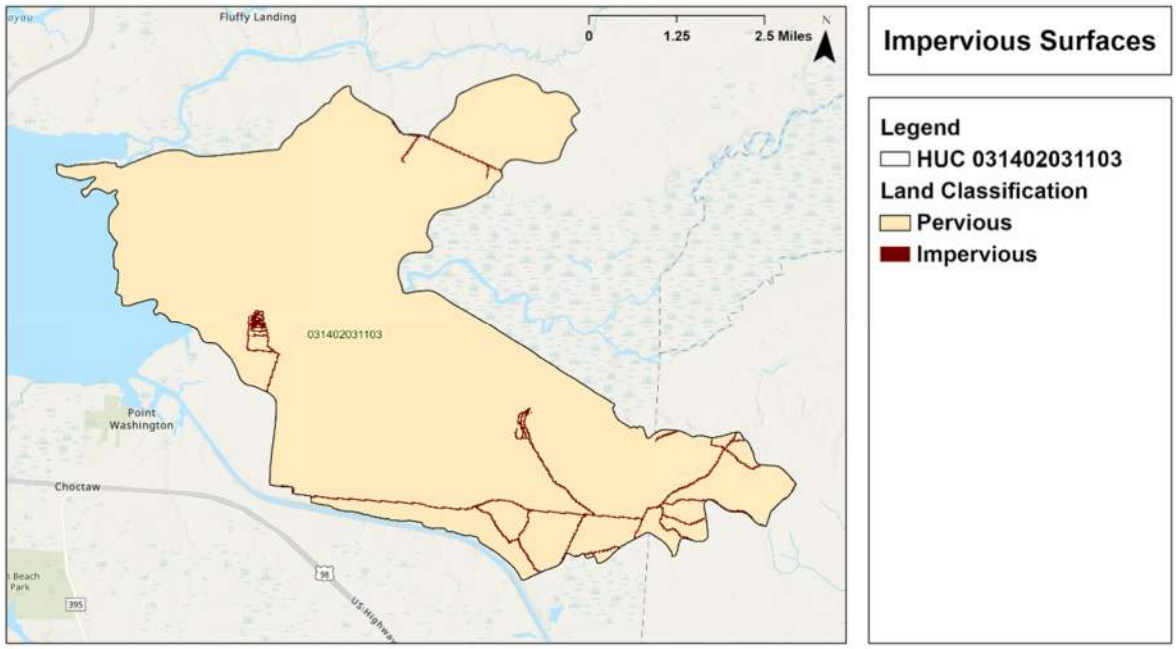

Figure 25. Impervious area map for the HUC 031402031103 sub-watershed, processed by FAU. (Source Data: NLCD, 2016)

1.9 Water bodies

Water bodies were defined in the statewide land use land cover dataset to set soil water holding capacity to zero in model simulations (**Error! Reference source not found.**). Note that tiny water bodies may be missing from the maps. Soils were discussed previously in Section 1.4.

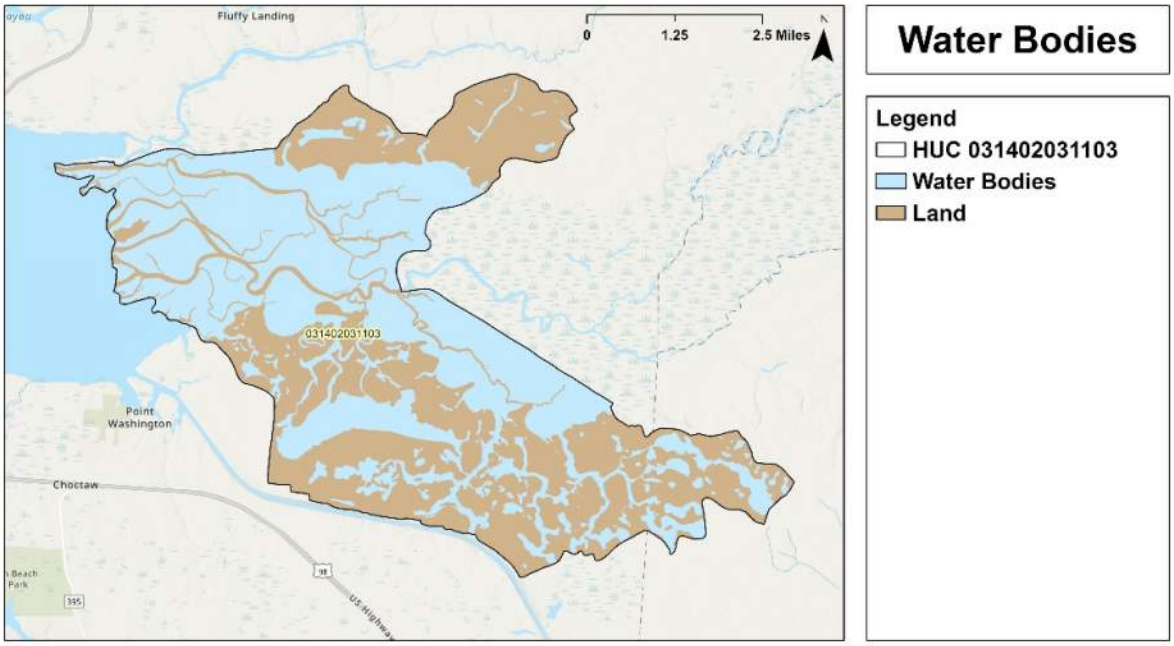

Figure 26. Water bodies map for the HUC031402031103 sub-watershed, processed by FAU. (Source Data: USEPA – National Hydrographic Dataset (NHD))

1.10 Natural Resources

Understanding the study area's natural resources is critical to identifying potential sources of water quality degradation and areas to designate for conservation, protection, and restoration. One possible goal of watershed master planning is to protect terrestrial wildlife, aquatic habitat, and buffer zones. USGS maintains important sources of information on physical and geographical features as well as soil and mineral resources, surface and ground water resources, topographic maps, and water quality monitoring data. The USDA's Natural Resources Inventory (NRI) (www.nrcs.usda.gov/technical/NRI) is a survey of information on natural resources on non-federal land in the United States that captures data on land cover and land use, soil erosion, prime farmland soils, wetlands, habitat diversity, erosion, conservation practices, and related items. Since 2001, the NRI has been updated continually with annual releases of NRI data from all 50 states. The information provided can be used for addressing agricultural and environmental issues down to the county or cataloging unit level. Therefore, this data can be used to determine erosion and site-specific soil characteristics for certain land uses such as croplands, pasturelands, forestlands, etc., but the data is typically provided as inventories, not GIS layers.

1.11 Demographics

Demographics data is important for determining several key indicators for watershed master planning such as the ability to pay for improvements, social justice issues, land acquisition costs, property/land use, and communication strategies. The US Census has databases at the census tract level. Based on the census data for the study area, **Error! Reference source not found.** outlines population and racial composition demographics.

Table 5. Demographics and Housing Characteristics of Cities and Towns in Walton County.

Demographic Parameter	**Miramar Beach**	**Freeport**	**DeFuniak Springs, City**	**Paxton**	**Rosemary Beach**	**Santa Rosa Beach***	**Walton County**
Type	CDP**	City	City - County Seat	Town	Unincorporated community		County
Area in square miles	7.02	18.94	13.95	4.01	17,021	68,722	1,038.29
Population (Census 2020)	8,002	5,861	5,919	556	2,878	20,567	75,305
Total Households	4,334	2,206	2,509	316	1,318	8,275	30,182
Median Household Income	$75,347	$75,637	$53,984	$41.750	$127,148	$94,648	$68,111
Median Age	56.3 years	41.4 years	37.1 years	50.6 years	52.4 years	43.20 years	45.0 years
White	7,688	2,086	4,021	482	2,638	17,268	89.8%
Black, African American	318	70	1,409	17	19	262	5.2%
American Indian, Native	52	8	41	14	6	117	0.8%
Asian	69	35	0	0	28	363	1.4%
Another Race	14	52	105	5	22	925	0.2%
Two or More Races	674	185	299	38			2.7%
Hispanic or Latino (Regardless of Race)	434	156	127	66	105	1,988	7.1%

(Source: US Census Bureau 2020, and Zip-codes.com)

*It includes the communities of Point Washington to the East and a 15-mile stretch of the Emerald Coast from the east side of Miramar Beach to the west side of Seagrove Beach and the beach communities along 30A, including Grayton Beach and Seaside.

** Census Designated Place

1.12 Stormwater Infrastructure Inventory

Local community stormwater systems consist of drainage ditches, storm sewers, retention ponds and other facilities constructed to store runoff or carry it to a receiving stream, lake, ocean, or other waterbody. Other man-made features include yards and swales that collect runoff and direct it to the sewers and ditches. When most of these systems were built, they were typically designed to handle the amount of water expected during a 10-year storm. Larger storms overload them, and the resulting backed-up sewers and overloaded ditches produce shallow flooding. Another urban drainage problem occurs in the areas protected by levees. Being in floodplains, they are flat and do not drain naturally, especially when a levee blocks the flow to the river. To drain these areas, channels have been built and pumps installed to mechanically move the water past the levee. Often, these man-made systems do not have the capacity to handle heavy rains or intense storms.

Another challenge with stormwater infrastructure is related to recordkeeping. It is not uncommon for stormwater data to be incomplete in most jurisdictions and completely lacking in others. Quality of data differs from jurisdiction to jurisdiction; some are in GIS formats, while others are paper maps or as-builts that represent the infrastructure at a macroscale level. The condition of the assets may be lacking, and the maintenance history may not be available either. Stormwater assets may have been installed with no records, especially in rural areas, farm fields, and private property.

Walton County passed Ordinance No. 2008-06 that prohibits unauthorized discharges into storm drains or ditch systems. In addition, the Public Works Division is currently running a continuous public awareness campaign aimed at encouraging the adoption of best management practices (BMPs) for managing stormwater runoff. This initiative targets both the business community and the residents of Walton County.

To address the issue of flooding, Walton County has implemented several measures along the years, such as:

- Drainage Systems: The county has invested in the development and maintenance of drainage systems, including ditches, canals, and retention ponds, to manage stormwater runoff and reduce flood risk.
- Floodplain Management: Walton County has adopted floodplain management regulations and participates in the National Flood Insurance Program (NFIP) to encourage responsible development in flood-prone areas.
- Elevation Standards: New construction projects within flood zones are required to adhere to specific elevation standards to minimize potential flood damage.

- Emergency Response: The county has established emergency response plans to assist residents during flood events, including evacuation procedures and the provision of emergency shelters.

Key stormwater assets for the HUC and Walton County are indicated in **Error! Reference source not found.** and **Error! Reference source not found.**, respectively. Stormwater structures and management processes in the county consist of stormwater outfall, water wells, weir, pollutant control boxes, inlets catch basins, pipes culverts, ditch conveyance swales, structures, pipes and open conveyance.

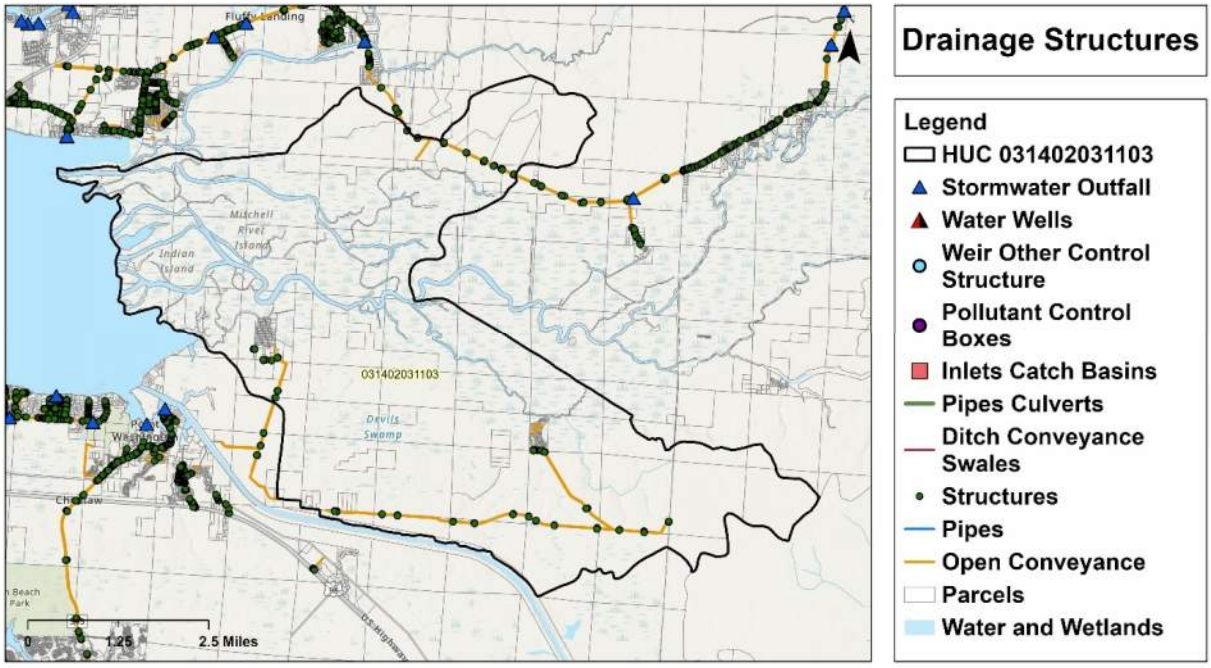

Figure 27. Stormwater Infrastructure for the HUC 031402031103. Processed by FAU.
(Source Data: Walton County Storm Asset Inventory and Stormwater Inventory)

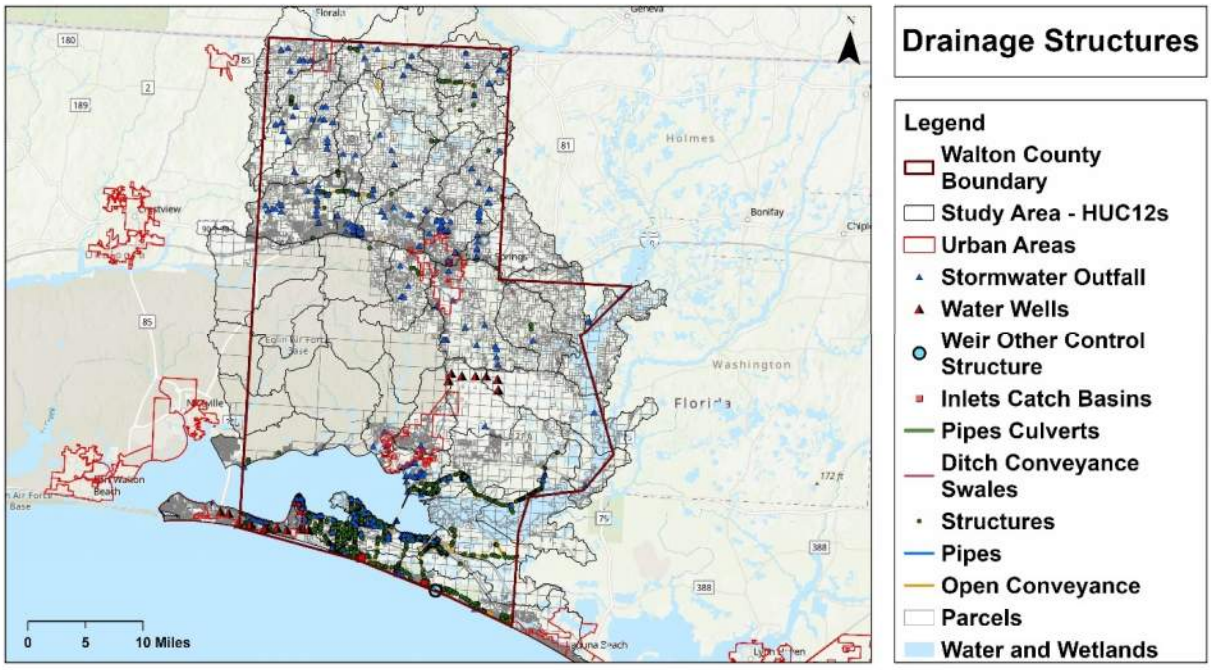

Figure 28. Stormwater Infrastructure for Walton County. Processed by FAU.
(Source Data: Walton County Storm Asset Inventory and Stormwater Inventory)

Although nature-based infrastructure might be installed, it is not certain. The stormwater system must maintain compliance with the stormwater regulations, which requires record-keeping, policy development, inspections and maintenance. The goals of such stormwater management may include:

- Best landscape practice;
- Control car washing contribution to pollution;
- Enforce the Stormwater Pollution Prevention Plan (SWPPP) by site evaluation, assessment, erosion and sediment controls, preventive maintenance, certification and inspection reporting for construction sites and city planning;
- Implement a hazardous material elimination system;
- Eliminate illicit dumping;
- Proactive and reactive catch basin inspections and maintenance;
- Street sweeping to control debris;
- Maintain swales to help prevent stormwater pollution flooding.

1.13 Data Gaps

FAU has developed comprehensive databases to address the information needed for the vulnerability assessment. These are included in Table 6. The data can be used to model the impacts

of flood routing during the storm of interest. As a result, the modeling pieces (discussed in Chapter 2) will include the following:

- Flood response model results (Cascade 2001)
- Flood risk/hazard mapping
- Vulnerability assessments to identify areas of concern for future repetitive losses

There is only one data gap for the area – existing stormwater infrastructure records are incomplete. However, for the purposes of this plan, this data gap does not limit the findings, as there are two scales: 1) the sub-watershed level and 2) community hotspots. A neighborhood level vulnerability assessment will require the local infrastructure inventory.

Table 6. List of datasets collected by FAU as of List of datasets collected by FAU for the project (12/20/2020).

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Topography	USGS_NED	USGS	Part of Florida, raster image in 1 m	Created by USGS in 2016	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_1m	3.28G bytes, raster images	Native
	USGS_NED	USGS	Part of Florida, raster image in 3m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m	40.9G bytes, raster images	Native
	USGS_DEM	USGS	Florida, Raster data in 10m	Created by USGS	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_DEM	22.6 G bytes, raster images	Native
	DEM_3m_merged	USGS	3m in tiff		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\DEM_3m_merged	186G bytes, raster images	FAU Processed
	SRTM_30m	NASA	30m Raster		\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\LiDAR_DEM\SRTM_30m_UCF_Chang	607M bytes, raster images	Native
Surface Water and Tides	Tidal	NOAA's Tides and Currents CO-OPS SOAP Web Services	State of Florida, Excel	Every 6 minutes since 1920, excel	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Tidal\	1.37 G bytes, excel	FAU Processed
Soil	FL_Soil	FY2019 USDA Soil SSURGO gSSURGO) Database https://sdmdataaccess.nrcs.usda.gov/	Florida, Raster data is in 10m	Released by USDA in 2019	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil Processed data for water holding capacity ratio is at: \\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_soil\aws0_150_whc1.tif	107G bytes, both vector and raster	FAU Processed

Data Category	Dataset Name	Original Source	Spatial Coverage/ Resolution	Temporal Coverage/ Resolution	Link to the Dataset on our Server (physical location)	Dataset size and Format	Native or FAU Processed dataset
Land Cover	USGS_LC	USGS	Conterminous United States, raster format, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\USGS_LC\NLCD_2016_Land_Cover_L48_20190424	20G bytes, raster	Native
	Impervious Surface	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\Impervious\NLCD_2016_Impervious_descriptor_L48_20190405\	24.6G Bytes, Raster Image	FAU Processed
	Open Space	USGS	Florida, 30m derived from satellite	Created by USGS in 2016 (Most recent)	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_LCLU\NLCD2016_OpenSpace\	21G bytes, raster	FAU Processed
Precipitation Records	FL_NOAA14_Precipitation	NOAA Atlas 14 Database	Florida, raster in 800m	Most recent release from NOAA	\\engsynws01.eng.fau.edu\Project_mastercopy\Datasets\FL_NOAA14_Precipitation\se25y3d_inch.tif	34 M bytes, raster images	FAU Processed, 3 day-25 year and 3 day-100 year

2.0 ASSESSMENT OF VULNERABLE AREAS

Defining flood risk due to compounding hydrographic influences is the central concern of this WMP. Modeling and assessment of vulnerability focused on the combination of a high-water table, heavy rains, and impervious conditions that can lead to localized nuisance flooding events. Through a previous survey with local officials, the number of days of continuous nuisance flooding that the public will tolerate before that flooding is considered destructive is about 4 days (E Science 2014).

For a large study area, small parts may actually be at risk. The point is to identify where further study might be needed. A screening tool accomplishes this goal applied to the sub-watershed scale to designate areas that are susceptible to periodic flooding events. Utilizing the information collected and analyzed in Chapters 1, analysis of flood vulnerability can be performed.

2.1 Historical and Existing Challenges

Walton County has faced various historical and existing challenges as well as natural hazards over the years. Some of these include:

- Hurricane and Tropical Storms: being situated along the Gulf Coast, Walton County is vulnerable to hurricanes and tropical storms, which can lead to damage to the built and natural environment, as well as poses risks to human and wild life.
- Coastal Erosion: The county's coastline is subject to erosion due to natural processes and human activities. Erosion can lead to the loss of beaches and threaten coastal structures and properties.
- Flooding: heavy rainfall, storm surges from hurricanes, and other factors can cause localized flooding, particularly in low-lying areas. Flood events can disrupt daily life, damage property, and impact transportation.
- Water Quality and Quantity: as in many coastal areas, managing water quality and maintaining an adequate water supply are ongoing challenges. Pollution from stormwater runoff and other sources can affect water quality, and groundwater resources need to be carefully managed to sustain the growing population.
- Wetland Loss: The county's wetlands face the threat of degradation and loss due to urban development and other human activities. Protecting these essential ecosystems is vital for maintaining biodiversity and mitigating flood risks.
- Urbanization and Development: Balancing the demand for development and growth with the preservation of natural habitats and resources is a persistent challenge. Unplanned

urbanization can lead to habitat destruction, increased runoff, and exacerbate flooding risks.

- Land Use and Zoning: Proper land use planning and zoning are essential to address issues related to population growth, infrastructure development, and natural hazard mitigation. Ensuring responsible development practices can help minimize risks.
- Invasive Species: Like many regions, Walton County faces the threat of invasive plant and animal species. These invasive species can disrupt local ecosystems, negatively impacting native flora and fauna.
- Sea-Level Rise: With rising sea levels due to climate change, coastal communities like Walton County's coastal areas are at greater risk of inundation and storm surges during extreme weather events.

The fast growth of the population and urban development in the coastal areas of the county exacerbates effort to protect open space for land percolation of water. While regulations are in place to reduce the influx of stormwater, the challenges will continue with development.

2.1.1 Existing Management Efforts in the Watershed

The county is under Northwest Florida Management District (NWFMWD) jurisdiction, which covers the Florida Panhandle region. The NWFMWD is responsible for managing and protecting water resources in its designated regions, which includes issues related to water supply, water quality, flood control, and natural resource conservation. Local governments have local stormwater utility infrastructure and planning/policy tools to reduce future flood potential. Most of the major projects to date have been focused on addressing the water quality issues and flooding due to extreme rainfall.

2.1.2 Critical Target Areas Identification

By modeling the HUC 031402031103 sub-watershed flood response to a series of rainfall events and sea levels (plus king tides), and further classifying flood risk as the probability of inundation, it is possible to identify critical target areas. These areas are particularly vulnerable to flooding and are subject to further study through a scaled-down modeling approach. The screening tool is first applied at the greater watershed level to provide an initial risk assessment focused on the hydrologic response to a rainfall event given the unique characteristics and features of the sub-watershed or study area. The process is discussed later in Section 2.2 with results presented in Section 2.4.

2.1.3 Potential Preservation Areas

Walton County boasts several areas with high biodiversity value. These areas include the unique coastal dune lakes, which support diverse ecosystems and contribute to water quality along the coast. Wetlands are crucial habitats that provide refuge for a variety of plant and animal species while acting as natural water filters. State parks like Topsail Hill Preserve and Grayton Beach State Park are valuable conservation areas with diverse coastal ecosystems. Additionally, preserving the Choctawhatchee River Basin is essential for the biodiversity of the region.

2.2 Vulnerability Maps

2.2.1 Screening Tool

The screening tool utilizes topographic data from various sources (Section 1.1), water table elevations (Section 1.2) and surface water gauges (Section 1.3) downloaded from the NWFWMD DBHYDRO website, tidal information for coastal areas obtained from the NOAA Current & Tides website (Section 1.3), soil maps obtained from the USDA (Section 1.4), and another key dataset as described previously in Chapter 1. The design storms are discussed in Section 1.6. The reason this is critical is that to do any modeling (as required by the CRS program), a screening tool should be used to identify regions with a high risk of inundation based on multiple collected datasets and hydrological models. **Error! Reference source not found.** shows how the GIS layers interface in the tool and how they are combined for spatial analysis.

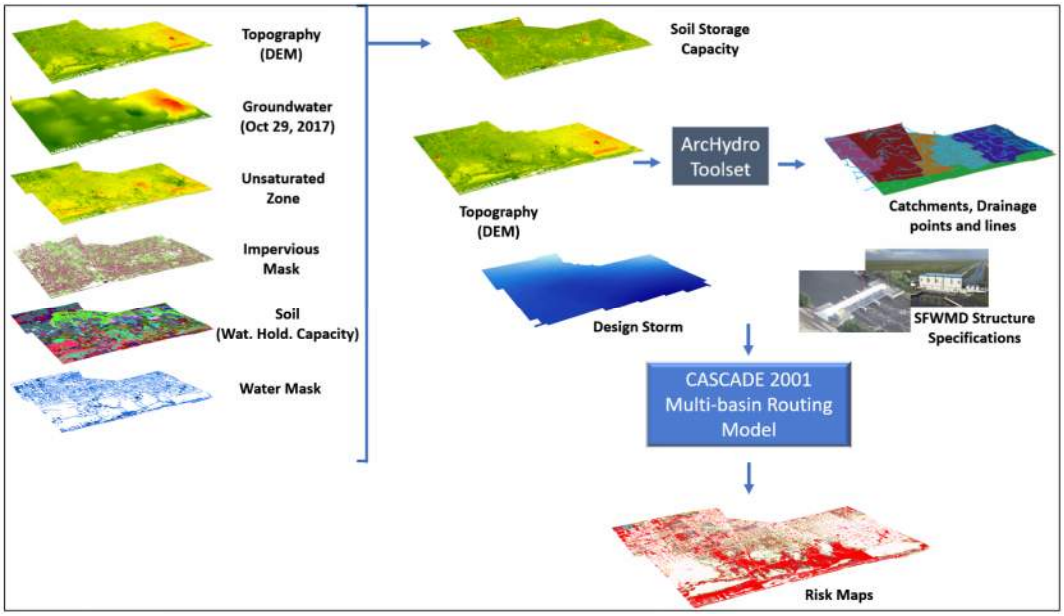

Figure 29. Screening tool methodology for creating flood risk maps.

The model chosen for this screening tool is Cascade 2001, which is a multi-basin hydrologic/hydraulic routing model developed by the SFWMD. The model permits the

investigator to run different storm events to determine flooding scenarios. The boundaries are critical for basin studies and must be chosen carefully. The following data layers collected in the prior section are processed to develop the input files for Cascade 2001:

- Topography
- Soils
- Development intensity
- Groundwater elevations
- Surface water/Outlet locations

The software creates a glass box where water rises to a certain level and then decreases. Running the simulation requires defining the basin (HUC or sub-HUC) and input of the following data:

- Area
- Portion of area above a given elevation
- Initial groundwater stage
- Longest travel time for the runoff to reach the most distance point of discharge
- Ground storage as estimated from the USDA gridded National Soil Survey Geographic Database (gNATSGO)

  Ground storage ≈ (Water holding capacity) × (Surface elevation – GW elevation)
  = 2 × (AWS for a soil layer of 0-150 cm) / 150cm × (Surface elevation – GW elevation)

- Available water storage (AWS) for a soil layer of 0-150 cm
- Average amount of precipitation that can be stored in the soil layer

The output from the model is an elevation surface that can be used to develop a flood map for the study area (**Error! Reference source not found.**), which shows the spatial distribution of probabilities of flooding during the modeled 1-day 100-year storm event.

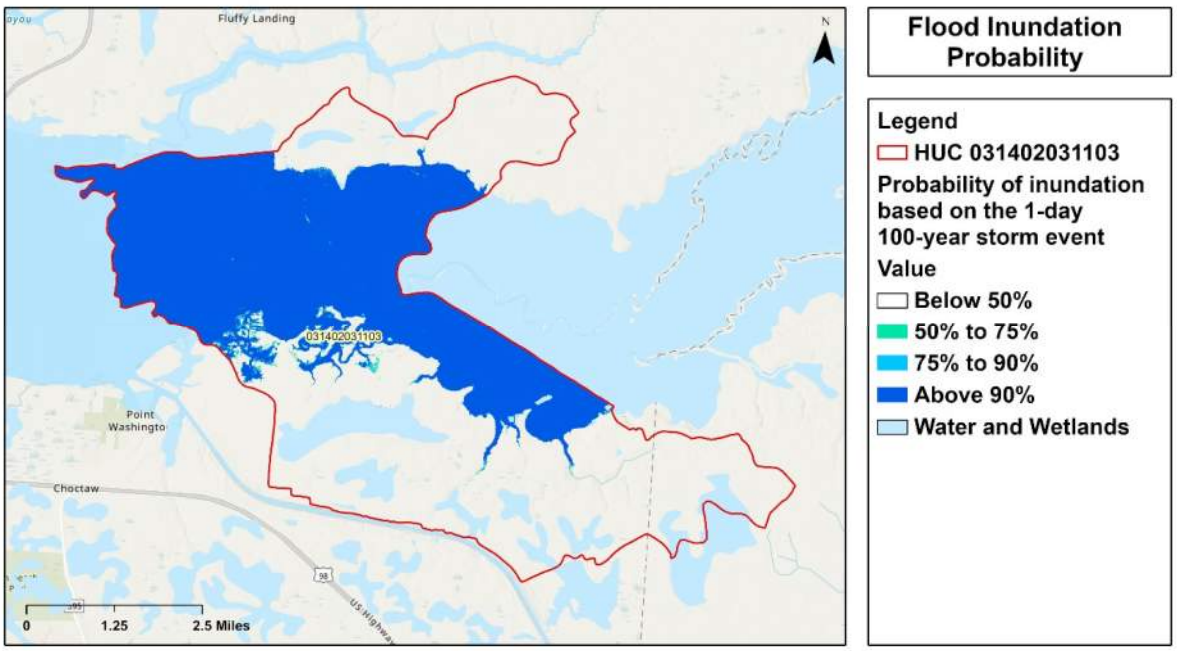

Figure 30. Probability of flood risk map during the modeled 1-day 100-year storm event for the HUC 031402031103, processed by FAU.

2.2.2 Identification of Vulnerable Areas

Given these assumptions and the Cascade 2001 outputs, the goal of this methodology is to produce a spatially-temporally quantified understanding of nuisance-destructive flood potential in the study area given observed values. Risk is a function of compounding geo-hydrological features, namely, surface water, groundwater, topography, build-out, and time of year. A GIS-based algorithm and spatial interpolation generated layers of the greatest observable hydrographic surfaces. These outputs were then compared with high resolution topographic LiDAR data to develop digital elevation models that reflect the observed risk landscape. These models can then be combined into Cascade 2001 to produce vector and volume information, in combination with soils, vegetation and impervious surfaces, allowing the observed model outputs to be extrapolated into a more predictive context.

To evaluate flood vulnerability at this scale, the analysis starts with a binary flooding surface (0 = below 50% chance of flooding; 1 = above 50% flooding) based on output from the screening tool for a specified design storm. Next, attributes of that raster based on "VALUE = 1" query are extracted using *Extract by Attributes* tool. Then the *Batch Project* tool was used to map critical facilities data to the common coordinate system (NAD83 UTM Zone 17N), unit = meters. Then a field was added using *Add Field* for [PriorityTier] = assigned Tier #1-4 value from the DOR codes and [Area_sqmeter]. The critical facilities layers were then merged into a single layer to calculate

the polygon geometry for [Area_sqmeter] using the *Merge* tool. Next, *Zonal Statistics as Table* is used to calculate the SUM of flooded values ("VALUE = 1") within each critical parcel. Output table has fields for SUM (i.e., total # of flooded pixels per critical parcel) and AREA in map units of square meters (since each pixel in the flooding surface has a cell size of 3-meters by 3-meters, each area is equal to the SUM value multiplied by 9 m^2). Using the *Join Field* tool, the SUM and AREA fields are joined to the merged critical facilities layer based on a key attribute, first renaming these fields for clarity (e.g., AREA_FLOODED_3d25y). Once all field data is included, the next step involves using *Export Table* to export the dataset as a CSV file. Note that non-flooded parcels have zero flooded area, so they receive a <Null> value from the zonal statistics tool. To replace null values with zeros, we use *Calculate Field* in the attribute table along with the following Python expression (replacing the respective field name): "0 if !AREA_FLOODED_3d25y! is None else !AREA_FLOODED_3d25y!". Next, the CSV file is saved as an Excel Workbook (.xlsx). The Range is converted to an Excel Table, and the columns are rearranged in the desired order. Finally, the "percent-flooded" columns are calculated as follows:

- PCT_FLOODED_3d25y = ([@[AREA_FLOODED_3d25y]]/[@[TotalArea_sqmeter]])*100
- PCT_FLOODED_1d100y = ([@[AREA_FLOODED_1d100y]]/[@[TotalArea_sqmeter]])*100

After this calculation, the table is sorted to show the higher priority tiers and higher percent-flooded values first. To reduce the number of critical facilities shown in the final table, a filter was created to show only critical facilities with 10% or more flooded area in the parcel during both storm events. Records with duplicate parcel ID numbers were removed from the table. The results of this procedure are discussed in Section 2.5 of this document.

With respect to dams and levees, for purposes of the NFIP, FEMA only recognizes systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with comprehensive floodplain management criteria. The Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10) describes the information needed for FEMA to determine if a levee system reduces the risk from the 1% annual chance flood. FEMA has accredited levees and Provisionally Accredited Levees (that have a specified timeframe to obtain the necessary data to confirm the levee's certification status). If a levee system no longer meets Section 65.10, FEMA will de-accredit the levee system and issue an effective FIRM showing the levee-impacted area as a SFHA. FEMA coordinates its programs with USACE, who may inspect, maintain, and repair levee systems. USACE has authority under Public Law 84-99 to supplement local efforts to repair flood control projects that are damaged by floods. Like FEMA, USACE provides a program to allow public sponsors or operators to address levee system maintenance deficiencies. Failure to do so within the required timeframe results in the levee system being placed in an inactive status in the USACE Rehabilitation and Inspection Program. Levee systems in an inactive status are not

eligible for rehabilitation assistance under Public Law 84-99. There are no levees/dams listed in the sub-watershed study area.

2.3 Future Challenges of Sea Level Rise and Climate Change

Global observations from satellites and long-term data collection have made it possible to document and analyze patterns in the Earth's climate. Scientific analysis of the impact of these changes has helped to improve the understanding of future flood hazard driving forces and long-term impacts on human activities and watershed master planning (http://www.research.noaa.gov/climate/t_observing.html). Examples of impacts are rising global average air and ocean temperatures, increased and earlier snow and ice melt, shorter subtropical rainy seasons, shifted seasons, sea level rise and greater variations in temperature and precipitation (IPCC, 2013; Freas et al., 2008; Marshall et al., 2004; Bloetscher et al., 2010). Marshall et al. (2004) specifically focused on the Florida peninsula to predict changes in rainfall and warmer temperatures but interspersed lower low temperatures due to the potential loss of wetlands.

Future changes in climate will add to the existing impacts, at a time when the population of the state is expected to nearly double by 2030. Additional research and high-resolution climate modeling for the Florida peninsula and local jurisdictions is needed to help guide long-term plans like WMPs. Rainfall appears to be decreasing and temperatures rising (see **Error! Reference source not found.**).

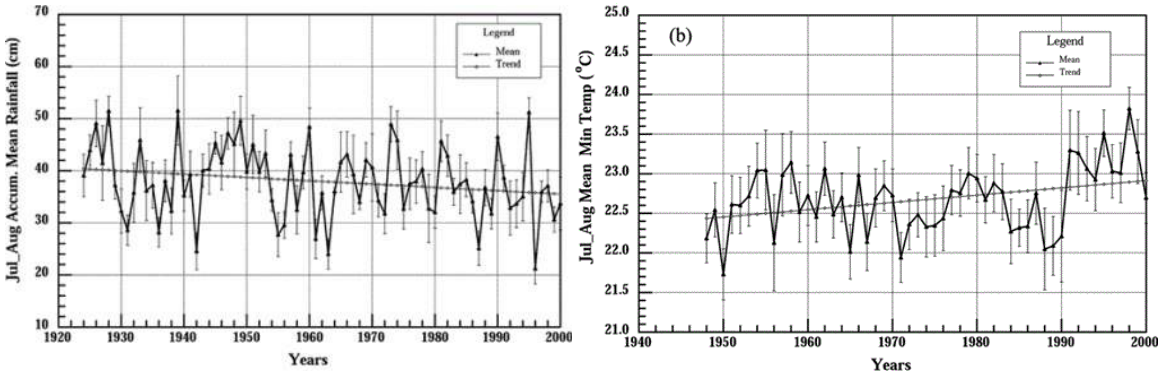

Figure 31. Change in average rainfall and change in average temp 1924 to 2000. Note the reversed trend, which means groundwater input variability is lessened.
(Source: Marshall et al., 2004)

Climate change is likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier

rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly compromised stormwater drainage systems, and d) more frequent inundation of barrier islands and coastal areas.

NOAA and IPCC (2013) predictions suggest that by 2100, global temperatures will be on the order of 2-3°C (3-5°F) higher and sea levels will rise by up to 3 feet. Accompanying these drivers are potential changes in storm frequency and intensity, desertification, population migration, ocean acidification and coastal flooding (IPCC, 2007), exacerbated by the land cover and land use changes, which are substantially impacted by the fluxes, timing and quality of precipitation (Adrians et al., 2003; Scanlon et al., 2005; Marshall et al., 2004; Salmun and Molod, 2006), and leading to changes in the timing of peak flows and volumes (Richey and Costa-Cabral, 2006).

The results of these climatic changes are likely to: 1) threaten the integrity and availability of fresh water supplies and 2) increase the risk of flooding, not only in the low-lying coastal areas, but also in the interior flood plains. Other issues include a) saltwater intrusion, which may be intensified by sea level rise, b) prolonged droughts that will contribute to water supply shortages and wildfires, and c) heavier rains during the rainy season and higher hurricane storm surge, which may increase the risk due to flooding. More frequent and damaging floods are likely to become an ever-increasing problem as sea level continues to rise because of: a) increasing groundwater table elevations and surface water gage heights, b) reduced groundwater seepage through the aquifer to the ocean, c) increasingly An outcome of these climatic patterns is that during the past 140 years, an increase in sea levels has been observed (Bloetscher, 2012), a worrying pattern since sea level rise is a permanent phenomenon, that can be catastrophic to low lying areas in the long-term. The question is how much and how soon? Various studies (Bindoff et al., 2007; Domingues et al., 2008; Edwards, 2007; Gregory, 2008; Vermeer and Rahmstorf, 2009; Jevrejeva, Moore and Grinsted, 2010; Bloetscher, 2010, 2011; IPCC, 2007; Heimlich et al., 2009) indicate large uncertainty in projections of sea level rise by 2100. Gregory et al. (2012) note that during the last two decades, the global rate of sea level rise has been larger than the 20th-century time-mean, and Church et al. (2011) suggested that the cause was increased rates of thermal expansion, glacier mass loss, and ice discharge from icesheets. Gregory et al. (2012) suggested that there may also be increasing contributions to global sea level rise from the effects of groundwater depletion, reservoir impoundment, and loss of storage capacity in surface waters due to siltation. Measurements of Florida's east coast (Maul, 2008) show an average rate of sea level rise of 2.27 ± 0.04 mm per year from 1915 to 1992 based on tide gauge readings. Analyzing the tidal gauge readings for Florida shows that:

1. Florida average sea level rise is 2.10 ± 0.49 mm/yr

2. All but one location is within the 95% confidence limit range (the exception is Panama City where there is evidence of submergence and other land-based issues)
3. None of the Florida sea level rise rates differ statistically
4. Average global sea level rise for 1920-2000 was 2.0 mm/yr – within 95% confidence limit for Florida locations

From 1929 to 1992, over eight inches of sea, with another 6 inches added since 1992, which is already having significant impacts on coastal communities where population growth has increased the need for improved flood management strategies (Bloetscher, 2008; Parkinson, 2010; Zhang et al., 2011, 2011a; NFIP, 2011; Schmidt et al., 2011; Warner et al., 2012).

As a result, the SFRCCC (2015) adopted USACE's methodology to derive scenarios of sea level change intermediate to high rates of sea level rise for years 2030 (3" to 7") and 2060 (9" to 24") as the consensus projection to guide future planning. The path keeps increasing – now 14 inches since 1929 (**Error! Reference source not found.**) caused by thermal expansion of the ocean and melting ice caps (Jevrejeva et al., 2010; Vermeer and Rahmstorf, 2009). Sea level rise is a major concern in Florida, including Walton County, since the majority of the state's population live on the coast, involving most major commercial, residential, and economic enterprises. **Error! Reference source not found.** demonstrate the estimated sea level change for Panama City, considering the predictions of NOAA 2017. For NOAA high scenario SLR change scenario, the estimated level change is higher than 8 ft., while for the intermediate and low scenarios are about 3.9 feet and 1.7 feet respectively.

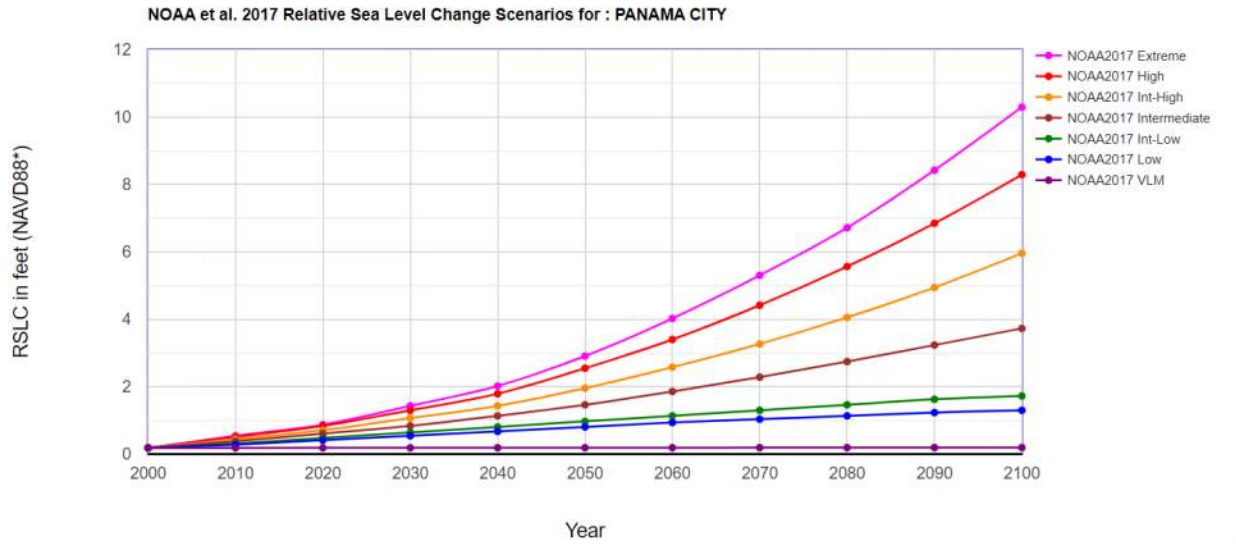

Figure 32. Relative Sea Level Change Scenarios for gauge 8729108, Panama City, FL. (Source: NOAA, 2017 available at https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html)

NOAA (2017) outlines five scenarios for sea level rise. The NFIP proposes the use of the intermediate high projection, which is 1.2 meters or 4 ft globally from current sea level elevations (**Error! Reference source not found.**).

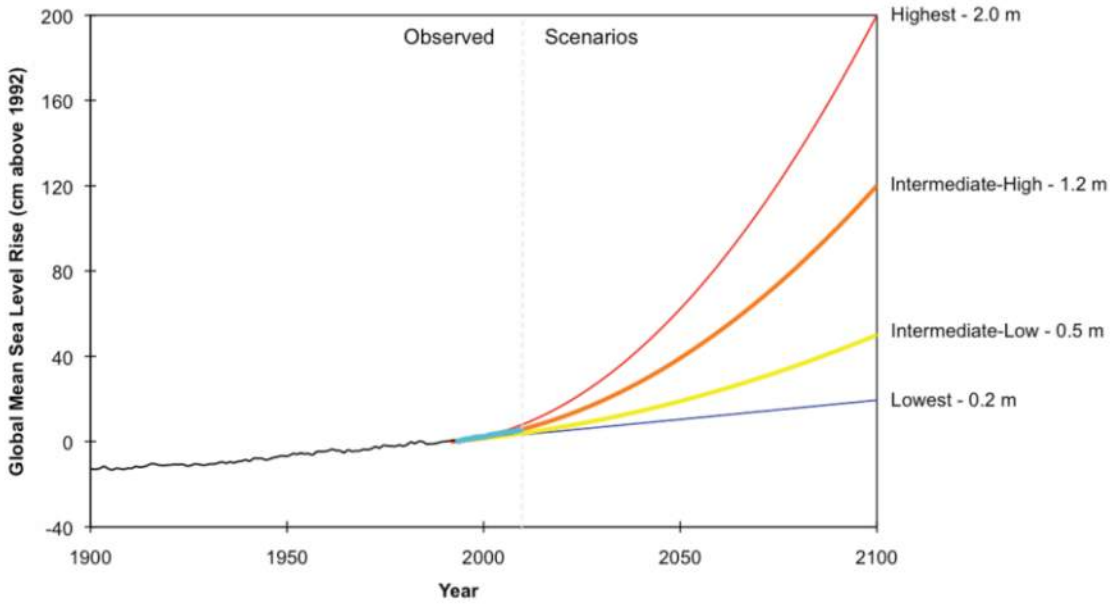

Figure 33. Graphic of global sea level rise projections from NOAA (2017).
(Source: NOAA, 2017 available at https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf)

As sea level rises, access to roads, bridges, rail, and transit could be at risk of flooding, causing the effects of sea level rise to spread indirectly throughout the entire transportation network, affecting the overall system performance. For example, the flooding of a critical road or facility access can cause a shifting of traffic flow causing congested conditions in other roadways that are not actually flooded. Since the roadway network would be unable to carry the traffic demand, the system would experience operational failure; as a result, causing travel times and delays. Moreover, the inundation of a critical access could cause transportation connectivity problems to essential infrastructure like ports or airports. Transportation infrastructure relies on the effectiveness of flood control and stormwater drainage systems for the transportation corridors. Road integrity relies on adequate drainage. The increased risk of severe flooding in Florida's low-lying terrain can adversely affect transportation infrastructure along the coastline; roads can be inundated, and roadway beds can be damaged. Sea level rise will cause increased water table levels (FDOT, 2012), as regional water tables cannot exist naturally below mean high tide (2 feet in Florida). Adding 3 feet of sea level rise on top of groundwater would compound the risk of flooding in low-lying areas. Road bases below 5 feet NVGD would become saturated under this scenario, likely causing premature base failure. As soil storage capacity is diminished due to rising

groundwater elevations associated with sea level rise, the potential for more frequently flooded roadways would likely damage pavements (FDOT, 2012). Hence sea level rise must be accounted for in WMPs in coastal areas. To allow flexibility in the analysis due to the range of increases within the different time periods, an approach that uses incremental increases of 1, 2, and 3 feet of sea level rise is suggested for modeling. The increments can work as threshold values in planning considerations in terms of allowing planners the ability to know ahead of time where the next set of vulnerable areas will be, to allow for a proactive response approach that can be matched to the observed future rates. Sea level rise is a major concern since nearly half the US population lives within 50 miles of the coast, involving most major commercial, residential, and economic enterprises. The effects of 5 ft sea level rise, King tide, and 1-day 100-year storm event are shown in Figure 34.

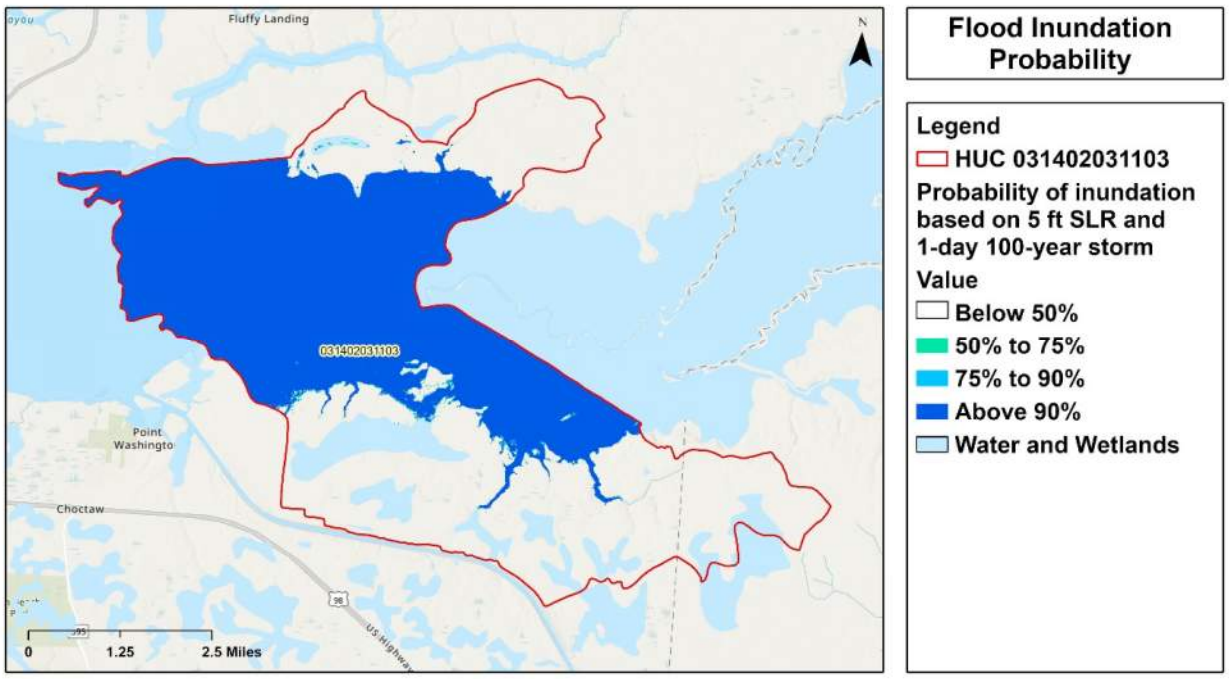

Figure 34. Flood Inundation Probability for a Sea level rise of 5 ft + 1-day 100-year storm event for HUC 031402031103 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Dark blue is area under 5 ft NAVD88 and potentially inundated at the 99th percentile tidal conditions. Processed by FAU.

2.4 Modeling Results

Error! Reference source not found. to **Error! Reference source not found.** are a series of maps that depict risk of flooding in the basin based on the following scenarios:

1. **3-day 25-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 35)
2. **1-day 100-year storm event**. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 36)
3. **1-day 10-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 37)
4. **1-day 5-year storm event.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 38)
5. **Sea level rise of 1 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 39)
6. **Sea level rise of 1 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations storm (Figure 40)
7. **Sea level rise of 1 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 41)
8. **Sea level rise of 1 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 1 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 42)
9. **Sea level rise of 2 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 43)
10. **Sea level rise of 2 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 44)
11. **Sea level rise of 2 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 45)
12. **Sea level rise of 2 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 2 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 46)
13. **Sea level rise of 3 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 47)
14. **Sea level rise of 3 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 48)

15. **Sea level rise of 3 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 49)
16. **Sea level rise of 3 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 3 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 50)
17. **Sea level rise of 4 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 51)
18. **Sea level rise of 4 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 52)
19. **Sea level rise of 4 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 53)
20. **Sea level rise of 4 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 4 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 54)
21. **Sea level rise of 5 ft + 3-day 25-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 55)
22. **Sea level rise of 5 ft + 1-day 100-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 56)
23. **Sea level rise of 5 ft + 1-day 10-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 57)
24. **Sea level rise of 5 ft + 1-day 5-year storm** (only coastal area and GW affected – GW layer rises 5 ft)**.** Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations (Figure 58)

In all scenarios, a considerable amount of flooding is noted at the river entrance to the HUC, extending to the wetland areas. As this basin connects to the ocean though Choctawhatchee River and Bay, SLR scenarios plays an important hole, implying a considered growth as the projected scenario of rising tides rises.

The design storm simulation determined that approximately 45% of the HUC total area or 14.21 mi^2 has a probability of inundation above 50% for a 3-day 25-year design storm. For comparison, approximately 45.1% of the HUC's total area, or 14.23 mi^2 would be expected to be

inundated during a 1-day 100-year design storm. Approximately 44.8% of the HUC's total area, or 14.14 mi², would be expected to be inundated during a 1-day 10-year design storm. Finally, approximately 43.8% of the HUC's total area, or 13.83 mi², would be expected to be inundated during the 1-day 5-year storm. **Error! Reference source not found.** compares the four storm events.

Table 7. HUC 031402031103 expected inundated area by storm event.

Storm Event	Area with probability of inundation below 50% (Sq Mi)	Area with probability of inundation above 50% (Sq Mi)	Area with probability of inundation below 50% (%)	Area with probability of inundation above 50% (%)
3-day 25-year	17.33	14.21	55.0%	45.0%
1-day 100-year	17.32	14.23	54.9%	45.1%
1-day 10-year	17.40	14.14	55.2%	44.8%
1-day 5-year	17.71	13.83	56.2%	43.8%

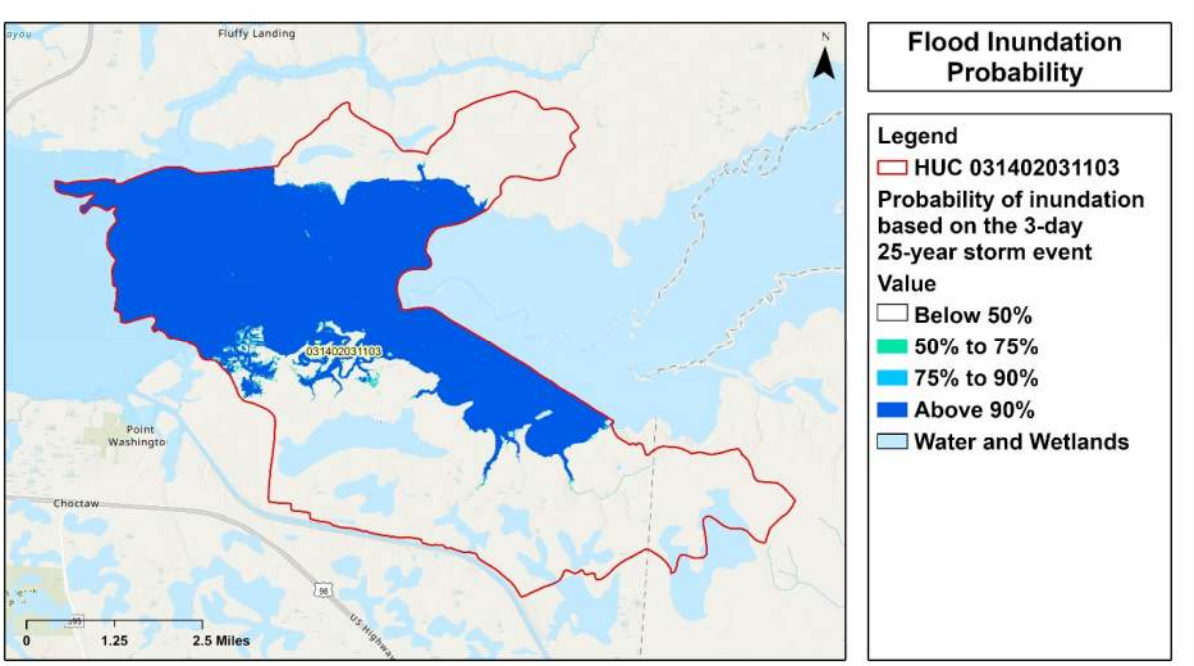

Figure 35. 3-day 25-year storm event for HUC 031402031103 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

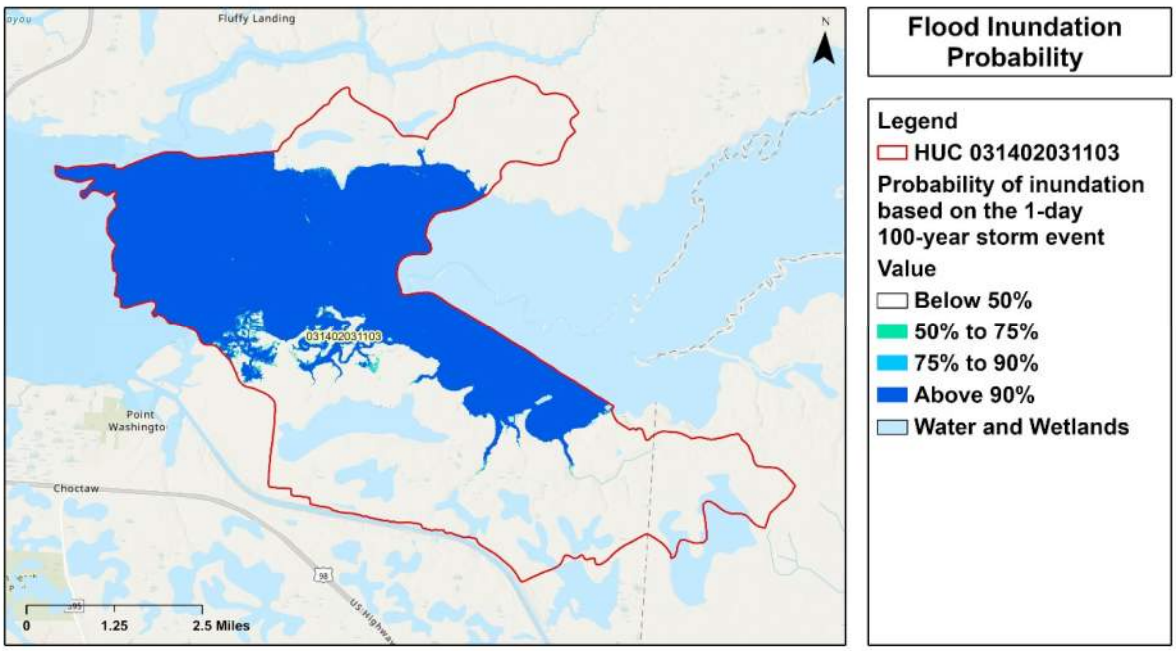

Figure 36. 1-day 100-year storm event for HUC 031402031103 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

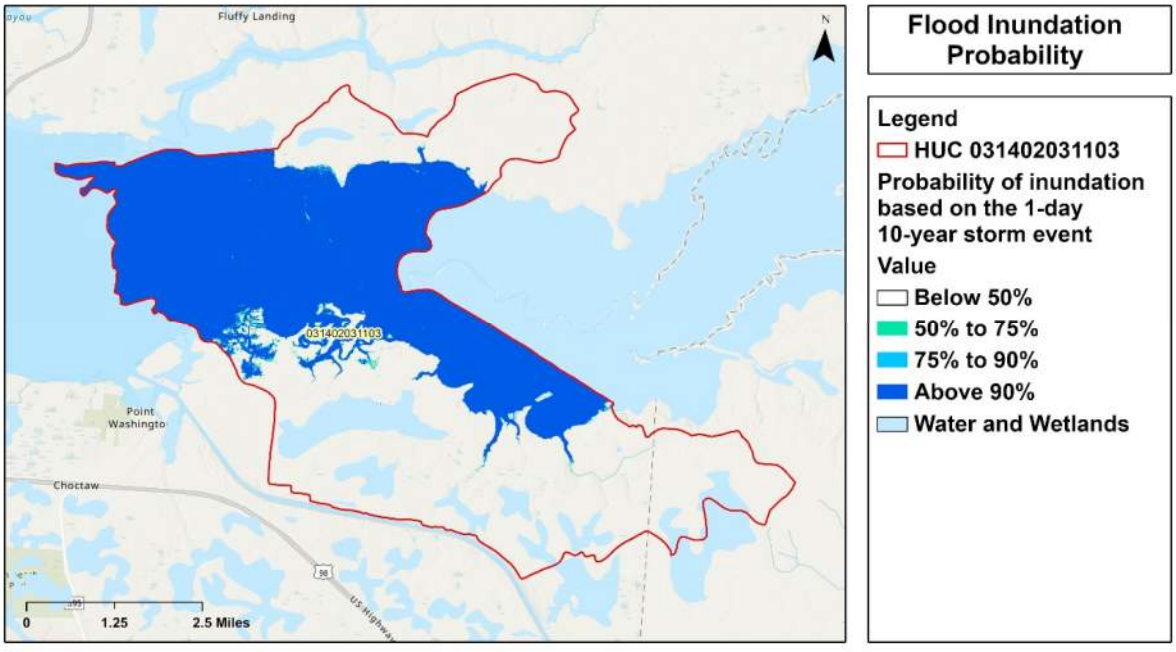

Figure 37. 1-day 10-year storm event for HUC 031402031103 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

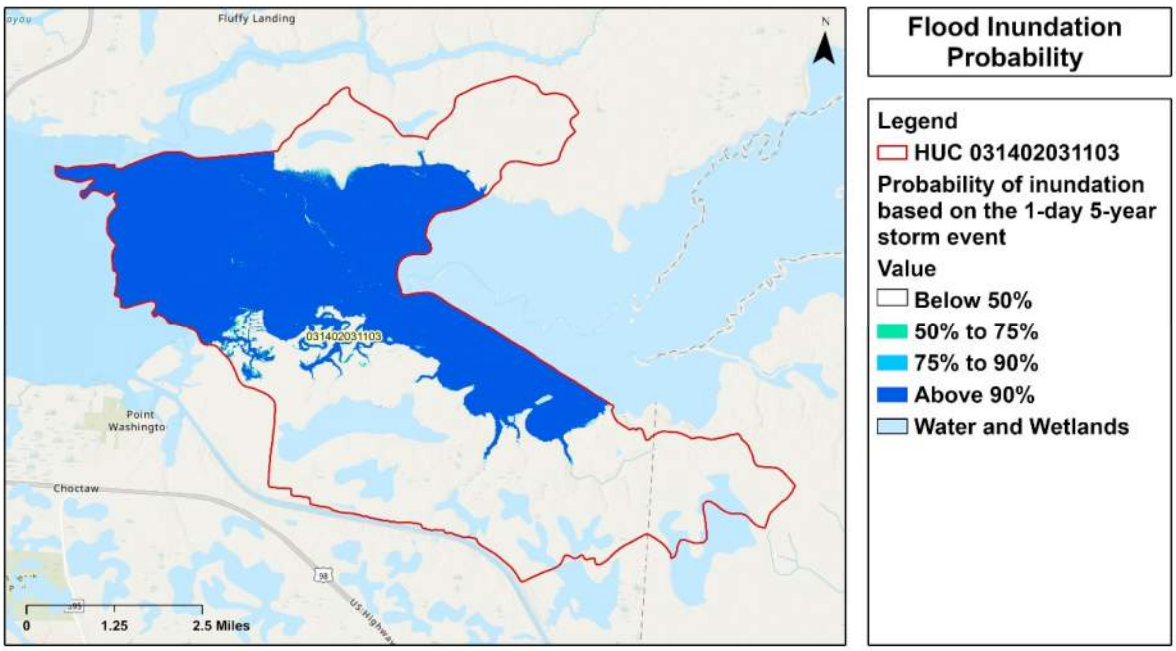

Figure 38. 1-day 5-year storm event for HUC 031402031103 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

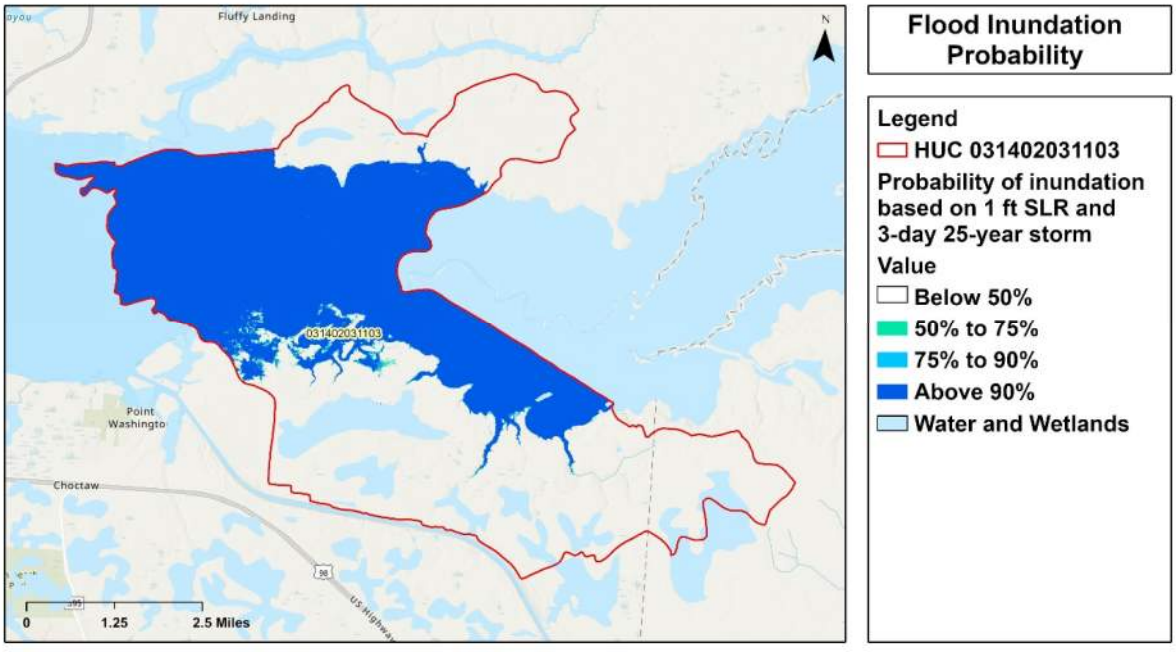

Figure 39. Sea level rise of 1 ft + 3-day 25-year storm for HUC 031402031103 sub-watershed.
Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations.
Processed by FAU.

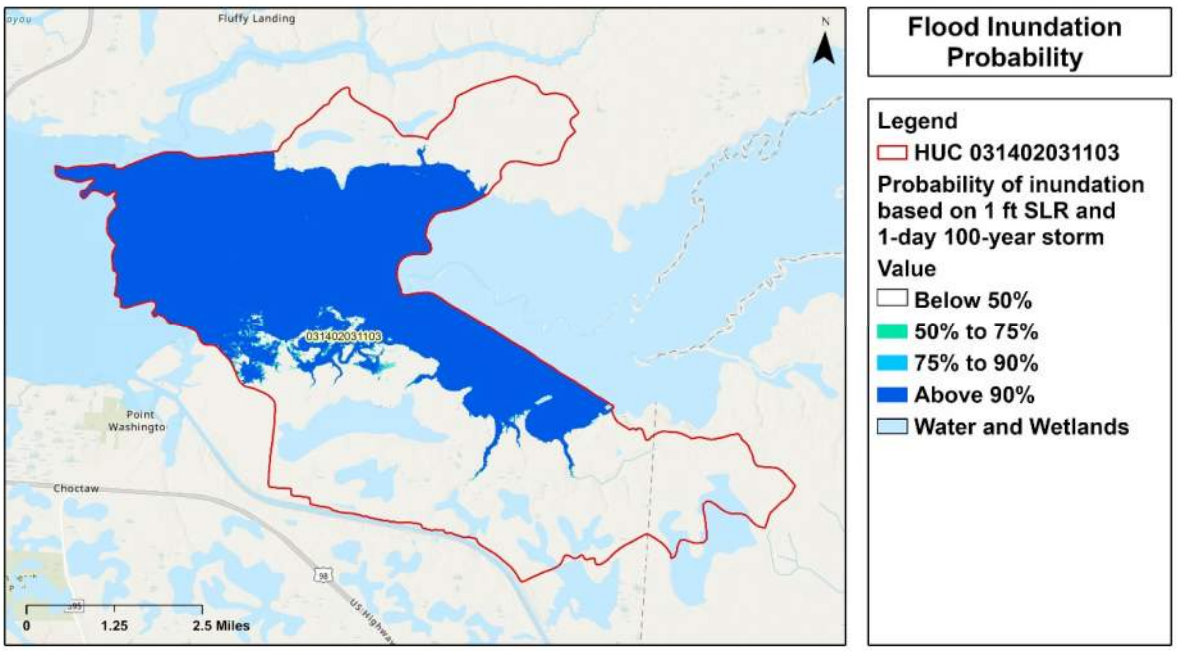

Figure 40. Sea level rise of 1 ft + 1-day 100-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

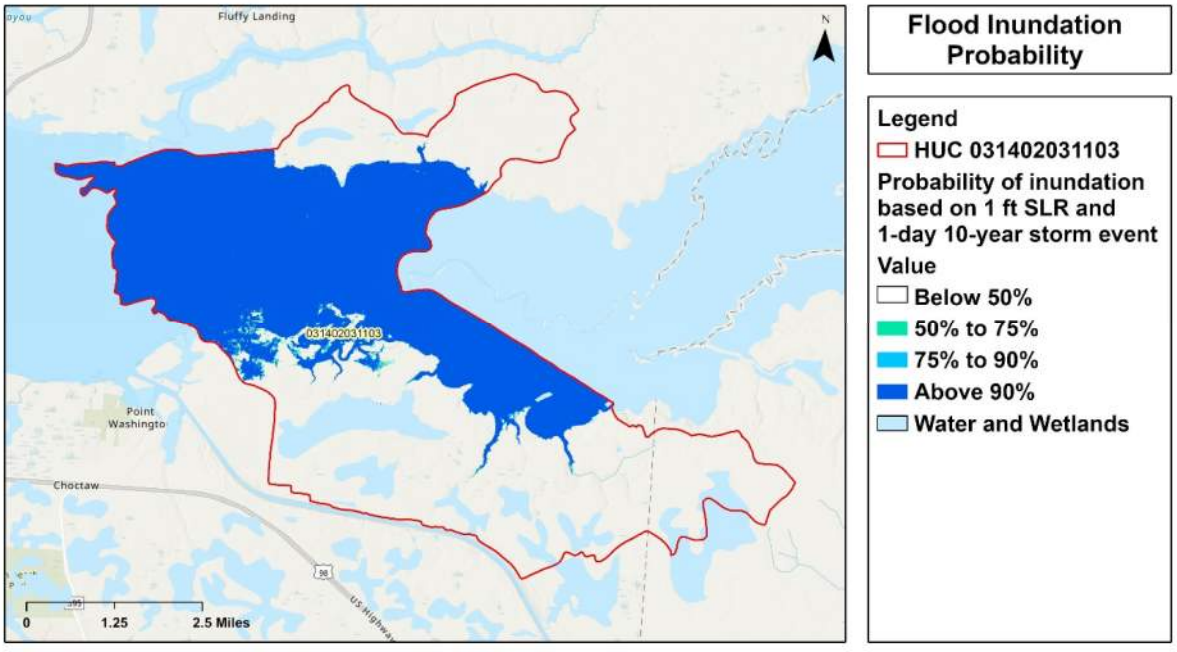

Figure 41. Sea level rise of 1 ft + 1-day 10-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

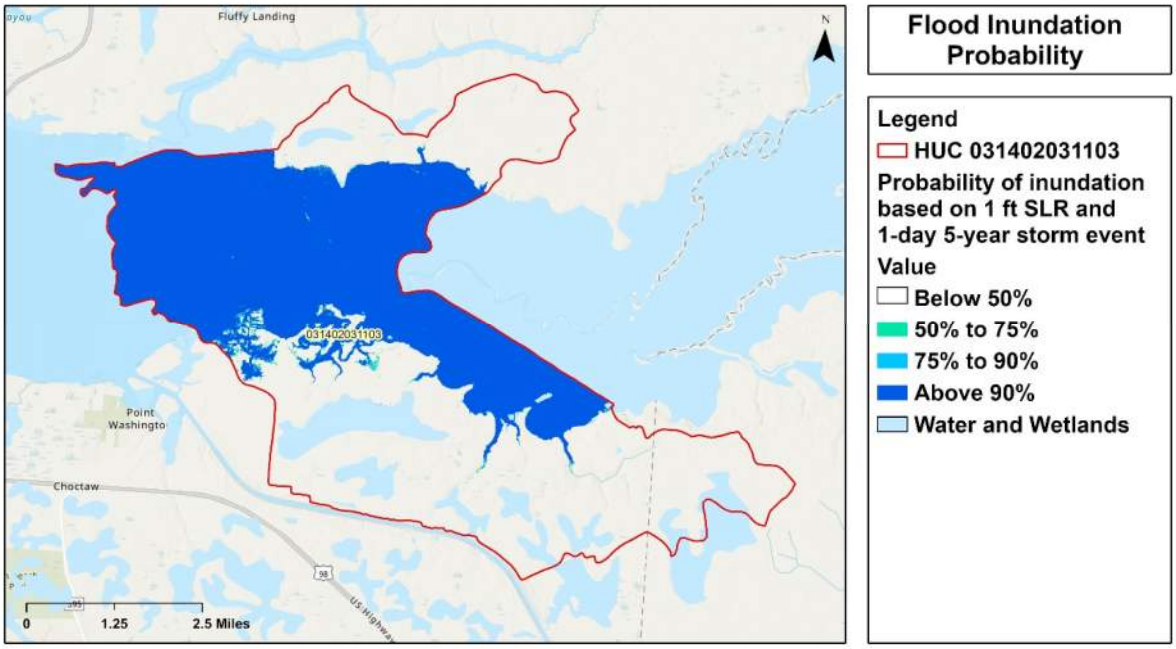

Figure 42. Sea level rise of 1 ft + 1-day 5-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

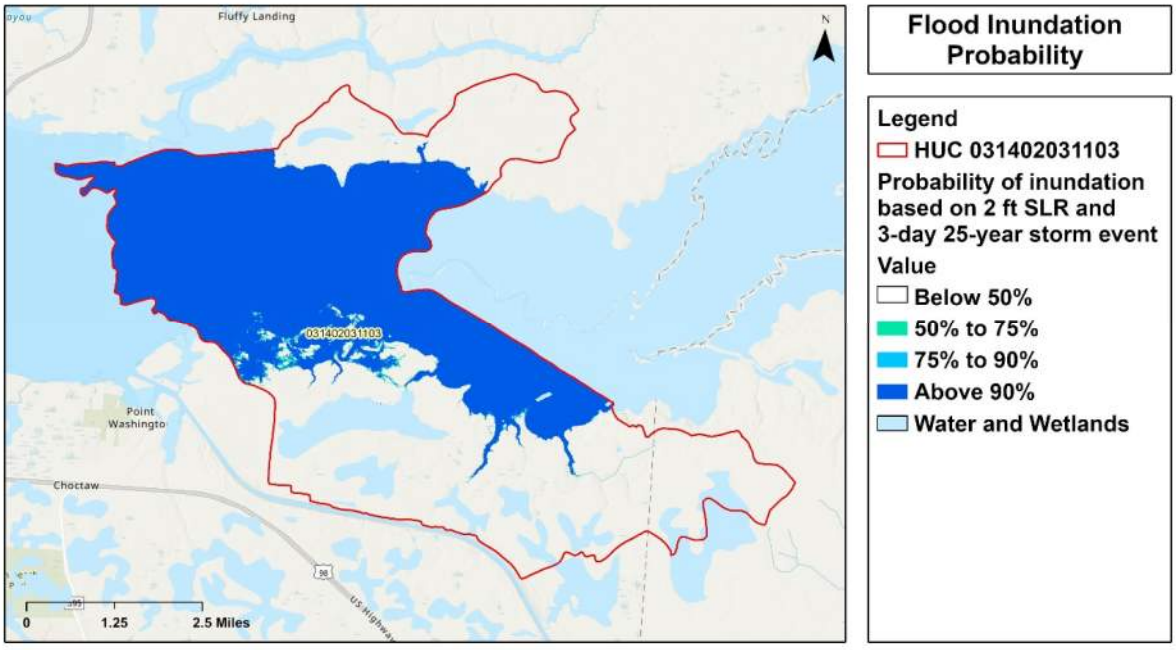

Figure 43. Sea level rise of 2 ft + 3-day 25-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

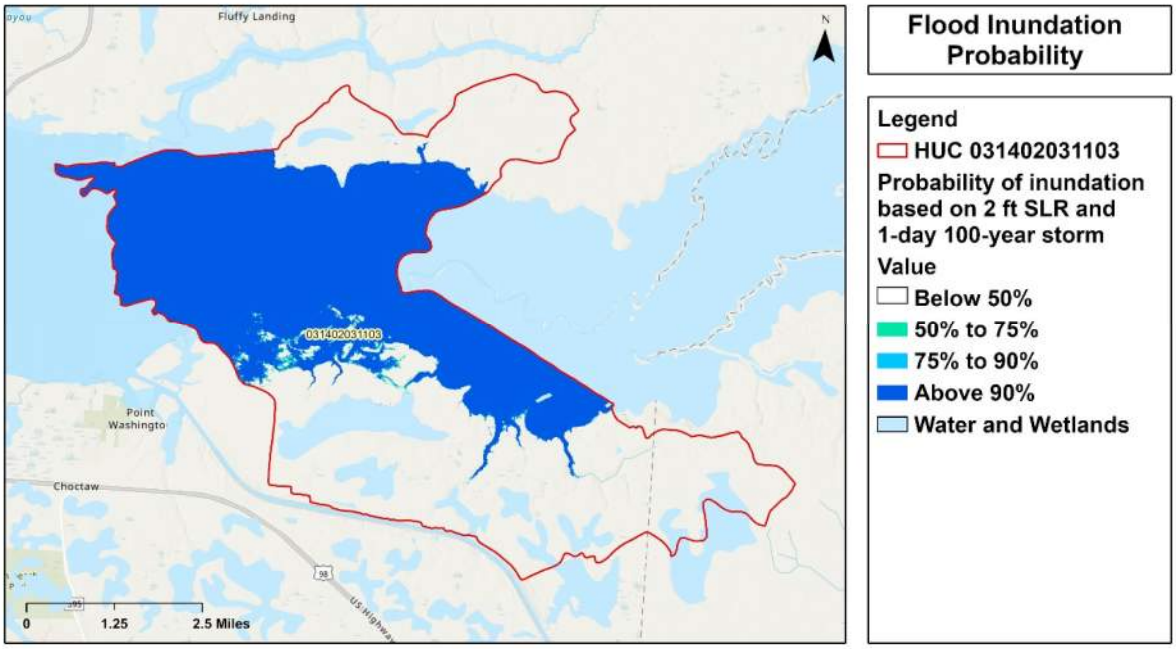

Figure 44. Sea level rise of 2 ft + 1-day 100-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

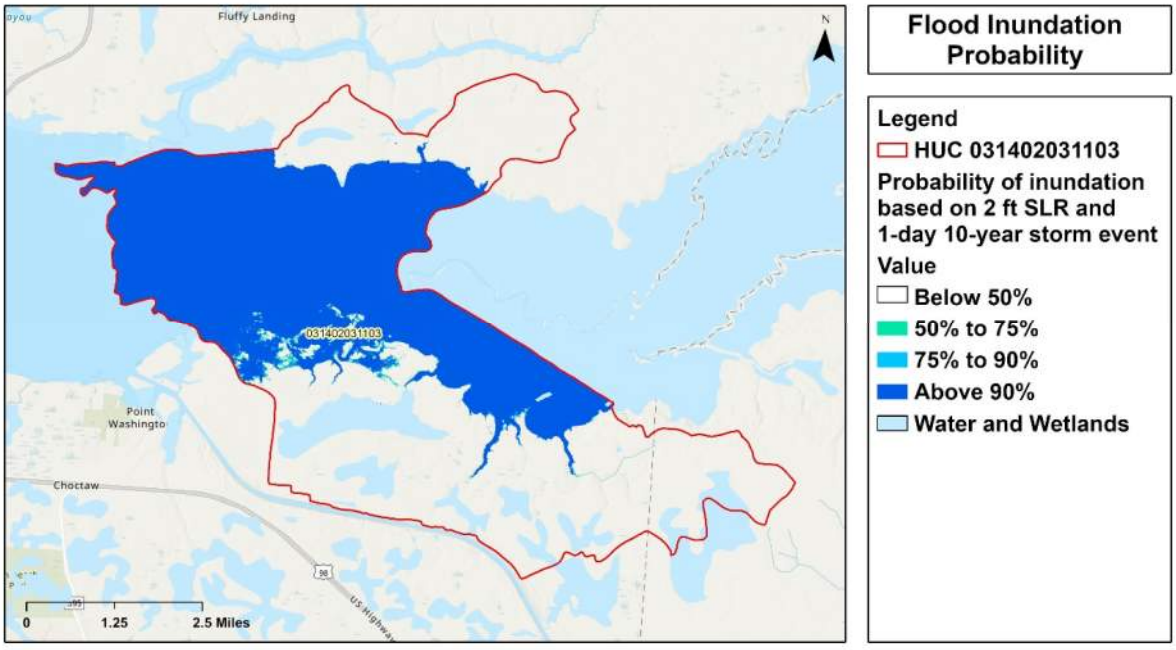

Figure 45. Sea level rise of 2 ft + 1-day 10-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

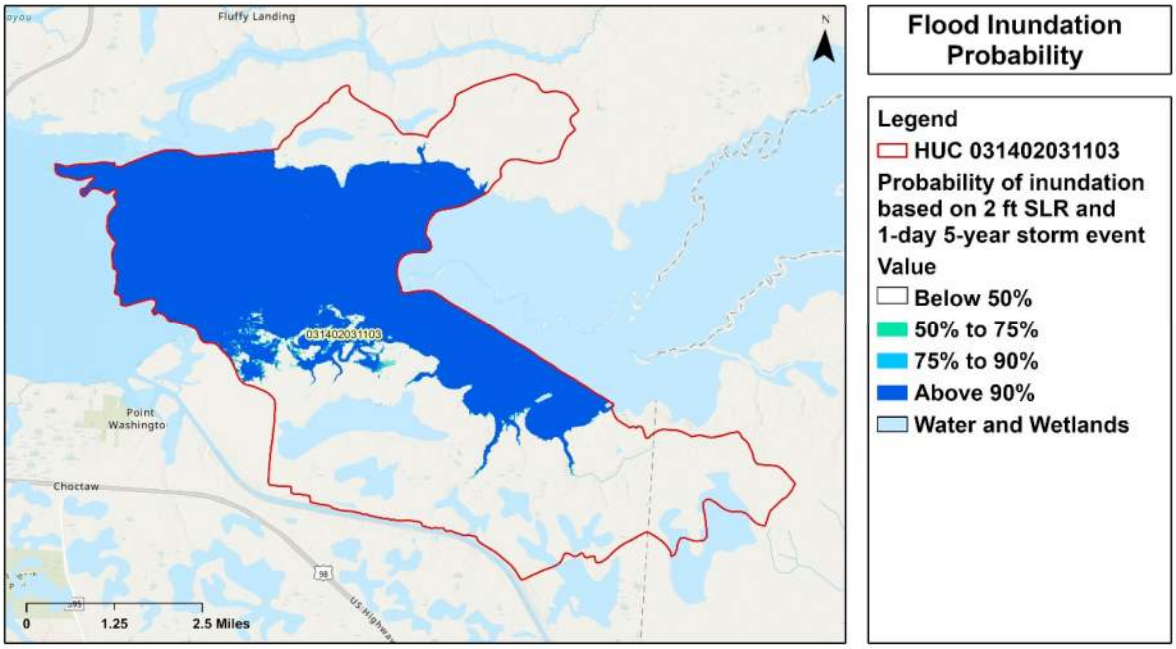

Figure 46. Sea level rise of 2 ft + 1-day 5-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

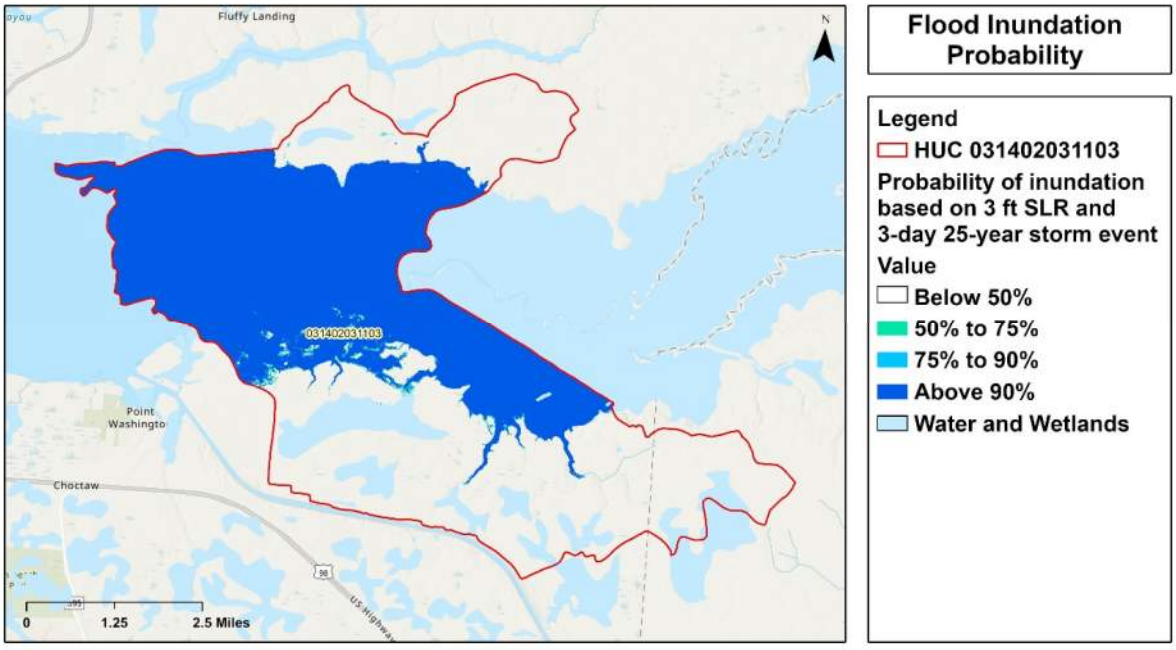

Figure 47. Sea level rise of 3 ft + 3-day 25-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

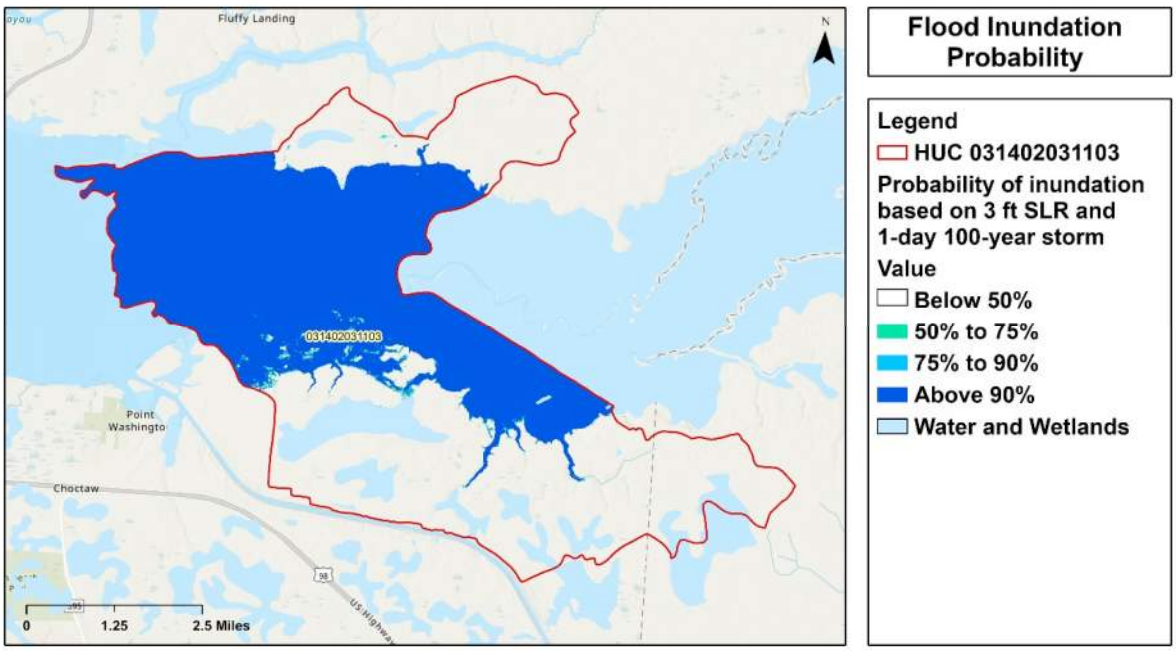

Figure 48. Sea level rise of 3 ft + 1-day 100-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

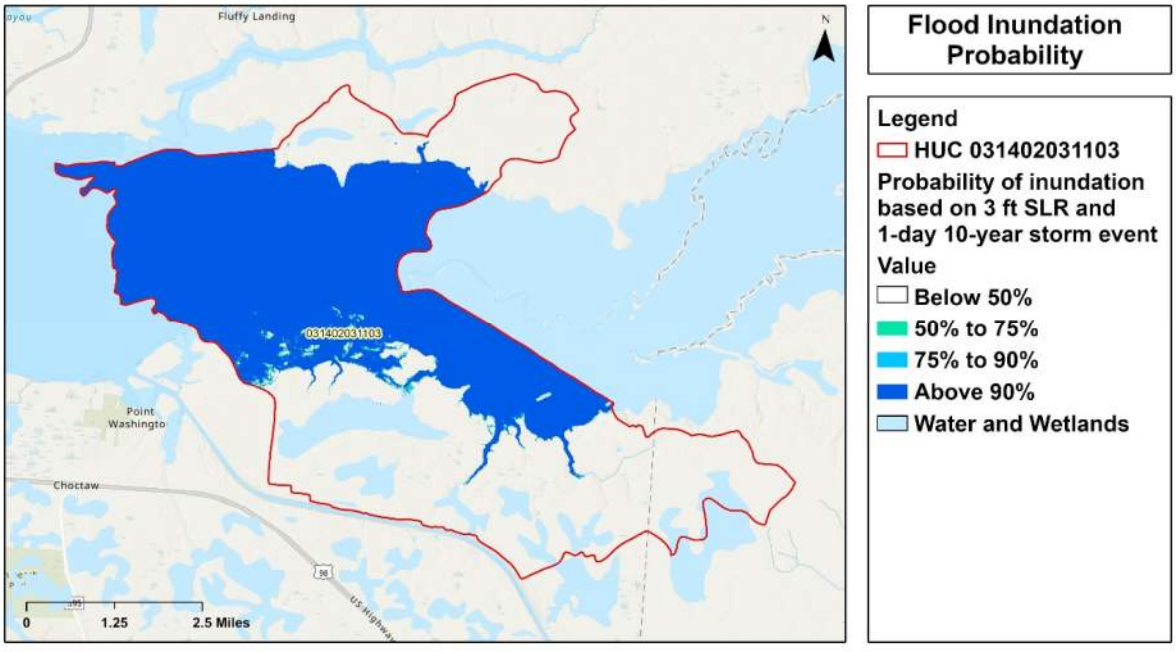

Figure 49. Sea level rise of 3 ft + 1-day 10-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

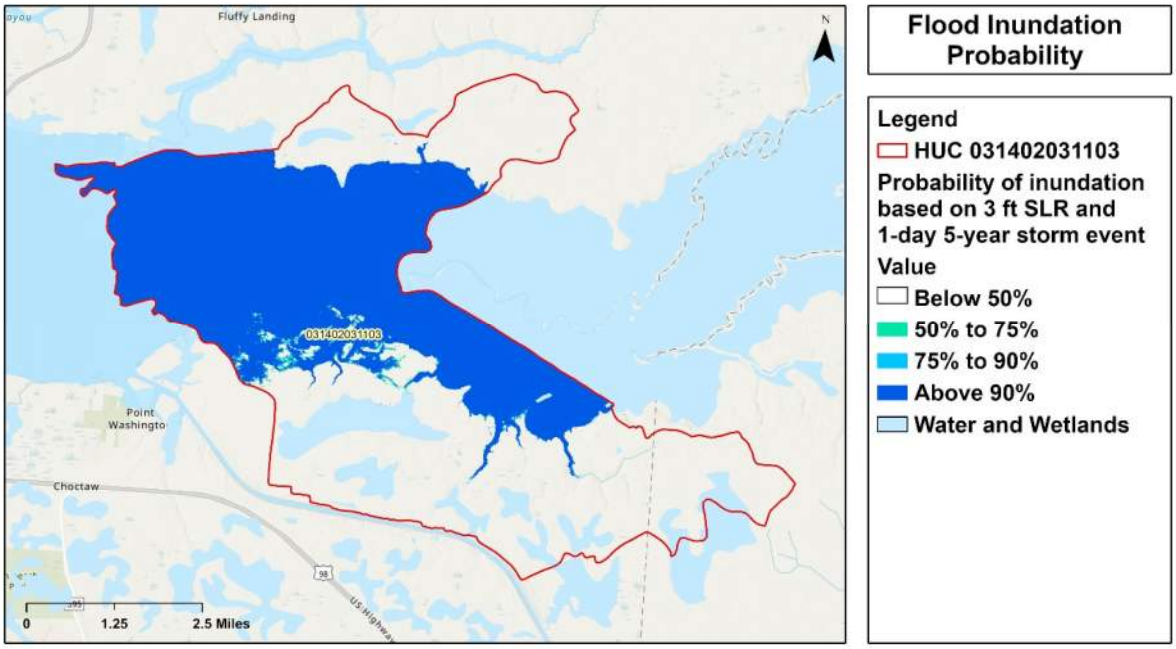

Figure 50. Sea level rise of 3 ft + 1-day 5-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

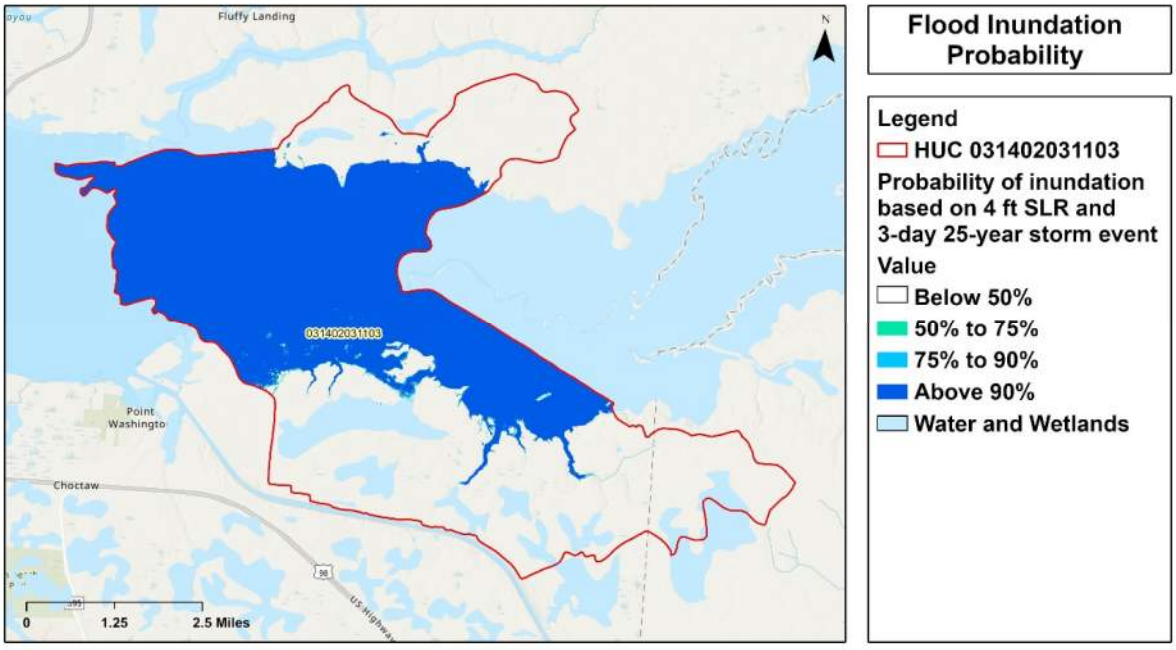

Figure 51. Sea level rise of 4 ft + 3-day 25-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

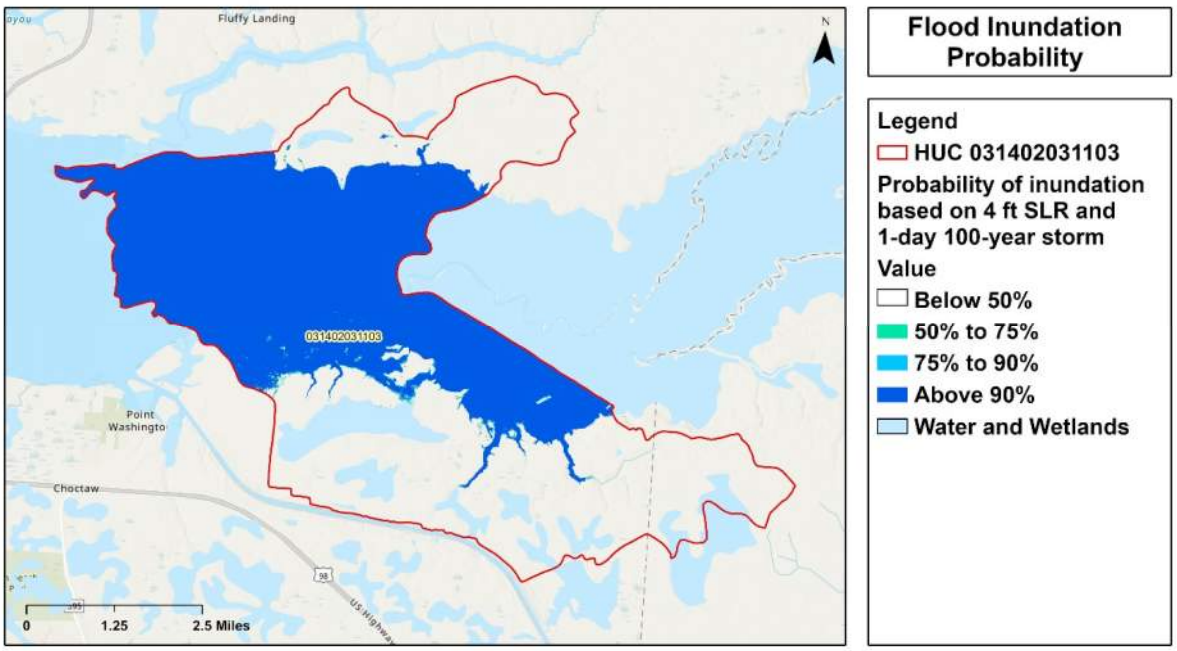

Figure 52. Sea level rise of 4 ft + 1-day 100-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

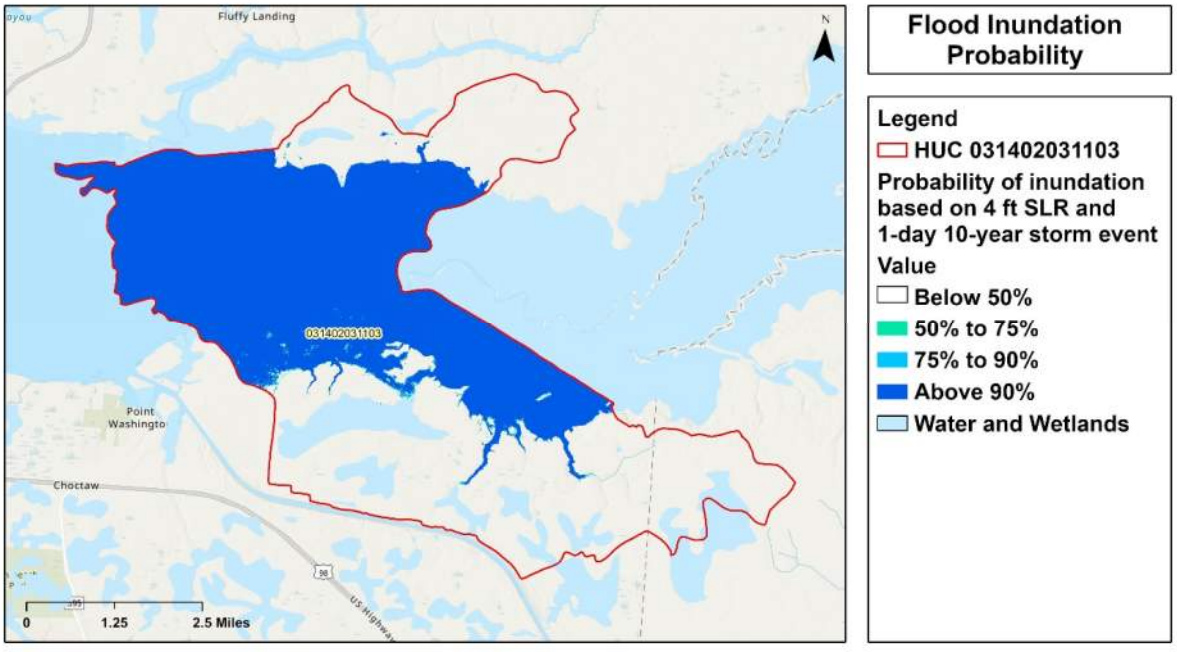

Figure 53. Sea level rise of 4 ft + 1-day 10-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

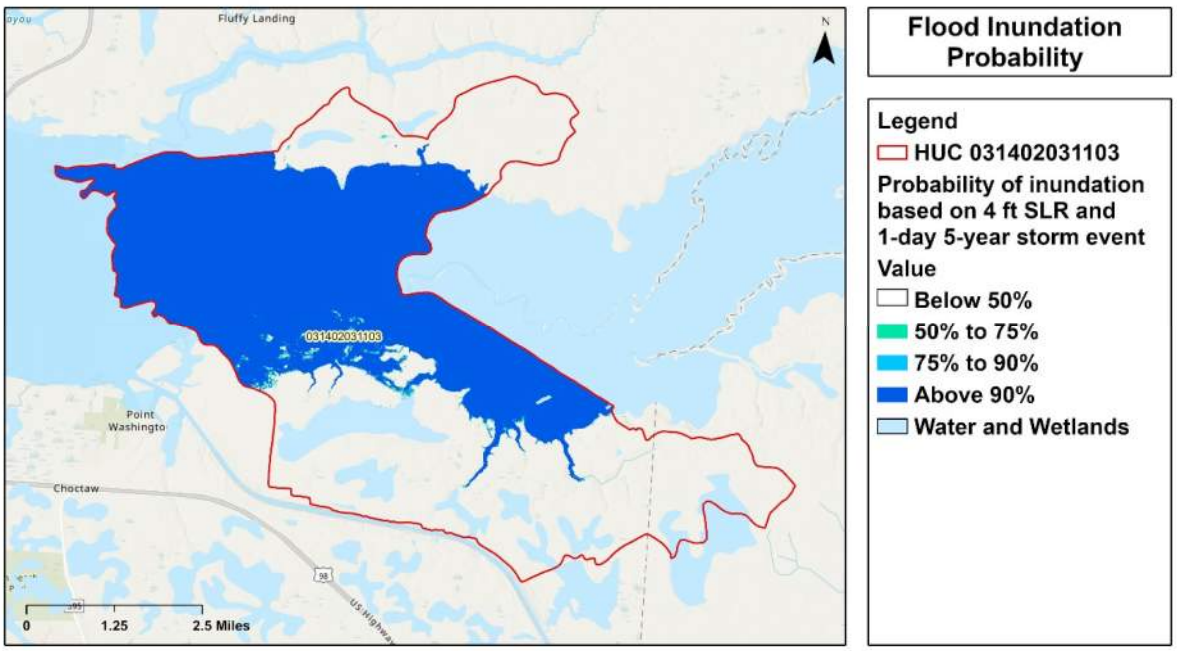

Figure 54. Sea level rise of 4 ft + 1-day 5-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

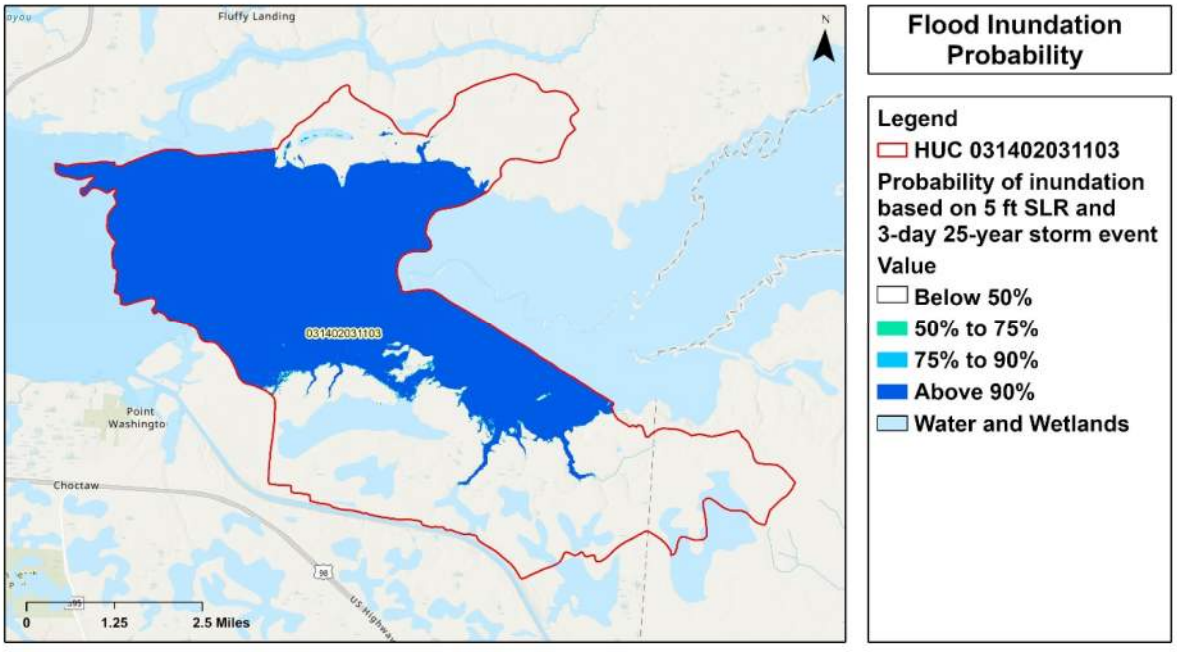

Figure 55. Sea level rise of 5 ft + 3-day 25-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

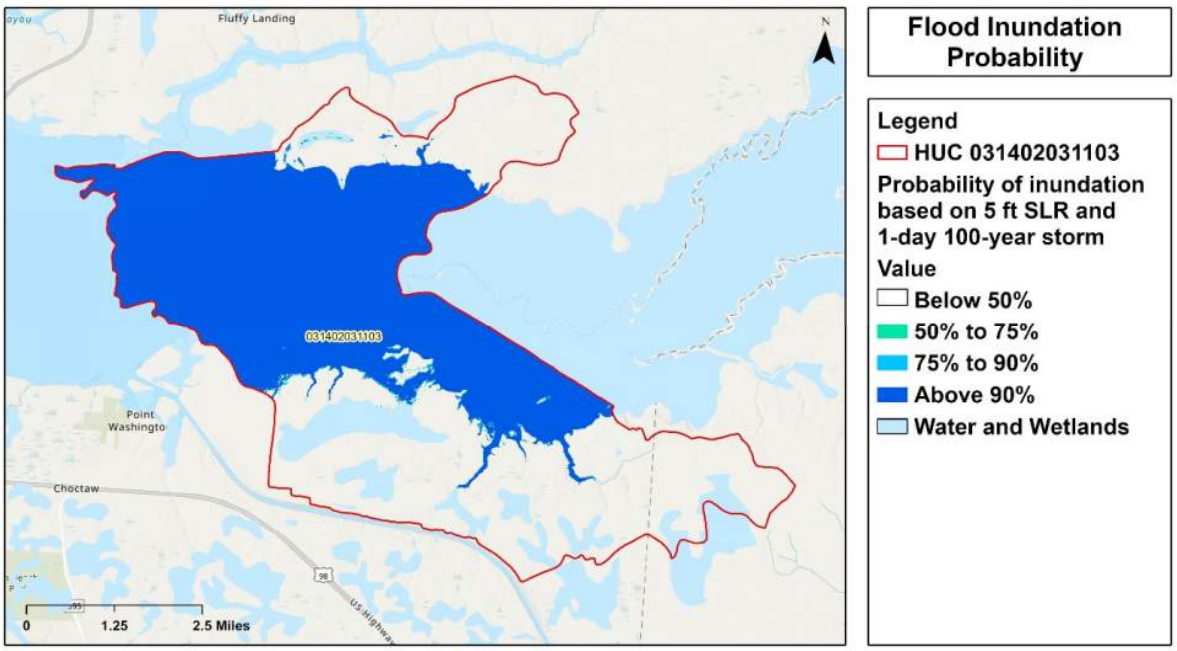

Figure 56. Sea level rise of 5 ft + 1-day 100-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

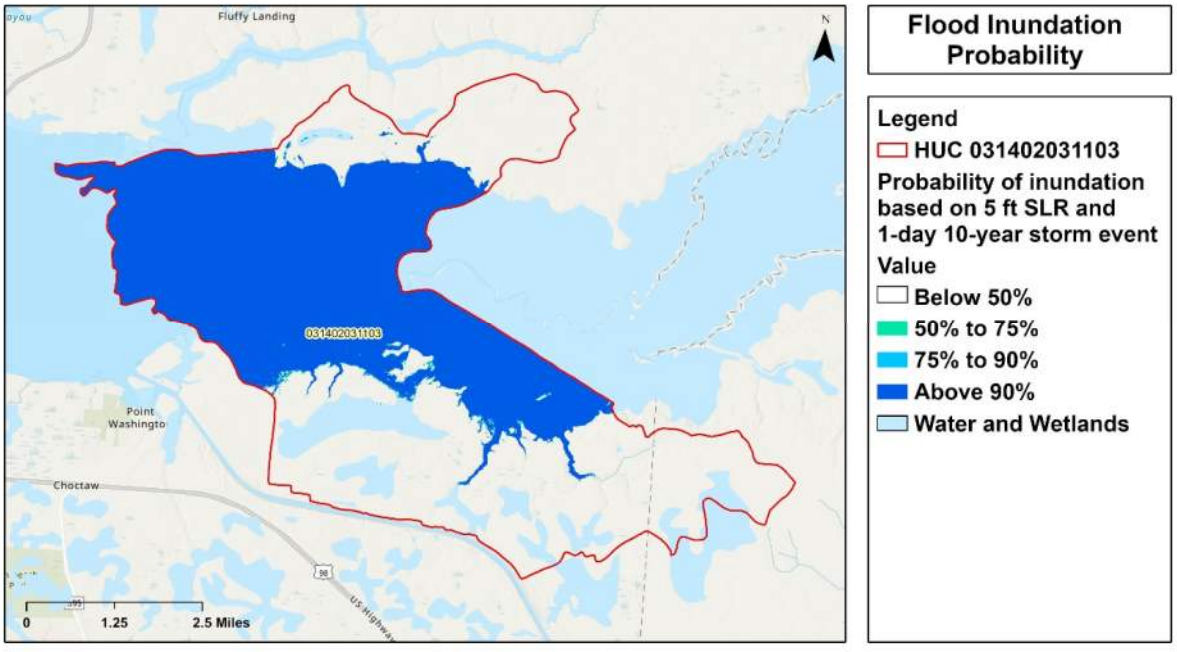

Figure 57. Sea level rise of 5 ft + 1-day 10-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

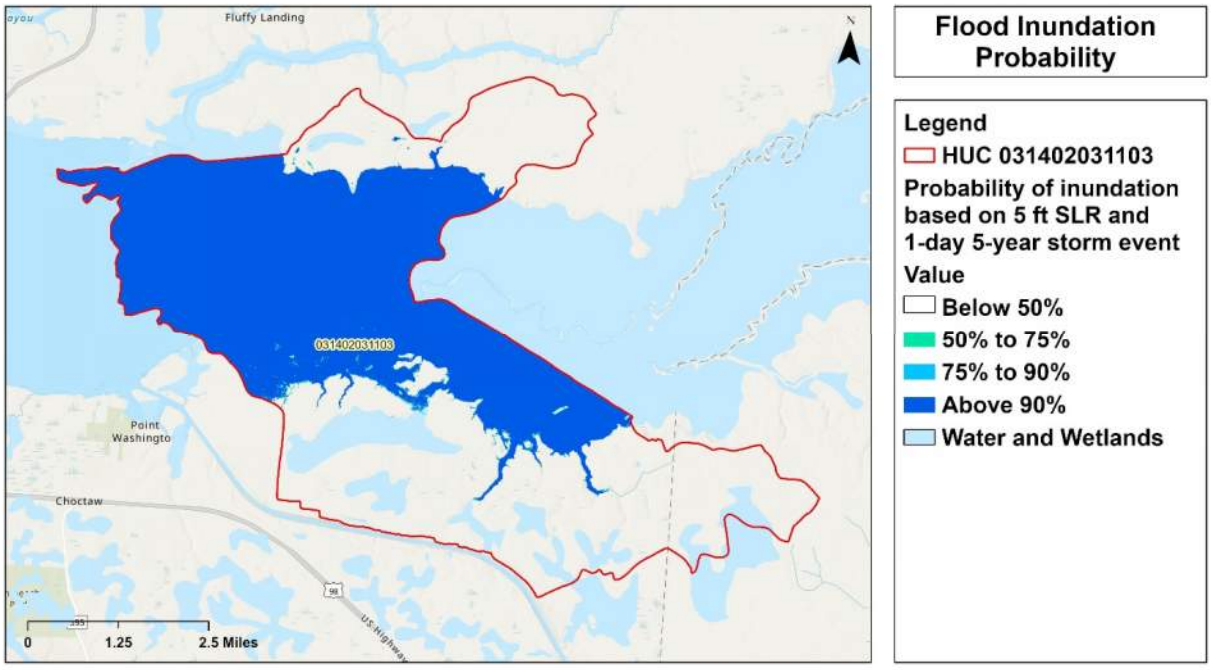

Figure 58. Sea level rise of 5 ft + 1-day 5-year storm for HUC 031402031103 sub-watershed. Note a 2.97 ft King Tide was also included based highest tide from NOAA tidal gauge stations. Processed by FAU.

2.5 Risk and Vulnerability

The screening tool modeling exercise from the prior section identified areas within the communities that are vulnerable to flooding. Higher priority concerns should be those properties or assets that are considered essential and need to be kept in service during a flooding event. All other improvements are local. To help with prioritization, the following is suggested:

- Tier 1 - Critical facility protection (water/sewer utilities, public safety, hospitals, schools, power, shelters)
- Tier 2 - Essential facilities (groceries, pharmacies, roadways)
- Tier 3 - Economic centers (protecting jobs)
- Tier 4 - At risk communities
- Tier 5 - Other urban/suburban property
- Tier 6 - Agriculture/public property/vacant/undeveloped

Error! Reference source not found. outlines the priority of land use based on DOR land use codes from the property appraiser's office and assigns an associated priority level to each parcel. Note that for residential property, identifying at-risk communities (income, age, disability, health)

requires a further drilldown to the neighborhood level (i.e. wealthy neighborhoods with few older, poor health individuals would have a lower priority than at risk communities, which generally have lower value housing and denser development). In the latter case, more people are impacted, and those people have less ability to mitigate risk. Based on these priorities, the relative risk priority DOR land use codes were evaluated based on a scale of 1 to 6, where 1 is higher priority (more vulnerable) and 6 is the least priority (least vulnerable).

Table 8. Priority of Land Use based on (DOR) land use codes. Processed by FAU.

DOR (Use code)	**Description**	**TIER (Priority of Land Use)**
0	Vacant Residential	6
1	Single Family Residential	5
2	Mobile Homes	4
3	Multi-Family >9 units	5
4	Residential Condo	5
5	Cooperatives	5
6	Retirement Homes	4
7	Misc. Residential	5
8	Multi-Family <10	5
9	Residential Common Area	6
10	Vacant Commercial	6
11	One-Story Stores	5
12	Mixed Use Store	5
13	Department Store	3
14	Supermarket	2
15	Regional Shopping Center	3
16	Community Shopping Center	3
17	Office Non Professional	3
18	Service Multi-Story	3
19	Professional Services Building	3
20	Terminals	2
21	Restaurant	3
22	Drive-in	5
23	Financial	2
24	Insurance Company Office	3

25	Repair Service Shops (excluding automotive), Radio And T.V. Repair, Refrigeration Service, Electric Repair, Laundries, Laundromats	3
26	Laundry	5
27	Service Station	3
28	Mobile Home Sales, Parking Lot, Mobile Home Parks	5
29	Wholesale Outlets, Produce Houses, Manufacturing Outlets	5
30	Florist, Greenhouses	6
31	Drive-in Theater	5
32	Auditoriums/Indoor Theaters	5
33	Bar	5
34	Skating Rinks, Pool Halls, Bowling Alleys	5
35	Tourist Attractions	5
36	Camps	6
37	Race Tracks (horse, auto or dog)	6
38	Golf Course	6
39	Hotel	3
40	Vacant Industrial	6
41	Light Manufacturing	3
42	Heavy Manufacturing	3
43	Lumber Yards, Sawmills, Planning Mills	6
44	Fruit, Vegetables, and Meat Packing	3
45	Canneries, Distilleries, And Wineries	5
46	Other Food Processing, Candy Factories, Bakeries, Potato Chip Factories	5
47	Mineral Processing, Phosphate Processing, Cement Plants, Refineries, Clay Plants, Rock and Gravel Plants	6
48	Warehouse Distribution	5
49	Open Storage	6
50	Improved Agricultural	6

51	Cropland Soil Capability Class I	6
52	Cropland	6
53	Cropland Soil Capability Class III	6
54	Timberland - Site Index 90 and Above	6
55	Timberland - Site Index 80 to 89	6
56	Timberland - Site Index 70 to 79	6
57	Timberland - Site Index 60 to 69	6
58	Timberland – Site Index 50 to 59	6
59	Timberland not Classified by Site Index to Pines	6
60	Grazing Land Soil Capability Class I	6
61	Grazing Land Soil Capability Class II	6
62	Grazing Land Soil Capability Class III	6
63	Grazing Land	6
66	Orchard	6
67	Poultry	6
69	Ornamentals	6
70	Vacant without Features	6
71	Church	5
72	Private School	2
73	Private Hospital	2
74	Home for the Aged	4
75	Orphanage	4
76	Cemetery	6
77	Club, Hall	5
78	Convalescent Homes	4
79	Cultural Organization Facilities	5
80	Vacant Government	6
81	Military	6
82	Military, Forest, Parks	6
83	Public School	1
84	Public College	1
85	Public Hospitals	1
86	County	6

87	State, Other than Military, Forests, Parks, Recreational Areas, Colleges, Hospitals	6
88	Federal	6
89	Municipal	6
90	Leasehold Interests (Government-Owned Property Leased By A Non-Governmental Lessee)	6
91	Utility	1
92	Mining Lands, Petroleum Lands, or Gas Lands	6
93	Subsurface Rights	6
94	Right of Way	2
95	Submerged, lakes	6
96	Sewage Disposal	6
97	Outdoor Recreational Or Parkland, Or High-Water Recharge Subject To Classified Use Assessment	6
98	Centrally Assessed	6
99	Other Non-Agricultural Acreage	6
100	Parcel With no Values	6
101	Parcels With no Values (ROW - avenues, highways, arterials)	2
102	Parcels With no Values (Water)	6
103	Parcels With no Values (Rail)	2

Having assigned the risk priority from 1 to 6 in the DOR codes and the percentage of the parcel that floods during the applicable design storm, properties that are more critical to the function of the community can be identified. The methodology is to first convert the DOR code priority tier to its inverse scale by the following equation:

Consequence of risk factor = 7 – DOR Code Priority Tier

The flood risk factor from the screening tool is interpreted based on flooding probability. We take all parcels in tiers #1-4 that have a greater than 50% chance of flooding during a particular design storm and calculate the percent of the parcel that would flood during that event. The percentage is converted to a 6-point scale termed as the Flood Risk Factor, shown in **Error! Reference source not found.**.

Table 9. Flood Risk Factor Classification.

Percent of Parcel Flooded	Flood Risk Factor
90-100%	6
80-89%	5
70-79%	4
60-69%	3
50-59%	2
<50%	1

The priority is further developed by assigning 75% of the importance to the consequence of flooding and 25% importance to flood risk, or three times the importance to the consequence of flooding to come up with a composite score as follows:

Flood Risk Factor × 25% + Consequence of Risk Factor × 75% = Composite Score

Example: 1 × 25% + 6 × 75% = 4.75

Those higher priority properties that received the higher composite score are where the mitigation strategies and financial resources should focus first.

2.5.1 Results

Error! Reference source not found. to **Error! Reference source not found.** depict the HUC 031402031103 sub-watershed priority of land uses showing the critical facilities that should receive priority. The first map (**Error! Reference source not found.**) exclusively displays critical facility parcels within the HUC without any flooding. The second map (Figure 60) overlays critical facilities onto the 1-day 100-year storm event scenario, while the third map (**Error! Reference source not found.**) represents the same overlay within the context of 5 feet of sea level rise (SLR) combined with the 1-day 100-year storm event. **Error! Reference source not found.** is a mosaic showing critical facilities overlaid in the 5 feet SLR + 1-day 100-year storm event for the whole county.

Additionally, **Error! Reference source not found.** and **Error! Reference source not found.** illustrate the composite score for the HUC, which is the result of the calculations explained above, pinpointing parcels that should be prioritized. It considers only parcels classified as 1 to 4 tiers, and within the 50% probability of inundation area. **Error! Reference source not found.** represents the calculation for composite score based on 1-day 100-year storm event, while **Error! Reference source not found.** shows the calculation for composite score for the same storm event, but including a 5 feet of Sea Level Rise scenario. **Error! Reference source not found.** shows the same area zoomed out.

Please note that the composite score results display outcomes exclusively for parcels within the flooding path area. Consequently, for parcels outside this flooding path, the composite results will be null. The composite score combines the flooding path area with the land use priority results to identify the most vulnerable areas deserving of priority.

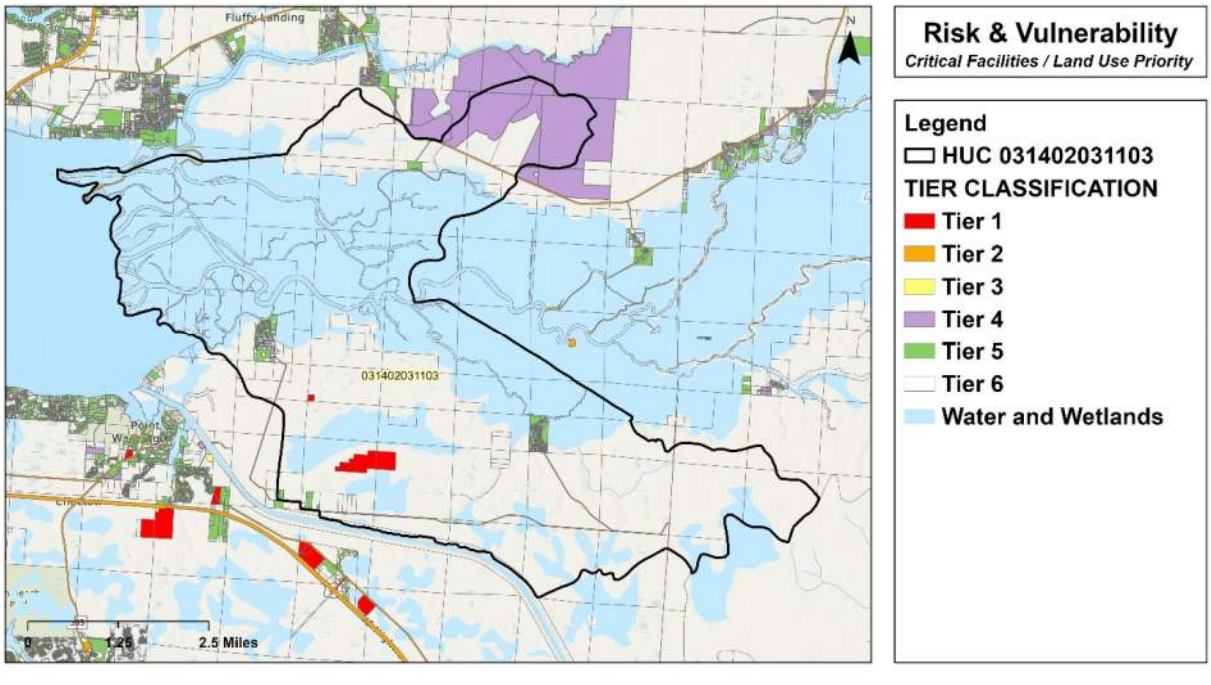

Figure 59. HUC 031402031103 sub-watershed Critical Facilities (priority of land uses) map. Processed by FAU.

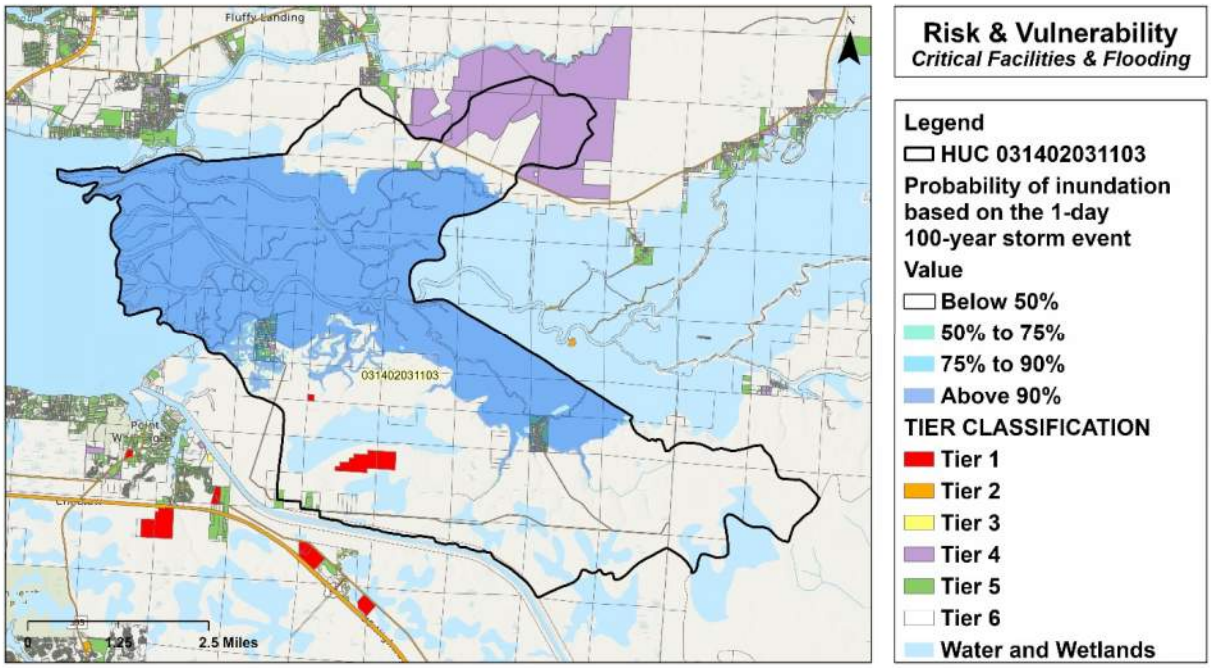

Figure 60. HUC 031402031103 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year storm event probability of inundation. Processed by FAU.

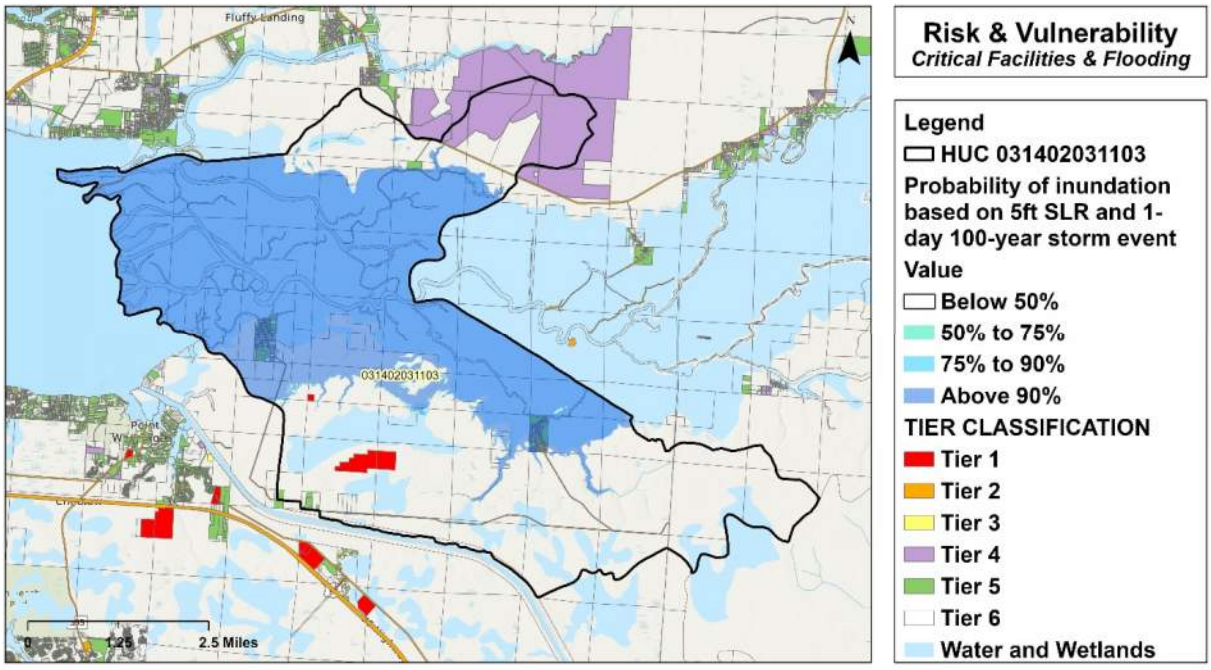

Figure 61. HUC 031402031103 sub-watershed Critical Facilities (priority of land uses) map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

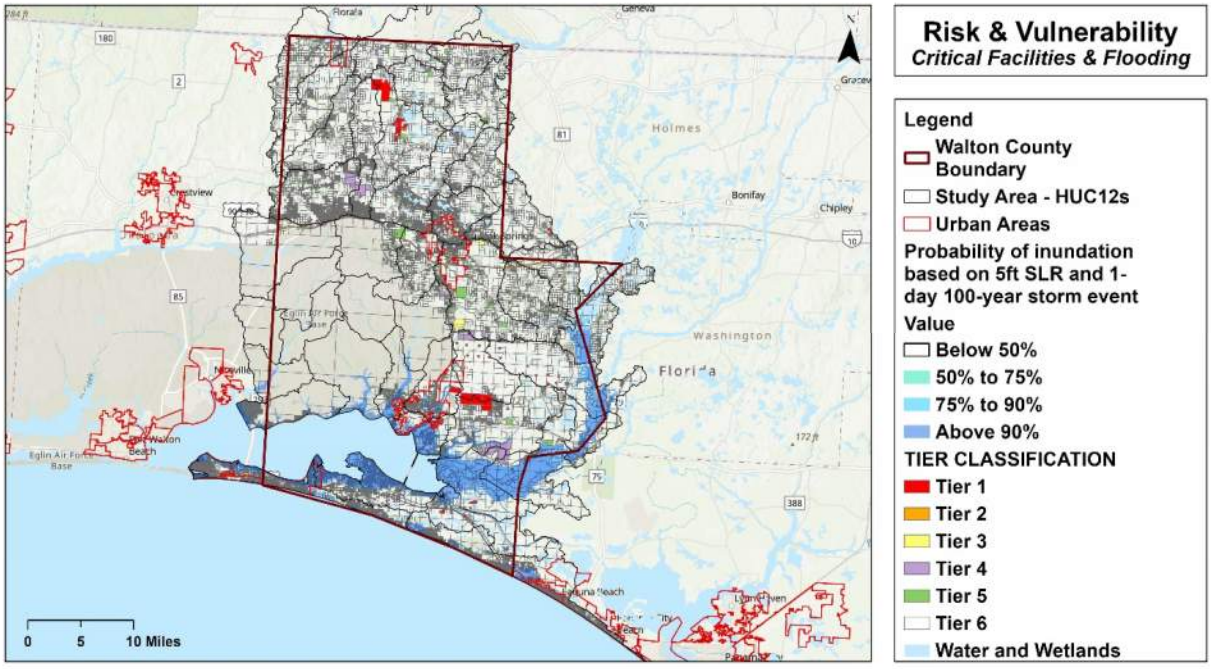

Figure 62. Walton County (mosaic) - Critical Facilities (priority of land uses) map, overlaid on the 1-day 100-year storm event + 5 ft. SLR probability of inundation for Walton County. Processed by FAU.

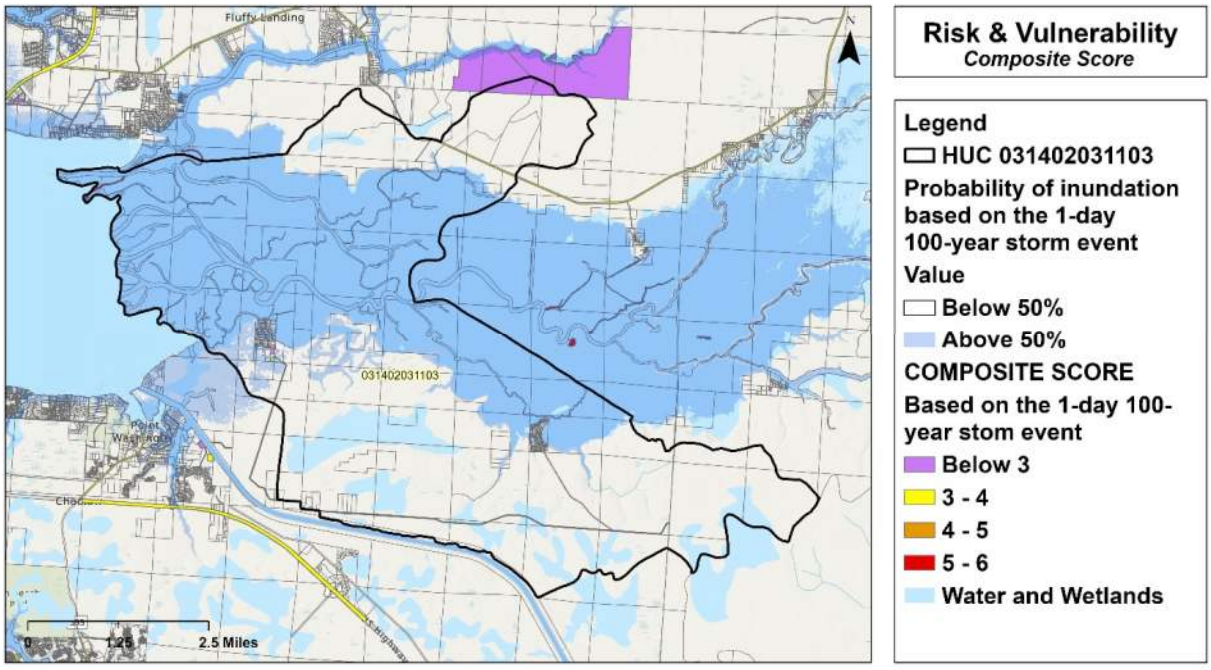

Figure 63. HUC 031402031103 sub-watershed Composite Score Risk map based on the 1-day 100-year storm event, overlaid on the 1-day 100-year probability of inundation. Processed by FAU.

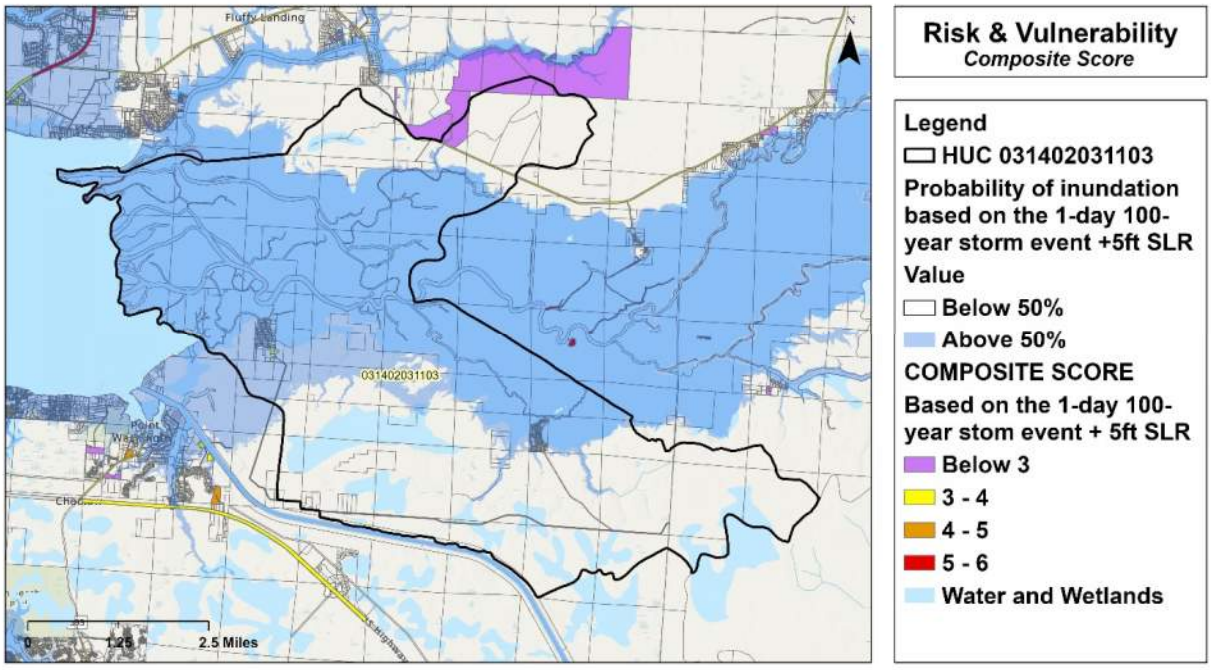

Figure 64. HUC 031402031103 sub-watershed Composite Score Risk map based on 1-day 100-year storm event + 5 ft. SRL, overlaid on the 1-day 100-year + 5 ft. SLR probability of inundation. Processed by FAU.

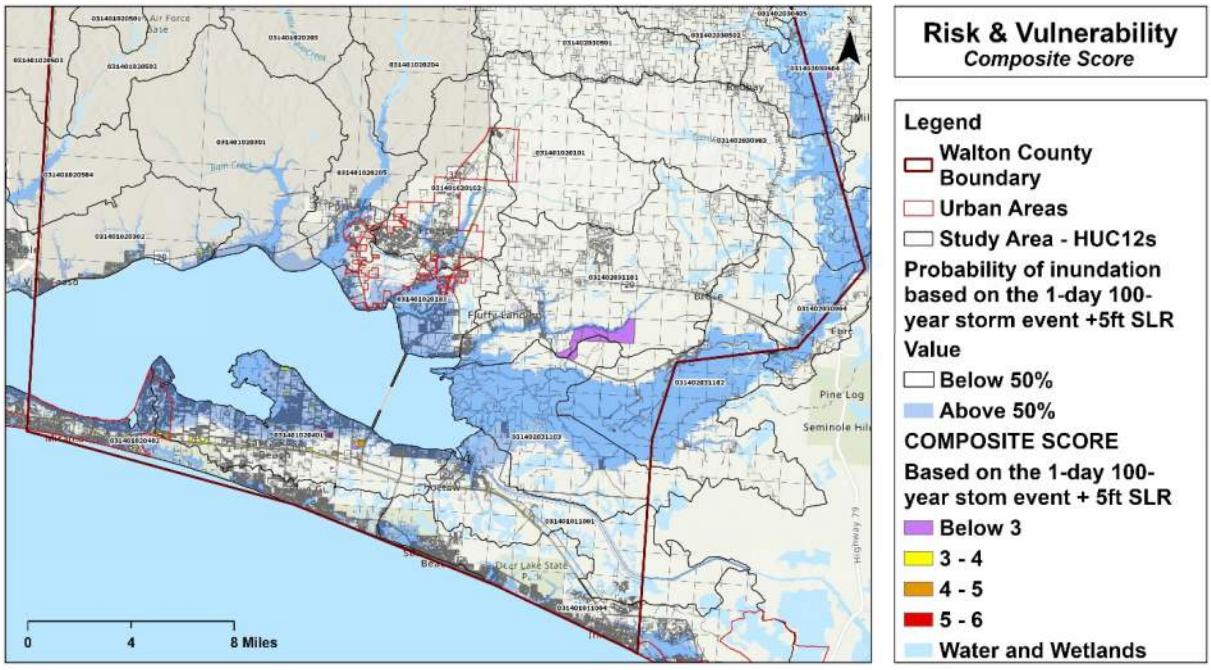

Figure 65. Coastal Area of Walton County (mosaic) - Composite Score Risk map overlaid on the 1-day 100-year + 5 ft. SLR storm event probability of inundation. Processed by FAU.

2.5.2 Solutions

Chapter 5 of the Watershed Master Plan for Walton County describes a list of possible gray and green stormwater strategies to combat flooding that can be implemented as solutions for the county. The same solutions can also be applied at the HUC level, including HUC 031402031103. A summary of these flood mitigation strategies is listed in **Error! Reference source not found.**. For more detailed information, please see Chapter 5-5.3 (Solutions).

Table 10. List of possible gray and green stormwater strategies to combat flooding.

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Rainwater harvesting	Local, small scale, easily implemented in developed areas	Protects property, treats runoff	Under $5,000	Limited volume disposed of, so many are needed, maintenance
Gray	Pervious paving	Parking lots, patios, driveways, anything except paved roads due to traffic loading	Reduces roadway and parking lot flooding	$10-20/sf, requires bumpers and sub-base to maintain paver integrity	Must be maintained via vacuuming or the perviousness fades after 2-3 years

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Green	Detention	Common for new development, but difficult to retrofit; limited to open areas	Removes water from streets, reduces flooding	$200K/ac	Land availability, maintenance of pond, discharge location Uses up land that could otherwise be developed
Gray	Exfiltration Trench	Any low-lying area where stormwater collects and the water table is more than 3 ft below the surface; densely developed areas where retention is not available, roadways	Excess water drains to aquifer, some treatment provided	$250/ft	Significant damage to roadways for installation, maintenance needed, clogging issues reduce benefits
Gray	Central sewer installation	All areas where there are septic tanks. Mostly a water quality issue	Public health benefit of reducing discharges to lawns, canals, and groundwater from septic tanks	$15,000 per household	Cost, assessments against property owners, property rights issues
Green	Flood prone property acquisition	Regional agency - could be any low-lying areas	Removes flood prone areas from risk	$2K-$100K/ac depending on whether it is already developed	Difficult to implement if occupied, issues with willing sellers, cost, lack of funds for acquisition
Gray	Pump stations	Any low-lying area where stormwater collects, and there is a place to pump the excess stormwater to such as a canal; common for developed areas	Removes water from streets, reduces flooding	Start at $1.5 to 5 million each, number unclear without more study	NPDES permits, maintenance cost, land acquisition, discharge quality
Gray	Armored sewer systems	Any area where gravity sanitary sewers are installed	Keeps stormwater out of sanitary sewer system and reduces potential for disease spread from sewage overflows	$500/manhole	Limited expense beyond capital cost
Gray	Sea walls	Barrier islands and downtown coastal areas	Protects property	$1200/ft	Private property rights, neighbors

Strategy Class	Implementation Strategy	Applications	Benefits	Cost	Barriers to Implementation
Policy	Changes in land use	Applicable universally	Achieves flood risk mitigation by adjusting permitted land use	Low but may incur private property rights conflicts and litigation	Private property rights conflicts and litigation
Gray	Roadway base protection	Low-lying areas, coastal communities	Protects roads and access routes	$1 million per lane-mile	Cost, adjacent properties become uninsurable
Policy	Enhanced elevation of buildings	Developers would implement this for new construction	Reduced flood risk	Varies	Potential issues with building structure or latticework, and existing homes that are not elevated

2.5.3 Impacted Adjustment Areas

In the evaluation of flood risk management strategies within the framework of the National Flood Insurance Program Community Rating System (CRS), the concept of impact adjustment plays a pivotal role in determining the extent to which CRS-credited activities or elements influence the vulnerability of a community's Special Flood Hazard Area (SFHA) and the structures located within it. It is important to note that while the usual results of impact adjustment are related to the SFHA area, in this specific analysis, it was used 1-day 100-year storm event inundation area performed by FAU instead.

In this context, the following table presents a breakdown of the impact adjustment calculations for a 1-day 100-year storm event inundation. The values are expressed in acres and depict the areas of interest as well as the deductions considered in the evaluation process.

The outcomes of these calculations provide valuable insights into the impact adjustment scenarios:

With ALL State Lands:

This scenario reflects the remaining inundation area after accounting for deductions A, B, and C. It represents the effect of CRS-credited activities without considering the influence of state lands in managing flood risks.

With NO State Lands:

In this case, the remaining inundation area is determined by considering all deductions, including state lands (both open space and not open space– see **Error! Reference source not found.**).

These calculations highlight the dynamic nature of impact adjustment within the CRS framework. By accurately gauging the influence of individual elements, the system ensures that credit allocations align closely with a community's efforts in flood risk mitigation.

Table 11. Impacted Adjustment Areas for HUC 031402031103. Processed by FAU.

AREAS	**ACRES**
HUC-12 Sub-watershed: 031402031103	20187.04
All of the 1-day 100-year storm event inundation	**9104.14**
Subtract	
A. Bodies of Water in 1-day 100-year inundation > 10 acres	7713.99
B. Federal Land in 1-day 100-year inundation > 10 acres	0.00
C. Reservation/Tribal Land in 1-day 100-year inundation > 10 acres	0
D. State Land in 1-day 100-year inundation > 10 acres that is open space	548.71
E. State Land in 1-day 100-year inundation > 10 acres that is NOT open space	11.25
The remainder is either:	
With ALL State Lands: All of the 1-day 100-year inundation minus (A+B+C) or	1390.15
With NO State Lands: All of the 1-day 100-year inundation minus (A+B+C+D+E)	830.19

2.5.4 Repetitive Loss Property Map

A Repetitive Loss (RL) property is a building that has had two or more loss or damage due to a specific hazard, such as floods, hurricanes, or other natural disasters, over $1,000 each, paid by the National Flood Insurance Program (NFIP) within any ten-year period since 1978. There are more than 122,000 RL properties in the nationwide (FEMA, 2005).

These data are essential for assessing the vulnerability of certain areas to recurrent losses and for developing strategies to mitigate the risks. However, due to privacy concerns, the data cannot be openly shared with the public. For this reason, the data were converted into a hot spot analysis map. These maps, instead of identifying the specific location of the repetitive loss properties, highlight clusters of repetitive loss claims and areas where the probability of repetitive losses is higher than would be expected by random chance. In other words, it helps pinpoint locations that have a higher concentration of properties prone to repetitive losses. **Error! Reference source not found.** indicates the results from hot spot analysis in point data, showing aggregated counts, and raster data, showing the estimated probability of repetitive loss.

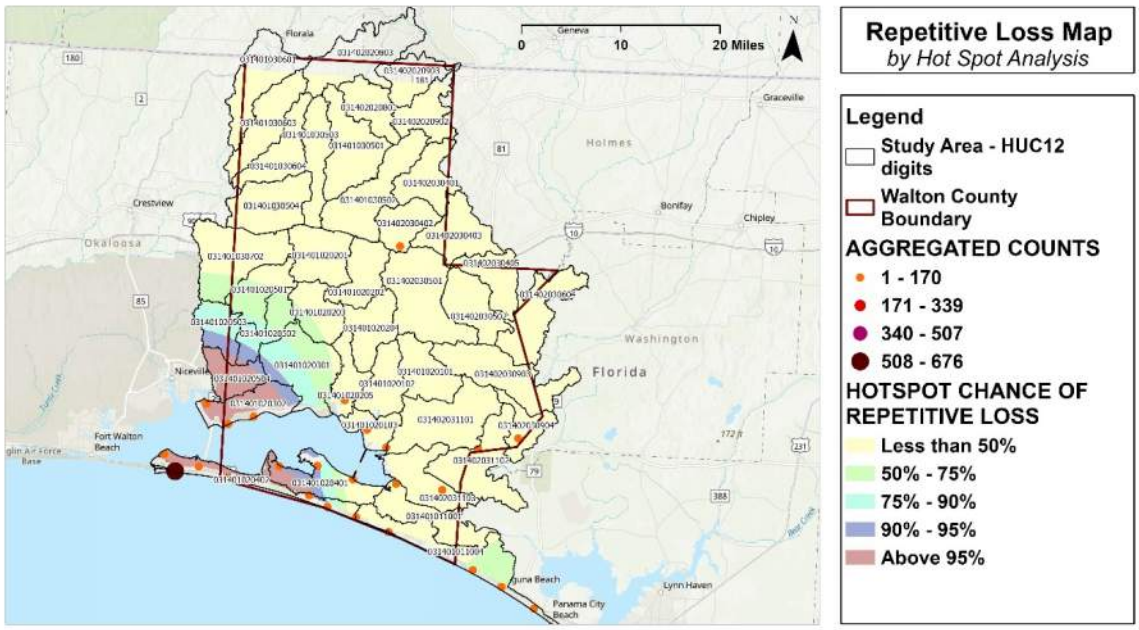

Figure 66. Repetitive Loss map for Walton County by Hot Spot Analysis. Processed by FAU. (Source Data: FEMA)

2.5.5 Priority Projects

While the basin does not have a significant amount of developed land, some parcels fall within the flood zone due to the area's susceptibility to significant flooding in both 1-day 100-year storm events and 1-day 100-year + 5 feet sea level rise scenarios. In terms of land use priority, there are numerous parcels in tiers 2 (roads), 4, and 5 within the flooding zone. Tier 1 priority parcels, however, are not affected by flooding.

Examining the composite score, there are a total of 59 parcels within the flood zone that require attention. Among them, three are in the score range of 5-6, all of which are roads (Nancy's Cut Off, Magnolia Run, and Rushing Cutoff), representing the highest priority for intervention. Additionally, there are three parcels, also roads (Steele Field Rd, Co Highway 3280, and Bunker Road), with scores in the range of 4-5, and 44 parcels with scores in the range of 3-4, all of which are mobile homes. Finally, there are 11 parcels with scores below 3, comprising 5 orphanages and 6 mobile homes.

APPENDIX AR

Watershed Master Planning Initiative

Walton County

25-Year, 1-Day Modeling Results

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Research Assistant: Leticia Sabio

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AR.0EXECUTIVE SUMMARY

The goal of this appendix to the watershed plan is to illustrate the 25-year, 1-day modeling results using the same methodologies outlined in Section 3.2 of the watershed plan for the 1-day, 5-, 10-, and 100-yr storm events. The following figures are for informational purposes, and the events and results outlined in the watershed plan exceed the guidance criteria to include storm events that are "at least" the 25-year storm event.

1.0 25-Year, 1-Day Storm Event Results

Figure 1 through Figure 11 illustrate the 25-year, 1-day storm event results for the Walton County modeling analysis.

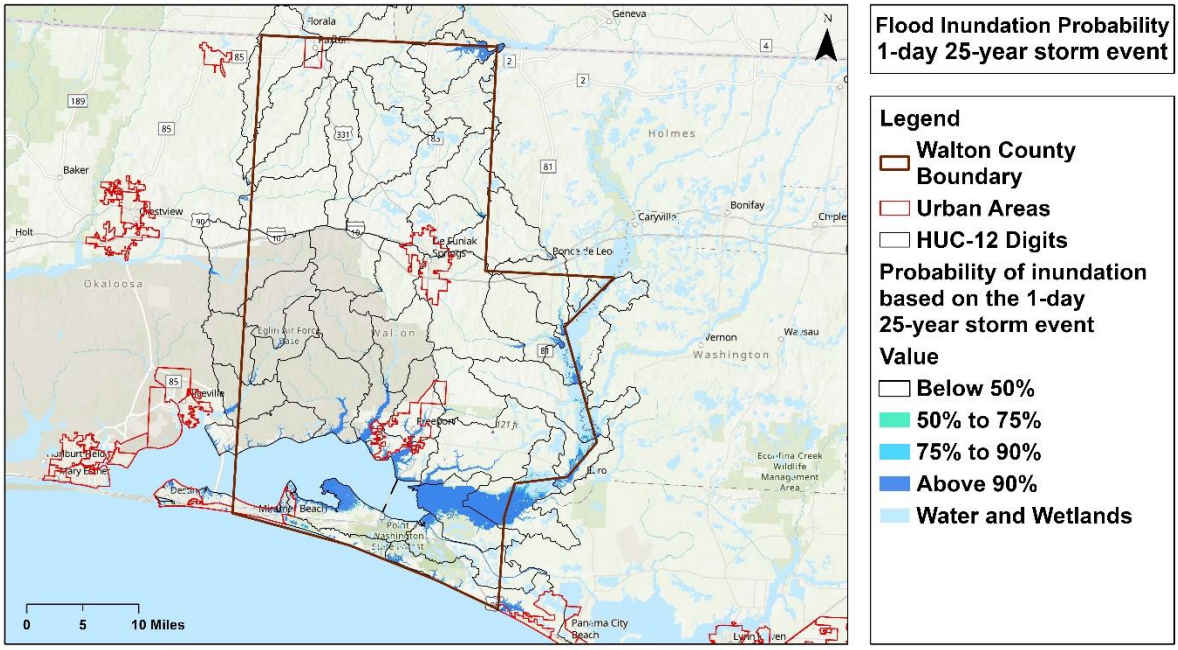

Figure 1. Probability of flood risk map for Walton County for the 1-day, 25-year storm event

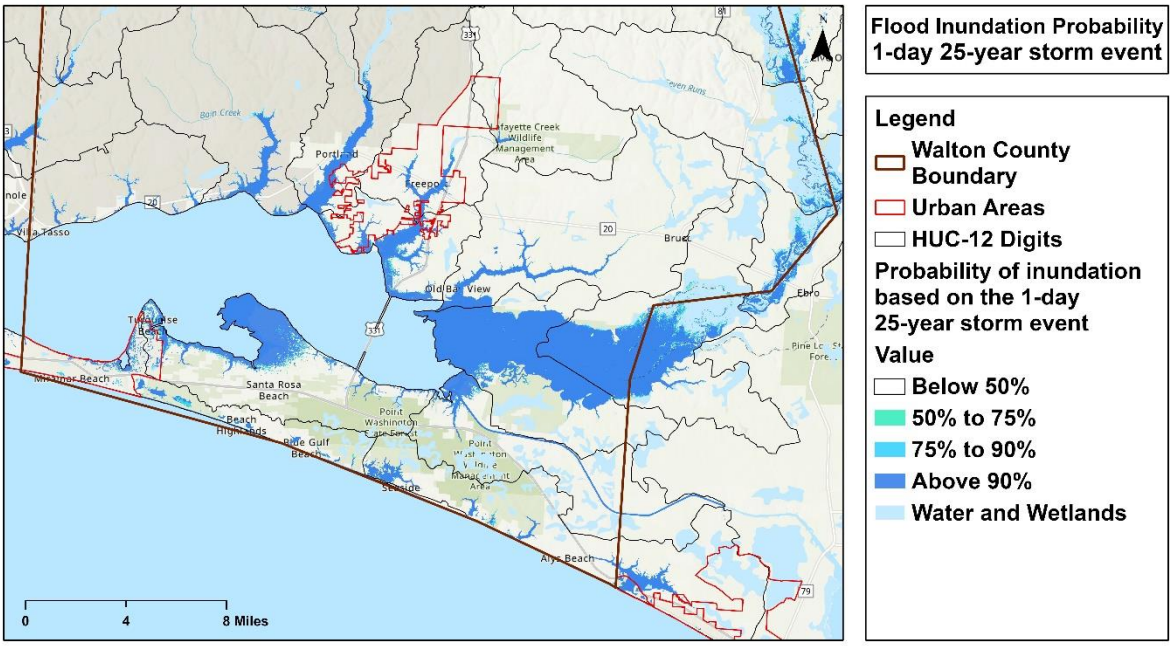

Figure 2. Probability of flood risk map for Coastal Walton County for the 1-day, 25 flood event

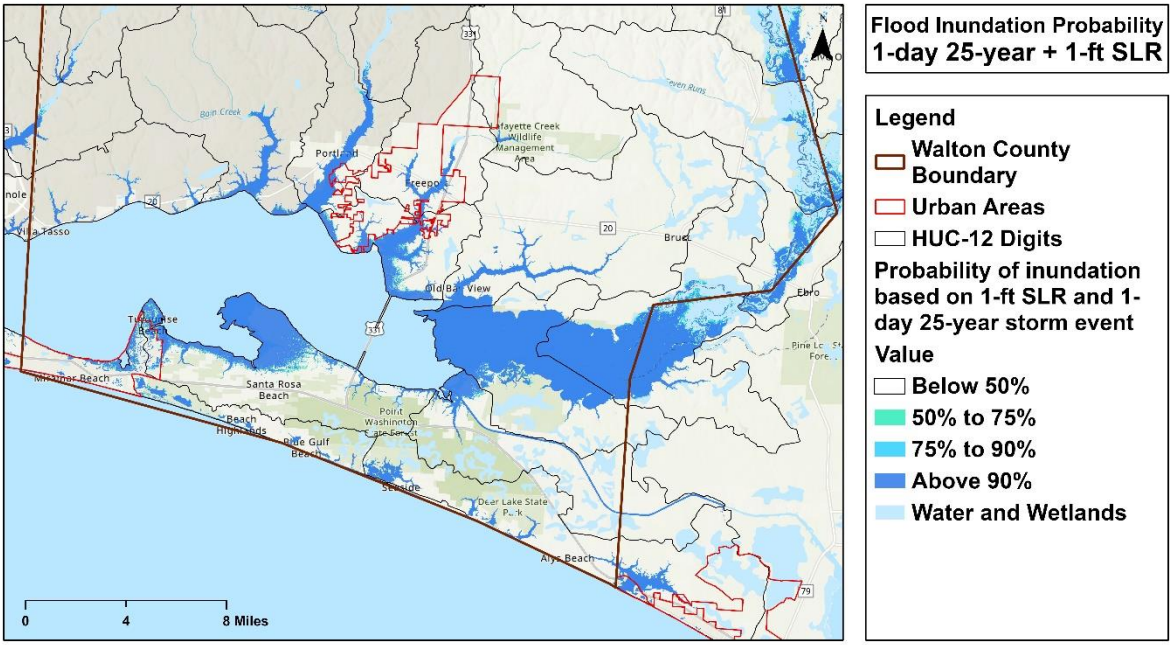

Figure 3. Probability of flood risk map for Walton County for the 1-day, 25-year flood event with 1 ft SLR

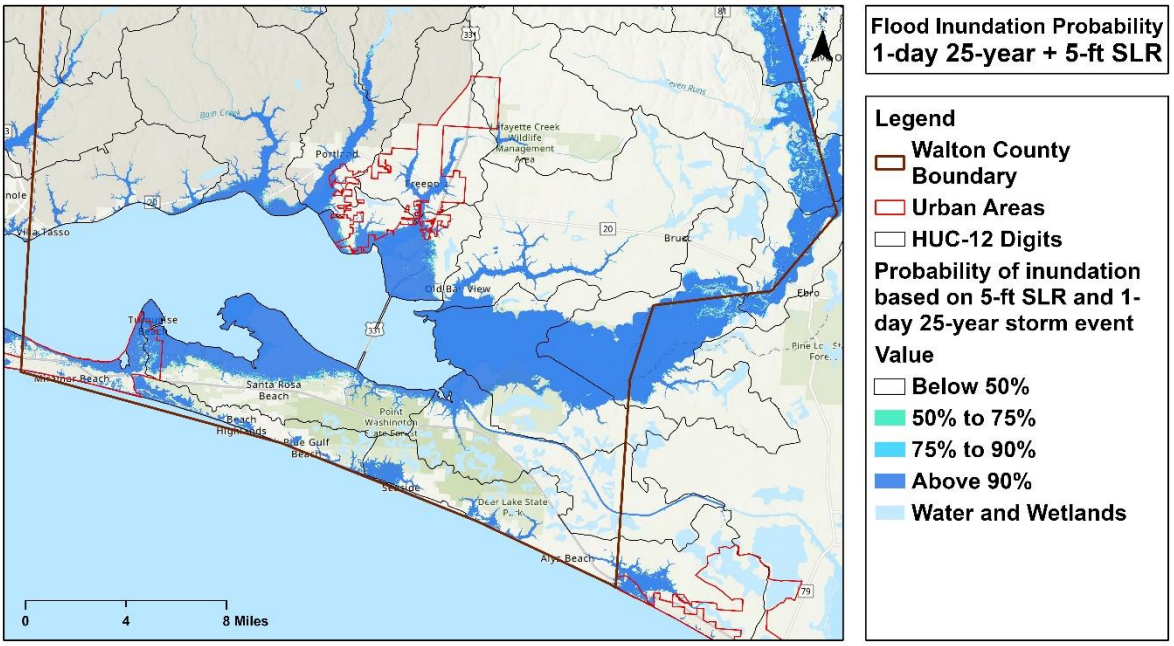

Figure 4. Probability of flood risk map for Walton County for the 1-day, 25-year flood event with 5 ft SLR

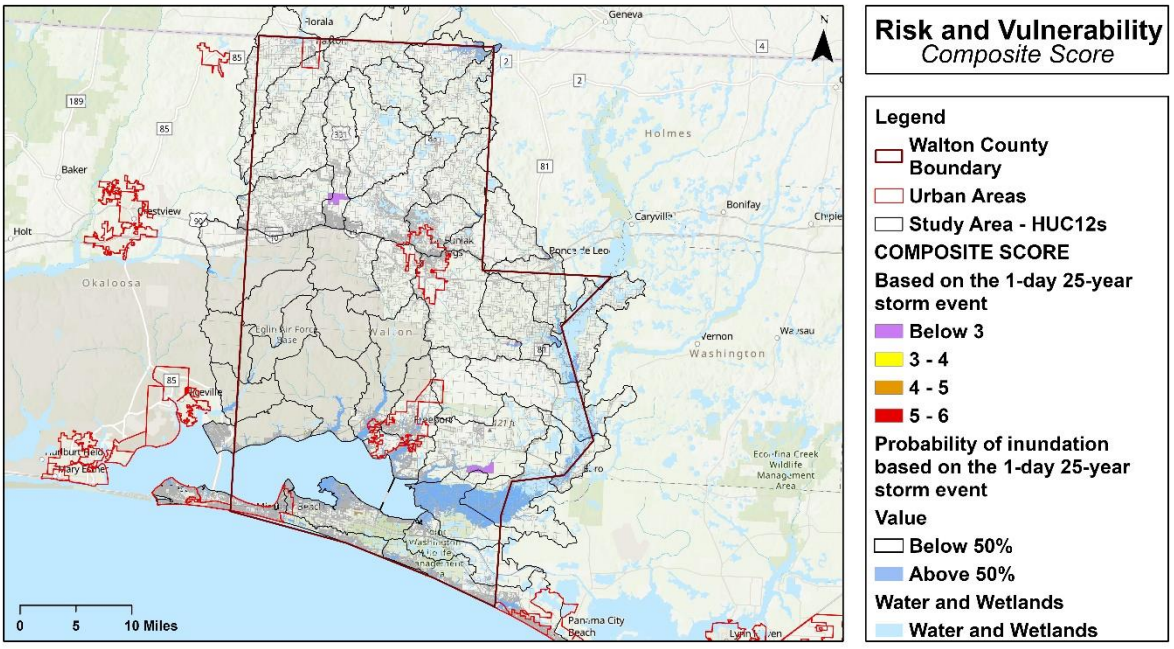

Figure 5. Composite Scores (Property Consequence Factor) Map for the 1-day, 25-year flood event

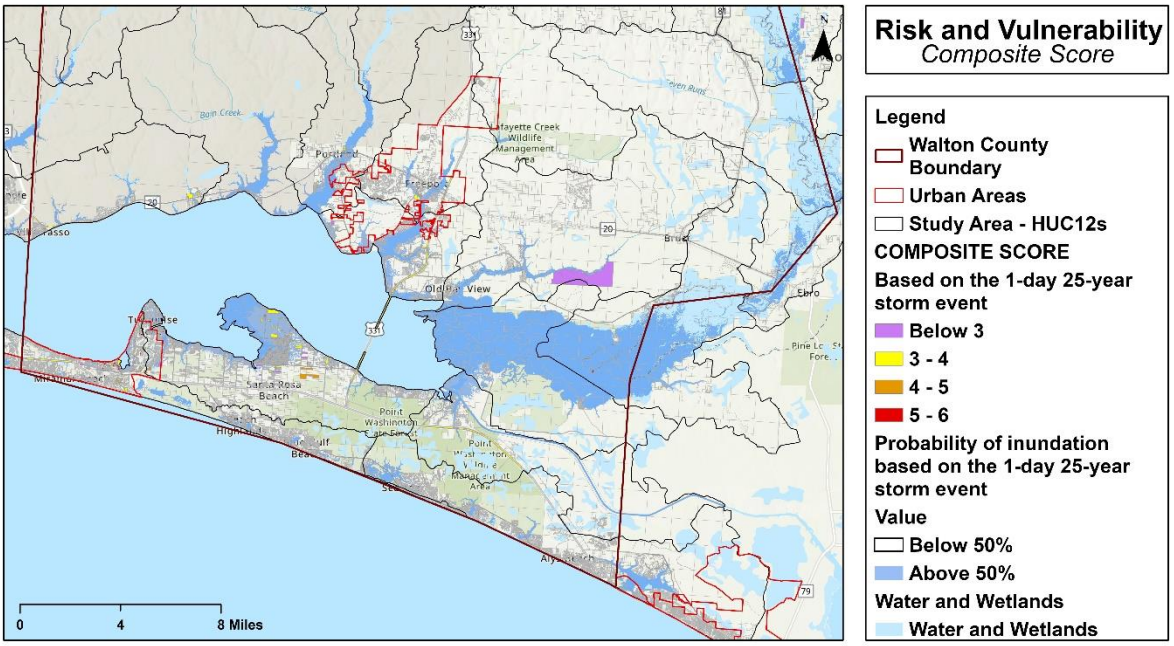

Figure 6. Composite Scores (Property Consequence Factor) Map of Coastal Walton County for the 1-day, 25-year flood event

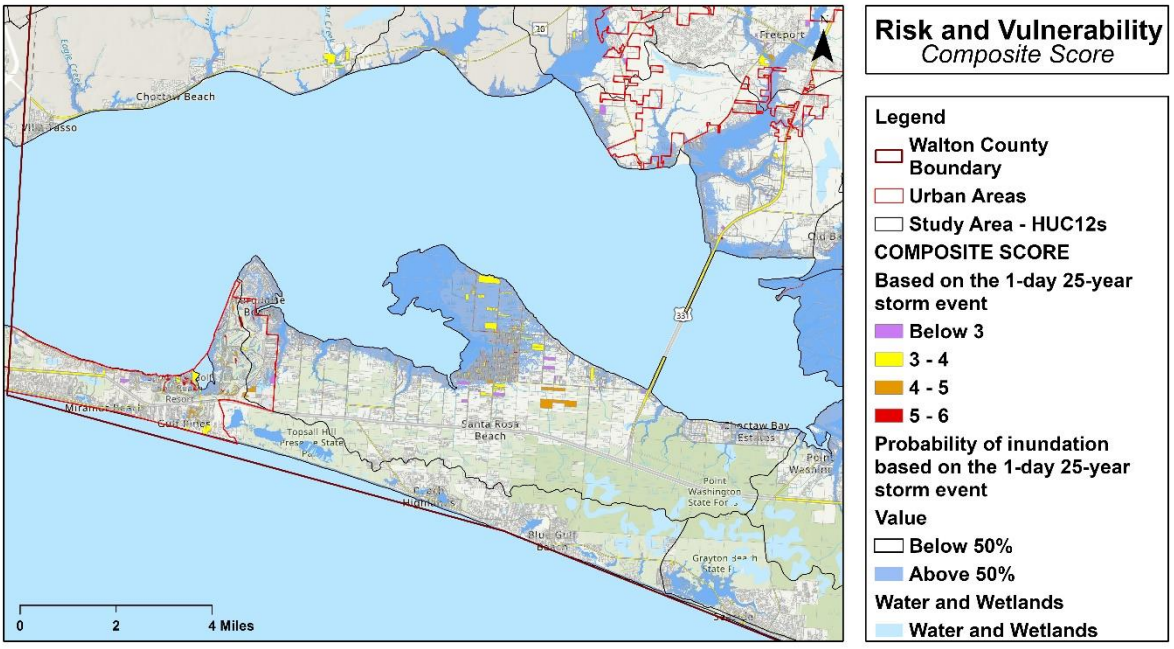

Figure 7. Composite Scores (Property Consequence Factor) Map of Walton County gulf area for the 1-day, 25-year flood event

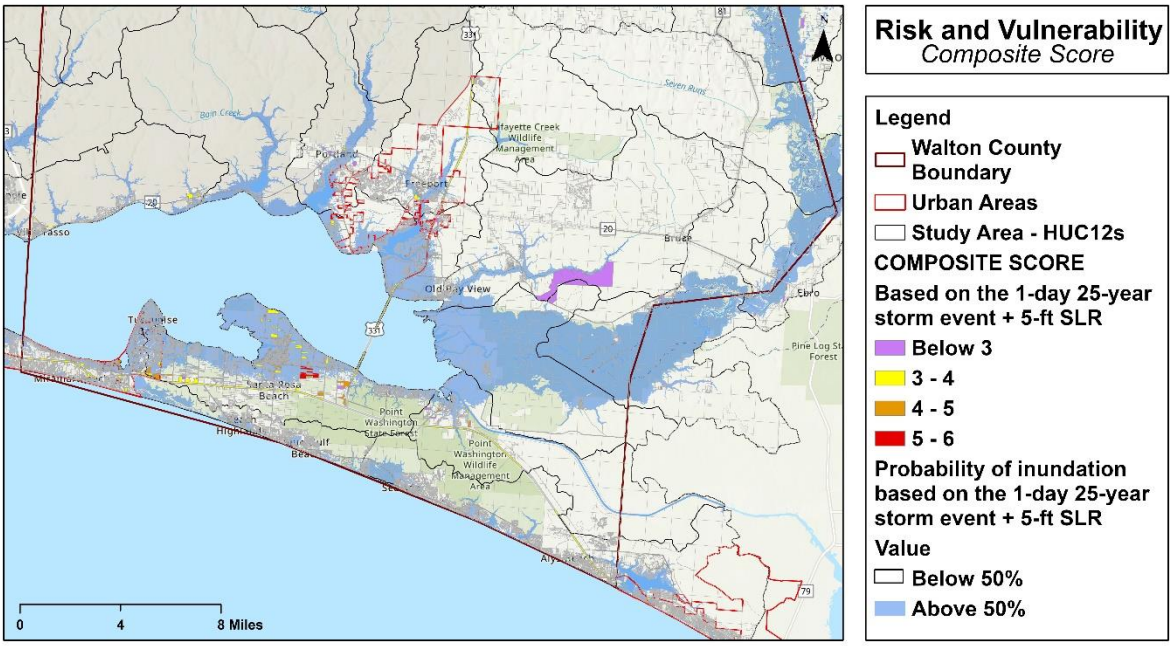

Figure 8. Composite Scores (Property Consequence Factor) Map of Coastal Walton County for the 1-day, 25-year flood event with 5 ft SLR

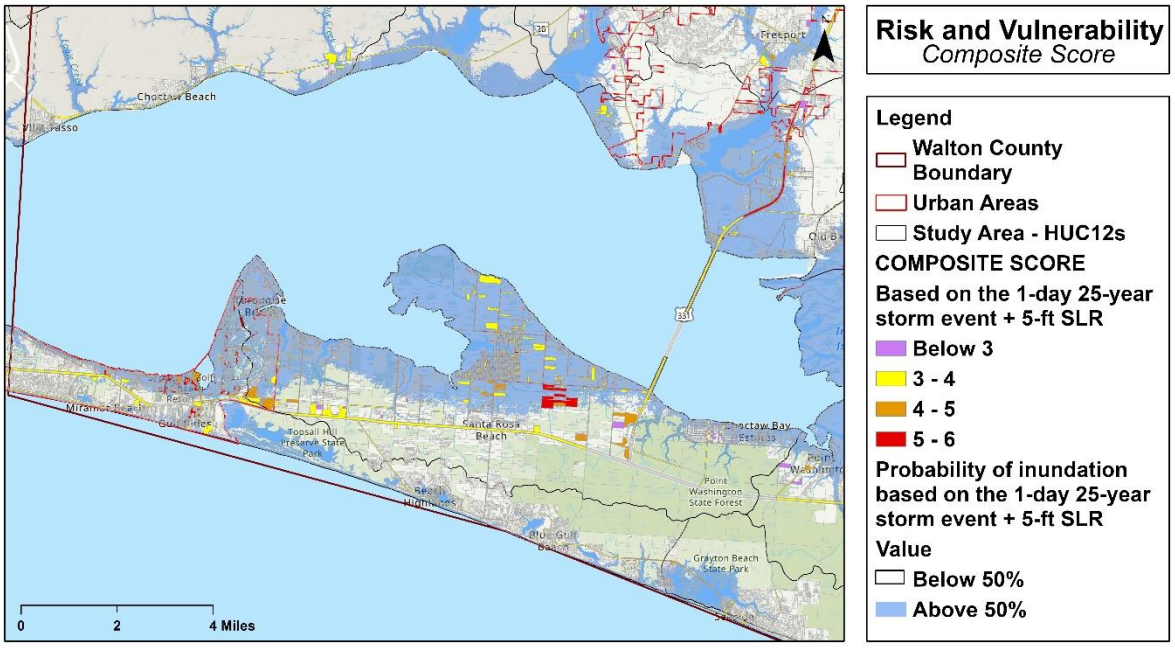

Figure 9. Composite Scores (Property Consequence Factor) Map of Walton County gulf area for the 1-day, 25-year flood event with 5 ft SLR

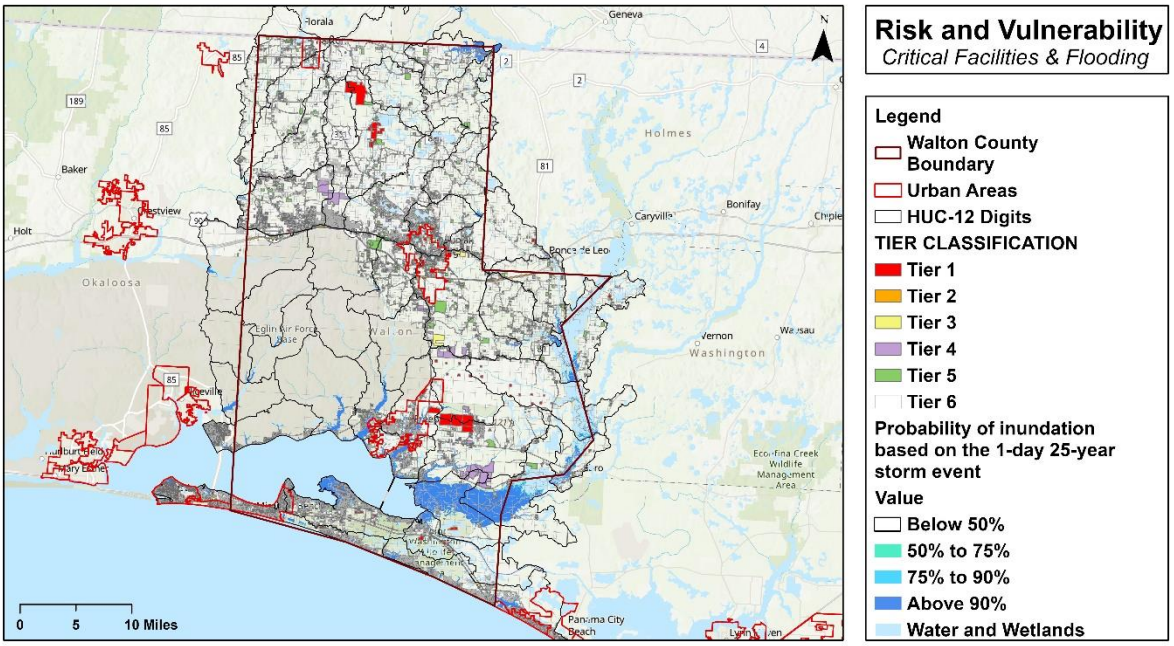

Figure 10. Critical Facilities of Walton County for the 1-day, 25-year flood event

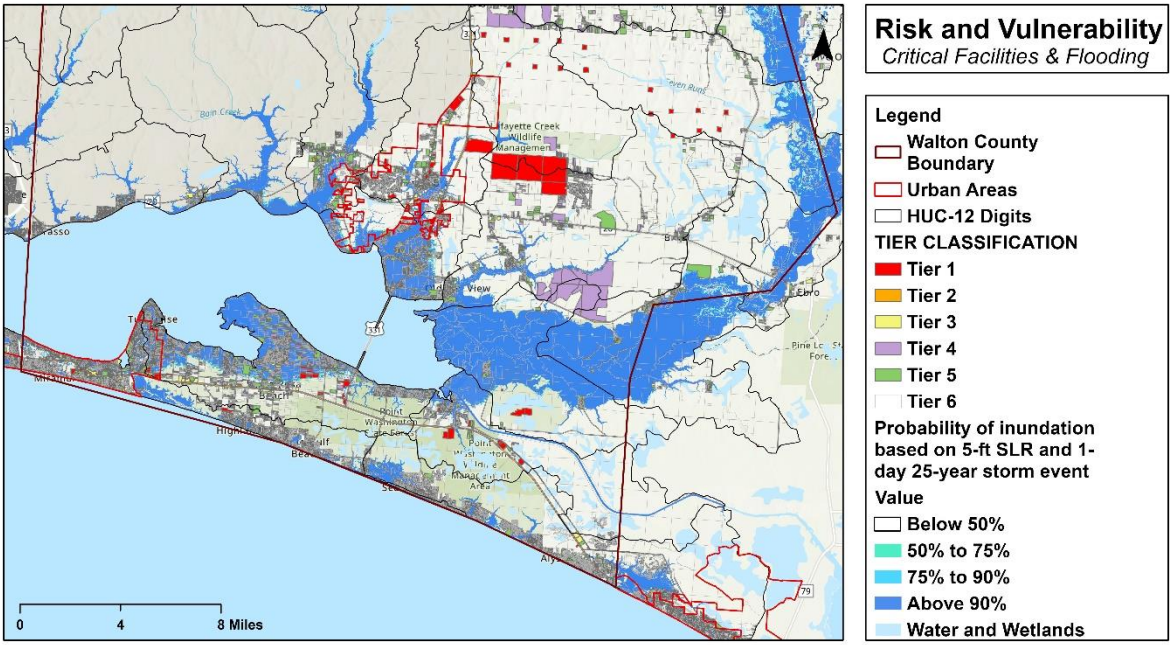

Figure 11. Critical Facilities of Walton County for the 1-day, 25-year flood event with 5 ft SLR