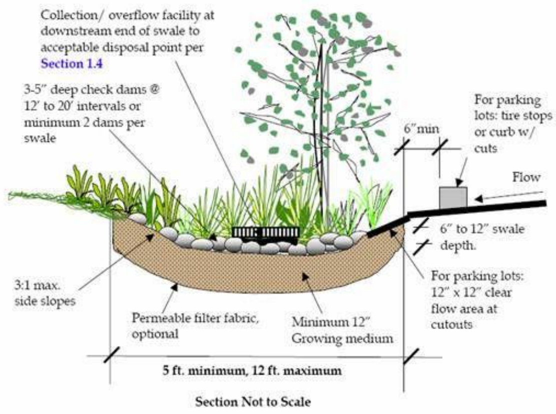
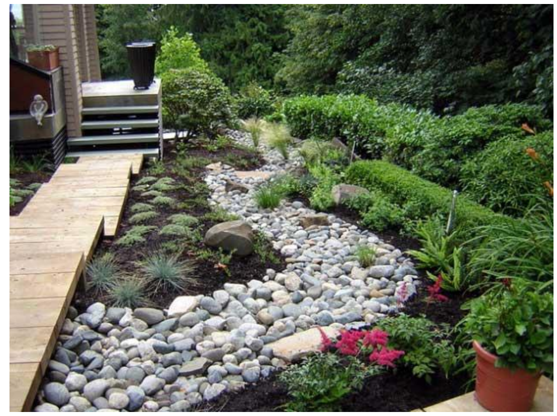
5.5 Enhanced Shallow Swales





The enhanced shallow swale is geared more towards water quality versus water quantity. This approach is similar to methods employed for traditional stormwater management with one distinct difference. Instead of moving stormwater away form a site as fast as possible, this approach allows vegetative cells to fill to a predetermined height before the water is released to the next cell through a berm or weir. The area is typically planted with vegetation that varies in height to emulate a natural succession of variation among long grasses, plants that reach mid-height, and river stones dispersed throughout deeper rooted vegetation that can withstand flowing water and durations of complete submergence. Refer to **Appendix A** for plant recommendations. Enhanced shallow swales can be designed as dry swales or wet swales; existing soil conditions and the depth to the SHGW determine the design type that is best suited for your location. Wet swales exhibit a higher nutrient removal compared to dry swales.

important **The native soil at the bottom of the swale should not be compacted in any way; this will reduce the ability of the water to drain from the swale.**

Advantages:

This LID SWMF approach can be used on a wide variety of soils. If the soils on your property are permeable and drain quickly (HSG A or B) then you can construct a dry swale design; on the other hand, if the soil on your property has low permeability and drains slowly (HSG C or D) than you should construct a wet swale. The only difference between the two options will be the type of plants and the recovery time.

Advantages to this LID SWMF approach includes the ability to enhance the visual aesthetics of your property, bridging the gap between the natural environment and hardscape. It also reduces the heat island effect that accompanies pavement. The swales can be designed to take on any shape that the property owner desires. If the shape of the LID SWMF is irregular, it will slow stormwater significantly thereby reducing erosion and siltation of nearby streams, lakes, and estuaries. It also offers a small buffer to on-site flood control for localized rain events and is generally less expensive than installing curb and gutter.

Limitations:

- This approach is limited to generally flat areas.
- Enhanced swales are not intended to mitigate large flooding events, therefore it is recommended to use an additional LID SWMF geared for high storage capacities in tandem with this approach.
- Wet swales have the potential to create habitat for mosquitoes and snakes.

Design Considerations:

- An important aspect to this LID SWMF approach is to identify the characteristics of the native soil, such as organic content, and pH. These characteristics will assist you in identifying plants that thrive in the existing conditions.
- The first consideration is the amount of area that is available to dedicate to the swale.
- Enhanced swales require a large amount of land, typically 10% to 20% of the contributing impervious area. This application is great for drainage areas up to five acres.
- The side slope of the enhanced swale shall be no steeper than 3H: 1V with 4H: 1V being optimal. Maintaining the recommended slope will provide pretreatment of lateral sheet flow entering the swale from the sides.
- The optimal bottom width for dry and wet swales is between 2 to 8 feet depending on site conditions.
- Provide a landscape plan and method of irrigation to establish the proposed plants.
- To reduce maintenance intervals caused by sedimentation, a small sediment trap should be installed prior to the inlet leading to the swale and or vegetated strip.
- Native plants to this region are the best bet for any type of LID SWMF; they have a significant chance of establishing a healthy root system and can tolerate the climate. In addition, they will require less irrigation and less maintenance.
- The elevation difference between the inflow and the outflow of a dry swale should be 3 to 5 feet.
- If the optimal elevation difference cannot be achieved and steeper slopes are necessary, installation of 6 to 12 inch drop structure every 50 feet is recommended. Berms or weirs should be installed in order to establish multiple cells along the swale; this will allow you to increase the storage volume.
- The water traveling along the swale should remain relatively tranquil in order to prevent extreme erosion and scour. Energy dissipators such as riprap or river rock can be used to reduce the hydraulic energy and should be installed at all outlets to reduce the occurrence of erosion and washouts.

Dry swale only:

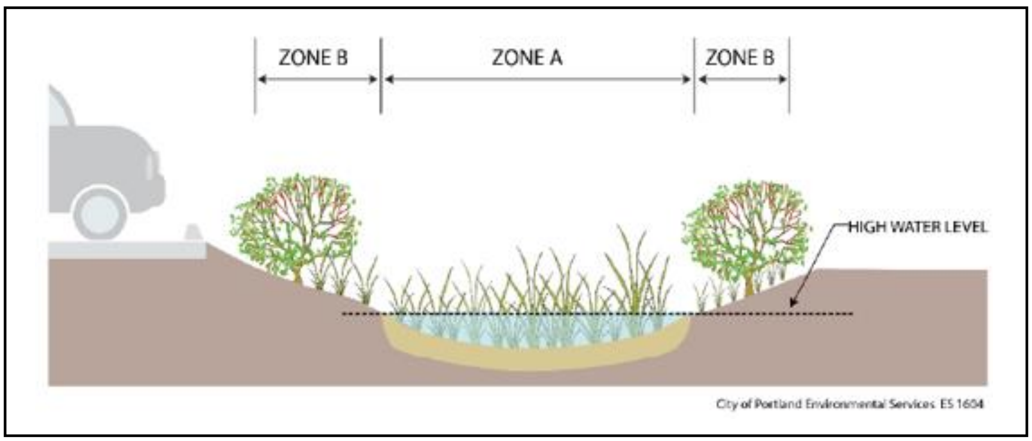
- Dry enhanced swales are constructed by excavating the area to a depth of approximately 3.5 feet below the ground surface.
- The depth of water near the outflow should not exceed 18 inches in order to provide adequate filtration.

Wet swale only:

- A wet swale should have an elevation difference of 1 foot between the inflow and the outflow. This will ensure that the water entering the swale does not become stagnant and is filtered by the plants as it travels through the system.
- Wet enhanced swales are conducive to areas where the water table is close to the ground surface.
- In wet swale applications, cells are established to allow for retention and over flow as necessary. The depth of water contained in a wet enhanced swale should not exceed 18 inches.

Different species of plants have inundation tolerances, the areas are divided into zones for simplicity. Refer to **Appendix A** for plant recommendations.

- **Zone A** is the area of the swale that will hold the most water; therefore the plants will need to be tolerant to excess water during the rainy season (typically June through September). They will also need to be tolerant of dry conditions during the times of limited rainfall if it is a dry swale.
- **Zone B** is the area along the slopes of the swale, plants in this region will need to be able to establish robust root systems in order to maintain the design slope and be able to withstand lateral sheet flow during extreme rain events. They will also need to be able to survive extended periods of dry conditions with smaller periods of inundation.
- **Zone C** is the area along the swale identified as the vegetative strip, this area is a pretreatment application to catch sediment and slow down sheet flow. The plants in this area will need to be able to withstand dry conditions.



Design Steps:

11. First determine the storage volume, soil conditions, depth to the SHGW, and the natural slope of the property at your location using the method described in **Section 2** and **Section 3**, this will assist in choosing the optimal location for the LID SWMF.

12. Determine the required storage volume using the approach presented in **Section 3**, for this example we will use 421 ft^3 as the storage requirement.

In order to get a representative volume for the capacity of the swale you will need to take into account the average porosity of the filter media (vegetation and soil), for this we will use 0.4 (40%). Porosity is the ratio of void volume to total volume, in other words it relates to the amount of water that can be stored between the voids in the soil. The swale will have vegetation distributed throughout, therefore you will need to increase the total volume by 60% (0.6) to accommodate the extra soil and vegetation.

Required Volume of Stormwater to Be Retained (ft^3)	***Space Allotted for Filter Media (%)***	***Required Volume of Stormwater to Be Retained (ft^3) / Porosity of Soil***	***Total Required Volume (ft^3)***
421 ft^3	*60 %*	$\frac{421\ ft^3}{0.4}$	*= 1,053 ft^3*

13. Determine the total required volume associated with the filter media.

Total Required Volume - Required Water Volume = Filter Media Volume (ft^3)	***Depth of Swale (in)***
1,053 ft^3 - 421 ft^3 = 632 ft^3	*18 in*

14. Determine the swale dimensions using the criteria previously mentioned in Design Considerations presented in this section. For this example, we will use the following dimensions: depth 18 inches, bottom width 4 feet, side slopes 4H:1V. Using this data, we will determine the required length.

Convert Design Depth From Inches to Feet
$18\ in * \frac{1\ ft}{12\ in} = 1.5\ ft$

Determine the Horizontal Length When the Water Depth is 1.5 ft Deep	***Solve for x To Determine Horizontal Length Associated With 1.5 ft Depth***	
Side Slopes		
$\frac{Horizontal}{Vertical} \quad \frac{4\ ft}{1\ ft} = \frac{x}{1.5\ ft}$	*x = 4*1.5*	*x = 6 ft*

Calculate the Area of The Swale		***Area of Swale (ft^2)***
Center Area	***Both Side Areas Combined***	
*1.5 ft * 4 ft = 6 ft^2*	*1.5 ft * 6 ft = 9 ft^2*	*6 ft^2 + 9 ft^2 = 15 ft^2*

Calculate the Required Length (ft)	
$\frac{1,053\ ft^3}{15\ ft^2}$	= 71 ft

From this, we can see that we need to install an enhanced swale that is 71 feet long, or if the property naturally drains in two separate directions, than you could install two swales that are 36 feet long. Another option would be to use multiple LID SWMF to meet the storage criteria.

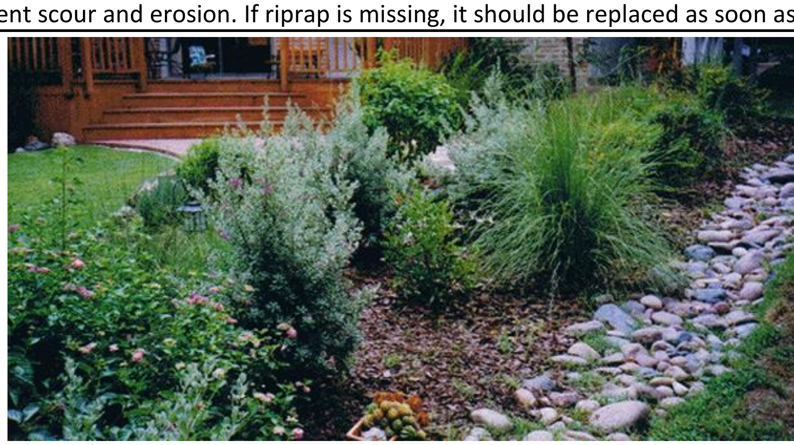
15. Next, determine the recovery time.

Recovery Time	Depth of LID SWMF (in) / 0.5*Permeability (in/hr)	= Hours
Recovery Time For Sandy Soils (Dry Swale with Well-Drained Soil)	$\frac{18\ in}{0.5 * 20\ (in/hr)}$	= 1.8 hr
Recovery Time For Clay Soils (Wet Swale with Poorly Drained Soils)	$\frac{18\ in}{0.5 * 0.6\ (in/hr)}$	= 60 hr

Refer to Calculation Sheet 5.5 included at the end of this section for assistance in designing an enhanced shallow swale.

Operation and Maintenance:

Maintenance for this type of approach is generally very low but will vary depending on the type of enhanced swale you are able to construct. In both cases, periodic removal of sediment will be required in order to maintain the design capacity of the system. Dry swales will require mowing or pruning. All clippings will need to be removed from the swale in order to maintain the design capacity. Visual inspections will include walking the perimeter and looking for signs of erosion or ponding (if it is a dry swale). Ponding in a dry swale is an indication that the system may be full of sediment or has failed in some way. Vegetation will need to be inspected in both dry and wet swales; dead or dying plants should be replaced. Riprap will need to be inspected to ensure it is still located in the correct area to prevent scour and erosion. If riprap is missing, it should be replaced as soon as possible.



https://heinenlandscape.com/the-best-ways-to-deal-with-storm-water/

Maintenance Form 5.5 – Enhanced Shallow Swale:

Enhanced Shallow Swale LID SWMF

Owner: ______________________

Address: ______________________

____

Phone: ______________________

E-mail: ______________________

Parcel Number: ______________________

____

Date of Last Inspection:

- Please attach pictures

List any additional LID SWMF on site:

List any previous concerns:

Inspection List	Yes	No
Does water drain freely through the system?	☐	☐
Are there any areas with prolonged standing water?	☐	☐
Is the vegetation thriving?	☐	☐
Are there any areas with stressed or dying plants?	☐	☐
Is there an excess of plant debris in the swale?	☐	☐
Is there a buildup of sediment in the swale?	☐	☐
Is there evidence of erosion?	☐	☐
Is the system over flowing?	☐	☐
Are sediment basins clean and clear from build up?	☐	☐
Is there any apparent erosion in the area?	☐	☐
Has the soil settled?	☐	☐
Has there been any soil compaction within or near the swale?	☐	☐
Last time rip rap was replenished (if applicable).		
Last time sediment was removed from the swale.		

Maintenance Items To be Completed:

By signing this form, I certify that I have inspected this system. ______________________

Owners Signature **Date**

Calculation Sheet 5.5 – Enhanced Shallow Swale Design:

*****Only Enter Information In To The Green Boxes - All Other Boxes Are Automatically Calculated*****

Low Impact Development Calculation Sheet

Owner			Line 1
Address			Line 2
Phone			Line 3
E-mail			Line 4
Parcel Identification Number			Line 5
Total Proposed Disturbed Area		ac	Line 6

Proposed Impervious Area Total

House		ft^2	Line 7
Detached Garage		ft^2	Line 8
Shed		ft^2	Line 9
Driveway		ft^2	Line 10
Patio / Porch / Deck		ft^2	Line 11
Pool		ft^2	Line 12
Misc Description:		ft^2	Line 13

Is Your Property In The Following Locations:

		Yes	No
ICPAL	If "yes" see section 3.4	☐	☐
Dune Lake	If "yes" see section 3.5	☐	☐
Near a Mosquito Control Ditch	If "yes" see section 3.6	☐	☐

Area Totals

Total Impervious Area		ft^2	Line 14
Total Impervious Area (acres)		ac	Line 15

Total Impervious Area (acres) = Total Area (ft^2) * (1 acre/ 43,560 ft^2)

Total Pervious Area		ac	Line 16
Total Pervious Area (ft^2)		ft^2	Line 17

Total Pervious Area (acres) = Total Area (acres) - Total Impervious Area (acres)

Next Determine the Volume Required Per the LDC Section 5.06.00

Total Property (square feet)		ft^2	Line 18

Soils Characteristics

Depth to Seasonal High Groundwater Table		ft below ground surface		Line 19

Predominant Soil Type

Predominant Soil Type				Value Taken From USGS Soils Survey	Line 20
Infiltration	Actual K_{sat}		in/hr	Provided in Table 3	Line 21
Design Infiltration	Design K_{sat}		in/hr		Line 22

Stormwater Volume Requirements

0.5 in Rainfall Over Disturbed Area		ft^3		Line 23
1 in Runoff Over Proposed Impervious Surface		ft^3		Line 24
Attenuation Volume		ft^3	Find Largest Value Between Line 23, 24, and 25 And Enter The Value On Line 26	Line 25
Required Retention Volume		ft^3		Line 26

*****Special Circumstances Only - Verify Your Location****

Section 3.4 Stormwater Volume Requirements for ICPAL

0.5 in Rainfall Over Disturbed Area		ft^3		Line 27
1 in Runoff Over Proposed Impervious Surface		ft^3		Line 28
Attenuation Volume		ft^3	Find Largest Value Between Line 27, 28, and 29 And Enter The Value On Line 30	Line 29
Required Retention Volume		ft^3		Line 30

Section 3.5 Stormwater Volume Requirements for Dune Lake

0.5 in Rainfall Over Disturbed Area		ft^3		Line 31
1 in Runoff Over Proposed Impervious Surface		ft^3		Line 32
Attenuation Volume		ft^3	Find Largest Value Between Line 31, 32, and 33 And Enter The Value On Line 34	Line 33
Required Retention Volume		ft^3		Line 34

Section 3.6 Stormwater Volume Requirements for Mosquito Control Ditch

0.5 in Rainfall Over Disturbed Area	0	ft^3		Line 35
1 in Runoff Over Proposed Impervious Surface	0	ft^3		Line 36
Attenuation Volume	0	ft^3	Find Largest Value Between Line 35, 36, and 37 And Enter The Value On Line 38	Line 37
Required Retention Volume	0	ft^3		Line 38

Table 3. NRCS Soil Data

Map Unit Symbol	Map Unit Name	HSG	SHGW Elevation (SHGW)	High Water Season	Permeability Rate (Ksat)
5	Chipley sand, 5 to 8 % slopes	A	-2 feet	Dec - Apr	6 in/hr
8	Dorovan-Pamlico association, frequently flooded	B/D	0 (at surface)	Jan – Dec	0.6 in/hr
12	Foxworth sand, 0 to 5 percent slopes	A	-3.5 feet	Jun – Oct	20 in/hr
16	Kureb sand, 0 to 8 percent slopes	A	-5 feet	----	6 in/hr
17	Lakeland sand, 0 to 5 percent slopes	A	-5 feet	----	6 in/hr
18	Lakeland sand, 5 to 12 percent slopes	A	-5 feet	----	6 in/hr
19	Lakeland sand, 12 to 30 percent slopes	A	-5 feet	----	6 in/hr
21	Leon sand, 0 to 2 percent slopes	A/D	0 (at surface)	Jun – Feb	0.6 in/hr
27	Rutlege fine sand, 0 to 2 percent slopes	A/D	0 (at surface)	Dec – May	6 in/hr
30	Tifton fine sandy loam, 5 to 8 percent slopes	B	-3.5 feet	Jan – Feb	0.6 in/hr
36	Pits	-	On-site test	On-site test	On-site test
45	Dirego muck, frequently flooded	A/D	0 (at surface)	Jan – Dec	6 in/hr
49	Eglin sand, 0 to 5 percent slopes	A	-5 feet	----	6 in/hr
50	Mandarin sand, 0 to 2 percent slopes	A	-1.5 feet	Jun – Dec	0.6 in/hr
51	Bigbee loamy sand, 0 to 5 percent slopes, occasionally flooded	A	-3.5 feet	Jan – Mar	6 in/hr
53	Arents, 2 to 8 percent slopes	A	-5 feet	----	20 in/hr
54	Newhan-Corolla sands, rolling	A	-5 feet	----	20 in/hr
55	Beaches	-	0 (at surface)	----	0 in/hr
56	Kureb sand, hilly	A	-5 feet	----	6 in/hr
57	Hurricane sand, 0 to 5 percent slopes	A/D	-2 feet	Nov – Apr	6 in/hr
58	Duckston muck, frequently flooded	A/D	0 (at surface)	Jan – Dec	6 in/hr
62	Resota sand, 0 to 5 percent slopes	A	-3.5 feet	Dec – Apr	20 in/hr
63	Pickney sand, depressional	A/D	0 (at surface)	Nov – Apr	6 in/hr
64	Pamlico muck	A/D	0 (at surface)	Dec – May	0.6 in/hr
69	Florala loamy fine sand, 2 to 5 percent slopes	C	-1.5 feet	Dec – Mar	0.06 in/hr
99	Water	-	-	-	-
100	Waters of Gulf of Mexico	-	-	-	-

Site Characteristics

Total Disturbed Area		ft^2	Line 1
Impervious Area		ft^2	Line 2
Impervious Surface Ratio (ISR)			Line 3

Soil Characteristics

Soil Type - Refer to Section 2.4			Line 4
Rainfall Intensity	0.43	in/hr	Line 5
Infiltration Rate - Refer to Table 3		in/hr	Line 6
Design Infiltration Rate (Divide By 2)		in/hr	Line 7
Rainfall Depth	8.73	in	Line 8
Reduced Rainfall Depth		in	Line 9

Attenuation Calculation

Design Factor - Choose One Based On The ISR Calculated In Line 3			Line 10
ISR Less Than 0.4	1		
ISR Between 0.4 and 0.7	1.2		
ISR Greater Than 0.7	1.4		
Design Rainfall Depth		in	Line 11
Design Rainfall Depth (Conversion)		ft	Line 12
Required Storage Volume		ft^3	Line 13

Site Characteristics

Total Disturbed Area		ft^2	Line 1
Impervious Area		ft^2	Line 2
Impervious Surface Ratio (ISR)			Line 3

Soil Characteristics

Soil Type - Refer to Section 2.4			Line 4
Rainfall Intensity	0.61	in/hr	Line 5
Infiltration Rate - Refer to Table 3		in/hr	Line 6
Design Infiltration Rate (Divide By 2)		in/hr	Line 7
Rainfall Depth	14.7	in	Line 8
Reduced Rainfall Depth		in	Line 9

Attenuation Calculation

Design Factor - Choose One Based On The ISR Calculated In Line 3			Line 10
ISR Less Than 0.4	1		
ISR Between 0.4 and 0.7	1.2		
ISR Greater Than 0.7	1.4		
Design Rainfall Depth		in	Line 11
Design Rainfall Depth (Conversion)		ft	Line 12
Required Storage Volume		ft^3	Line 13

Only Enter Information In To The Green Boxes - All Other Boxes Are Automatically Calculated

Site Characteristics

Total Disturbed Area		ft^2	Line 1
Depth To SHGW		ft	Line 2
Infiltration		in/hr	Line 3

Treatment Volumes

Design Volume (largest value fron Site Characteristics sheet)		ft^3	Line 4

Enhanced Shallow Swale Design - Single LID Application

Additional Volume Requirement			ft^3	Line 5
Total Required Volume of Swale			ft^3	Line 6
Depth of Swale			in	Line 7
			ft	Line 8
Bottom Width of Swale			ft	Line 9
Required Area			ft^2	Line 10
Slope	Horizontal		ft	Line 11
	Vertical		ft	Line 12
	Design Horizontal		ft	Line 13
	Area in the Center		ft^2	Line 14
	Area of Both Sides		ft^2	Line 15
	Total Area		ft^2	Line 16
Required Bottom Length of Enhanced Swale			ft	Line 17
Recovery Time			hr	Line 18

Enhanced Shallow Swale Construction Layout

Top Width		ft
Top Length		ft
Bottom Width		ft
Bottom Length		ft

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