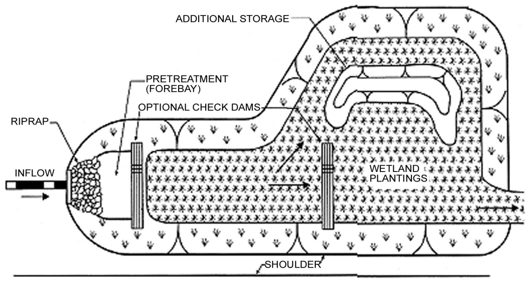
Constructed Wetlands

Wet Swales



Description

The wet swale, also called a grassed open channel consists of a broad open channel capable of temporarily storing water. Unlike the dry swale, a wet swale does not have an underlying filtering bed. The wet swale is constructed directly within existing soils and may or may not intersect the water table. Similar to the dry swale, water quality storage should be approximately 24 hours. The wet swale has water quality treatment mechanisms similar to stormwater wetlands, which rely primarily on settling of suspended solids, adsorption, and microbial breakdown of pollutants. Wet swales reduce the flow velocity of storm water runoff and may promote infiltration.

Wet swales are similar to stormwater wetlands in their use of vegetation to treat stormwater runoff. Wet swales can serve as part of a stormwater drainage system and can replace curbs, gutters and storm sewer systems.

The feasibility of installing a wet swale at a particular site depends on the area and slope of the contributing watershed, as well as dimensions of the areas in which the swale system is to be installed. Wetland vegetation can be planted or allowed to naturally colonize these systems. Wet swales are designed to retain the water quality volume for 24 hours. Vegetated swales are easy to design and can be incorporated into a site drainage plan.

A wet swale occurs when the water table is located very close to the surface. As a result, swale soils often become fully saturated, or have standing water all or part of the year after the channel has been excavated. This "wet swale" essentially acts as a very long and linear shallow wetland treatment system. Like the dry swale, the entire water quality treatment volume is stored and retained within a series of cells in the channel, formed by berms or checkdams.

In some cases, the cells may be planted with emergent wetland plant species to improve removal rates. Existing perennial vegetation adjacent

Purpose

Water Quantity	
Flow attenuation	■
Runoff volume reduction	■
Water Quality	
Pollution prevention	
Soil erosion	◧
Sediment control	■
Nutrient loading	◧
Pollutant removal	
Total suspended sediment (TSS)	■
Total phosphorus (P)	◧
Nitrogen (N)	◧
Heavy metals	◧
Floatables	□
Oil and grease	□
Other	
Fecal coliform	◧
Biochemical oxygen demand (BOD)	◧

■	Primary design benefit
◧	Secondary design benefit
□	Little or no design benefit

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to receiving waters of interest may provide wildlife benefits, but not significant pollutant-reduction benefits, depending on ground cover and runoff type. However, wet swale design should consider preserving natural areas.

Wet swales are typically located along property boundaries along a natural grade, although they can be used effectively wherever the site provides adequate space. The water quality volume (WQv) for high density residential, commercial and industrial land uses will most likely be too great to be accommodated with most swale designs. However, swales may be appropriate for pretreatment in association with other practices for these higher density land uses.

The difference between water quality swales and drainage channels is in the design and planned use of the open channel conveyance. Wet swales are designed primarily for the prescribed stormwater water quality volume and have incorporated specific features to enhance their stormwater pollutant removal effectiveness. Pollutant removal rates are significantly higher for wet swales than for drainage channels.

Advantages

- Control peak discharges by reducing runoff velocity and promoting infiltration.
- Provide effective pretreatment for BMPs in series by trapping, filtering and infiltrating pollutants.
- Accent natural landscape.
- Reduce peak flows.
- Increase pollutant removal efficiency.
- Promote runoff infiltration.
- Offer lower capital costs than traditional storm sewer system.
- Convey water in properly protected channels.
- Divert water around potential pollutant sources..
- Provide water quality treatment by sedimentation and biological uptake.
- Enhance biological diversity and create beneficial habitat between upland and surface waters.

Limitations

- Impractical in areas with very flat grades, steep topography, or wet or poorly drained soils.
- May erode when flow volumes and/or velocities are high during storm events.
- Area requirements can be excessive for highly developed sites.
- Roadside swales become less feasible as the number of driveway entrances requiring culverts increases.

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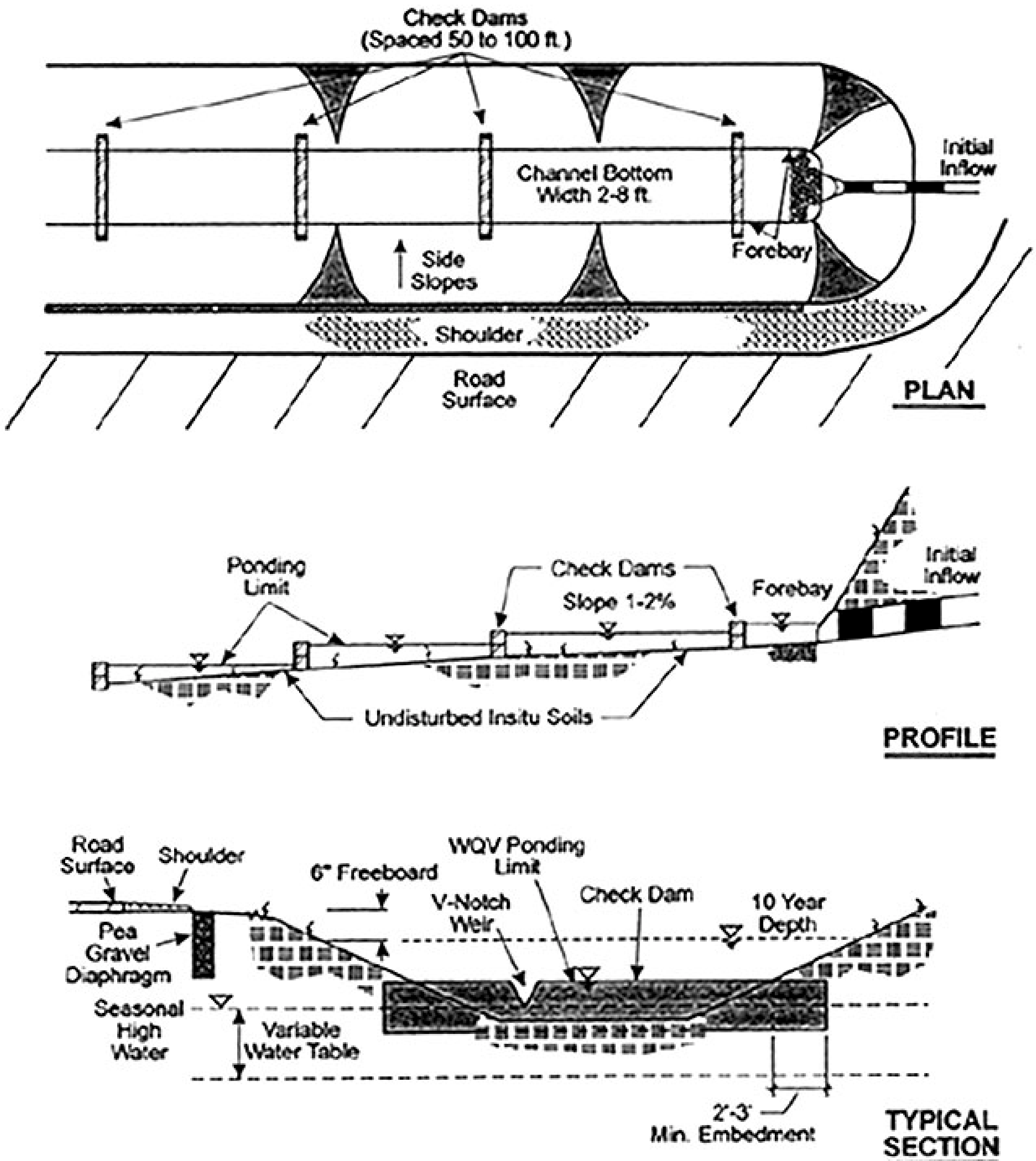

Figure 1. Wet Swale
Source: Center for Watershed Protection 1999

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Wet Swales

Design Requirements

The design approach for sizing wet swales is based on temporarily storing the Water Quality Volume (WQv) within a shallow linear ponding area. This methodology incorporates a **volume-based** sizing criteria for the WQv, and a rate based criteria for checking the erosive potential for the two-year frequency storm and capacity for the ten-year frequency storm (See Figure 1).

The following design specifications are summarized in Table 1.

Shape and Slopes

- The swales should generally be **trapezoidal in shape,** although a parabolic shape is also acceptable (provided the width is equal to or greater than, the design bottom width for a trapezoidal cross section). The criteria presented in this section assumes a trapezoidal cross section.
- For the trapezoidal cross section, size the **bottom width** between two and eight feet. The two feet minimum allows for construction considerations and ensures a minimum filtering surface for water quality treatment. The eight feet maximum reduces the likelihood of flow channelization within a portion of the bottom of the swale. Widths up to 16 feet may be used if separated by a dividing berm or structure to avoid braiding.
- The **side slopes** of the channel should be no steeper than 3:1 for maintenance and safety considerations. Flatter slopes are encouraged where adequate space is available to aid in providing pretreatment for lateral flows. Steeper maximum side slopes for the wet swales are permitted because these practices are designed to retain a storage volume versus being designed for a minimum residence time.
- The **longitudinal slope** of the swale should be moderately flat to permit the temporary ponding of the WQv within the channel without having excessively deep water at the downstream end. A slope between 1.0 percent and 2.0 percent is recommended. When natural topography necessitates, steeper slopes may be acceptable if check

Parameter	*Swale Design Criteria*
Pretreatment volume	.05" per impervious acre, at initial inflow point.
Preferred shape	Trapezoidal or parabolic.
Bottom width	2 feet minimum, 8 feet maximum widths up to 16 feet are allowable if a dividing berm or structure is used.
Side slopes	2:1 maximum, 3:1, or flatter preferred.
Longitudinal slope	1.0% to 2.0% without, check dams.
Sizing criteria	Length, width, depth, and slope needed to provide surface storage for WQV. Outlet structures sized to release WQV over 24 hours.
Underlying soil bed	Equal to swale width Dry Swale: Moderately permeable soils (USCS ML, SM, or SC) 30" deep with gravel/pipe underdrain system Wet Swale: Undisturbed soils, No underdrain system
Depth and capacity	▸ Surface storage of WQV with a maximum ▸ depth of 18 inches for water quality treatment (12" average depth). ▸ Safely convey 2 year storm with non-erosive velocity (≤ 4.0 to 5.0 ft/s) ▸ Adequate capacity for 10 year storm with 6" of freeboard

Table 1. Design Summary for Wet Swales
Source: Center for Watershed Protection 1999

dams (vertical drops of 6 to 12 inches) are used. These structures will require additional energy dissipating measures and should be placed no closer than 50 to 100 feet intervals.

Design Size and Soils

- The detention/retention capacity of wet swales is governed by the runoff associated with the "water quality storm." The swale length, width, depth and slope should be designed to temporarily accommodate the WQv through surface ponding. The WQv is retained for 24 hours, but ponding may continue indefinitely depending on the depth and elevation to the water table. The WQv for high density residential, commercial and industrial land uses will most likely be too great to be accommodated with most swale designs. However, swales may be appropriate for pretreatment in association with other practices for these higher density land uses (See Figures 2 and 3).

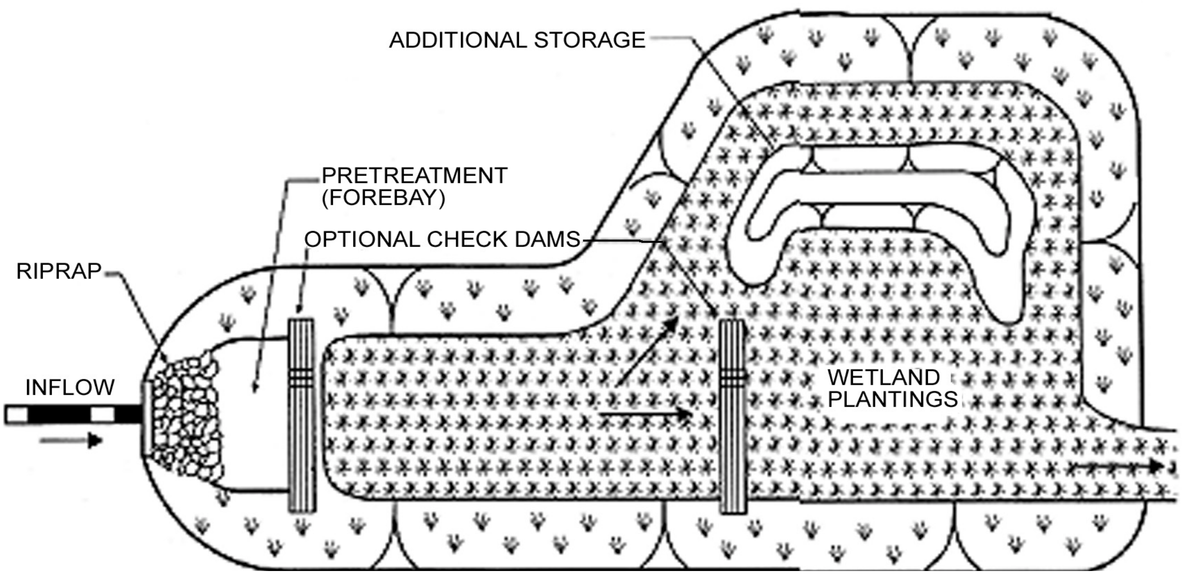

Figure 2. Wet Swale

- Design swales to provide a shallow ponding depth for the WQv (a maximum depth of 18 inches for the WQv is recommended), safely convey the 2 year storm with design velocities less than 4.0 fps, and provide adequate capacity for the 10 year storm with a minimum of 6 inches of freeboard.
- See that the soil bed below the wet swale consists of undisturbed soils. This area may be periodically inundated and remain wet for long periods of time.
- Do not construct wet swales in gravelly and coarse sandy soils that cannot easily support dense vegetations.
- In areas with steep slopes, employ vegetated swales in locations where they can be parallel to the contours.
- Size channels to convey 10-year storm volumes and design channel slopes to prevent erosion during 2-year storm events.

Requirements

Design (continued)

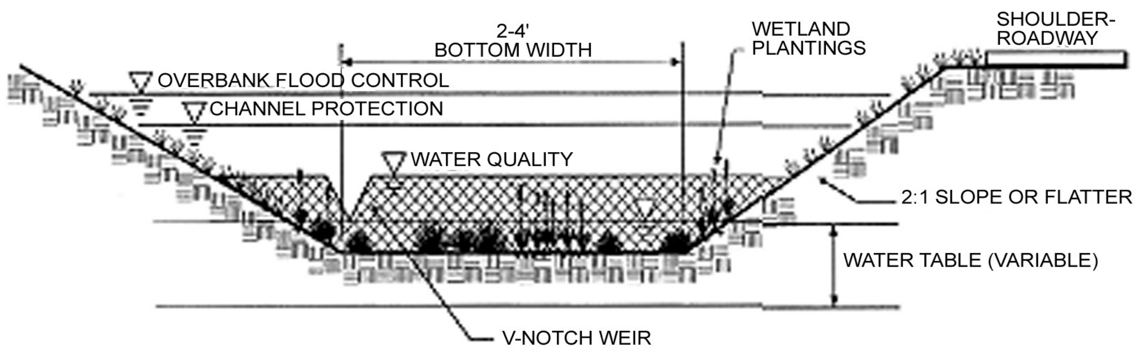

Figure 3. Wet Swale Cross Section
Source: Center for Watershed Protection. 2001

- Use outlet protection at any discharge point from water quality swales to prevent scour at the outlet.
- Provide minimum freeboard above 10 year storm water surface profile (6 inches minimum or as required by local ordinance).
- Specify vegetation required to meet design condition.
- Identify the swale bottom, width, depth, length, and slope necessary to store the WQv within a shallow ponding depth (approximate maximum depth of 18 inches).
- Compute the 2-year and 10-year frequency storm event peak discharges.
- Check the 10-year velocity for erosive potential (adjust swale geometry, if necessary and reevaluate WQv design parameters).
- Provide pretreatment to protect the filtering and infiltration capacity of the swale bed. Pretreatment can occur in a sediment forebay behind a checkdam with a pipe inlet.
- Use check dams in wet swales to achieve multiple cells. V-notched weirs in the check dams can be utilized to direct low flow volumes.
- Plant emergent vegetation or spread wetland soils on swale bottom for seed stock.
- Design wet swales with parabolic or trapezoidal cross-sections, and with side slopes no greater than 3:1 (horizontal:vertical) and bottom widths ranging from 2 to 8 feet.
- Specify grasses resistant to periodic inundation and periodic drought.
- Check permissible velocities of selected vegetation to ensure the 2-year frequency storm velocity is non-erosive.
- Compute the WQv drawdown time to ensure that it is less than 24 hours.

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Vegetative Cover

- Species selection will depend upon the duration of water inundation, soil type and amount of light.
- Desirable vegetative characteristics include species that form a dense sod with vigorous, upright growth. Species that have tendencies to mat down should not be used when sediment filtering is a desired outcome.
- Appropriate soil stabilization methods, such as mulch, blankets or mats should be used before establishment of vegetation. Seeding, sodding and other items related to establishing vegetation should be in accordance with accepted erosion-control and planting practices. (See Erosion Control BMP section.)

Construction

- Avoid soil compaction.
- Provide a bypass for high flows if the swale cannot be stable for the 10-year storm. The swale should adequately handle the 2-year storm at a minimum.

Maintenance

- Inspect wet swales on a semiannual basis for the first year, and after major storm events.
- The initial inflow forebay should be inspected annually for sediment buildup. Any excessive sediment, trash, and debris should be removed and disposed of in an appropriate location.
- The grass vegetation along the side slopes should be inspected for erosion rills or gullies, and corrected as needed. Bare areas should be seeded or sodded as necessary.
- Mowing may be necessary.

Annually or Semiannually

- Inspect swale several times the first few months to ensure grass cover is establishing well. If not, reseed or plant an alternative species. Once established, continue to inspect semiannually for erosion problems.
- At least annually inspect pea gravel diaphragm for clogging from excess sediment; remove sediment and correct associated problems.
- Remove trash and debris accumulated in the swale.

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Sources

1. Center for Watershed Protection. 1999. *Design for Stormwater Filtering Systems*. Ellicott City, MD.
2. Center for Watershed Protection. 2001. "Grass Channel" fact sheet in *Stormwater Manager's Resource Center.* www.stormwatercenter.net. Ellicott City, MD.
3. Center for Watershed Protection. 1996. "Ditches or Biological Filters? Classifying the Pollutant Removal Performance of Open Channels "in *Watershed Protection Techniques* Vol. 2, No. 2. Ellicott City, MD.
4. Environmental Protection Agency. 1999. "Vegetated Swales" Storm Water Technology Fact Sheet, Office of Water, Washington, D.C.
5. Massachusetts Department of Environmental Protection. 1997. *Stormwater Management Volume Two: Stormwater Technical Handbook.* Boston, MA.
6. Metropolitan Washington Council of Governments. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs.* Washington, D.C.
7. Minnesota Pollution Control Agency. 2000. *Protecting Water Quality in Urban Areas: Best Management Practices for Dealing with Storm Water Runoff from Urban, Suburban and Developing Areas of Minnesota.* Minneapolis.
8. North Carolina University, Department of Environment and Natural Resources. 1999. *Stormwater Best Management Practices.* Raleigh-Durham, NC.