Bowling Green, Kentucky
Stormwater Best Management Practices (BMPs)
Stormwater Pollution Treatment Practices (Structural)

PTP-02

Activity: Open Channel Systems

PLANNING CONSIDERATIONS:

Design Life: Life

Acreage Needed: High

Estimated Unit Cost: Moderate

Annual Maintenance: Low

Target Pollutants; Pollutant Removal

Total Suspended Solids (TSS); 75% (Wet Swale), 90% (Dry Swale)
Nutrients – Total Phosphorous/Total Nitrogen; 50/50%
Metals – Cadmium, Copper, Lead, and Zinc; 50%
Pathogens – Coliform, Streptococci, E.Coli; 40%

Description

Open channel systems are vegetated swales that are designed to capture, treat, and release stormwater runoff. Open channel systems consist of treatment via dry or wet cells created through the installation of check dams or berms. Wet swales (shown above) and dry swales are two types of open channel systems. Dry swales typically utilize a permeable soil layer, and wet swales typically have wetland plants. Open channel systems treat stormwater while also acting as a stormwater runoff conveyance system. They incorporate water quality features that typical drainage channels do not offer. Installation costs are less expensive than a curb and gutter system, although maintenance costs are typically higher.

Open channel systems must be designed with limited longitudinal slopes to reduce runoff velocities and allow particulates to settle. Berms or check dams placed perpendicular to the flow path also aid in reducing velocities and promoting infiltration.

Inlets to open channel systems can be enhanced through the use of the following options:

- Riprap or other energy dissipaters
- Pretreatment through a sediment forebay
- Flow spreader for situations of direct and concentrated flow

Outlet structures for open channel systems should discharge into the storm drainage system or a stable outfall. For wet swales, outlet protection should be used to prevent scour and downstream erosion.

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Suitable Applications

Open channel systems are designed to manage stormwater runoff in water quality situations, with the limited ability to provide benefits of channel protection. Open channel systems are typically suitable in the following applications:

- Residential subdivisions of low to moderate density (dry swales)
- Small impervious area in the contributing drainage area
- Along roads and highways (off right-of-way)
- Adjacent to parking lots
- Small drainage areas (less than 5 acres)
- Landscaped commercial areas (wet swales)

Approach

- Wet Swales

A wet swale is constructed as an open conveyance channel excavated to the water table, or alternatively, to poorly drained soils. Check dams can be utilized to construct pooling areas, which imitate small shallow marshes.

- Dry Swales

Dry swales also allow open conveyance and incorporate a filter bed of permeable soils paired with an underdrain system. Flow is directed to the main channel of the swale, where filtration occurs through the filter bed layer. Runoff is thereafter conveyed through the gravel and perforated pipe of the underdrain system.

Installation Procedures

- Longitudinal slopes should be less than 4%, with a 1-2% slope recommended.
- Bottom width should be approximately 2 to 8 feet.
- Side slopes should be 3:1 (H:V) or less, where 4:1 (H:V) is recommended.
- Design should convey the 25-year storm event with a minimum of 6 inches of freeboard.
- Geotextile fabric should be placed around underdrain.

Maintenance

Adequate access should be provided to allow for inspection and maintenance.

- Grass heights should be maintained at heights of approximately 4 to 6 inches for dry swales
- Sediment should be removed from forebay and channel regularly and disposed of properly

Dry Swale

Dry Swale
Source, Stormwater Managers Resource Center, www.stormwatercenter.net

Dry swales are open channel systems that convey stormwater runoff through vegetation and a filter bed. Sizing for dry swales should allow the entire water quality volume to be filtered or infiltrated through the swale, such that there is no standing water between rain events. Dry swales are the preferred option in residential areas.

Dry swales are made up of an open conveyance channel with a filter bed of prepared soil that overlays an underdrain system. Flow is conveyed into the main channel of the swale where it is filtered by the soil bed. Runoff is then collected and passes into a perforated pipe and gravel underdrain system to the outlet.

Design Criteria

- Size to store a water quality volume with less than 18 inches of ponding
- Maximum ponding time is 48 hours, design for 24 hours
- Bed material should be permeable soil at least 30 inches deep, with an infiltration rate of at least 1 foot per day (1.5 feet per day maximum)
- Soil should have a high organic content to allow pollutant removal
- Underdrain should consist of a 4 inch diameter PVC pipe, installed longitudinally in a 6 inch gravel layer
- Permeable filter fabric installed encompassing the stone underdrain
- Channel excavation should not result in soil compaction

See Figures PTP-02-01 and PTP-02-02 for example drawings of a dry swale.

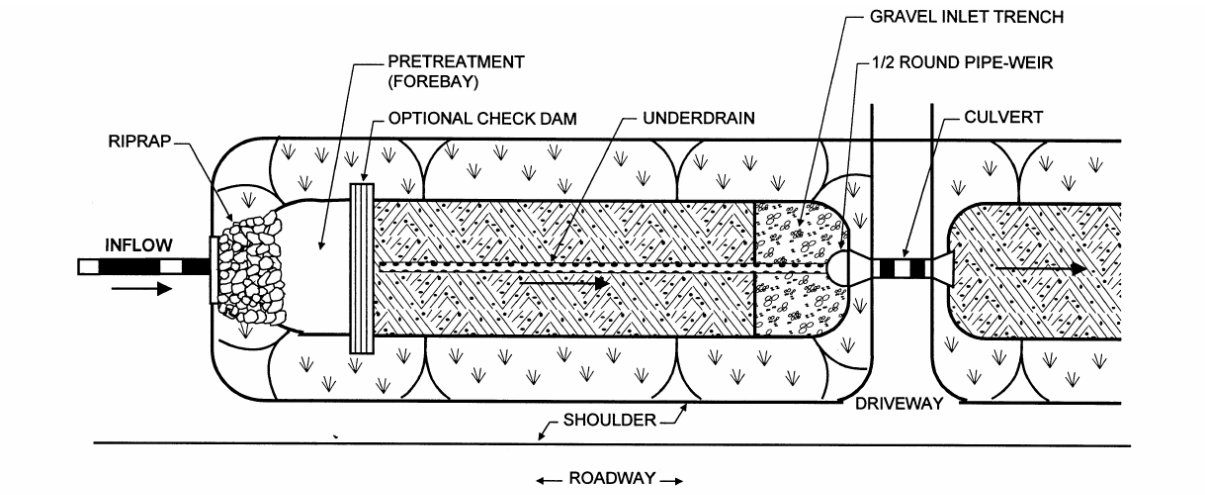

Figure PTP-02-01
Source, Georgia Stormwater Management Manual

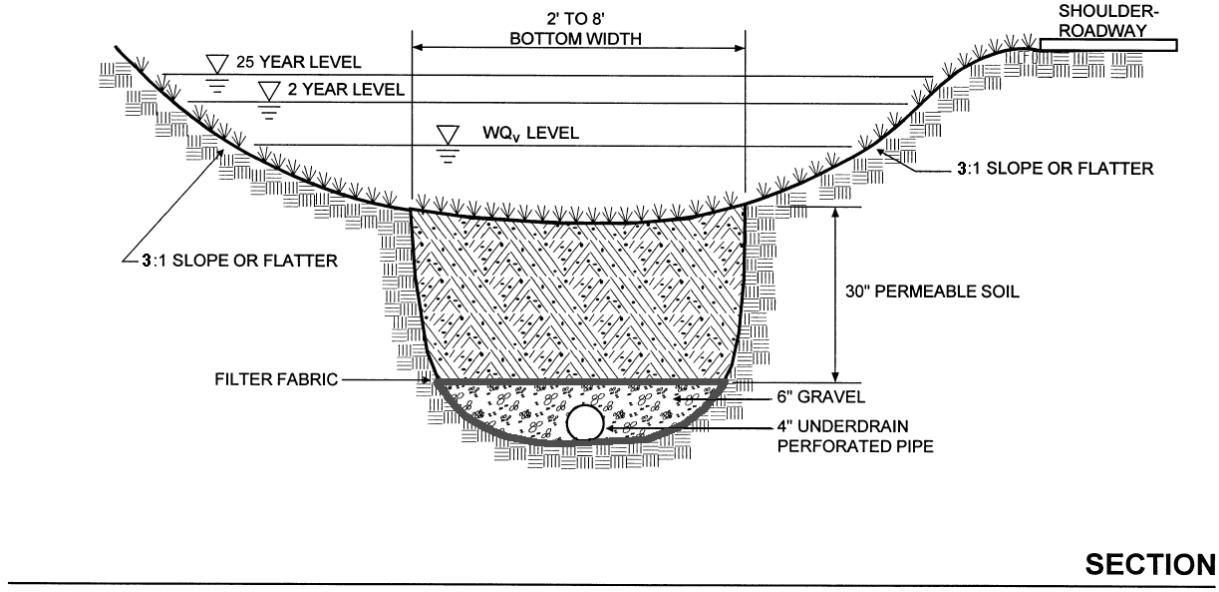

Figure PTP-02-02
Source, Georgia Stormwater Management Manual

Wet Swale

Wet Swale
Source, Stormwater Managers Resource Center, www.stormwatercenter.net

Wet swales are also referred to as wetland channels. Like the dry swale, wet swales are vegetated channels that treat stormwater runoff. They differ in that wet swales are designed to retain water, imitating marshy conditions and supporting wetland vegetation. A high water table or soils that retain water are necessary to retain water in the system. In these regards, a wet swale is much like a wetland, with a shallow and linear design.

Wet swales are constructed by excavating the channel to the water table or to poorly drained soils. Check dames are installed to create wetland "cells". These cells contain the runoff similar to a shallow wetland.

Design Criteria

- Size to store the entire water quality volume with less than 18 inches of ponding at the maximum depth point
- Check dams and wetland plantings should be installed to form wetland cells. Flow direction can be achieved through the use of V-notch weirs in the check dams

See Figures PTP-02-03 and PTP-02-04 for example drawings of a wet swale.

Wet Swale
(cont.)

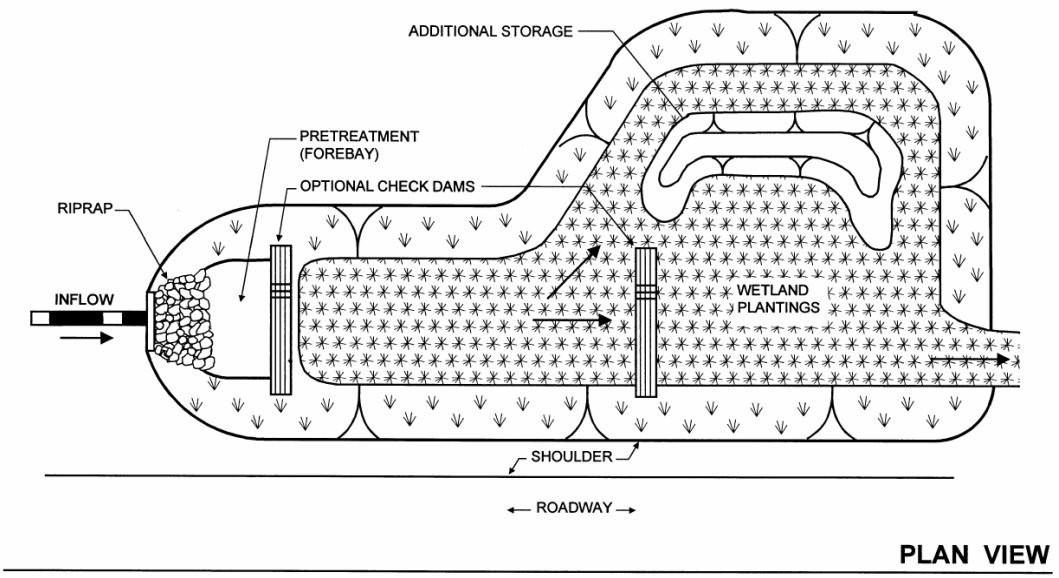

Figure PTP-02-03
Source, Georgia Stormwater Management Manual

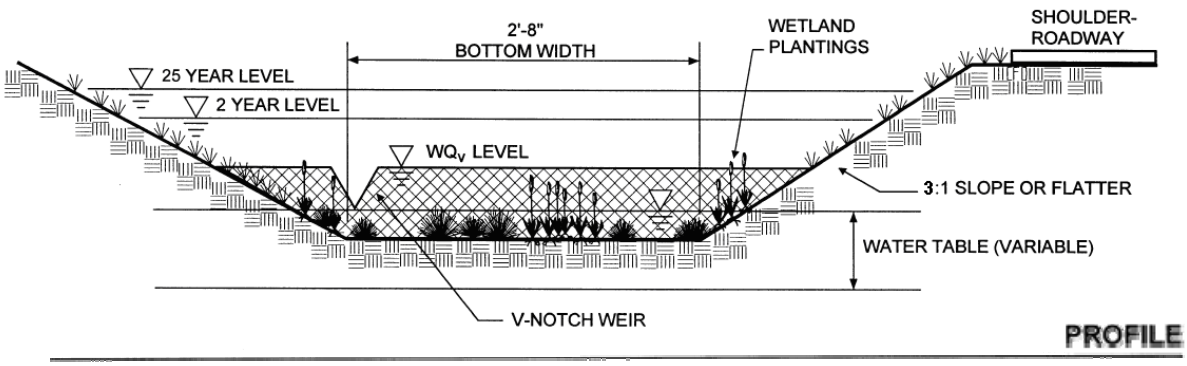

Figure PTP-02-04
Source, Georgia Stormwater Management Manual

Swale Design Procedures

Step 1. Compute runoff control volumes.

Calculate the Water Quality Volume (WQ_v), Channel Protection Volume (Cp_v) Overbank, Flood Protection Volume (Q_p), and Extreme Flood Volume (Q_f). See Section 1.6.

Step 2. Determine if the development site and conditions are appropriate for the use of an enhanced swale system (dry or wet swale).

- Topography?
- % Impervious Area?
- Low to moderate density area?
- Type of development?

Step 3. Confirm local design criteria and applicability.

Consider any special site-specific design conditions/criteria (Additional Site-Specific Design Criteria and Issues). Check with local officials and other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply.

Step 4. Determine pretreatment volume.

The forebay should be sized to contain 0.1 inches per impervious acre of contributing drainage. The forebay storage volume counts toward the total WQ_v requirement, and should be subtracted from the WQ_v for subsequent calculations.

Step 5. Determine swale dimensions

Size bottom width, depth, length, and slope necessary to store WQv with less than 18 inches of ponding at the downstream end.

- Slope cannot exceed 4% (1 to 2% recommended)
- Bottom width should range from 2 to 8 feet
- Ensure that side slopes are no greater than 2:1 (4:1 recommended)

See Design Criteria for more details.

Step 6. Compute number of check dams (or similar structures) required to detain WQ v

Step 7. Calculate draw-down time

Dry swale: Planting soil should pass a maximum rate of 1.5 feet in 24 hours and must completely filter WQ_v within 48 hours.

Wet swale: Must hold the WQ_v.

Swale Design Procedures (cont.)

Step 8. Check 2-year and 25-year velocity erosion potential and freeboard

Check for erosive velocities and modify design as appropriate. Provide 6 inches of freeboard.

Step 9. Design low flow orifice at downstream headwalls and checkdams. Design orifice to pass WQv in 6 hours. Use Orifice equation.

Step 10. Design inlets, sediment forebay(s), and underdrain system (dry swale). See Design Criteria for more details.

Step 11. Prepare Vegetation and Landscaping Plan

A landscaping plan for a dry or wet swale should be prepared to indicate how the enhanced swale system will be stabilized and established with vegetation. The appropriate grass species and wetland plants should be chosen based on the site location, soil type, and hydric conditions.