North Carolina Department of Transportation

FIELD GUIDE FOR POST-CONSTRUCTION STORMWATER BEST MANAGEMENT PRACTICES







NCDOT Highway Stormwater Program

2018 EDITION

BMP TOOLBOX FIELD GUIDE

The purpose of this field guide is to provide contractors, NCDOT inspection technicians, and division staff guidance for construction of best management practices (BMPs). Each section provides an overview of the BMP, common structural components, and critical issues to consider during construction. Comprehensive guidance, criteria, and considerations for design of BMPs are located in the NCDOT STORMWATER BMP TOOLBOX. Stormwater BMPs are implemented in accordance with NCDOT's Post-Construction Stormwater Management Program (PCSP), with guidance provided in the PCSP Program Manual ("NCDOT Post-Construction Stormwater Program Post-Construction Stormwater Controls for Roadway and Non-Roadway Projects"). Post-construction inspection and maintenance considerations are provided in the Inspection and Maintenance Manual. The BMP Toolbox, PCSP Program Manual, and I&M Manual can be found on the Connect NCDOT website under "Resources>Hydraulics>Highway Stormwater Program (HSP)".

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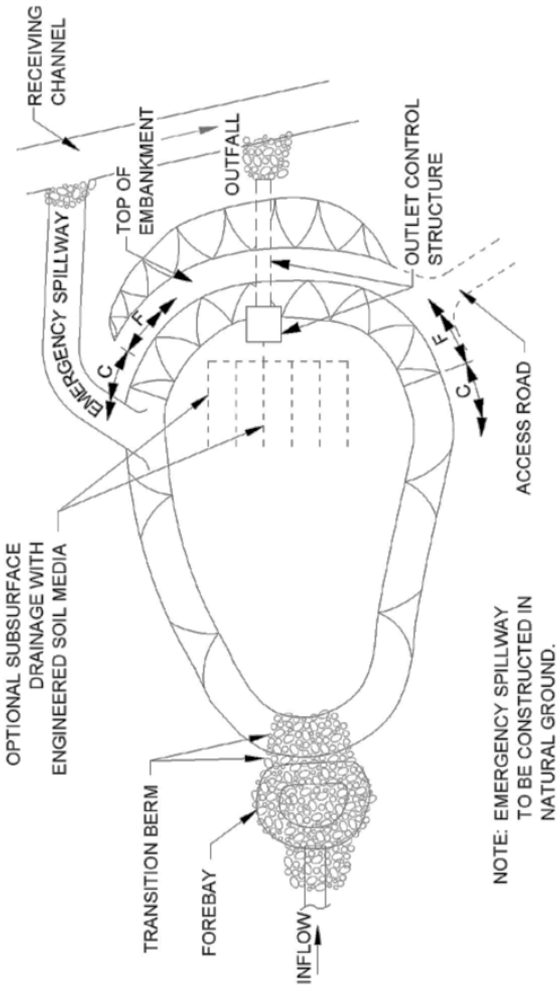
SECTION 1

BASIN COMPONENTS

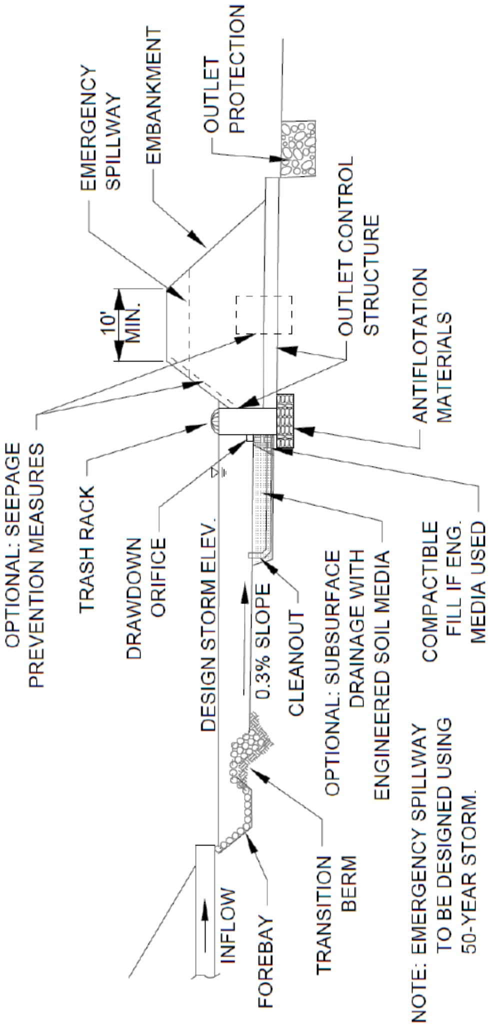
Basins, or ponds, are primary components of Toolbox BMPs, including Dry Detention Basins (Chapter 4), Hazardous Spill Basins (Chapter 7), Infiltration Basins (Chapter 9), Media Filters (Chapter 10), Wet Detention Basins (Chapter 11), and Stormwater Wetlands (Chapter 12).

This section focuses on basin-related components such as:

- ✓ **Basin Bottoms** – The flat or gently sloped section at the lowest storage elevation.
- ✓ **Basin Embankment**– The slope or embankment that creates the desired basin volume (holds water).
- ✓ **Emergency Spillway** – Releases large storm events to prevent embankment overtopping and erosion.



Typical basin components, plan view (dry detention basin shown).



Typical basin components, profile view (dry detention basin shown).

Example of DDB with well graded bottom, embankments, and good vegetative cover.

Basin bottom dimensions and embankment slopes (H:V) must be constructed per the plans. Provide smooth transitions at the embankment tie-ins. The design basin depth must also be provided.

Proper permanent stable cover must be provided. Sod should be placed properly without gaps and anchored properly. Filter fabric should not be placed under sod (PSRM or matting may be specified in certain high flow situations).

Vegetation must be maintained during construction until permanently established. Watering may be required.

Sod should be thoroughly watered after placement and subsequently as directed to establish a permanent stand of grass.

Embankment in fill areas must be properly compacted.

Pipes through embankments must be installed per plans. Clay cores (if included) must be properly constructed. Improper pipe installation and embankment compaction can result in embankment failure.

In most cases, compaction of the basin bottom should be avoided, especially for infiltration basins and media filters.

The basin bottom can be tilled to improve infiltration capacity prior to installation of media and other appurtenances.

Tilling should meet the requirements in the specifications, or can otherwise be used to recover infiltration capacity should the bottom become compacted.

The basin bottom must be protected from offsite flows. Silt fence, wattles, or other perimeter controls are effective.

Unprotected bottoms can result in sedimentation and replacement of stone, media, or sod, if present.

Emergency spillways must have the designed cross-section (width and depth) through the embankment and should be located in natural ground.

Permanent stabilization must be provided, usually in the form of PSRM or riprap. PSRM must be installed per plans or manufacturer's instructions. Riprap must be provided with filter fabric underlayment.

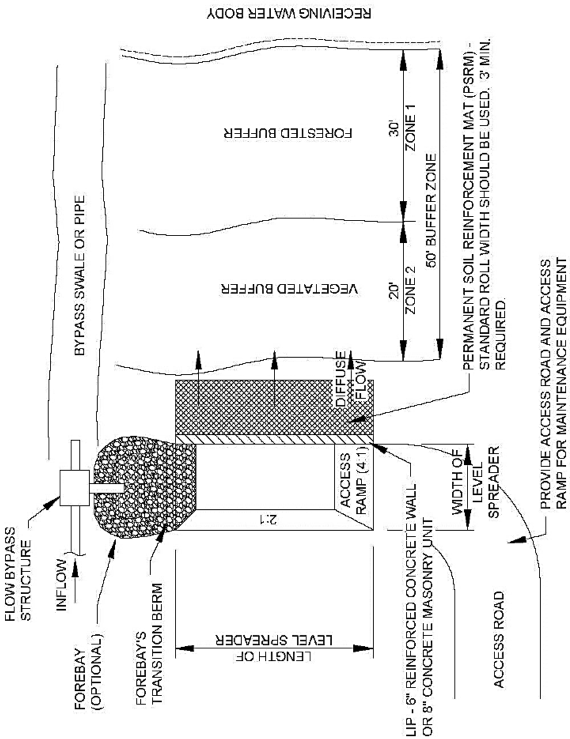
SECTION 2

LEVEL SPREADER

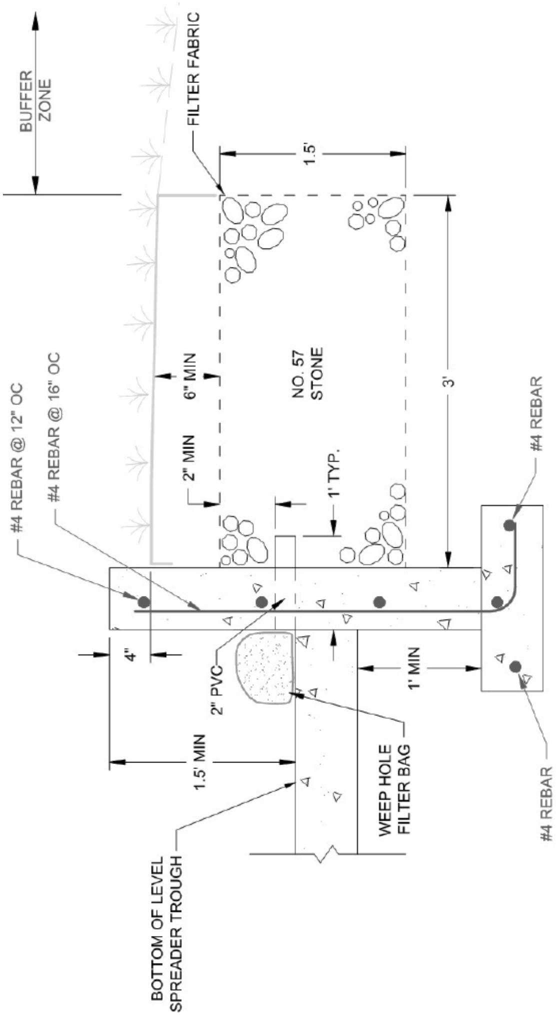
A Level Spreader converts concentrated stormwater flow to sheet flow.

Level spreaders are generally comprised of:

- ✓ **Flow Bypass Structure** – Routes a predetermined amount of stormwater runoff to the level spreader and additional stormwater runoff is routed away from the level spreader
- ✓ **Forebay (optional)** – Dissipates energy and captures sediment from inflow. See Chapter 6.
- ✓ **Level Spreader Trough** – Concrete section that contains water and directs it over the level spreader lip.
- ✓ **Level Spreader Lip** – The level wall designed for overflow of trough stormwater.
- ✓ **Drawdown System** – A series of weep holes designed to drain the trough over an extended period of time.
- ✓ **Filter Strip** – A grassed linear section of land that filters and infiltrates stormwater.



Typical level spreader configuration, plan view.



Typical level spreader configuration, profile view.

Design elevations in the flow bypass structure (if present), the level spreader trough and level spreader lip must be met. The level spreader lip must be level, without any dips or cracks along its length. Level spreaders often discharge to filter strips, which are covered in Section 12.

Example of a level spreader with common components. Depending on the design, energy dissipation (rock checks shown) may be required along the length of the trough.

Flow bypass structures may come in many different configurations depending on the site. Critical box elements that need to be constructed per design include overflow weirs (length, elevation), orifice dimensions and inverts, and pipe sizes and inverts.

Low spots in the level spreader will cause localized concentrated flow that will result in erosion.

Erosion will occur if the level spreader lip is not level. In addition to being level, the lip must be at the design elevation so flow velocities are as intended.

Level spreader lips that are not level will need to be reformed and re-poured.

Weepholes for trough drawdown must provide permanent filter bags to prevent weephole clogging. Any stone specified for drawndown cells must be washed (typically #57) and produced from hard, non-reactive stone sources (NO marl, coquina, or limestone).

Design trough width must be per design and consistent along the length. Remove sediment from the trough as needed during construction. If PSRM is specified downstream of the lip, it must be installed properly and anchored at the ends.

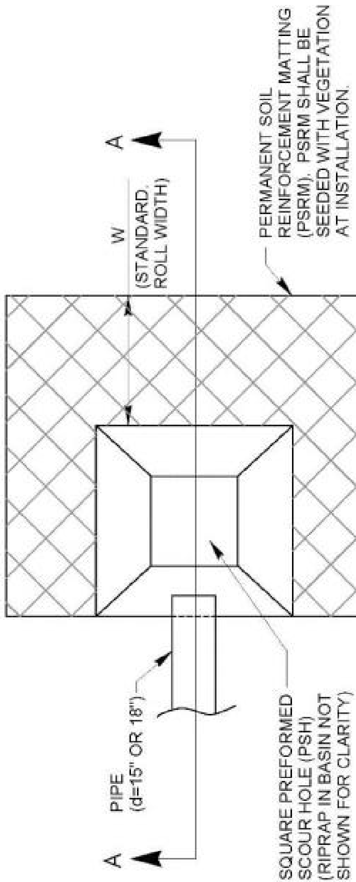
SECTION 3

PREFORMED SCOUR HOLE

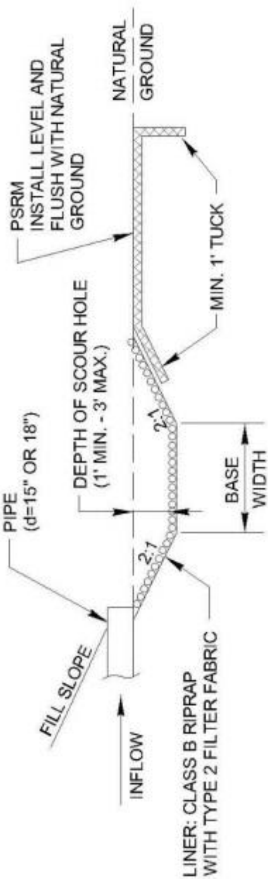
A Preformed Scour Hole (PSH) is a structural BMP designed to dissipate energy and promote diffuse flow.

PSHs are generally comprised of:

- ✓ **Pipe** – 15-in. pipe or 18-in. pipe that is the source of flow
- ✓ **Riprap** – Class B riprap which consists of a mixture of rocks with stone sizes between 5 inches and 12 inches for stabilization of flow.
- ✓ **Permanent Soil Reinforcement Matting (PSRM)** – A permanent erosion control reinforcement mat constructed of synthetic or coconut fibers to protect surrounding areas.



Typical preformed scour hole configuration, plan view.



Typical preformed scour hole configuration, profile view. The design depth must be provided, which is measured from the top of riprap at the base to the natural ground.

PSHs should be installed on level ground and not have any low points around the perimeter. Class B riprap must be used, which has an average 8" size. A 1'-3' depth should be provided.

PSHs should have a defined shape and depth, and complete riprap coverage with a uniform thickness. The underlying filter fabric should not be visible.

A 1' – 3' depression must be provided. Filter fabric must be installed underneath the riprap and keyed into the ground at the perimeter. PSRM must be installed at the downstream end of the preformed scour hole.

Preformed scour holes should not be installed on a slope and should have the dimensions indicated on the plans.

SECTION 4

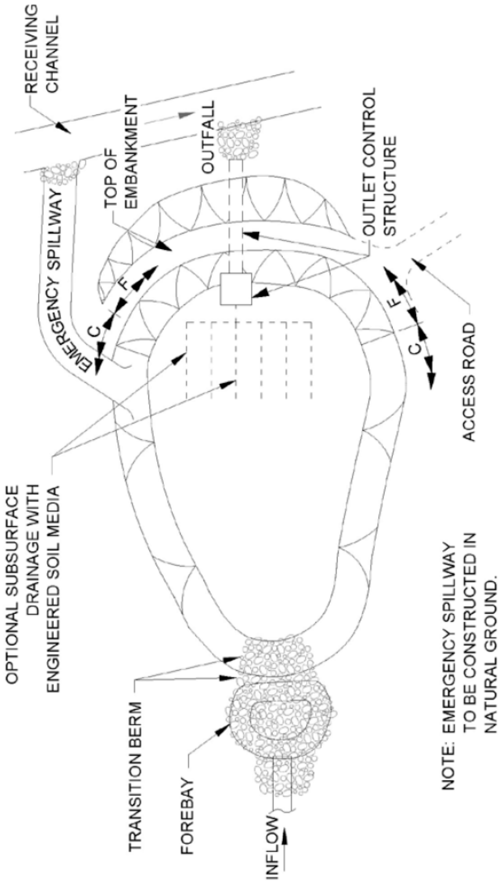
Dry Detention Basin

A Dry Detention Basin (DDB) is a basin that captures a volume of water, releases it over an extended period of time, and returns to a dry condition following an event. It is designed to reduce stormwater runoff, promote sedimentation of dirt and debris, and reduce velocity of flow downstream.

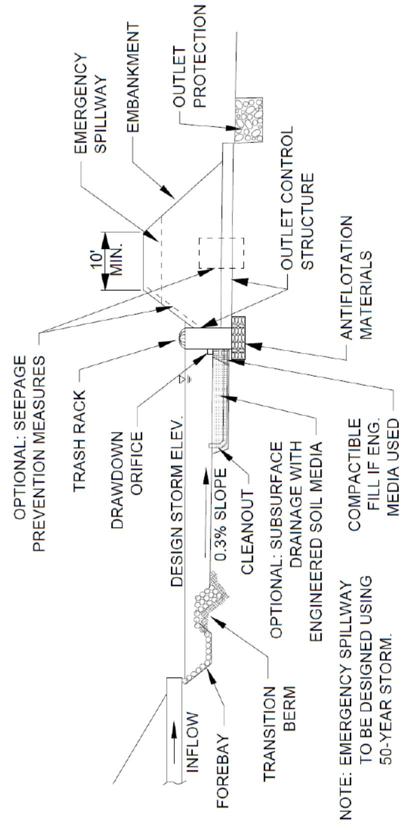
DDBs are generally comprised of:

- ✓ **Forebay** – Dissipates energy and captures sediment from inflow. See Section 6.
- ✓ **Basin** – Impoundment area for storage of runoff.
- ✓ **Outlet Control Structure** – Concrete or brick and mortar box with drawdown device, trash rack, and outlet pipe with outlet protection.
- ✓ **Drawdown Device** – An orifice or skimmer type device associated with the outlet structure to control release of water.
- ✓ **Embankment** – Earthen berm used to form basin. Used when basin is not entirely in cut.
- ✓ **Emergency Spillway** – Releases large storm events to prevent embankment overtopping and erosion. May be a separate component or integrated into the outlet control structure.
- ✓ **Underdrain System (optional)** – See Section 10. An additional measure used to drain the basin to return to dry conditions in between events.

An example of a DDB with common components. This DDB is well graded with a vegetated bottom and berms. It is critical that design elevations for the top of the embankment and basin bottom are achieved. The footprint dimensions must be provided in order to furnish the appropriate storage volume.



Typical dry detention basin configuration, plan view.



Typical dry detention basin configuration, section view. Proper outlet structure construction is critical to proper DDB function. The size, shape, and elevation of top openings, orifices, drawdown structures and outflow culverts must be constructed per design. Trash racks must be able open freely and should be accessible for maintenance from the basin embankment.

Drawdown trash rack should provide plenty of clearance and hinges should be located to allow easy access without interference with other components.

Emergency/maintenance drawdown device should be located at the bottom of the basin to allow for complete dewatering and provided with a concrete pad (if in design). A 'skimmer' type device may be used for dewatering and would connect to the bottom of the box.

As shown, the shear gate (maintenance valve) is on the appropriate side so that it can be operated while the orifice trash rack is in place.

The maintenance orifice gate or valve (shown to the right of the opened orifice trash rack) must be able to operate as intended. Here, the shear gate cannot be opened without opening the orifice trash rack first.

The drawdown orifice must be installed at the elevation designated on the plans and at the indicated diameter.

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Trash rack should open freely without interference from other outlet structure appurtenances, such as sluice gate stems.

Hinges should be located on opposite sides from other components. Trash rack should be accessible 'in the dry'. Note: split trash rack may be required.

All connections to the outlet structure box must be watertight. Seepage at connection points indicate poor seals. Note this photo is not of a dry detention basin and is used only to illustrate poor connections to outlet structure boxes.

Safe, easy access to the outlet structure should be provided for maintenance activities. Trash racks and sluice gates should be accessible from the berm.

SECTION 5

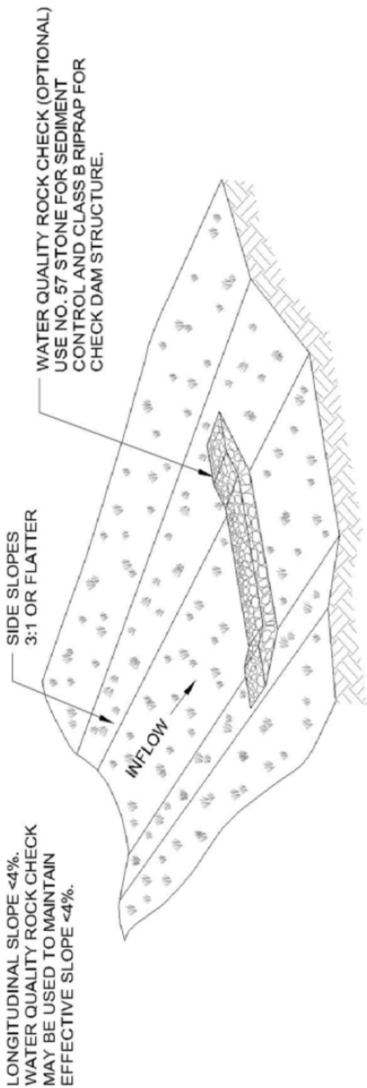
SWALE

A Swale is a vegetated channel with a trapezoidal or V-shaped cross section designed to convey stormwater and remove pollutants from stormwater.

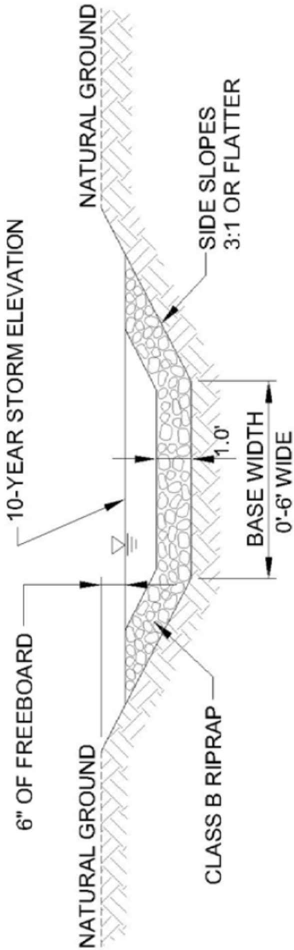
Swales are generally comprised of:

- ✓ **Side Slopes** – Side slopes that tie into natural ground. Typically be 3:1 or flatter
- ✓ **Swale Bottom** – The swale bottom is flat from side-to-side and typically has a longitudinal slope <4%
- ✓ **Water Quality Rock Check (Optional)** – Sometime provided to reduce velocity and encourage infiltration. Typically constructed of Class B riprap and No. 57 Stone

Swales are common BMPs that are used in a variety of settings. Critical design elements include the bottom width, depth, side slopes, and longitudinal slope. Proper permanent vegetative cover must be provided.



Typical swale configuration, isometric view.



Typical swale configuration, section view. Note riprap is shown depicting a rock check dam. In non-rock check dam locations, the swale will have vegetative cover.

Swales should be well vegetated, smoothly tie into natural ground, and meet design cross-section dimensions (depth, bottom width, side slopes).

Rock checks are sometimes provided to enhance water quality. Rock checks should be constructed per plans and at the correct spacing. Checks should span the width of the swale so flow cannot bypass them.

Design depth must be provided. Depth is measured vertically from the bottom of the swale to the natural surface.

Swales with drop inlets are prone to erosion if not properly compacted. Ensure compaction requirements are met per specification. If proper compaction cannot be achieved consider providing a concrete apron, or rock protection around the perimeter of the grate.

Sod must be properly installed and thoroughly watered after placement as directed to establish a permanent stand of grass.

3-D Geotextile is not keyed-in and no soil was placed between the 3-D Geotextile and the sod.

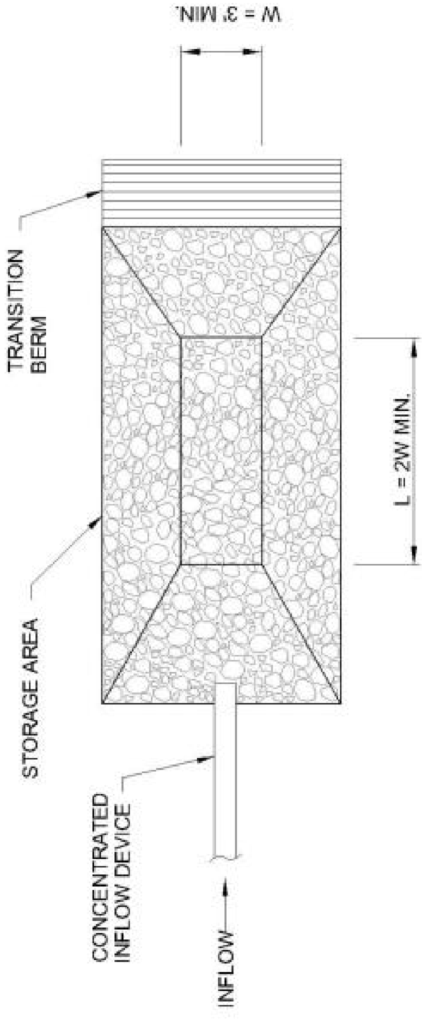
SECTION 6

FOREBAY

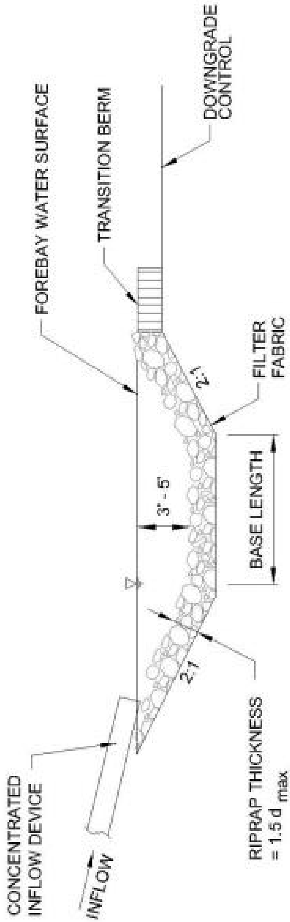
A Forebay is a pretreatment best management practice (BMP) used in conjunction with other BMPs. It is designed to dissipate energy and capture sediment, trash, and debris.

Forebays are generally comprised of:

- ✓ **Storage Area** – Impoundment area for collection of sediment.
- ✓ **Liner** – Forebays are typically lined with riprap underlain with filter fabric, although other liners such as grass and concrete may be used.
- ✓ **Transition Berm** – Forms storage area impoundment and provides diffuse flow into basin.



Typical forebay configuration, plan view.



Typical forebay configuration, profile view.

Example of forebay lined with riprap.

Forebay design depth must be provided (typically 3'-5') to capture sediment and debris. Depth is measured from the bottom of the storage area to the top of the transition berm.

Here, the forebay design depth was not provided, evidenced by no visible transition berm.

Filter fabric must be provided under riprap. Ensure the size riprap specified in the plans is provided.

The transition berm must be stable and well compacted if in fill to prevent erosion. The specified permanent cover/protection must be provided. The stormwater must be directed over the transition berm so that the BMP functions as designed.

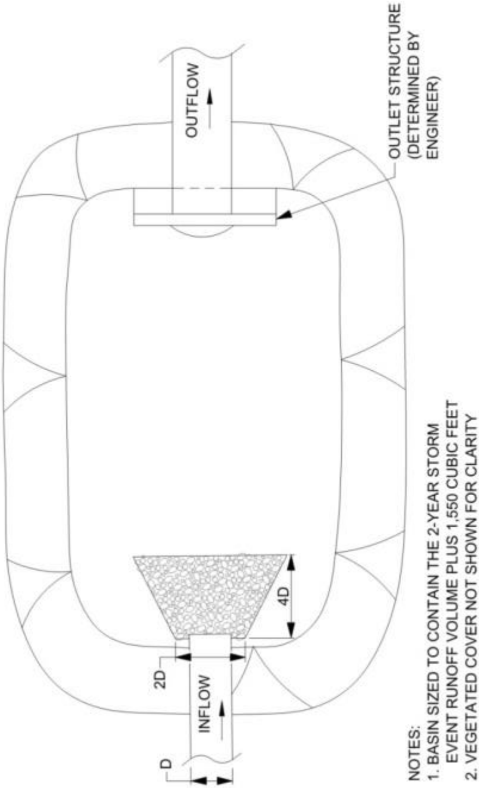
SECTION 7

HAZARDOUS SPILL BASIN

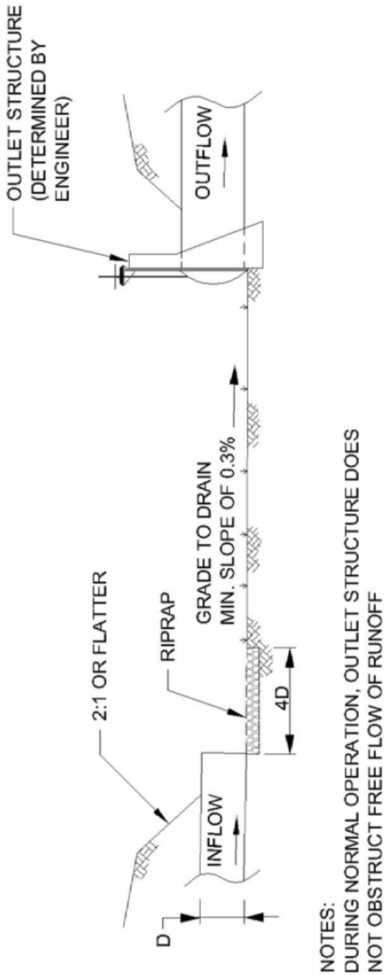
A Hazardous Spill Basin (HSB) is designed to protect water quality by detaining hazardous materials accidentally spilled on roadways, parking lots, or maintenance facilities.

HSB are generally comprised of:

- ✓ **Basin** – Impoundment area for storage of runoff.
- ✓ **Outlet Structure** – A concrete endwall connected to an outlet pipe or a box with a cut-off device. Could also be a narrowed channel to restrict flow.
- ✓ **Cut-off Device** – A sluice gate, shear gate, valve, sandbags, shoveled earth or other means used to prevent flow from leaving the basin.
- ✓ **Embankment (if needed)** – Earthen berm used to form basin.



Typical hazardous spill basin configuration, plan view.



Typical hazardous spill basin configuration, section view.

It is critical that design elevations for the top of the embankment and basin bottom are achieved, as well as the footprint area, so that proper storage volume is achieved. Some HSBs will have an endwall type outlet with a sluice gate over the pipe opening. Others will have an outlet structure similar to a DDB with a sluice gate or other device over the orifice that can be closed in the event of a spill.

Example of an HSB with endwall outlet and sluice gate.

Sluice gates should be OPEN during normal operation.

Proper pipe connections to structures and compaction are essential.

Sluice gate worm gear should be installed with grease protection to ensure proper and long-term operation.

Sluice gate must seat properly and cover the orifice to prevent outflow.

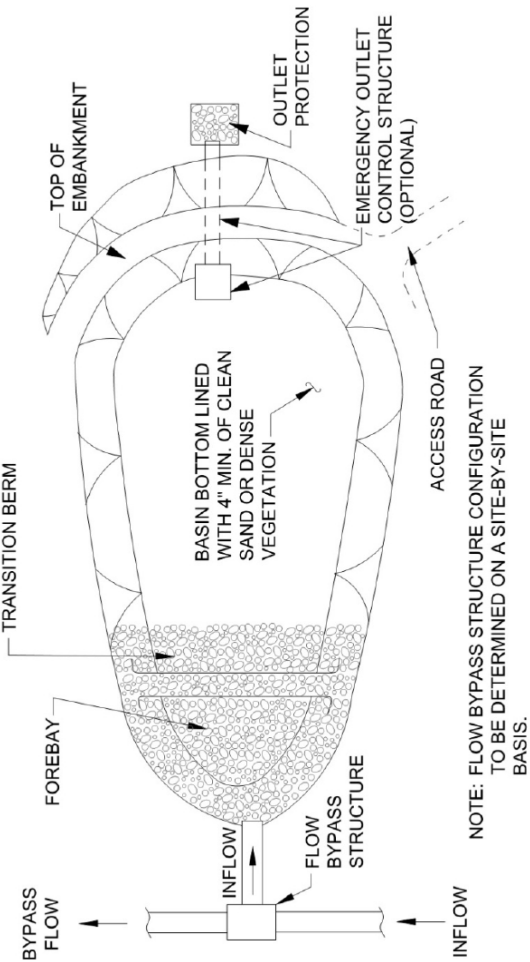
SECTION 8

INFILTRATION BASIN

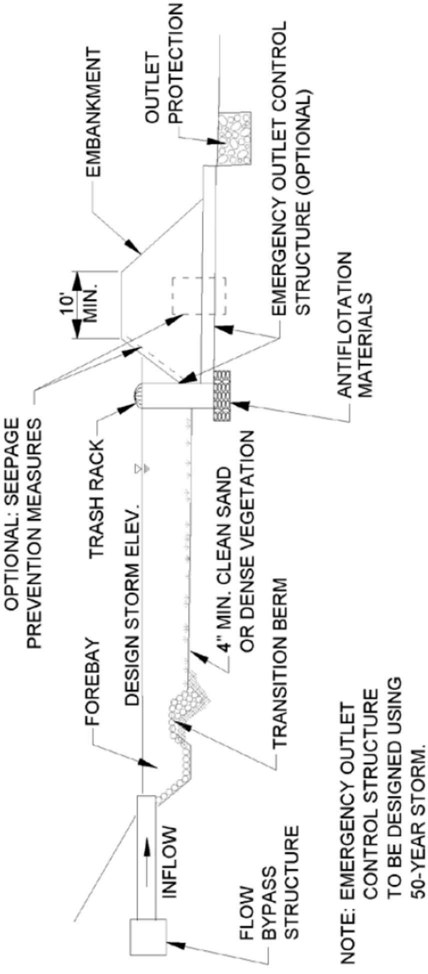
An Infiltration Basin is a basin or pond that contains permeable soils and is designed to detain and infiltrate stormwater runoff.

Infiltration Basins are generally comprised of:

- ✓ **Bypass structure (optional)**
- ✓ **Forebay** – pretreatment BMP to collect sediment. See Section 6.
- ✓ **Basin** – Impoundment area for storage of runoff.
- ✓ **Emergency Outlet Control Structure (optional)** – Concrete box with trash rack used to release flows that exceed the design volume for controlled release.
- ✓ **Embankment (if needed)** – Earthen berm used to form basin.
- ✓ **Spillway (optional)** – releases flows that exceed the design volume for controlled release.



Typical infiltration basin configuration, plan view.



Typical infiltration basin configuration, section view. Outlet structure design elevations (top of box overflow, orifice) and berm height are critical elevations that must meet design.

Maintenance dewatering gates and valves should be in the closed position during normal operation.

The basin bottom elevation must agree with the plans. Bottom elevations are set to have sufficient clearance from groundwater and bedrock. If groundwater is encountered during excavation and grading activities, the engineer should be notified.

Splitter boxes may come in many different configurations depending on the site. Critical box elements that need to be constructed per design include overflow weirs (length, elevation), orifice dimensions and inverts, and pipe sizes and inverts.

Pre-treatment devices, such as forebays and swales, must be constructed properly to prevent sediment and debris from reducing infiltration capacity.

The basin bottom must not be compacted in order to preserve infiltration capacity. Heavy equipment, especially tracked machines, are not permitted in the basin bottom. Tilling or other methods to loosen the top layer of bottom material can be used to reestablish or improve infiltration capacity.

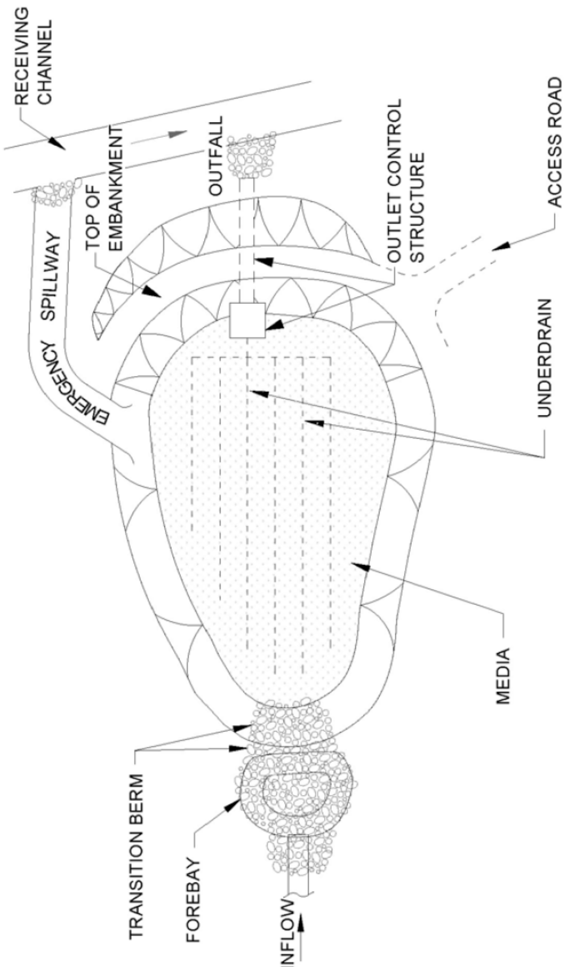
The basin bottom can be tilled to improve infiltration capacity prior to installation of media and other appurtenances.

SECTION 9

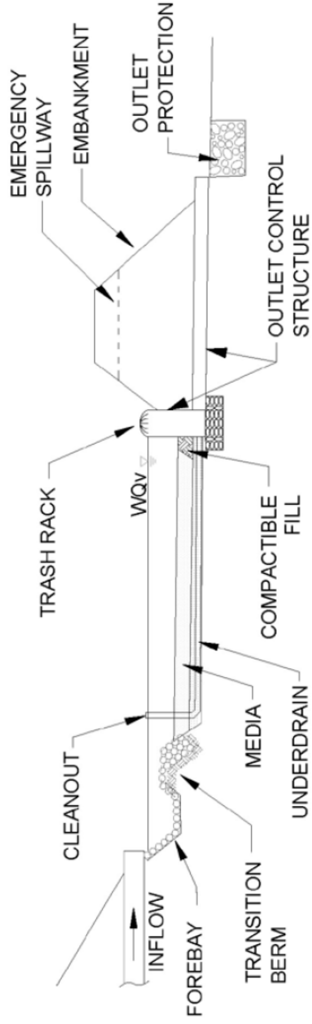
MEDIA FILTERS

Media filters (Filtration Basins and Bioretention Basins) are shallow basins or ponds that treat stormwater through filtration and reduce peak flows. Filtration basins are grassed media filters, while bioretention basins are landscaped, and incorporate a mulch layer and other vegetation like trees, shrubs, and ground cover. Media Filters are generally comprised of:

- ✓ **Bypass Structure (optional)**
- ✓ **Forebay** – Dissipates energy and captures sediment from inflow. See Section 6.
- ✓ **Basin** – Impoundment area for storage of runoff.
- ✓ **Media** – Material placed in the basin that filters stormwater.
- ✓ **Landscaping** – Bioretention only – mulch layer, trees, shrubs, and ground cover. Filtration basin – sod grass.
- ✓ **Underdrain System** – Perforated pipe with cleanouts below media that drains to outlet structure.
- ✓ **Outlet Control Structure** – Concrete box with drawdown device and trash rack.
- ✓ **Embankment** – Earthen berm used to form basin if in fill material (side slopes if in cut).
- ✓ **Emergency Spillway** – Releases large storm events to prevent embankment overtopping and erosion.



Typical media basin configuration, plan view.



Typical media basin configuration, profile view.

Maintenance dewatering gates and valves should be in the closed position during normal operation.

Watertight connections to the outlet structure must be provided, or the filter will not function as intended.

Upturned elbows may be present in the outlet structure. The penetration into the structure must be properly sealed and watertight.

Cleanouts should be provided as shown on the plans. Preferably, concrete rings or collars should be provided with the cleanout cap recessed from the surface to prevent damage during maintenance activities.

Heavy construction equipment, especially tracked vehicles, must not be allowed in the basin bottom. The resulting compaction will reduce the effectiveness of the BMP.

Tilling is an effective means of improving media filter performance, as it promotes infiltration.

Filter media must be protected until the site is permanently stabilized. Erosion and sedimentation can ruin the filter media.

Filter media must be protected until the site is permanently stabilized. Wattles, silt fence or other perimeter controls should be established to prevent sediment from reaching the filter media. Filter media should not be compacted.

When possible, divert flows around the basin area during construction to protect the excavation and media.

Stockpiled filter media should be protected from contamination until it is installed.

Filter media must meet the project specification. It must have the specified percentage of sand, fines, and organic matter. It should be free of debris and protected before and after installation from contamination, especially sediment.

Filter media and stone materials (in the underdrain layer) must not be sourced from limestone, marle, or coquina. These materials can react with water and harden resulting in clogging of the media.

Stone used in Stormwater BMPs should be washed. There should not be a cloud of dust formed when stone is dumped.

Filter Fabric between media layers should be a high-flow non-woven geotextile fabric .

Sod should be thoroughly watered after placement and subsequently as directed to establish a permanent stand of grass.

Sod should be thoroughly watered after placement and subsequently as directed to establish a permanent stand of grass (note a basin is shown in the image).

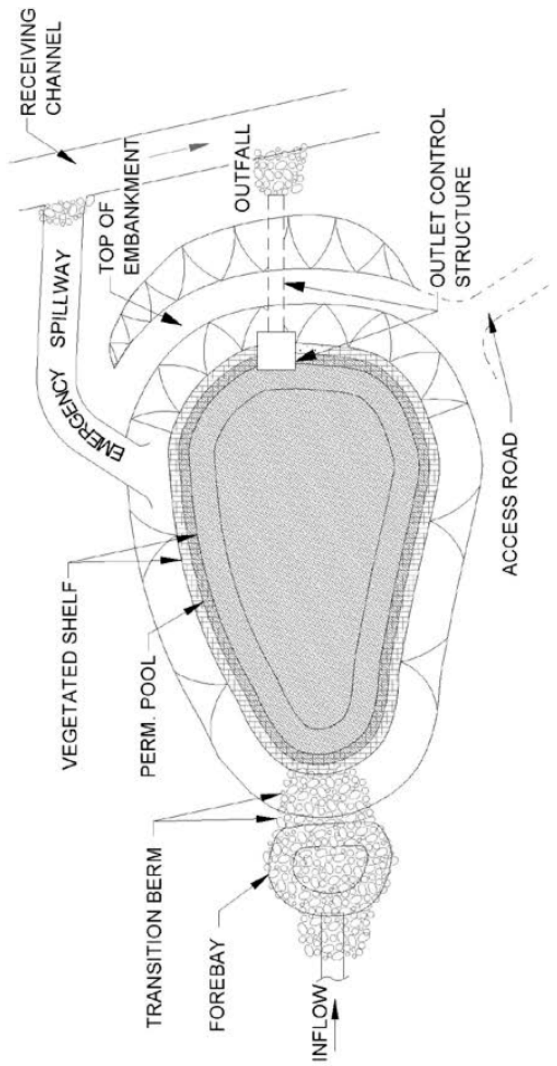
SECTION 10

WET DETENTION BASIN

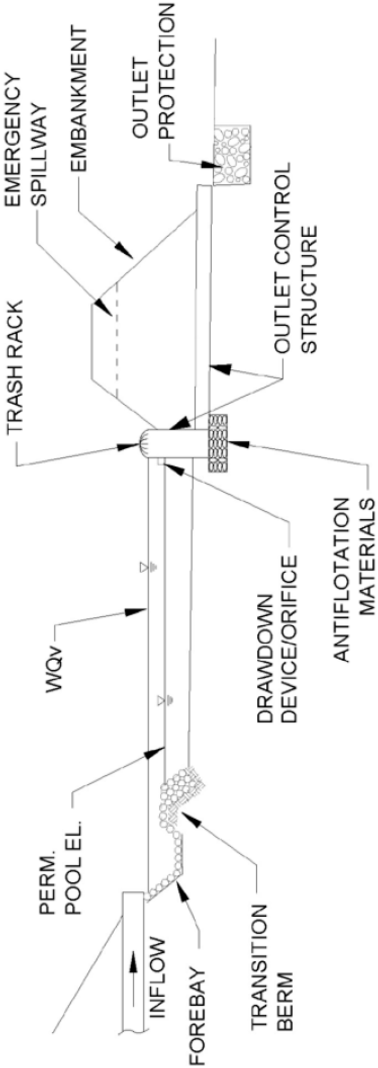
A Wet Detention Basin is a basin or pond that is designed to maintain a permanent pool of water, reduce stormwater runoff, promote sedimentation of dirt and debris, and reduce velocity of flow downstream.

Wet Detention Basins are generally comprised of:

- ✓ **Forebay** – Dissipates energy and captures sediment from inflow. See Section 6.
- ✓ **Basin** – Impoundment area for storage or runoff.
- ✓ **Vegetated Shelf** – Perimeter of the basin planted with wetland vegetation.
- ✓ **Outlet Control Structure** – Concrete box with drawdown device and trash rack.
- ✓ **Drawdown Device** – Set at the permanent pool elevation for controlled release of flow.
- ✓ **Embankment** – Earthen berm used to form basin.
- ✓ **Emergency Spillway** – Releases large storm events to prevent embankment overtopping and erosion.



Typical wet detention configuration, plan view.



Typical wet detention configuration, profile view.

It is critical that design elevations for the top of the embankment and basin bottom are achieved, as well as the footprint area, so that proper storage volume is achieved.

Example of wet detention basin with common components and healthy wetland vegetation.

Critical outlet structure elevations need to match the design plan. Orifice invert(s) and structure top (grate overflow) must be at the proper elevation.

Sluice gates and valves for maintenance dewatering shall be in the closed position and provide a water tight seal during normal operation.

Trash rack should open freely without interference from other outlet structure appurtenances, such as sluice gate stems.

Trash rack should open freely without interference from other outlet structure appurtenances.

All connections to the outlet structure box below the normal pool elevation must be watertight.

Safe, easy access to the outlet structure should be provided for maintenance activities. Trash racks and sluice gates should be accessible from the berm.

The vegetated shelf, if present, shall meet the project specifications. Generally, the shelf should be at a gentle (10:1) slope and extend no deeper than 6 inches below the permanent pool elevation.

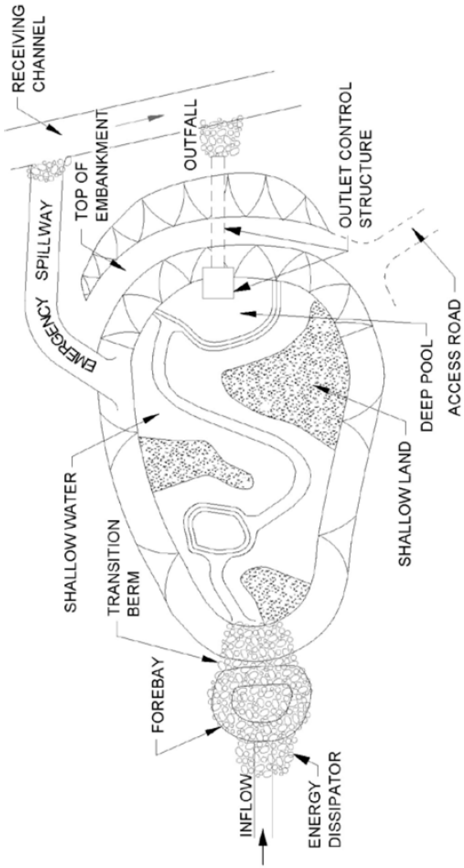
SECTION 11

STORMWATER WETLAND

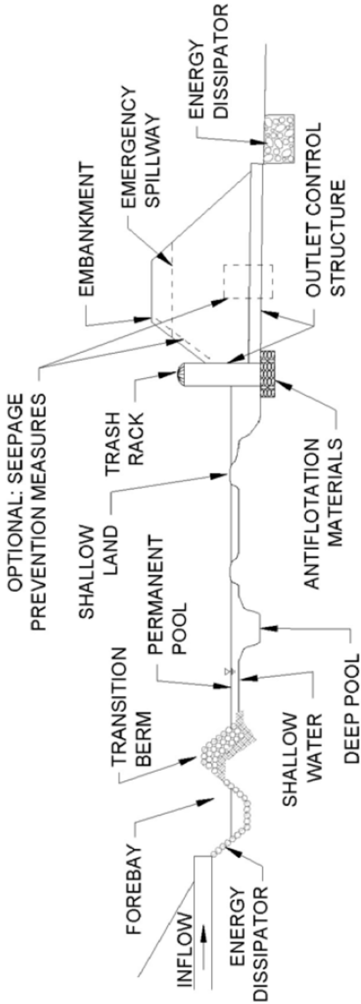
A Stormwater Wetland is an engineered marsh or swamp planted with wetland vegetation. Biological processes remove stormwater pollutants.

Stormwater Wetlands are generally comprised of:

- ✓ **Forebay** – Dissipates energy and captures sediment from inflow. See Chapter 6.
- ✓ **Shallow Water Zone** – Areas between 3 and 6 inches deep and planted with wetland plants.
- ✓ **Shallow Land Zone** – Areas that are submerged for short periods of time after storm events.
- ✓ **Deep Pools** – Permanently deep depressions that hold water even during drought conditions.
- ✓ **Outlet Control Structure** – Concrete box with drawdown device and trash rack.
- ✓ **Drawdown Device** – Set at the permanent pool elevation for controlled release of flow.
- ✓ **Embankment** – Earthen berm used to form basin.
- ✓ **Emergency Spillway** – Releases large storm events to prevent embankment overtopping and erosion.



Typical stormwater wetland configuration, plan view. Designated shallow land, shallow water, and deep pool zones are critically important components.



Typical stormwater wetland configuration, profile view.

It is critical that the grading within a stormwater wetland is completed per the plans. There should be no deviation from contour shape and elevation. The wetland plantings depend on very specific hydrologic conditions in order to survive.

A stormwater wetland with healthy vegetation. Elevations of designated zones shallow land, shallow water, and deep pools must be provided per the plans in order to have healthy vegetation. Also, the correct plants must be placed in each designated zone per the plans. Plants are typically specified by size and spacing. These parameters should be verified during installation.

Elevations are critical for wetland function and vegetation survival.

Various wetland plants have specific inundation depths and timeframes they can withstand. It is critical that proper plants are placed in the correct zones at correct water depths. Various zones are indicated by colored flags in this photo.

Stormwater wetland outlet structures should have a drawdown orifice to dewater the wetland to the permanent pool elevation after a storm event. Sluice gates will likely be provided for maintenance activities and should be in the closed (down) position during normal operation. The pictured sluice gate on the right is closed.

Stormwater wetland may have flashboard risers. The flashboards must be provided as designated on the plans. Note the water elevation may need to be gradually brought to final elevation while plants are established.

Trash racks must open without interference from sluice gates or other outlet structure appurtenances.

SECTION 12

FILTER STRIP

A Filter Strip is a uniformly sloped, vegetated area designed to filter stormwater pollutants and allow runoff to infiltrate into the soil.

Filter strips are generally comprised of:

- ✓ **Vegetation** – A filter strip should consist of a uniformly sloped, well graded area of densely covered grass. The filter strip will promote sedimentation, filtration (through vegetation), and infiltration.

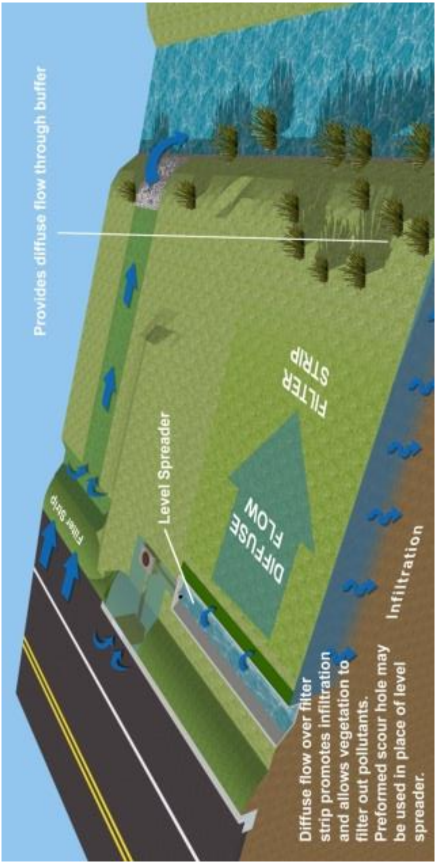


Illustration of common configurations of filter strips. Filter strips are designed to encourage diffuse flow. It is critical the design slope is achieved, a smooth, uniform surface is provided, and sod in appropriately installed (if in the design).

Example of a filter strip in a linear, highway application with uniformly graded, well vegetated slope. In the application shown, a shoulder provides a functional filter strip prior to convergence with a swale.

Filter strips should be located downstream of a level spreader or other source of diffuse flow. It should be have a well graded, uniform slope and be well vegetated. Channelization may be an indicator of low areas. Any channelization should be addressed during construction.

Proper sod installation is critical. A smooth, rolled surface should be provided without noticeable seams. Vertical seems (along slope) should be staggered. Seams should not be obviously noticeable with proper installation. Seams should not be readily visible as shown here.

Filter strips must be properly vegetated and sod installed per specification. Runoff should be diverted away from the filter strip until vegetation is established. Here, the level spreader is receiving flow before the sod is properly established. Seams with significant gaps are visible.

Sod should be thoroughly watered after placement and subsequently as directed to establish a permanent stand of grass (note a basin is shown in the image).

STATE OF NORTH CAROLINA
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