NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

STORMWATER CONTROL
INSPECTION AND MAINTENANCE MANUAL
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Acronyms

ARC	Atlanta Regional Commission
BMP	Best Management Practice
DEO	Division Environmental Officer
DSO	Division Safety Officer
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
HSB	Hazardous Spill Basin
LOS	Level of Service
NCDENR	North Carolina Department of Environment and Natural Resources
NCDLR	North Carolina Division of Land Resources (NCDENR)
NCDOT	North Carolina Department of Transportation
NCDWQ	North Carolina Division of Water Quality (NCDENR)
NCHRP	National Cooperative Highway Research Program
NPDES	National Pollutant Discharge Elimination System
NRC	National Response Center
PSH	Preformed Scour Hole
PSRM	Permanent Soil Reinforcement Matting
PVC	Polyvinyl Chloride
REU	Roadside Environmental Unit (NCDOT)
SC	Stormwater Control
SCMS	Stormwater Control Management System

Glossary

Attenuate	The reduction of flow in volume and/or force.
Best Management Practice (BMP)	A general term most often used to describe methods that are the most effective and practical means of preventing or minimizing pollution. The term BMP is often used to describe the structures that are built to reduce stormwater pollution.
Channelization	The process by which concentrated flow erodes a channel through areas in or around a stormwater control that can lead to compromised performance of the control or even failure.
Concentrated Flow	Water that is flowing in a channel or pipe, or that has otherwise collected and is flowing in a manner not consistent with sheet flow.
Confined Space	A space that (1) is large enough and so configured that an employee can bodily enter and perform assigned work; (2) has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits); and (3) is not designed for continuous employee occupancy (29 CFR 1910.146).
Diffuse Flow	Another term used to describe sheet flow.
Drawdown	The lowering of a water level in a controlled manner.
Dredging	Most often done with a machine (commonly on a boat) used to scoop up sediment, gravel, or obstructions from submerged areas (in this case, stormwater controls), so as to deepen them or restore them to their original volume.
Embankment	An earthen berm, constructed from fill material, used to store runoff in basins.
Erosion	The process by which a surface is worn away. In the context of this manual, erosion refers to the process by which runoff washes away soil.
Impervious Surface	A land cover through which water cannot infiltrate; examples include concrete, asphalt, rooftops.
Infiltration	The act of water soaking through the surface of the soil.
Intermittent Stream	An intermittent stream has flowing water during certain times of the year, when groundwater provides water for stream flow. During dry periods, intermittent streams may not have flowing water. Runoff from rainfall is a supplemental source of water for stream flow.
Level of Service (LOS)	A rating system used by NCDOT that is assigned to each stormwater control based on its condition after inspecting. Ratings are A, B, C, D, and F. See Chapter 4 for a description of each rating.
Percolation	The act of water traveling downward through the soil.
Perennial Stream	A perennial stream has flowing water year-round during a typical year. The water table is located above the stream bed for most of the year. Groundwater is the primary source of water for stream flow. Runoff from rainfall is a supplemental source of water for stream flow.

Permanent Soil Reinforcement Matting (PSRM)	A material used to hold soil in place so that vegetation can take root and prevent erosion; commonly used in areas with steep slopes or other erosive conditions.
Riparian Buffer	The term riparian refers to an area adjacent to a body of water. Riparian buffers are naturally vegetated (undisturbed) areas through which stormwater runoff passes as sheet flow so that infiltration of runoff and filtration of pollutants occur before stormwater reaches the body of water.
Runoff	Precipitation on land that eventually reaches streams and rivers.
SA Waters	Tidal salt waters that are used for commercial shellfishing or marketing purposes and are also protected for all Class SC and Class SB uses. All SA waters are also High Quality Waters by supplemental classification.
Sediment	Soil that has been eroded and deposited elsewhere; typically contains pollutants and has a negative impact on aquatic environments.
Seepage	The slow discharge or escape of water.
Sheet Flow	A shallow layer of water flowing over land at a low velocity, enabling pollutants to settle out.
Stormwater	A term used to describe water that originates from precipitation; often used interchangeably with the term *runoff*.
Stormwater Control (SC)	A structure designed to manage stormwater and/or treat stormwater pollutants in an effort to reduce surface water pollution.
Suspended Solids	Small particles carried in stormwater as a result of erosion; regarded as an indicator of water quality.
Toe (of embankment)	The bottom of the embankment where it meets the natural ground.
Vegetated Shelf	Also known as aquatic benches or shelves, vegetated shelves are those shallow areas around the edge of stormwater controls with permanent pools that support aquatic vegetation, both submerged and emergent.

CHAPTER 1 Introduction

1.1 Background

When it rains or snow melts, part of the water soaks into the ground, part of it evaporates, and part of it flows over land. The part that flows over land is called stormwater runoff. In natural settings, water from storm events is slowed by vegetation and other obstacles as it flows over land. As a result, most of the stormwater infiltrates into the soil. This is beneficial to the environment because it helps to maintain a relatively constant source of groundwater to streams, rivers, and other bodies of water.

Unfortunately, this is not the case in developed areas. In developed areas, much of the land is covered by hard surfaces such as buildings and pavement. These hard surfaces, due to their impervious nature, allow little to no infiltration and stormwater in essence becomes a transportation system for pollutants. As stormwater flows over hard surfaces it picks up oil, antifreeze, salt, cigarette butts, paper and other pollutants. It also picks up soil and organic material as it flows from hard surfaces and erodes less stable surfaces. Pollutants transported by stormwater are deposited into streams, rivers and other bodies of water where they destroy habitat and have a detrimental effect on aquatic insects, fish, birds, and mammals.

The North Carolina Department of Transportation (NCDOT) has installed a number of stormwater controls (SCs) across the state, within NCDOT rights-of-way, to reduce the amount of pollutants found in stormwater. These are engineered structures or devices that are generally designed to slow down or hold the water for a short time and remove pollutants before it is released to a stream. Stormwater controls are widely referred to as best management practices or BMPs. They are also called "post-construction" stormwater controls because they are designed to stay in place and treat runoff after an impervious surface is built, as opposed to temporary erosion control practices used during a construction project (such as silt fences and sediment basins).

1.2 Purpose

Stormwater controls must be routinely inspected and maintained to ensure they continually function as designed. If proper maintenance is not provided, adverse environmental impacts such as the discharge of pollutants into ground and surface waters may occur.

In 1998, the NCDOT was issued a National Pollutant Discharge Elimination System (NPDES) permit by the North Carolina Department of Environment and Natural Resources (NCDENR) Division of Water Quality (DWQ). The NPDES permit authorizes NCDOT to discharge borrow pit wastewater and stormwater runoff from its roadways and industrial facilities into North Carolina's waterways, following proper stormwater management methods. Part II.B.4.b.(b) of NCDOT's NPDES Permit requires that NCDOT develop a BMP Inspection and Maintenance Manual. It states, "NCDOT will develop a written procedure outlining the inspection and maintenance requirements for various types of stormwater BMPs. This document will outline the regular inspection frequency, an inspection checklist, 'how-to' instructions for regular maintenance, evaluation and reporting procedures for nonroutine maintenance, and an inspection and maintenance tracking mechanism."

This manual, entitled *North Carolina Department of Transportation Stormwater Control Inspection and Maintenance Manual*, fulfills this requirement of the NPDES permit and its intended use is to serve as a source of guidance to those individuals responsible for the inspection and maintenance of SCs on NCDOT's rights-of-way.

1.3 How to Use this Manual

This manual is intended to be a practical tool to aid in the inspection and maintenance of SCs. As such, the first several chapters include a general discussion of inspection requirements, maintenance considerations, and reporting requirements for structural SCs. The remainder of the manual features chapters on individual stormwater controls.

CHAPTER 2 — INSPECTION

Chapter 2 lists some of the common inspection procedures required for most stormwater controls; however, it is critical that one refer to the individual chapters for specific inspection guidance. On occasion, one may encounter control types with unique features that are not covered in this manual.

CHAPTER 3 — MAINTENANCE

Chapter 3 outlines routine and emergency maintenance procedures that may be needed when maintaining highway stormwater controls.

CHAPTER 4 — REPORTING AND RECORD KEEPING

Chapter 4 discusses the procedure for reporting and documenting inspection and maintenance activities in the Stormwater Control Management System (SCMS, pronounced "skims").

CHAPTERS 5 THROUGH 13 — STORMWATER CONTROLS

Chapters 5 through 13 provide an overview of different types of stormwater controls. Included is a general description of the SC and its components, guidance on inspection and maintenance requirements for each component of the SC, photos of the SC in the highway setting, and detailed diagrams of the SC.

APPENDIX A — INSPECTION CHECKLISTS

Appendix A provides an inspection checklist for each type of SC. This inspection form, which covers structural components and areas of maintenance, is to be filled out at the time of the inspection.

APPENDIX B — NCDOT STORMWATER CONTROLS NAMING CONVENTION

Appendix B provides a list of acceptable terms used to describe SCs, this memo includes a field guide with photos and descriptions of the different types of post-construction stormwater controls used by NCDOT.

1.4 Disclaimer

This manual provides guidance for inspection and maintenance procedures for typical stormwater controls owned by the North Carolina Department of Transportation. These guidelines are not intended to be a comprehensive reference on SC inspection and maintenance. Additional references should be consulted as needed to maintain a safe and functional structural control. Further, it would not be possible to properly address every configuration or issue that might arise. Unique circumstances may require deviation from this guidance. Sound professional judgment, resourcefulness, and ingenuity are expected and encouraged.

1.5 Contact Information

The information provided in this manual is intended to serve as a guideline to those individuals responsible for maintaining stormwater controls. If a particular situation should require deviation from the methods, procedures, and/or criteria presented in this manual, contact the NCDOT REU at (919) 733-2920 for additional guidance.

CHAPTER 2 Inspection

2.1 Inspections

Stormwater controls (SCs) must be routinely inspected and have the necessary maintenance performed on them to be certain that they continually function as designed. Specific inspection details for each SC are presented in Chapters 5-13 of this manual. Refer to the appropriate chapter when completing the inspection checklist. The following is a list of problems that may be encountered during an inspection.

General Site Conditions

- Trash and debris
- Animal burrows
- Algae, stagnation, and odors
- Vandalism

Structural/Mechanical

- Obstructions of the inlet or outlet devices by trash, debris, and vegetative growth
- Cracks and deterioration of inlets, outlets, pipes, and catch basins
- Malfunctioning valves, sluice gates, locks, and access hatches

- Slow-draining infiltration devices
- Inadequate outlet protection
- Water seepage or ponding

Vegetation

- Distressed aquatic shoreline vegetation
- Poor and distressed stands of grass
- Unwanted weeds, grasses, and woody plants
- Bare ground

Earthworks

- Excessive erosion or sedimentation, particularly in emergency spillways, filter strips, or forebays
- Cracks or settling in the embankment or berms
- Deterioration of downstream channels

Spills/Releases

- Hazardous spill
- Illicit discharge
- Illegal dumping

2.2 Frequency of Inspection

NCDOT stormwater controls shall be inspected annually at a minimum (unless otherwise specified by environmental permits) and after any major rainfall event such as a hurricane, tropical storm, or flooding.

2.3 Site Visit Preparation

Before going into the field to conduct inspections, one should be adequately prepared. The following list summarizes items that may be needed when conducting SC inspections.

- A copy of this manual
- Copies of appropriate inspection checklists
- GPS unit and local maps (if available)
- Trash bags
- A digital camera (if available)
- A shovel, bush axe, and/or rake
- Hand pruners and/or loppers

2.4 Safety Considerations

Safety considerations must be a constant focus during stormwater control inspections. Prior to conducting the inspection, anticipate any potential hazards based on recent or current conditions (i.e., flooding after a heavy rain). Always avoid hazardous conditions and document them on the inspection checklist.

The following list highlights common safety concerns when performing stormwater control inspections:

- Never conduct inspections of confined spaces alone, without proper training.
- Take precautions around standing water; depths are likely unknown and the ground may be unstable.
- Be alert and take proper precautions when entering and exiting the highway.
- Park in areas that provide safe entrance and exit of work area; do not create potential conflicts with other vehicles/equipment operating in the work area; and provide maximum protection for workers entering and exiting the vehicle, especially along open highways.
- Always wear protective clothing, boots, and safety vests.
- Be aware of large vertical drops and avoid standing on retaining walls or other structures that present a fall hazard. Make a note of hazard areas on the inspection form.
- If toxic, hazardous or unknown substances are discovered in the area, leave the vicinity and report the findings by contacting 911 and Division Safety staff.
- Be aware of loose material (such as riprap), excavation drop-off, tripping hazards, uneven ground, and other obstructions.
- Be aware of poisonous plants, insects, and snakes.

Refer to NCDOT's *Workplace Safety Manual* (2004) for additional safety guidelines.

2.5 Reporting and Record Keeping

Observations made at the time of inspection pertaining to the status of the stormwater control shall be documented according to the reporting procedures presented in Chapter 4 of this manual. All inspection findings and maintenance activities should be noted on the appropriate inspection form (see Appendix A), then entered into SCMS. Refer to Chapter 4 for further guidance on documentation and entering information into SCMS.

CHAPTER 3 Maintenance

3.1 Maintenance of Stormwater Controls

Stormwater controls (SCs) require two basic types of maintenance: (1) routine maintenance and (2) emergency maintenance. All routine maintenance and/or emergency repair needs found at the time of inspection should be identified and reported. Visual observations, contacts made, maintenance performed, and any maintenance recommended at the time of inspection must be documented using the reporting procedures presented in Chapter 4 of this manual.

If emergency maintenance needs are found, the inspector should either take immediate action to correct the problem(s) or alert the responsible parties of maintenance and/or repair needs. A follow-up inspection should be made to ensure that corrective actions have been satisfactorily completed and normal operation has been restored. All correspondence and corrective actions shall be documented.

This chapter describes the maintenance activities most commonly required when maintaining highway stormwater controls. Actual maintenance needs may vary, depending on specific site conditions.

3.2 Routine Maintenance

Routine maintenance is any procedure performed on a regular basis to maintain the proper working order of a stormwater control. Tasks associated with routine maintenance include, but are not limited to, the following:

- Periodic maintenance of grasses, trees, shrubs, and other desirable plant species
- Removal of undesirable plant species
- Removal of trash and debris
- Upkeep of mechanical/structural components

Since routine maintenance predominately involves some type of vegetation management practice, it is anticipated that the majority of the routine maintenance will be performed by Division Roadside Environmental forces.

Care should be taken to avoid using equipment that can cause soil compaction in or around stormwater controls. Heavy equipment with narrow tracks or narrow tires, rubber tires with large lugs, or high-pressure tires can cause excessive compaction resulting in reduced infiltration and damage to underdrain systems. When mowing in or around a stormwater control, use riding mowers or tractor mowers with turf-type tires, push mowers and/or weed eaters.

Safety considerations must be a constant focus when conducting routine maintenance. Refer to section 2.4 for a list of common safety concerns.

3.2.1 Desirable Vegetation Maintenance

Desirable vegetation is an important component of many stormwater controls. Turf-type grasses, native/ornamental grasses, trees, shrubs, and herbaceous plants help control erosion, provide structural stability, and remove pollutants from stormwater runoff. Desirable vegetation can also enhance the aesthetic appeal of stormwater controls and enable them to blend into the landscape.

Periodic maintenance of desirable vegetation is required to ensure that it remains healthy and established. Climatic conditions, lack of proper maintenance, storm events, vehicular/equipment traffic, and vandalism can have a detrimental effect on plant material. Provisions may be needed to supplement or replant some vegetated areas due to plant loss. Supplemental and replacement planting should occur during the appropriate planting season for the particular plant species being utilized. These new plantings will require additional care until they are established.

The following are general guidelines for the maintenance of turf-type grasses, native/ornamental grasses, trees, shrubs, and herbaceous plants used in association with stormwater controls. Additional information and guidance can be found in NCDOT's *Vegetation Management Manual* (NCDOT, 1998).

Turf-Type Grasses

Turf-type grasses are common to most stormwater controls. They can be the major component in a stormwater control's makeup or simply used to stabilize the areas surrounding a stormwater control.

Turf-type grasses provide soil stability, reduce water flow velocities, and help maintain the structural integrity of stormwater controls. They serve as pretreatment for stormwater controls by slowing the overland runoff and filtering out sediment and pollutants. If maintained properly, turf-type grasses can also improve access to stormwater controls, making inspection and maintenance tasks easier. The following is a list of the turf-type grasses most commonly used in association with stormwater controls.

Turf-Type Grasses

Eremochloa ophiuroides	Centipedegrass
Cynodon dactylon	Bermudagrass
Zoysia japonica	Zoysia
Festuca arundinacea	Tall Fescue
Paspalum notatum	Bahiagrass
Poa pratensis	Kentucky Bluegrass

CENTIPEDEGRASS, SOURCE: VIRGINIA TECH WEED ID GUIDE

Provisions should be made to reestablish a uniform cover of turf-type grass on those areas damaged by sediment accumulation, stormwater flow, and/or vehicular/equipment traffic. Failure to maintain a uniform turf-grass cover could result in structural failure and sediment loss. Any turf found not in a healthy growing state should be evaluated to determine the maintenance needs (i.e., fertilization, repair seeding, sodding).

Mowing should be tailored to the specific site conditions, turf-grass type, and seasonal variations. Ideally, turf-type grasses should be mowed at a frequency to maintain a maximum height of 4 inches for warm-season grasses and 6 inches for cool-season grasses. However, on highway right-of-way facilities, it is more practical to maintain grass height between 6 and 15 inches. Mowing activities should include trimming grass around fences and structures. **All clippings discharged from mowers or string trimmers should be directed away from the stormwater device so they do not add nutrients to the water.**

Herbaceous Plants and Native/Ornamental Grasses

Some stormwater controls have as a part of their makeup a carefully designed mixture of herbaceous plants and native/ornamental grasses. This plant material is essential to the operation and function of the stormwater control. Planted within certain stormwater controls, this plant material not only stabilizes the soil and prevents erosion, but it also removes nutrients, metals, and other pollutants from stormwater runoff. The following is a list of the native/ornamental grass and herbaceous plant species most commonly used in association with stormwater controls.

Herbaceous Plants

Aster laevis	Smooth Aster
Echinacea purpurea	Purple Cone Flower
Eupatorium fistulosum	Joe Pye Weed
Helianthus angustifolius	Swamp Sunflower
Heliopsis helianthoides	Ox Eye Sunflower
Hibiscus moscheutos	Marsh Mallow
Iris virginica	Blue Flag Iris
Lobelia cardinalis	Cardinal Flower
Monarda fistulosa	Wild Bergamot
Rudbeckia subtomentosa	Sweet Coneflower
Solidago speciosa	Showy Goldenrod
Tradescantia virginiana	Virginia Spiderwort
Verbena noveboracensis	New York Ironweed

Joe Pye Weed, Source: NCDOT

Native/Ornamental Grasses

Andropogon gerardii	Big Bluestem
Andropogon glomeratus	Bushy Bluestem
Chasmanthium latifolium	River Oats
Juncus effusus	Soft Rush
Muhlenbergia capillaris	Pink Muhly Grass
Panicum virgatum	Switch Grass
Scirpus cyperinus	Wool Grass
Sorghastrum nutans	Indian Grass
Spartina alternifolia	Smooth Cord Grass
Spartina bakeri	Cord Grass

Wool Grass, Source: NCDOT

Herbaceous plant material should be allowed to die-back at season's end. Stalks and other dead plant material may be cut as needed to maintain the stormwater control's aesthetic appeal. All cut material should be removed from the site and disposed of properly.

Native and ornamental grasses, with the exception of evergreen species, should be cut back every two to three years based on the plant's growth during that period. Use a chain saw, hedge trimmer, or any other cutting device that will not pull the crown from the ground. Top growth should be cut to a height of 4-12 inches, and all cut material should be removed from the site and disposed of properly.

Cut back of native and ornamental grasses should be delayed until the late winter months (mid-February to mid-March) to take advantage of their ornamental quality. While in their dormant state, most native and ornamental grasses have an ornamental quality that is desirable until new growth begins in the spring. If these grasses are cut back too early, this added benefit will be lost.

Note: Evergreen native grass species such as Juncus should not be cut back. Evergreen species have ornamental qualities year round and provide an added bonus of pollution uptake while other native grasses are in their dormant state. Cutting back can be detrimental to evergreen grass species. Established plant material is very slow to recover when compromised, and the end result is often death of the plant.

JUNCUS, SOURCE: NCDOT

Trees and Shrubs

Trees and shrubs are essential to the operation and function of certain stormwater controls. Often used on the floor of wetlands and wet detention basins, trees and shrubs provide valuable shade which helps regulate water temperatures. High water temperatures can be harmful to aquatic animals and direct sunlight upon the water's surface can cause an increase in algal blooms. Sometimes trees and shrubs are used on the side-slopes and outside edges of those stormwater controls (i.e., bioretention basin) that contain underdrain systems. Trees and shrubs used in this capacity can increase safety by discouraging people from entering the stormwater control. They can also enhance the aesthetic appeal of stormwater controls enabling them to blend into the landscape. The following is a list of the tree and shrub species commonly used in association with some stormwater controls.

Shrubs

Aronia arbutifolia	Red Chokeberry
Callicarpa americana	Beautyberry
Cephalanthus occidentalis	Buttonbush
Clethra alnifolia	Summersweet
Cornus sericea	Redosier Dogwood
Ilex glabra	Inkberry
Ilex vomitoria	Yaupon Holly
Ilex verticillata	Winterberry
Itea virginica	Virginia Sweetspire
Myrica cerifera	Wax Myrtle
Sambucus canadensis	American Elderberry

BEAUTYBERRY, SOURCE: NCDOT

Trees

Amelanchier arborea	Downy Serviceberry
Cornus florida	Flowering Dogwood
Ilex opaca	American Holly
Juniperus virginiana	Eastern Red Cedar
Magnolia virginiana	Sweetbay Magnolia
Nyssa sylvatica	Black Gum
Quercus lyrata	Overcup Oak
Quercus prinus	Chestnut Oak
Quercus nuttallii	Nuttall Oak
Taxodium distichum	Bald Cypress

YAUPON HOLLY, SOURCE: U.S. FISH & WILDLIFE

Trees and shrubs should be maintained in a healthy condition. Check routinely for any disease or insect infestation problems and treat accordingly. Prune dead, broken, and damaged branches and stems as needed. Remove pruning debris from grounds and dispose of properly.

Turfgrasses, native/ornamental grasses, trees, shrubs, and herbaceous plants should be maintained in a healthy growing state and mulch plays an important role in the performance of most plantings. Mulch also helps to maintain soil moisture, promotes infiltration, prevents soil erosion, and provides a habitat for microorganisms in a stormwater control. A mulch layer of aged, double-shredded hardwood bark should cover the entire surface of the planted area and should be maintained at a maximum depth of four inches.

3.2.2 FERTILIZATION

Fertilizer should only be used when necessary and not as a routine seasonal practice. Spread fertilizer uniformly over the targeted area; during application, use extreme care to prevent the fertilizer from contaminating the stormwater control or adjacent streams, ponds, lakes, or other bodies of water. Immediately incorporate fertilizers into the soil when seeding. Do not apply topdressing fertilizers to grass swales, filter strips, or buffer areas that drain to nutrient sensitive water bodies unless allowed by rule or approved by the appropriate resource agency.

When working in river basins subject to riparian buffer rules, consult with the NCDOT Division Environmental Officer prior to applying fertilizer. The buffer rules generally limit fertilizer applications to one time only within 50 feet of intermittent or perennial streams, ponds, or lakes. Note: The Randleman Rules prohibit any fertilizer application within Zone 1 (within 30 feet) of any stream or water body subject to the rules. North Carolina's Neuse and Tar-Pamlico "Buffer Rules" (Sections .0233 and .0259 of NCDWQ's Redbook of Surface Waters and Wetlands Standards [NCAC 2007]) provide the following guidance for riparian buffer areas:

- No fertilizer shall be used other than a one-time application to reestablish vegetation.
- Ongoing fertilizer application is prohibited.

For one-time applications of fertilizer for reestablishment of vegetation in riparian buffer areas that allow such application, place slow-release fertilizer into the hole dug for the plant rather than broadcasting fertilizer after planting.

For guidance with fertilizer application, contact the Roadside Environmental Unit at (919) 733-2920 or your Division Environmental Officer, or refer to NCDOT's *Vegetation Management Manual* (NCDOT 1998). Some environmental permits might prohibit the use of fertilizers for maintenance purposes. For information pertaining to site-specific fertilizer restrictions, contact the Division Environmental Officer.

3.2.3 Undesirable Vegetation Removal

If proper maintenance is not provided, undesirable vegetation such as weeds, grasses, and woody plants (trees and shrubs) will invade the vegetated areas of stormwater controls. In time, this vegetation can inhibit the ability of a stormwater control to store, treat, and/or convey water.

Desirable plant material can even become undesirable if it becomes established in areas where it is not wanted. For example, turf-type grasses become undesirable vegetation when they invade planted/mulched areas. Trees and shrubs become undesirable when they invade and establish themselves on the floors of stormwater control systems that have under-drain piping.

The following is a list of the most common undesirable plant species found during stormwater control inspection and maintenance activities. Although some of these plants are native species to North Carolina, due to their aggressive nature and/or seeding habits they are not wanted where species diversity is desired.

Broadleaf Weeds

Ambrosia artemisiifolia	Common Ragweed
Cardamine hirsute	Hairy Bittercress
Cerastium vulgatum	Chickweed
Chamaesyce maculate	Spotted Spurge
Chenopodium album	Lambsquarter
Conyza canadensis	Horseweed
Diodia virginiana	Virginia Buttonweed
Geranium carolinianum	Carolina Geranium
Glechoma hederacea	Ground Ivy
Ipomoea sp.	Morning Glory
Lactuca serriola	Prickly Lettuce
Lamium amplexicaule	Henbit
Lespedeza striata	Common Lespedeza
Mollugo verticillata	Carpetweed
Plantago sp.	Plantain
Polygonum aviculare	Prostrate Knotweed
Portulaca pilosa	Pink Purslane
Rubus spp	Blackberry

Common Ragweed, Source: USDA

Broadleaf Weeds(continued)

Ambrosia artemisiifolia	Common Ragweed
Cardamine hirsute	Hairy Bittercress
Cerastium vulgatum	Chickweed
Chamaesyce maculate	Spotted Spurge
Rumex acetosella	Red Sorrel
Rumex crispus	Curly Dock
Stachys floridana	Florida Betony
Trifolium spp	Hop Clover
Vicia sp.	Vetch

Grasses, Sedges and Grass-like Plants

Cynodon dactylon	Common Bermudagrass
Cyperus esculentus	Yellow Nutsedge
Cyperus rotundus	Purple Nutsedge
Microstegium vimineum	Japanese Stiltgrass
Typha sp.	Cattail

YELLOW NUTSEDGE, SOURCE: NCCES

Trees

Acer rubrum	Red Maple
Ailanthus altissima	Tree of Heaven
Liquidambar styraciflua	Sweetgum
Paulownia tomentosa	Princess Tree
Salix nigra	Black Willow

Remove undesirable vegetation before it becomes established. Once established, this plant material can have an adverse effect on the survivability of desirable plants and the aesthetic appeal of stormwater controls. The best time to do this is during routine mowing or plant maintenance activities. Undesirable plants can be removed by physical, mechanical, and/or herbicidal practices. Dispose of the trimmed plant material properly; do not discard into waterways because the material could clog the waterways and add nutrients to the water. Additional information on removal of invasive species can be found in NCDOT's *Invasive Exotic Plants of North Carolina* (NCDOT 2008a).

3.2.4 TRASH AND DEBRIS REMOVAL

Trash and other debris can pollute surface waters and damage stormwater control devices. The removal of floating trash and other debris will not only improve water quality, it will reduce the potential for outlet clogging during storm events and improve the overall aesthetic appeal of a SC. Trash should be removed on a routine basis as part of the maintenance activities. Remove trash and debris from outlet orifices, trash racks, basin and swale floors and side slopes, and other components, as well as from the area surrounding the SC.

3.2.5 MECHANICAL/STRUCTURAL COMPONENT MAINTENANCE

Mechanical/structural components need to be maintained regularly in accordance with the manufacturer's recommendations to ensure that they remain functional at all times. All mechanical components, including valves, sluice gates, pumps, fences, gates, trash racks, and access hatches, should be operated during each inspection to ensure that they function properly.

Check security components such as fences, gates, and locks for soundness. Repair any fence, gate, or lock found damaged in a timely manner in order to restore site security and safety.

3.3 Emergency Maintenance

Emergency maintenance is a nonroutine repair performed to correct a problem and restore a stormwater control to its proper working order. Tasks associated with emergency maintenance include, but are not limited to:

- Sediment removal
- Structural repair
- Erosion repair/bank stabilization

Since emergency maintenance needs (i.e., berm failure) often require both structural repair and soil stabilization work, it is anticipated that most emergency repairs will performed jointly by Division Maintenance and Roadside Environmental forces. If emergency maintenance needs are found, the inspector should either take immediate action to correct the problem(s) or alert the responsible parties of maintenance and/or repair needs.

Care should be taken to avoid using equipment that can cause soil compaction in or around stormwater controls. Heavy equipment with narrow tracks or narrow tires, rubber tires with large lugs, or high-pressure tires can cause excessive compaction resulting in reduced infiltration and damage to underdrain systems. When mowing in or around a stormwater control, use riding mowers or tractor mowers with turf-type tires, push mowers and/or weed eaters.

Safety considerations must be a constant focus when conducting routine maintenance. Refer to section 2.4 for a list of common safety concerns.

3.3.1 SEDIMENT REMOVAL

Sediment will eventually accumulate in every type of stormwater control. The degree to which it accumulates will depend on the upstream sediment source, rainfall intensity, and the amount of runoff that a SC receives.

Any sediment found blocking the inlet or outlet of a stormwater control should be removed. If sediment buildups are allowed to block inlets or outlets, stormwater may be diverted to areas of the SC not designed for concentrated water flow and cause these areas to erode.

Sediment that has accumulated and is inhibiting the function of a SC must be removed. In general, sediment should be removed when it exceeds 50% of the forebay's storage capacity or the original design sediment storage depth. The dredged or removed sediment must be

transferred to a waste pile or area that is protected from stormwater run-on. Make sure the removed sediment is not left in the vicinity of the SC where stormwater could come into contact with it and transport it back to the SC or nearby receiving waters. If there is evidence of pollution (a sheen on the sediment or odor), contact your Division Environmental and Safety Officer for assistance with disposal.

3.3.2 Mechanical/Structural Repair

Mechanical/structural repairs should be made promptly by qualified personnel. Equipment, materials, and personnel should be readily available to perform repairs on short notice. The following conditions could lead to structure failure and may necessitate an emergency repair: a broken sluice gate; cracks in concrete outlet structures; settling, scouring, cracking, sloughing, or furrowing on embankments; or seepage around an outflow pipe.

3.3.3 Erosion Repair/Soil Stabilization

It is necessary that a uniform vegetative cover be maintained to prevent soil loss, to maintain structural integrity, and to enhance the pollutant removal benefits of a SC. Failure to maintain a uniform vegetative cover could result in structural failure and sediment loss.

Take corrective actions when erosion is found. Repair activities should be tailored to the specific site conditions, grass type, and seasonal variations. Repair may include the use of one or a combination of the following measures: erosion control blankets, riprap, matting, sodding, and/or seeding and mulching.

3.3.4 Undesirable Woody Vegetation Removal

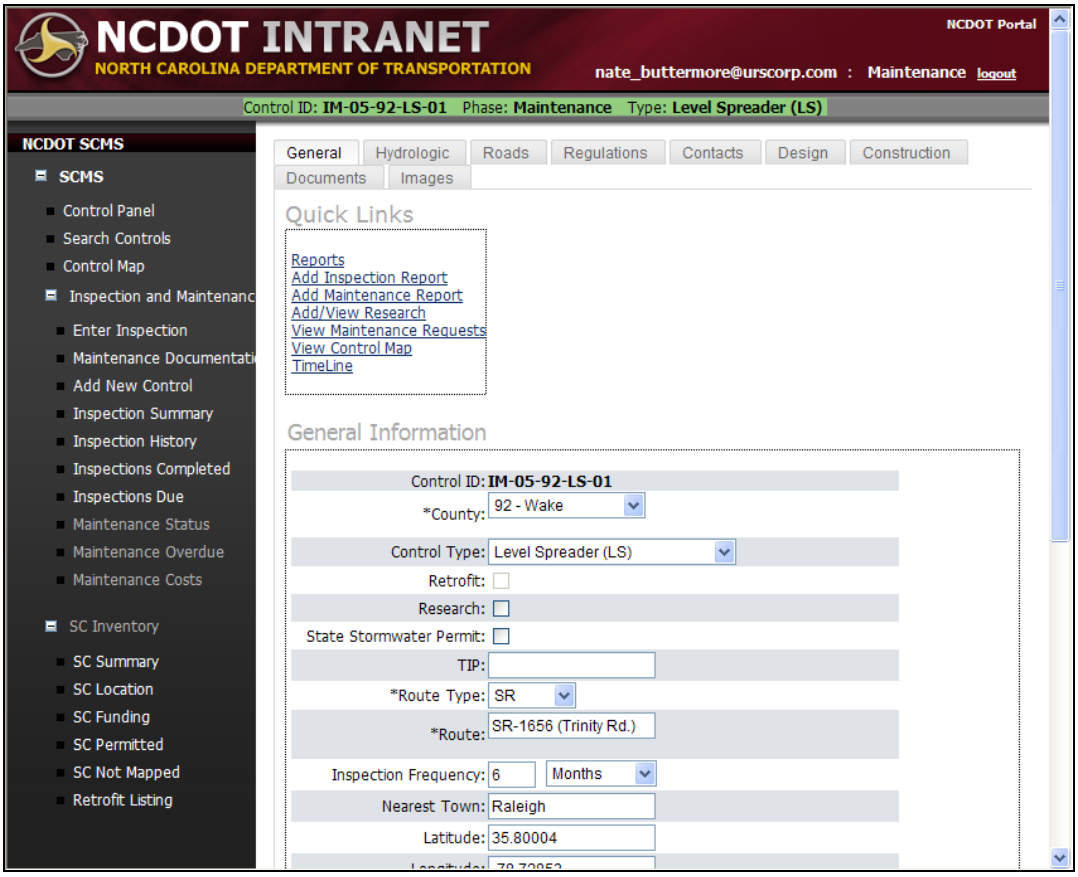
Although plant roots are important for soil stabilization, they can present problems if volunteer trees and shrubs are allowed to mature in locations they are not wanted. Mature trees and shrubs can impede and redirect water flow in inlet and outlet ditches. As trees and shrubs mature, their root systems can penetrate deep into the basin and clog the underdrain system. Decaying plant roots can create voids in the dams and embankments when mature trees die or are cut. This can result in structural failure if the situation is not addressed. Woody vegetation not removed can also impede access to SC control structures. This can prevent proper operation of such devices as hazardous spill basins.

Remove undesirable woody vegetation when found and dispose of it off-site. Any void created by removal activities should be completely filled in and properly compacted using an appropriate earthen material. Reestablish desirable vegetation to stabilize the area and prevent erosion.

3.3.5 Animal Burrow Repair

Voids created by animal burrows can weaken dams and embankments, and result in structure failure. Animal burrows found in the dams, berms, and embankments of SCs should be filled in as soon as possible. Burrows should be completely filled in and properly compacted using an appropriate earthen material. Reestablish desirable vegetation to stabilize the area and prevent erosion. If burrowing problems persist, local wildlife officials should be consulted for information regarding preventive tactics or animal removal.

CHAPTER 4 Reporting and Record Keeping



4.1 Reporting Overview

Part II.B.4.b.(b) of NCDOT's NPDES Permit requires that NCDOT develop a BMP Inspection and Maintenance Manual "outlining the inspection and maintenance requirements for various types of stormwater BMPs. The document will outline the regular inspection frequency, an inspection checklist, 'how-to' instructions for regular maintenance, evaluation and reporting procedures for non-routine maintenance, and an inspection and maintenance tracking mechanism." This manual and the website described in the following paragraph were developed to comply with this requirement.

4.2 Inspection Documentation

Each inspection must be documented using the corresponding inspection report form presented in Appendix A of this manual. Proper documentation ensures that NCDOT is adequately performing its inspection and maintenance responsibilities as required by the stormwater NPDES Permit.

Each completed report should contain the following information:

- Date of inspection
- Type of inspection (routine or follow-up)
  - **If a Level of Service (LOS) of a "D" or "F" was issued and maintenance was necessary, a follow-up inspection must be performed after the maintenance has been completed.**
- Name of the inspector
- Type of stormwater control (SC) and location
- Current condition of the stormwater control
- Description of necessary maintenance (if applicable)
- Description of any corrective actions taken at the time of inspection (if applicable)
- Names of contacts made (if applicable)

A copy of each completed inspection report must be maintained at a central location in the division for a period of five years and made available to the Director of the Division of Water Quality, or an authorized representative, immediately upon request.

4.3 LOS Ratings

After each inspection, the SC must be given a Level of Service rating. The following table describes the ratings; however, it is important to note that ratings are subjective, and the overall functionality of the SC must always be considered. For example, debris preventing the sluice gate of a hazardous spill basin from closing may initially appear as a minor impediment; but, until that debris is removed, the LOS should be rated as an "F" because the debris is inhibiting the function of the basin. If a spill occurred and the basin could not contain the spill, the device would not be functional.

LOS Category	LOS Description
A	Some aging and wear has occurred, but no structural deterioration or maintenance needs were found. Device is functioning properly.
B	Minor structural deterioration and/or maintenance needs were found, but function of the device has not been affected.
C	Moderate structural deterioration and/or maintenance needs were found, but function of the device has not been significantly affected.
D	Serious deterioration in at least one structural component and/or major maintenance needs were found. Function of the device is inadequate.
F	Device is no longer functional due to the general or complete failure of a major structural component and/or the lack of adequate maintenance.

4.4 Reporting Special Circumstances

If you discover any type of accidental spill while conducting an inspection of a stormwater control, assess the situation and contact your Division Safety Officer (DSO). If the spill appears to be a hazardous substance, call 911 in addition to your DSO. **At no time should an inspector attempt any hazardous material cleanup, or enter a spill area, unless he or she is properly trained.**

4.5 Stormwater Control Management System (SCMS)

The Stormwater Control Management System or SCMS (pronounced "skims") is available on the NCDOT Intranet at **https://intranet.dot.state.nc.us/Hydro/SCMS**. This is an online management tool used to track stormwater control inspection and maintenance activities. SCMS is to be used in conjunction with the hard copy inspection checklists provided in Appendix A of this manual. The general process for documenting inspection and maintenance of stormwater controls is as follows:

1. Perform the inspection and complete the hard copy of the appropriate inspection checklist. Note any necessary maintenance on the checklist, as well as any notable findings or observations.
2. Upon returning to the office, log in to SCMS and transfer the inspection information to the online inspection form for each specific stormwater control inspected. SCs can be searched by type or county, or by typing in the partial identification code (select the desired control from the automated dropdown list).
3. Enter any relevant or notable information into the description text box below the inspection questions. Assign the LOS in the space below the inspection checklist.
4. If maintenance is necessary, enter the maintenance needed or maintenance that was done (see the "Maintenance Needed" and "Maintenance Done " text boxes) in the appropriate space at the bottom of the screen and select "Save." You will have the option to check an "Outstanding Maintenance" checkbox so that an "Outstanding Maintenance" report can later be generated to determine what maintenance has not been completed.
    a. If maintenance is performed NOT in association with an inspection, this information can later be entered and the LOS can be changed IF the respective maintenance improved the LOS of the control.

A follow-up inspection must be conducted and entered into SCMS after all significant maintenance is performed on a control with an existing LOS of a D or F to verify that each need has been properly addressed and to ensure that the LOS is properly updated.

It is suggested that photos be taken and stored on SCMS to track the status of the stormwater control and document the maintenance activities conducted. Preferably, photos should be taken before and after maintenance is performed to document the improvements made to the SC. In addition, photos can be taken at each inspection to document the general condition of the SC. Upload the appropriate photos to the "Images" tab on the SCMS website when you are viewing the relevant stormwater control.

CHAPTER 5 Bioretention Basin

Overview

A BIORETENTION BASIN (BB) is a type of filtration basin (see Chapter 8) with landscaped shrubs and other various plants, filter media, and a mulch cover to enhance pollutant removal.

PURPOSE AND DESCRIPTION

- Bioretention basins are structural stormwater controls (SCs) designed to temporarily capture stormwater runoff, filter and retain pollutants, and reduce peak flows.
- Inflow to the bioretention basin is filtered through engineered media or amended soil. The filtered water exits through an underdrain system at the bottom of the filter media.
- Specially selected plants enhance the pollutant removal capabilities of the basin.

INSPECTION

- Ponded water should infiltrate into the filter media within 48-72 hours of a storm event; prolonged ponding indicates that the filter media or underdrain system requires maintenance.
- The mulch layer and vegetation should be carefully inspected. Use landscaping plans as an aid during the inspection.
- Inspections should occur annually, unless otherwise required by environmental permits or more frequent inspections are deemed necessary.

TYPICAL MAINTENANCE

- Trash and debris should be removed from inlet grates, forebays, the basin, and trash racks.

Note: This is a specialized device and if major maintenance is needed, such as the flushing of the underdrain system, please contact the Hydraulics and/or Roadside Environmental Units in Raleigh for guidance.

5.1 Stormwater Control Overview

A Bioretention Basin (BB) is a soil and plant-based filtering system designed to remove pollutants from stormwater runoff. It works by temporarily retaining stormwater runoff and allowing it to slowly infiltrate into the soil over a period of 48-72 hours. As stormwater slowly passes through the soil, it comes in contact with soil particles and plant roots where pollutants are absorbed and removed. The filtered water then enters the basin's underdrain system where it exits the bioretention basin and flows to the nearest stream, river, or lake.

Figure 5-1 illustrates the flow path and treatment processes in a typical bioretention basin.

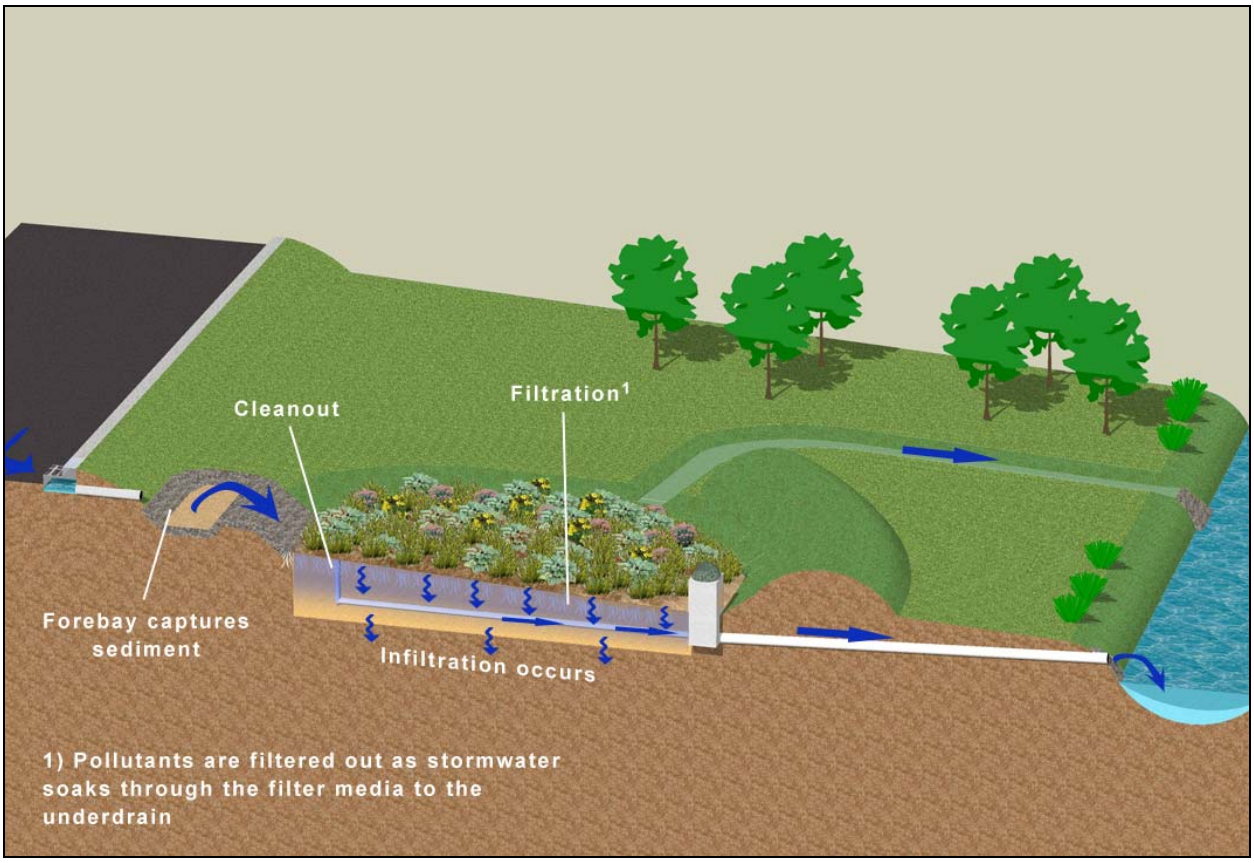


Figure 5-1. Cutaway of a bioretention basin layout and treatment processes

5.2 Bioretention Components

Figure 5-2 illustrates the various components of a typical bioretention basin. Note that layouts vary. Some bioretention basins are designed to include a flow bypass structure. For these systems, runoff enters the bioretention basin via a flow bypass structure, which is designed to divert a set amount of runoff to the bioretention basin. Excess flow bypasses the bioretention basin and is discharged downstream via a filter strip and/or swale. This configuration is typical of infiltration basins. See Chapter 10 for inspection and maintenance information and figures for flow bypass systems. The typical bioretention basin configuration includes the following components:

- Inlet Drainage System
- Forebay
- Basin
- Landscaping
- Underdrain System
- Outlet Control Structure
- Outlet Drainage System

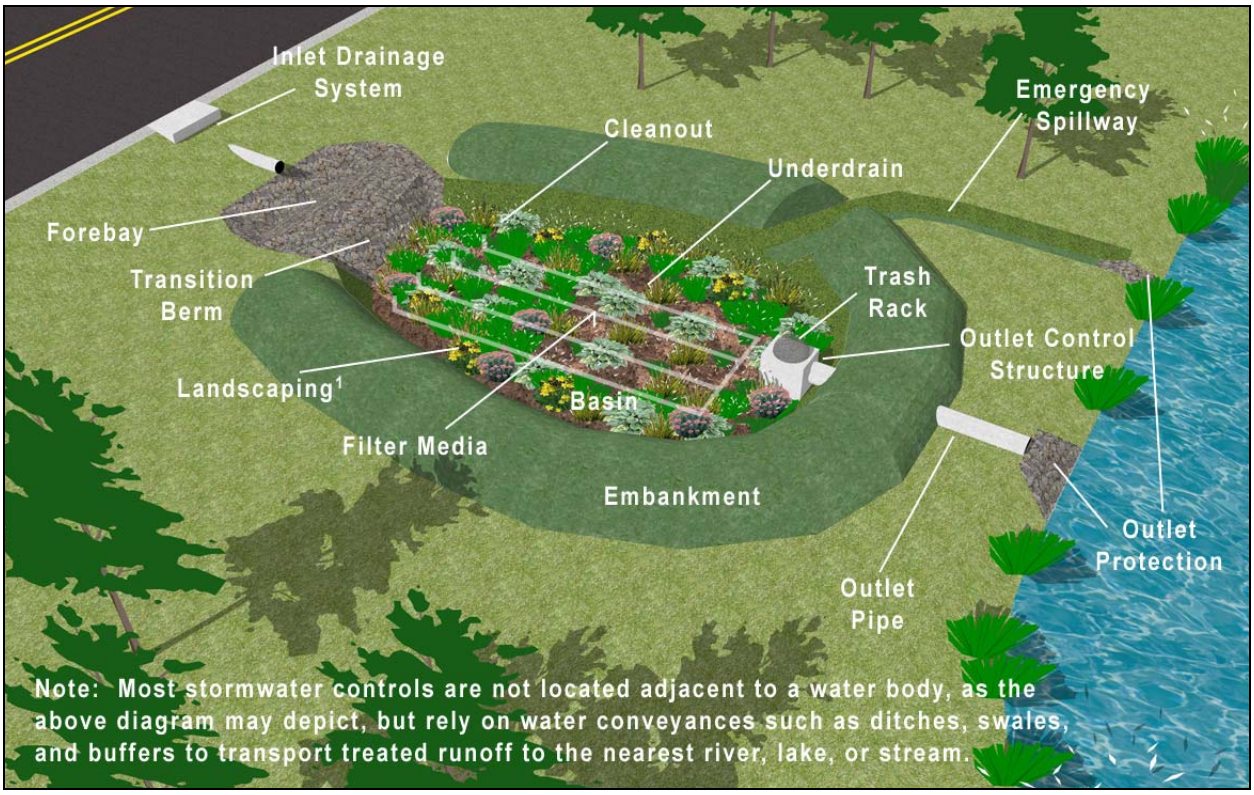


Figure 5-2. Bioretention basin layout and components

All filtration basins, including bioretention basins, have underdrain systems. If an underdrain system is present, cleanouts will be found within the basin.

5.3 Inspection and Maintenance

Bioretention basins should be inspected periodically to determine whether they are functioning as intended. If any part of the bioretention basin is not functioning properly, determine the cause and restore to working order as soon as possible. Figures 5-3 and 5-4 illustrate a plan and profile view of the areas that should be inspected and maintained in a typical bioretention basin configuration.

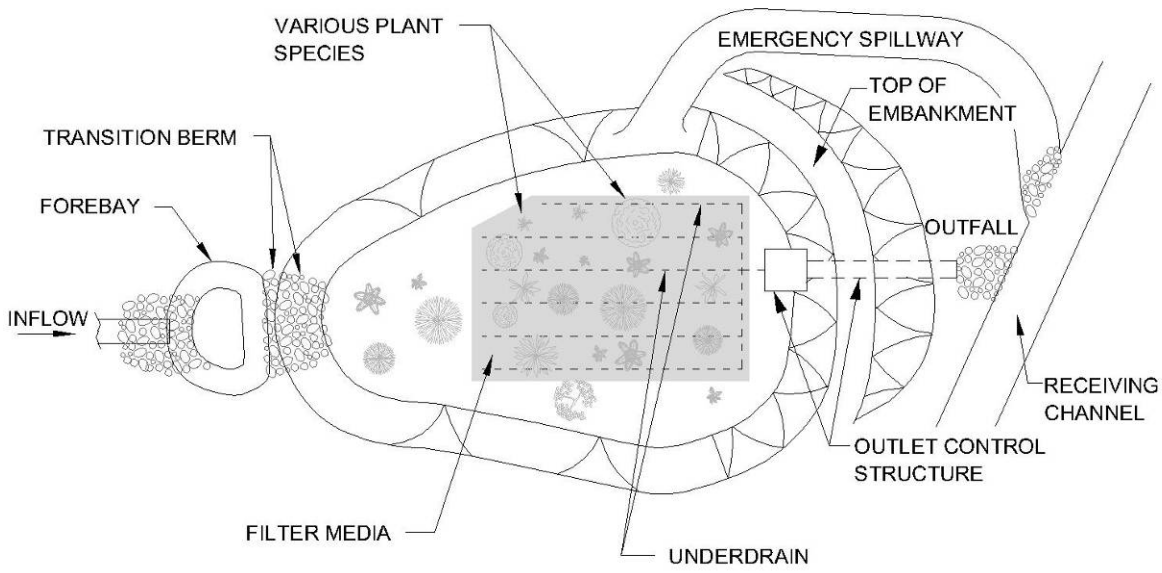


Figure 5-3. Plan view of a bioretention basin and its components

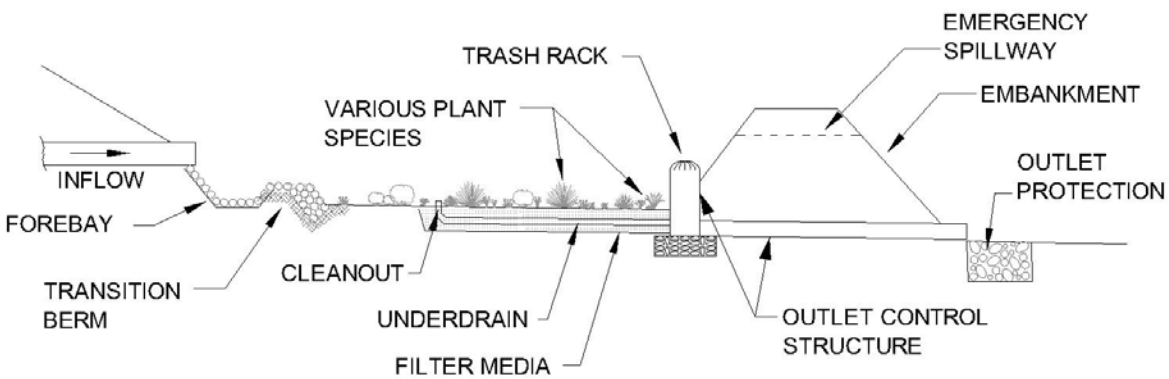


Figure 5-4. Profile view of a bioretention basin and its components

All inspection findings and maintenance activities should be noted on the inspection form (see Appendix A) and then entered into the Stormwater Control Management System (SCMS). Photos should be taken to track the status of the stormwater control (SC) and document the maintenance activities conducted. These, too, can be uploaded to SCMS. Refer to Chapter 4 for further guidance.

The following sections describe the function of a bioretention basin and provide guidance on the inspection and maintenance of its major components.

5.3.1 INLET DRAINAGE SYSTEM

Function

The inlet drainage system collects and conveys water to the bioretention basin. Inlet drainage systems can consist of open channels, pipes, curb and gutter, and catch basins. Some bioretention basin designs use flow bypass structures to divert a predetermined amount of runoff to the SC while bypassing excess flow so that the basin, outlet control structure, and embankment do not fail. If this is the case, refer to Sections 10.3.2 through 10.3.4 in Chapter 10, Infiltration Basin, for inspection and maintenance guidance on flow bypass systems.

Inspection

Stormwater runoff should be allowed to flow freely into the basin. Inspect all ditches, pipes, and/or catch basins draining to the bioretention basin for trash, sediment, and debris. Inspect the ground surface above buried pipes and structures for depressions and other signs of pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation. Bioretention basins are particularly susceptible to sedimentation. The area draining to the basin should be carefully inspected for bare soil (NCDWQ, 2007). Desirable vegetation includes grass cover in an open ditch to prevent soil erosion. Undesirable vegetation includes any woody plants or invasive species that may impede the inlet drainage system.

Maintenance

Remove and properly dispose of debris, undesirable vegetation, and major sediment accumulations. Repair all eroded areas and damaged pipes. Refer to Chapter 3 for additional guidance on maintenance techniques.

5.3.2 FOREBAY

Function

A forebay is a basin located at the inlet of an SC that pretreats stormwater (see Figure 5-5). A forebay reduces the runoff velocity of stormwater, which in turn allows sediment in the stormwater to settle before the stormwater enters the bioretention basin. A transition berm is the component located at the downstream end of the forebay that acts as a weir and releases runoff to the stormwater control. The presence of a forebay reduces the risk of SC failure.

Some forebays within bioretention basins have been designed with special transition weirs that function much like a level spreader lip. A hard, flat material is used to convert concentrated water flow into sheet water flow. This process prevents mulch from being washed out of the area immediately downstream of the forebay, which would lead to erosion within the basin. Figure 5-6 illustrates two examples of transition weirs.

Inspection

Inspect forebays for trash, debris, and undesirable vegetation. Inspect to determine whether forebays are structurally sound and that they do not contain excessive amounts of accumulated sediment. Inspect the embankment and transition berm for structural integrity and signs of erosion. Inspect the forebay for undesirable vegetation. Forebays may have grass-covered embankments and berms, but they are not designed to support vegetation. Minimal plant growth is tolerable, but if it becomes excessive, the storage volume for sediment is reduced and dredging becomes more difficult. If any invasive species are present, it is generally preferable to remove them before they become well-established.

Maintenance

Remove trash, debris, and undesirable vegetation and properly dispose of it off-site. Remove sediment and dispose of it off-site if it appears to occupy more than 50% of the forebay's storage capacity. Replace erosion protection materials (i.e., riprap) as needed. If the surrounding soil is disturbed during cleanout of the forebay, or at any other time, reseed any areas of bare soil with grass to prevent erosion. Repair the transition berm as necessary, taking care to maintain the original elevation of the berm. Refer to Chapter 3 for additional guidance on sediment disposal. Consult the North Carolina Department of Transportation *Stormwater Best Management Practices Toolbox* (NCDOT, 2008b) or the Hydraulics Unit if major repairs are required.

Figure 5-5. Typical forebay (foreground)

Figure 5-6. Two examples of transition weirs

5.3.3 Basin and Surrounding Area

Function

The basin is the component of the bioretention basin that reduces the rate of runoff and filters out contaminants (see Figure 5-7). The basin bottom has special filter media and an underdrain system. See Section 5.3.5 for further information regarding underdrain systems. Filter media in bioretention basins is typically well-mixed engineered media consisting of washed sand, fine clay and silt, and organics. The media is covered with a layer of mulch and planted with landscape vegetation. See Section 5.3.4 for further information regarding the mulch layer and vegetation.

Ponded water should take 48-72 hours to infiltrate into the filter media. This is known as the drawdown period. Some basins are designed with a shorter drawdown period. If available, consult design drawings to determine whether this is the case for a given bioretention basin.

Inspection

Inspect the basin for structural integrity. Note any signs of erosion (see Figure 5-8) or burrowing animals. Inspect the embankment or berms for settling, scouring, cracking, sloughing, and furrowing, and for invasive shrubs and trees. Also, inspect the downstream toe of the embankment for seepage (NCDWQ, 2007). Note trash, debris, and/or sediment found in the basin or surrounding areas. Sediment should be removed if it is clogging the filter media or if it has reached a depth of 3 inches (NCDWQ, 2007). Refer to Chapter 3 for guidance on sediment removal.

Figure 5-7. Typical basin area

Figure 5-8. Examples of erosion within a bioretention basin

Inspect the basin for evidence that water remains in the basin longer than the design drawdown period. Cattails and other wetland vegetation are good indicators that water is remaining in the basin longer than intended. If this is the case, try to determine the cause of the standing water. Likely causes include a clogged underdrain system or clogged filter media.

Maintenance

The permeability of the filter media must be maintained or the bioretention basin will not function properly. Vehicles and construction equipment should not be driven on the basin bottom (NCDWQ, 2007). Use best professional judgment when selecting landscaping equipment for use in the basin and minimize foot traffic on the basin bottom.

Flush the underdrain system if the basin is not draining properly (see Section 5.3.5). Consider flushing the underdrain system annually as a preventative maintenance measure if the system appears to have the tendency to plug. If the problem persists, remove and replace the first few inches of the filter media. Finally, as a last resort, excavate the underdrain system and repair or replace it if necessary, and replace the original filter media with new media (NCDWQ, 2007). These components should be repaired or replaced to meet the original design specifications unless they are deemed insufficient. For additional guidance, consult the North Carolina Division of Water Quality *Stormwater Best Management Practices Manual*.

Repair areas with erosion, channelization, or animal burrows by regrading and reestablishing the proper cover (see Section 5.3.4). Take care to preserve the filter media's grade and mixture. Consult the design drawings or landscaping plan if necessary. If soil testing indicates a pH problem or toxic conditions, the addition of lime or replacement of the filter media may be warranted. If the filter media is to be replaced, consult the original design specification to ensure that the correct mixture and testing procedures are followed. Contact the NCDOT Roadside Environmental Unit (REU) for guidance.

5.3.4 LANDSCAPING

Function

The mulch layer and vegetation in the basin are important in the removal of stormwater pollutants. Mulch regulates soil conditions, prevents weed establishment, and protects plants. Mulch also plays an important role in removing heavy metals from runoff. Other stormwater pollutants are filtered out as runoff soaks through the filter media.

Contact with vegetation allows for biological treatment of metals and nutrients through primarily microbial processes (NCHRP, 2006). Plant roots improve soil structure and enhance the soil's ability to filter out stormwater pollutants (NCDWQ, 2007). Photos of some plants appropriate for use in bioretention basins are presented in Figure 5-9. For further information on appropriate plants, contact the NCDOT REU.

Inspection

Note any undesirable vegetation. Consult the design drawings or landscaping plan to determine whether the appropriate vegetation appears to be present. Bioretention basins may have several species of plants and identifying them all may not be practical. If this is the case, verify that there is a variety of healthy species, making sure that one species is not out-competing the others. Inspect the basin to verify that desirable vegetation is healthy. Note any areas in and around the basin that have exposed soil. All areas should be covered with mulch, landscaped vegetation, grass, or erosion protection materials (i.e., riprap).

The basin floor should be covered with a layer of mulch 3 to 4 inches thick. Note areas that require additional mulch. The surrounding area should be stabilized with at least a cover of grass. Inspect the grass to ensure that it is being mowed at a frequency to maintain a height of 6 to 15 inches.

Figure 5-9. Examples of plant species used in North Carolina bioretention basins

Maintenance

The permeability of the filter media must be maintained or the bioretention basin may fail. Vehicles and construction equipment should not be driven on the basin bottom (NCDWQ, 2007). Use best professional judgment when selecting landscaping equipment for use in the basin and minimize foot traffic on the basin bottom.

Mow grass to the ideal height. Turfgrass is typically mowed at a frequency to maintain a maximum height of 4 inches for warm-season grasses and 6 inches for cool-season grasses. However, on highway right-of-way facilities, it is more practical to maintain a grass height between 6 and 15 inches.

Add mulch and reestablish grass or herbaceous groundcover where cover is insufficient. Use double-shredded hardwood bark where mulch is needed. Remove undesirable vegetation, taking care not to damage desirable vegetation. Replace dead or unhealthy plants using the original design drawings or landscaping plan if necessary. Fertilize turfgrass and/or plants upon reestablishment if necessary. The use of fertilizer may be restricted at some locations. Refer to Chapter 3 when considering the use of fertilizer and for additional information on caring for vegetation.

5.3.5 UNDERDRAIN SYSTEM

Function

Bioretention basins are equipped with underdrain systems to drain runoff that has passed through the filter media. Positioned beneath the filter media, the underdrain system is usually constructed of perforated PVC pipe. The perforated pipe is wrapped in filter fabric to prevent clogging and installed in a shallow layer (typically less than 12 inches) of No. 57 stone. Cleanouts provide access to the underdrain system for inspection and maintenance activities.

Inspection

Inspect the cleanouts to ensure that their caps are in place and undamaged. Damaged or missing caps will allow stormwater to exit the basin untreated. Cleanouts can also be used to drain the basin if the filter media has become clogged. To inspect, remove the caps from the cleanouts and observe the inside for sediment or standing water using a flashlight. If water is available, pour water in the cleanouts using a bucket or hose and observe the flow in the outlet control structure or outlet pipe. If the water does not exit freely, the underdrain system may be clogged. If sediment is flushed from the underdrain system, the filter fabric may have been damaged and will need to be excavated and repaired. Also, the basin should be inspected for depressions, which is another indication that the filter fabric is damaged and soil is entering the underdrain system.

Maintenance

A high-pressure hose can be used to flush out underdrain system by spraying water into cleanouts. Replace all cleanout caps that are missing, cracked, or otherwise damaged. Consider flushing underdrain systems annually if they appear to have a tendency to plug. If roots or soil are present in the underdrain system, it is likely that the filter fabric protecting the perforated PVC pipe is damaged. If this is the case, the underdrain system should be excavated and repaired or replaced. All repairs should be made in accordance with the original design specifications. To avoid crushing the underdrain system, heavy equipment should not be driven in the basin. Refer to Chapter 3 for additional information.

5.3.6 OUTLET CONTROL STRUCTURE (BOX)

Function

Typically, the underdrain system connects to an outlet control structure, which is designed to release excess stormwater during large storm events. Outlet control structures for bioretention basins generally resemble catch basins that are elevated, typically 12 inches or less (NCDWQ, 2007), above the basin bottom. Figure 5-10 shows two examples of outlet control structures.

Figure 5-10. Bioretention basin outlet control structures

Inspection

Inspect the outlet control structure thoroughly for any sign of damage such as cracks, holes, or leaks. Confirm that the outlet box remains covered with a trash rack or grate and that the trash rack or grate is structurally sound. Note the amount of trash and debris buildup on the trash rack.

Maintenance

Repair any damaged areas of the outlet control structure, and remove sediment and debris. Replace metal components if necessary.

5.3.7 OUTLET DRAINAGE SYSTEM

Function

The outlet drainage system conveys water from the SC to the downstream drainage system or receiving water. Components of this system can include channels, pipes, catch basins, manholes, culverts, and other structures.

Inspection

Inspect pipes and drainage structures for cracks or leaks. Inspect the ground surface above buried pipes and structures for depressions or other signs that might indicate pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation. If outlet protection materials (i.e., riprap) are present, verify that these materials are adequate to protect against erosion.

Maintenance

Remove and properly dispose of debris, undesirable vegetation, and major sediment accumulations. Repair all eroded areas and damaged pipes. Replace outlet protection materials as necessary. Refer to Chapter 3 for additional guidance on maintenance techniques.

5.3.8 EMERGENCY SPILLWAY (IF PRESENT)

Function

The emergency spillway serves as an overflow structure that is typically constructed as a channel in natural ground.

Inspection

The emergency spillway should remain free of trash and debris at all times. Emergency spillways are typically covered with grass, but concrete and riprap are also used. For grass channels, verify that grass is maintained between 6 and 15 inches. Inspect concrete to verify that it is in good condition, or verify that adequate riprap is present. Note all erosion and undesirable vegetation.

Maintenance

Emergency spillways must be free of trash, debris, and undesirable vegetation or they may become blocked and will not function properly. Remove these if present. Grass should be carefully maintained at a height of 6 to 15 inches. If applicable, repair concrete or replace riprap as necessary. Repair areas of erosion.

5.4 Inspection and Maintenance Summary

Observations made while inspecting stormwater controls must be documented on the appropriate SC inspection report form and entered into SCMS. Observations recorded would include a general description of the SC and those maintenance needs identified such as the removal of accessible trash, sediment, and unwanted vegetation.

If during an inspection emergency maintenance needs are identified (i.e., a sluice gate frozen in the open position), the inspector should either correct the problem at that time or contact the party(s) responsible for emergency maintenance repairs. If emergency maintenance needs are not corrected at the time of the inspection, a follow-up inspection should be conducted to verify that the responsible party(s) has taken action and all needs have been addressed. Observations made during the follow-up inspection must be documented on the appropriate SC inspection report form and entered into SCMS.

CHAPTER 6 Filtration Basin

Overview

A FILTRATION BASIN (FB) is a stormwater control (SC) that captures and temporarily stores runoff, allowing it to percolate through filter media to an underdrain system, where it is conveyed downstream.

PURPOSE AND DESCRIPTION

- Filtration basins are structural SCs designed to temporarily capture stormwater runoff, filter out pollutants, and minimize peak flows.
- Inflow to the SC is detained and filtered through a natural or engineered media, which removes pollutants.
- Filtration basins are designed with an underdrain system that typically conveys filtered runoff to an outlet control structure.

INSPECTION

- Filtration basins should drain within 40 hours after a storm event; prolonged ponding indicates that the filter media or underdrain system requires maintenance.
- Inspections should occur annually, unless otherwise required by environmental permits or more frequent inspections are deemed necessary.

TYPICAL MAINTENANCE

- Trash and debris should be removed from inlet grates, forebays, the basin, and trash racks.
- The underdrain system should be flushed and its components replaced or repaired as necessary.
- Undesirable vegetation, especially woody vegetation on the embankment, should be removed.

6.1 Stormwater Control Overview

A Filtration Basin (FB) is a stormwater control that uses a filter media (typically sand) to remove pollutants from stormwater runoff. It works by temporarily detaining stormwater runoff and allowing it to slowly soak into the filter media. As stormwater slowly seeps through the filter media, pollutants are absorbed and removed as it makes contact with soil particles. The filtered water then enters the basin's underdrain system where it exits and flows to the nearest river, lake or stream (see Section 6.3.4).

Filtration basins are effective in removing many of the common pollutants found in stormwater runoff, especially finer sediments and sediment-bound pollutants. Filtration basins are currently designed to drain within 40 hours following a storm event (NCDWQ, 2007). Previous designs may have used a 2-5 day drawdown period. The stormwater flow path and treatment process described here are illustrated in Figure 6-1.

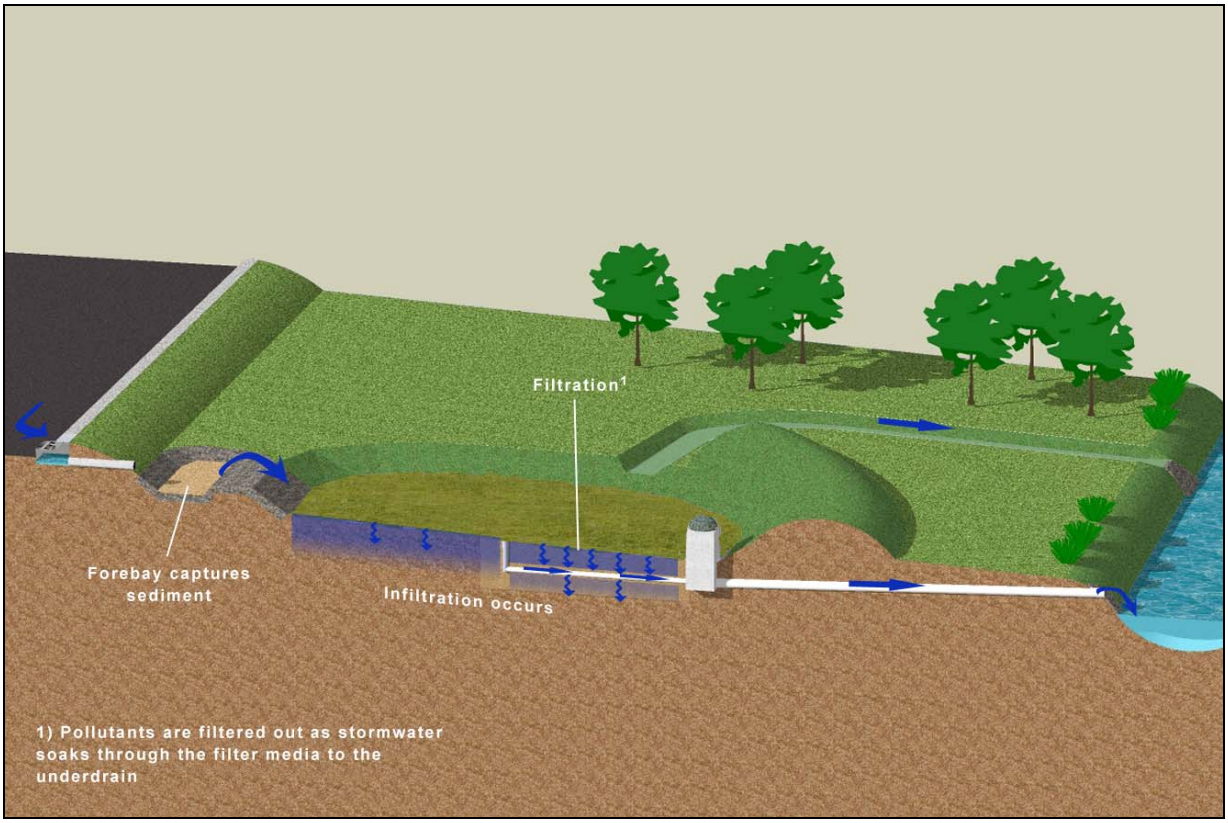


Figure 6-1. Cutaway of a filtration basin flow diagram and treatment processes

6.2 Filtration Basin Components

Figure 6-2 illustrates the various components of a typical filtration basin; however, layouts can vary. Some systems will have additional components, whereas others may lack certain components. Filtration basin may include the following:

- Inlet Drainage System
- Forebay
- Basin
- Filter Media
- Underdrain System
- Outlet Control Structure
- Outlet Drainage System
- Emergency Spillway

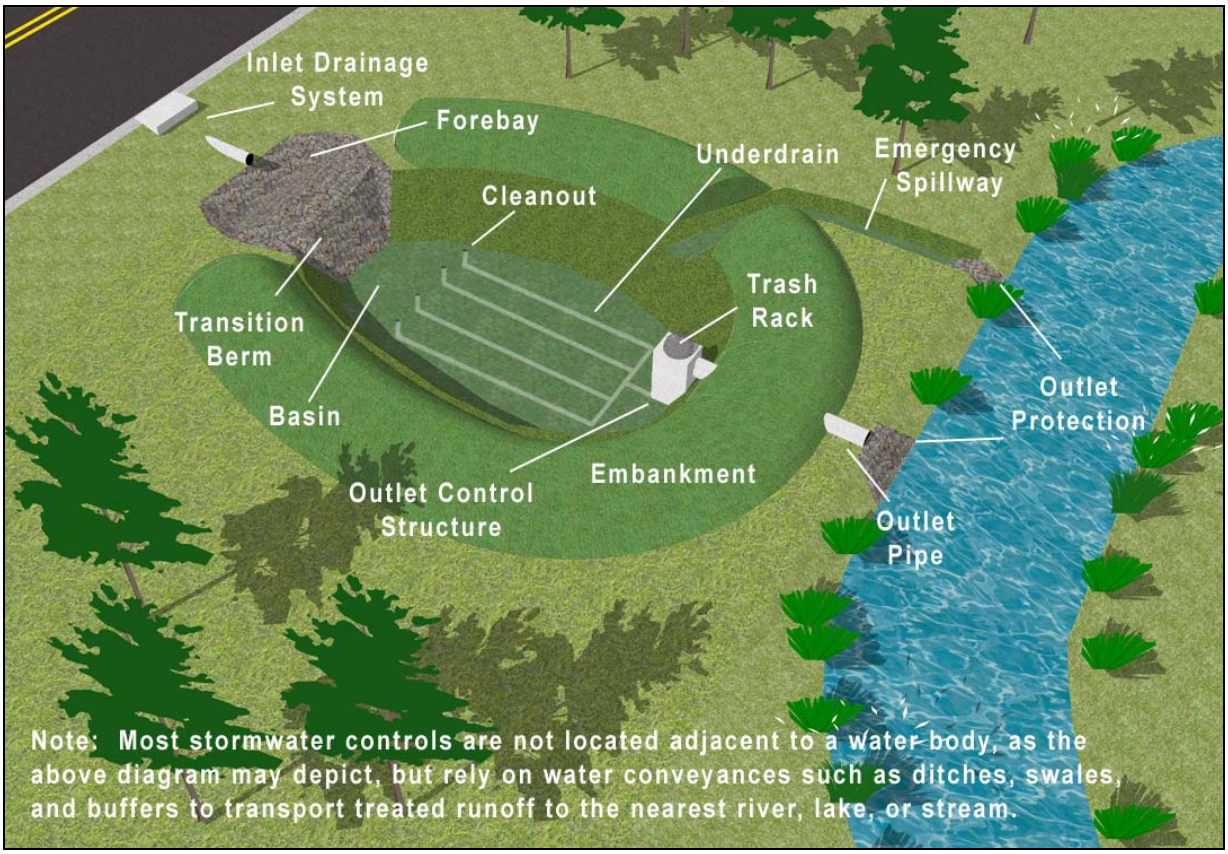


Figure 6-2. Filtration basin layout and components

The underdrain system is the component that sets a filtration basin apart from an infiltration basin. If it is unclear whether an underdrain system is present, cleanouts should be visible in the basin. Sand filters and bioretention basins are types of filtration basins. Because bioretention basins are well known and widely used, a separate chapter on bioretention basins has been developed (see Chapter 5).

6.3 Inspection and Maintenance

Filtration basins should be inspected at least annually to determine whether they are functioning as intended. If a filtration basin is found to not be functioning properly, determine the cause and restore to working order as soon as possible. Figures 6-3 and 6-4 illustrate a plan and profile view of the areas that should be inspected and maintained in a typical filtration basin configuration.

All inspection findings and maintenance activities should be noted on the inspection form (see Appendix A) and then entered into the Stormwater Control Management System (SCMS) on NCDOT's Intranet. Photos should be taken to track the status of the stormwater control (SC) and document the maintenance activities conducted. These, too, can be uploaded to SCMS. Refer to Chapter 4 for further guidance.

The following sections describe the function of a filtration basin, and provide inspection and maintenance guidance for its major components.

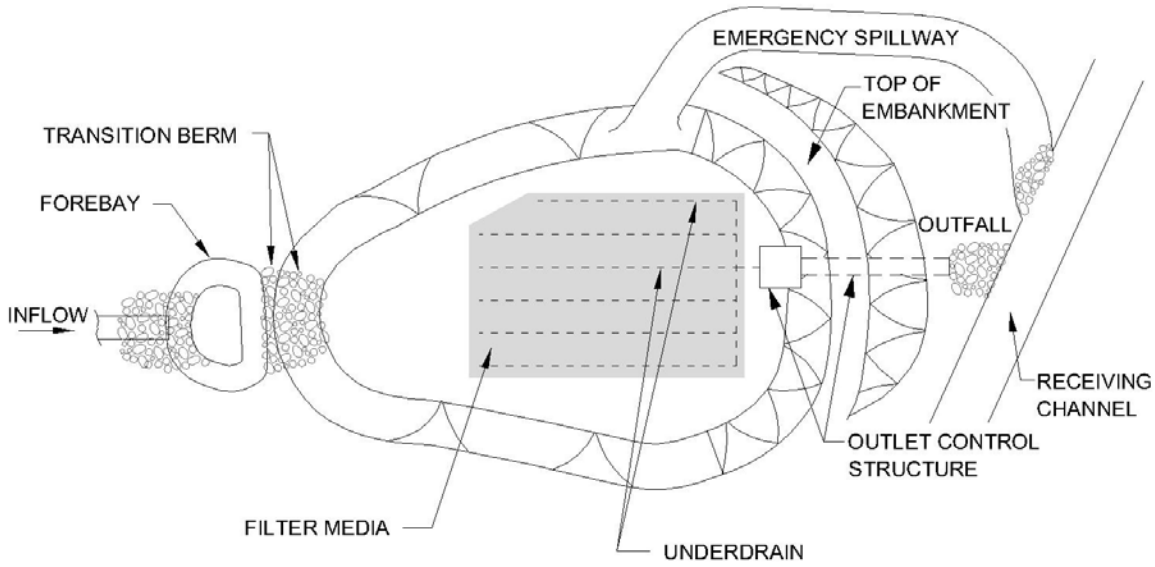


Figure 6-3. Plan view of a filtration basin and its components

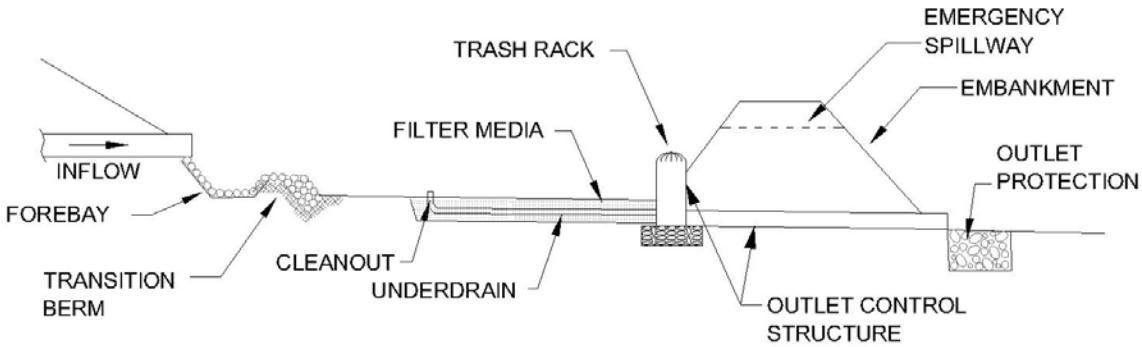


Figure 6-4. Profile view of a filtration basin and its components

6.3.1 INLET DRAINAGE SYSTEM

Function

The inlet drainage system collects and conveys water to the filtration basin. Inlet drainage systems can consist of open channels, pipes, curb and gutter, and catch basins. Some filtration basin designs use flow bypass structures to divert a predetermined amount of runoff to the SC while bypassing excess flow so that the basin, outlet control structure, and embankment do not fail. If this is the case, refer to Sections 13.3.3 and 13.3.6 in Chapter 13, Level Spreader, for inspection and maintenance guidance.

Inspection

Stormwater runoff should be allowed to flow freely into the basin. Inspect all ditches, pipes, and/or catch basins draining to the filtration basin for trash, sediment, and debris. Inspect the ground surface above buried pipes and structures for depressions and other signs of pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation. Filtration basins are particularly susceptible to sedimentation. The area draining to the basin should be carefully inspected for bare soil (NCDWQ, 2007).

Maintenance

Remove and properly dispose of debris, unwanted vegetation, and major sediment accumulations. Reseed the area draining to the basin if necessary to maintain a dense stand of vegetative cover. Repair all eroded areas and damaged pipes. Refer to Chapter 3 for additional guidance on maintenance techniques.

6.3.2 FOREBAY

Function

A forebay is a basin located at the inlet of a SC that pretreats stormwater. A forebay reduces the runoff velocity of stormwater, which in turn allows sediment in the stormwater to settle before the stormwater enters the filtration basin. A transition berm is the component located at the

downstream end of the forebay that acts as a weir and releases runoff to the stormwater control. The presence of a forebay reduces the risk of SC failure.

Inspection

Inspect to ensure that all forebays remain free of trash, debris, and undesirable vegetation. Inspect to determine whether forebays are structurally sound and that they do not contain excessive amounts of accumulated sediment. Inspect the transition berm to determine whether it is structurally sound and shows signs of erosion.

Maintenance

Remove trash, debris, and undesirable vegetation and properly dispose of it off-site. Remove sediment and dispose of it off-site if it appears to occupy more than 50% of the forebay's storage capacity. Replace erosion protection materials (i.e., riprap) as needed. Reestablish vegetation for earthen forebays. Repair the transition berm as necessary, taking care to maintain the original elevation of the weir. Refer to Chapter 3 for additional guidance on sediment disposal. Consult the North Carolina Department of Transportation *Stormwater Best Management Practices Toolbox* if major repairs are required.

6.3.3 Basin and Surrounding Area

Function

The basin is the component of the filtration basin that reduces the rate of runoff and filters out contaminants. The basin bottom has special filter media and an underdrain system. See Section 6.3.4 for further information regarding underdrain systems. Filter media can consist of synthetic material, amended soil, or sand. The filter media is typically covered with a layer of topsoil and grass.

Inspection

The interior and exterior side slopes of the basin and all areas surrounding the basin should be stabilized with at least a cover of turf-type grass. Typically, a uniform cover of grass will be established on the floor of the basin, however, filtration basin designs can vary; for example, some filtration basins use sand as a filter media and have no additional cover. Consult the design drawings to determine the intended configuration and note any differences from the original cover.

Inspect grass to ensure that it is being mowed at a frequency to maintain a height of 6 to 15 inches. Inspect the basin for structural integrity. Note any signs of erosion, burrowing animals, or undesirable vegetation. Inspect the embankment for settling, scouring, cracking, sloughing, and furrowing, and for invasive shrubs and trees. Also, inspect the downstream toe of the embankment for seepage (NCDWQ, 2007). Note trash and debris found in the basin or in surrounding areas. Currently, filtration basins are designed to drain within 40 hours; however, a 2-5 day drawdown period has been used in the past. Use design drawings to determine the drawdown period and inspect the basin for evidence that water remains in the basin longer than intended. Cattails and other wetland vegetation are good indicators that water is remaining in the

basin longer than intended. If this is the case, try to determine the cause of the standing water. Likely causes include a clogged underdrain system or clogged filter media.

Maintenance

The permeability of the filter media must be maintained or the filtration basin will fail. Vehicles and construction equipment should not be driven on the basin bottom (NCDWQ, 2007). Use best professional judgment when selecting mowing and other landscaping equipment for use in the basin. Avoid the use of riding lawnmowers and minimize foot traffic on the basin bottom.

Mow grass to the ideal height. Turfgrass is typically mowed at a frequency to maintain a maximum height of 4 inches for warm-season grasses and 6 inches for cool-season grasses. However, on highway right-of-way facilities, it is more practical to maintain a grass height between 6 and 15 inches.

If erosion has occurred, reestablish grass (seed or sod) and fertilize if necessary. The use of fertilizer may be restricted at some locations. Refer to Chapter 3 when considering the use of fertilizer. Repair all animal burrows. If there is channelization, consult the design drawings and restore the proper grade and cover.

Remove undesirable vegetation (using an approved mechanical or herbicidal treatment). If cattails and other undesirable wetland vegetation are present, the underdrain system or the filter media could be clogged. Flush the underdrain system if the basin is not draining properly (see Section 6.3.4). If the problem persists, remove and replace the first few inches of the filter media. As a last resort, excavate the underdrain system and repair or replace it if necessary, and replace the original filter media with new media (NCDWQ, 2007). These components should be repaired or replaced to meet the original design specifications unless deemed insufficient. If additional guidance is needed consult the North Carolina Division of Water Quality *Stormwater Best Management Practices Manual* (NCDWQ, 2007).

6.3.4 UNDERDRAIN SYSTEM

Function

Filtration basins are equipped with underdrain systems to drain runoff that has passed through the filter media. Positioned beneath the filter media, the underdrain system is usually constructed of perforated PVC pipe. The perforated pipe is wrapped in filter fabric to prevent clogging and installed in a shallow layer (typically 12 inches) of No. 57 stone. Cleanouts provide access to the underdrain system for inspection and maintenance activities. To avoid crushing the underdrain system, heavy equipment should not be driven in the basin. Refer to Chapter 3 for additional information.

Inspection

Inspect the cleanouts to ensure the caps are in place and undamaged. Damaged or missing caps will allow stormwater to exit the basin untreated. Alternatively, the cleanouts can be used to drain the basin in the event that the filter media has become clogged. To inspect, remove the caps from the cleanouts and observe the inside for sediment or standing water using a flashlight.

If water is available, pour water in the cleanouts using a bucket or hose and observe the flow in the outlet control structure or outlet pipe. If the water does not exit freely, the underdrain system may be clogged. If sediment is flushed from the underdrain system, the filter fabric may have been damaged and will need to be excavated and repaired. Also, the basin should be inspected for depressions, which is another indication that the filter fabric is damaged and soil is entering the underdrain system.

Maintenance

A high-pressure hose can be used to flush out underdrain systems by spraying water into cleanouts. Replace all cleanout caps that are missing, cracked, or otherwise damaged. NCDWQ recommends flushing underdrain systems annually (NCDWQ, 2007). If roots or soil are present in the underdrain system, it is likely that the filter fabric protecting the perforated PVC pipe is damaged. If this is the case, the underdrain system should be excavated and repaired or replaced. All repairs should be made in accordance with the original design specifications.

6.3.5 OUTLET CONTROL STRUCTURE (BOX)

Function

Typically, the underdrain system connects to an outlet control structure, which is designed to release excess stormwater during large storm events. Outlet control structures can have several components, including a riser, trash rack, sluice gate, and outlet pipe. If standing water is present and it is inhibiting the inspection, the basin can be drained or pumped out; however, the water must first be visually inspected for obvious signs of pollutants. Check for an oily sheen or excessive suspended solids. If either of these is present, do not drain the basin. Call the Division Safety Officer or the Roadside Environmental Unit for guidance. The sluice gate should be returned to the closed position when inspection and maintenance activities are completed. Figure 6-5 illustrates the configuration of a typical outlet control structure.

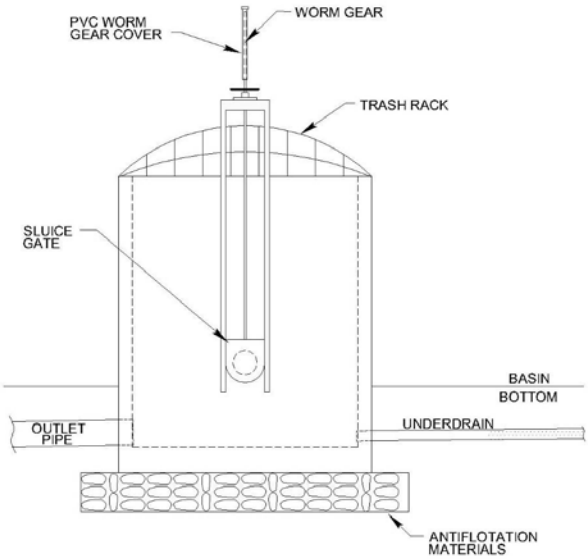


Figure 6-5. Components of an outlet control structure

Inspection

Inspect the outlet control structure thoroughly for any sign of damage such as cracks, holes, or leaks. Inspect to ensure that the outlet box remains covered with a trash rack and that the trash rack is not excessively corroded. Note the amount of trash and debris buildup on the trash rack. If a sluice gate is present, open and close it to ensure that it can be operated through its entire range of motion. Inspect the sluice gate for excessive corrosion. Verify that there is no sediment or debris below the sluice gate that could prevent it from being fully closed.

Maintenance

Repair any damaged areas of the outlet control structure, and remove sediment and debris if it is accessible. Replace metal components if necessary. Lubricate sluice gates with a marine-type grease as needed. It is recommended that a cover be fabricated to protect the sluice gate's worm gear from corrosion and increase the visibility of the device. The cover can be made by placing a cap on one end of a section of PVC pipe (see Figure 6-6). If the sluice gate is damaged beyond repair, replace it with one that meets the requirement presented in NCDOT Standard Drawing No. 838.02 (NCDOT, 2006). Perform additional maintenance and repairs as described in the manufacturer's instructions. If the outlet is clogged or blocked and standing water prevents access to the structure, hip waders or a small boat may be needed to make the necessary repairs. Ensure that the proper NCDOT safety procedures are followed when working in or around standing water.

Figure 6-6. Two large sluice gates with PVC covers

6.3.6 Outlet Drainage System

Function

The outlet drainage system conveys water from the SC to the downstream drainage system or receiving water. Components of this system can include channels, pipes, catch basins, manholes, culverts, and other structures.

Inspection

Inspect pipes and drainage structures for cracks or leaks. Inspect the ground surface above buried pipes and structures for depressions or other signs that might indicate pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation. If outlet protection materials (i.e., riprap) are present, verify that these materials are adequate to protect against erosion.

Maintenance

Remove and properly dispose of debris, undesirable vegetation, and major sediment accumulations. Repair all eroded areas and damaged pipes. Replace outlet protection materials as necessary. Refer to Chapter 3 for additional guidance on maintenance techniques.

6.3.7 Emergency Spillway (if present)

Function

The emergency spillway serves as an overflow structure that is typically constructed as a channel in natural ground.

Inspection

Note trash and debris collected in the emergency spillway. Emergency spillways are typically covered with grass, but concrete and riprap are also used. For grass channels, verify that grass is maintained between 6 and 15 inches. Inspect concrete to verify that it is in good condition, or verify that adequate riprap is present. Note all erosion and undesirable vegetation.

Maintenance

Emergency spillways must be free of trash, debris, and undesirable vegetation to maintain their functionality. Remove these if present. Grass should be maintained at a height of 6 to 15 inches. If applicable, repair concrete or replace riprap as necessary. Repair areas of erosion.

6.4 Inspection and Maintenance Summary

Observations made while inspecting stormwater controls must be documented on the appropriate SC inspection report form and entered into SCMS. Observations recorded would include a general description of the SC and those maintenance needs identified such as the removal of accessible trash, sediment, and unwanted vegetation.

If during an inspection emergency maintenance needs are identified (i.e., a sluice gate frozen in the open position), the inspector should either correct the problem at that time or contact the

CHAPTER 7 Infiltration Basin

Overview

An INFILTRATION BASIN (IB) is a stormwater control that uses the natural filtering ability of the soil to remove pollutants from stormwater runoff.

PURPOSE AND DESCRIPTION

- Infiltration basins are structural stormwater controls (SCs) designed to temporarily capture stormwater runoff, allowing it to soak into the soil.
- Infiltration helps to reduce peak flows and recharge groundwater.
- As runoff percolates through the soil, fine sediment and associated pollutants are absorbed and removed from the runoff.

INSPECTION

- Infiltration basins should drain completely during dry periods; standing water in the basin may indicate the need for maintenance.
- Pretreatment SCs, such as forebays, are of particular importance to the function of the infiltration basin. If pretreatment SCs are neglected, excessive sedimentation in the basin can occur, which may require intensive maintenance to correct.
- Inspections should occur annually, unless otherwise required by environmental permits or more frequent inspections are deemed necessary.

TYPICAL MAINTENANCE

- A four-inch layer of clean sand or a dense cover of turf grass must be maintained at all times.
- Any structural deficiencies should be corrected.
- Undesirable vegetation, especially woody vegetation in the embankment, should be removed.

7.1 Stormwater Control Overview

An Infiltration Basin (IB) is a shallow impoundment constructed over a permeable soil that uses the natural filtering ability of the soil to remove pollutants found in stormwater runoff. During storm events, runoff is directed into the basin where it is temporarily detained and allowed to infiltrate slowly into the soil and eventually into the water table. As runoff slowly passes through the soil, fine sediment and associated pollutants are absorbed and removed from the runoff as it makes contact with soil particles. This stormwater control (SC) has high pollutant removal efficiency and can also help recharge the groundwater.

In North Carolina, infiltration basins are more common in the coastal region where sandy soils promote infiltration. All of the stormwater in the basin should infiltrate into the soil within five days after a storm.

Figure 7-1 illustrates flow entering the basin, being detained, and infiltrating into the soil. The figure also shows the treatment processes that occur in a typical dry detention basin.

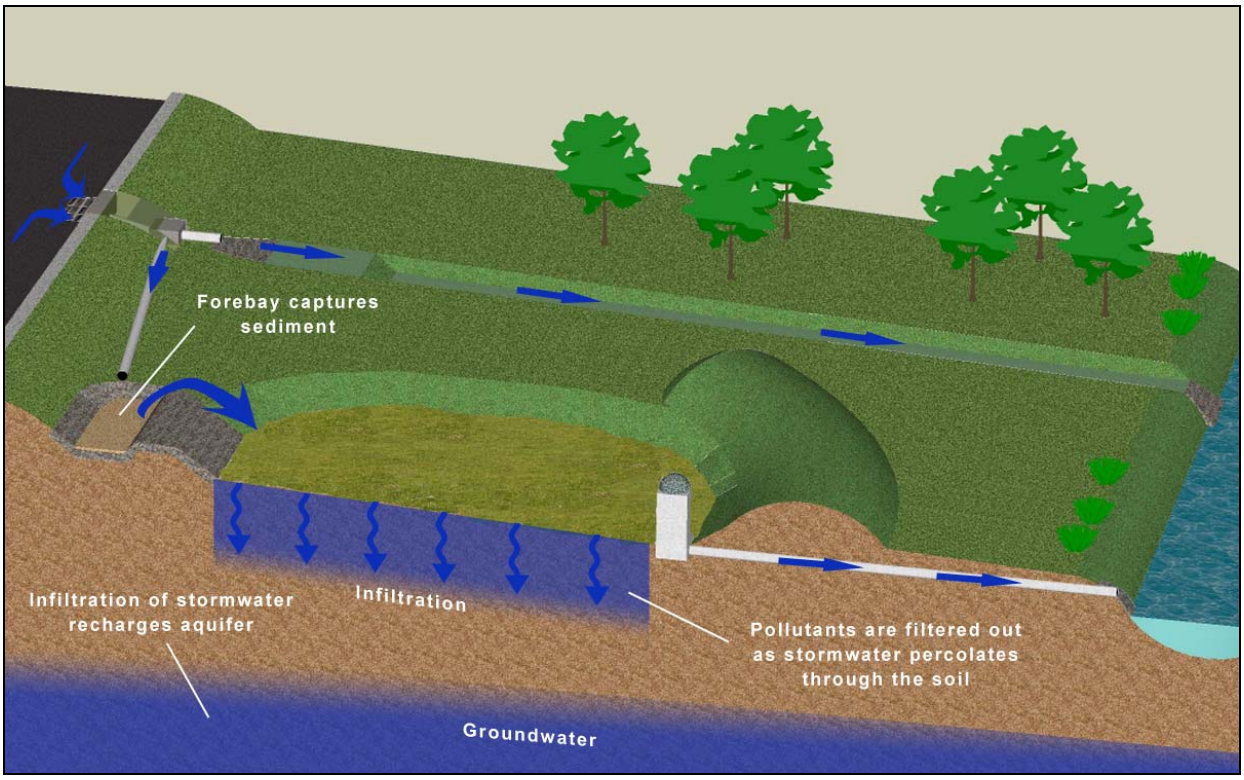


Figure 7-1. Cutaway of an infiltration basin flow diagram and treatment processes

7.2 Infiltration Basin Components

Figure 7-2 illustrates the various components of a typical infiltration basin. Infiltration basins are typically designed to include a flow bypass system. Runoff enters the infiltration basin via a flow bypass structure, which is designed to divert a set amount of runoff to the basin. Excess flow bypasses the infiltration basin and is conveyed by ditch or pipe directly downstream.

In contrast, infiltration basins without a flow bypass system will receive all runoff regardless of the flow rate. Both configurations may or may not have an emergency outlet control structure.

Infiltration basins may include the following components:

- Inlet Drainage System
- Flow Bypass System
- Forebay
- Basin
- Emergency Outlet Control Structure
- Outlet Drainage System

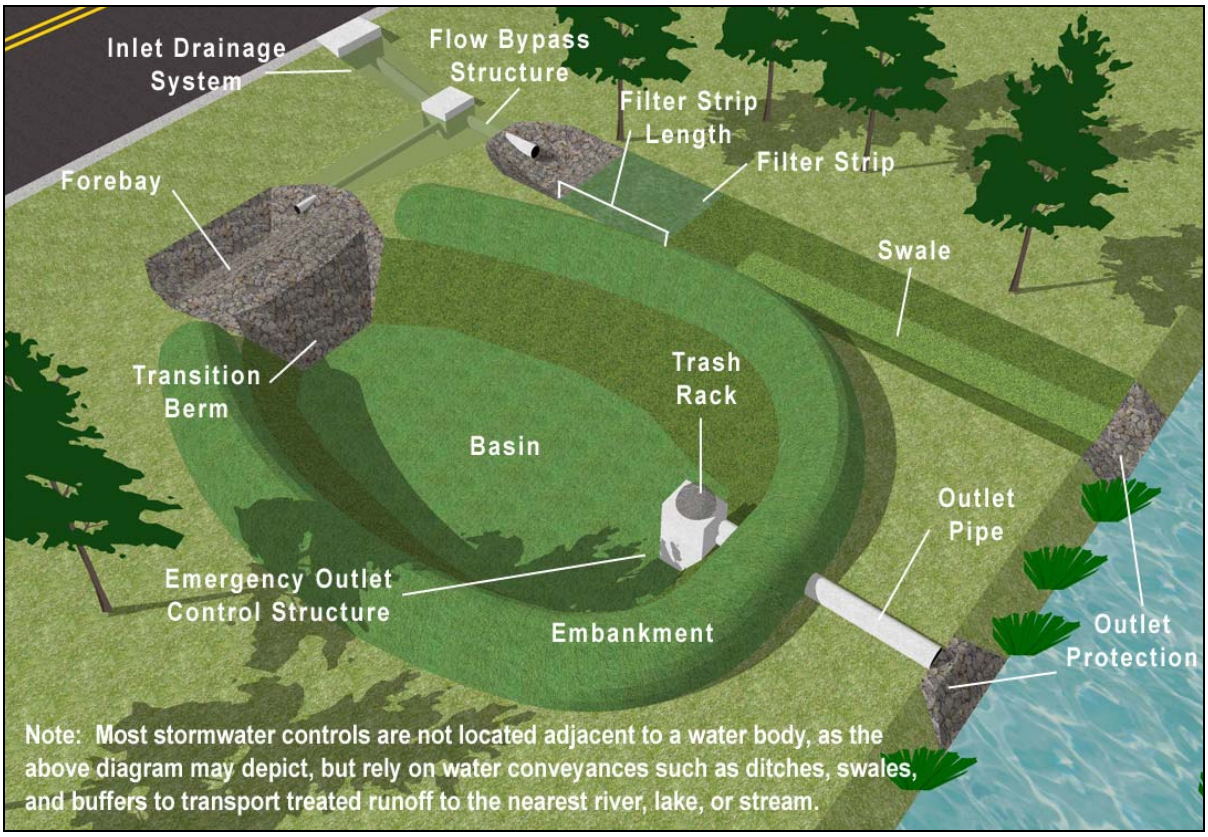


Figure 7-2. Components of a typical infiltration basin

7.3 Inspection and Maintenance

Infiltration basins should be inspected at least annually to determine whether they are functioning as intended. If an infiltration basin is found to not be functioning properly, determine the cause and restore to working order as soon as possible. Figures 7-3 and 7-4 illustrate a plan and profile view of the areas that should be inspected and maintained in a typical infiltration basin configuration.

All inspection findings and maintenance activities should be noted on the inspection form (see Appendix A) and then entered into the Stormwater Control Management System (SCMS) on NCDOT's Intranet. Photos should be taken to track the status of the stormwater control and document the maintenance activities conducted. These, too, can be uploaded to SCMS. Refer to Chapter 4 for additional guidance.

Note that the ability of the soil in the infiltration basin to percolate water is critical to the SC's function. To minimize compaction, heavy machinery should not be used in the basin (NCDOT, 2008b). Refer to Chapter 3 for additional guidance.

The following sections describe the function of an infiltration basin, and provide inspection and maintenance guidance for its major components.

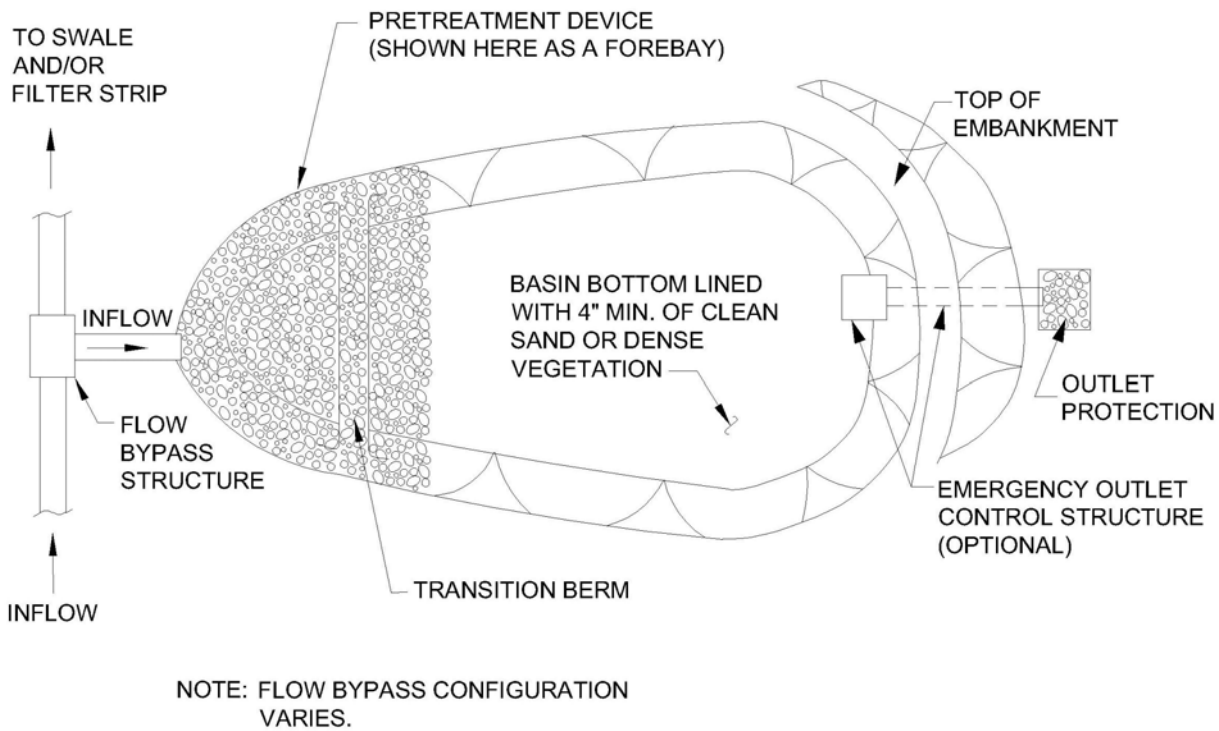


Figure 7-3. Plan view of an infiltration basin and its components

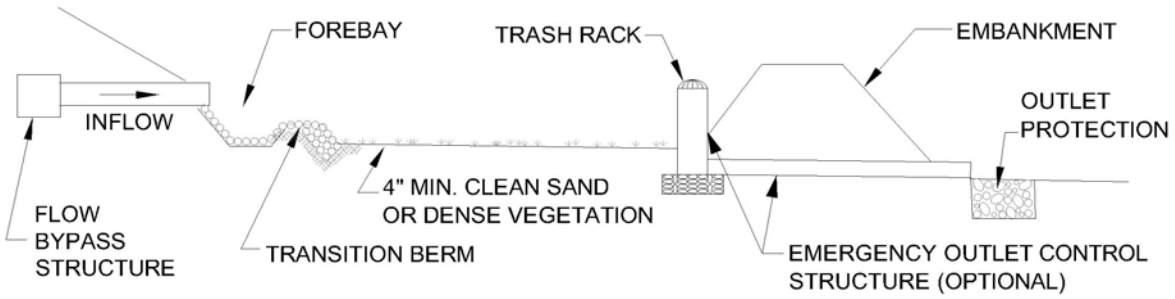


Figure 7-4. Profile view of an infiltration basin and its components

7.3.1 INLET DRAINAGE SYSTEM

Function

The inlet drainage system collects and conveys water to the SC. Inlet drainage systems can consist of open channels, pipes, curb and gutter, and catch basins.

Inspection

Stormwater runoff should be allowed to flow freely into the flow bypass structure, pretreatment device, and infiltration basin. Inspect all ditches, pipes, and/or catch basins draining to the infiltration basin for trash, sediment and debris. Inspect the ground surface above buried pipes and structures for depressions and other signs of pipe breakage or separation. If the inlet drainage system consists of an earthen ditch, inspect the ditch for signs of erosion and undesirable vegetation. Infiltration basins are particularly susceptible to sedimentation. The area draining to the basin should be carefully inspected for bare soil.

Maintenance

Remove and properly dispose of debris, undesirable vegetation, and major sediment accumulations. Repair all eroded areas and damaged pipes. Refer to Chapter 3 for additional guidance on maintenance techniques.

7.3.2 FLOW BYPASS SYSTEM

Because the primary outlet is infiltration through the soil, infiltration basins are typically installed offline. This means that a flow bypass system diverts a predetermined amount of runoff to the SC while bypassing excess flow so that stormwater does not overtop the banks of the basin during heavy rainfall. The bypass system generally consists of a flow bypass structure in conjunction with a swale and/or filter strip. The flow bypass structure directs the flow, and the swale and/or filter strip provides treatment of stormwater that bypasses the infiltration basin. Refer to Chapter 12 for guidance on swales. Refer to the subsequent sections within this chapter for guidance on filter strips and flow bypass structures.

7.3.3 FLOW BYPASS STRUCTURE

Function

The flow bypass structure diverts runoff to the infiltration basin under usual circumstances, but will allow high flow to bypass the basin via a swale and/or filter strip during large storm events.

Inspection

The flow bypass structure uses a weir or other configuration, and must be free of any sediment, trash, and debris to function properly. Inspect the flow bypass structure for holes and cracks, and for any erosion that would allow runoff to flow around the structure. If applicable, inspect metal components for excessive corrosion. Note any undesirable vegetation that might prevent the flow bypass structure from functioning properly.

Check the basin and swale/filter strip for visual signs that they are receiving flow and have not been overwhelmed. If the basin does not appear to be receiving flow or if there is evidence of excessive flow, the flow bypass structure is not functioning properly. Erosion protection materials may have been installed at the bypass structures' outlet to the swale or filter strip. If this is the case, inspect to ensure that these materials remain in place and are properly installed.

Maintenance

Remove all undesirable vegetation, sediment, trash, and debris. If the flow bypass structure is clogged, remove sediment and properly dispose of it off-site. Repair any cracks and holes, and eroded areas associated with the flow bypass structure. Replace components as necessary. Replace or repair any materials (e.g., riprap, permanent soil reinforcement matting [PSRM]) used to protect the outlet of the bypass structure to the filter strip or swale.

7.3.4 FILTER STRIP

Function

Some flow bypass systems use filter strips to treat runoff that has bypassed the infiltration basin. Filter strips promote infiltration and biological uptake of pollutants, and filter out sediment. The filter strip should have a minimum length of 50 feet if draining to an SA water (i.e., tidal saltwater used for commercial shellfishing), or 30 feet for all other areas (NCDOT, 2008b).

Inspection

The filter strip should be vegetated with a uniform, dense cover of desirable vegetation. Inspect for signs of erosion and channelization. Also, verify that the vegetation is being mowed at the proper frequency. Ideally, turf grasses should be mowed at a frequency to maintain a maximum height of 4 inches for warm-season grasses and 6 inches for cool-season grasses. However, within the NCDOT right-of-way, it is more practical to maintain grass height between 6 and 15 inches. Note any undesirable vegetation growing in the filter strip.

Maintenance

Remove trash and undesirable vegetation. Remove debris that could cause channelization. Repair areas affected by erosion or channelization. Mow grass and repair or replace PSRM as necessary. Ensure that grass remains dense for optimum removal of pollutants. If excessive sediment has accumulated, remove the sediment and regrade the filter strip. Reestablish vegetation where necessary (NCDWQ, 2007).

7.3.5 PRETREATMENT CONTROL

Function

Infiltration basins are prone to failure when heavy sediment loads are allowed to enter the basin. Stormwater that has not been pretreated to remove large solids will quickly clog the first few inches of soil, reducing the infiltration rate of the basin. Once the basin is clogged, it will begin to retain water, potentially causing a mosquito hazard and erosion of the emergency spillway from overuse.

Swales or forebays are often used to pretreat runoff upstream of the infiltration basin. Refer to Chapter 12 for in-depth guidance on swales. Guidance on forebays follows.

A forebay reduces the runoff velocity of stormwater, which in turn allows solids suspended in the stormwater to settle before the stormwater enters the infiltration basin. A transition berm is the component located at the downstream end of the forebay that acts as a weir and releases runoff to the stormwater control. The presence of a forebay reduces the risk of SC failure.

Inspection (Forebay)

Inspect to ensure that all forebays remain free of trash, debris, and undesirable vegetation. Inspect to determine whether forebays are structurally sound and that they do not contain excessive amounts of accumulated sediment. Inspect the transition berm to determine whether it is structurally sound and shows signs of erosion.

Maintenance (Forebay)

Remove trash, debris, and undesirable vegetation and properly dispose of it off-site. Remove sediment and properly dispose of it off-site if it appears to occupy more than 50% of the forebay's storage capacity. Replace erosion protection materials (i.e., riprap) as needed. If necessary, reestablish vegetation for earthen forebays. Repair the transition berm as necessary, taking care to maintain the original elevation of the weir. Refer to Chapter 3 for further guidance on sediment disposal. Consult the North Carolina Department of Transportation *Stormwater Best Management Practices Toolbox* if major repairs are required.

7.3.6 BASIN AND SURROUNDING AREA

Function

The main pollutant removal processes occur in the basin. Runoff is detained and allowed to infiltrate into the soil and eventually into the water table. Infiltration of stormwater into the

basin soil is the primary outlet for this SC. **The permeability of the soil beneath the basin must be maintained or the infiltration basin will fail.** Vehicles and construction equipment should not be operated within the basin (NCDWQ, 2007). Use best professional judgment when selecting mowing and other landscaping equipment for use in the basin. Avoid the use of riding lawnmowers and minimize foot traffic on the basin bottom.

Some flow bypass structure configurations require the addition of an emergency outlet in the form of an emergency outlet control structure or an emergency spillway. Emergency outlet systems are also installed if failure of the bypass structure is a concern.

Inspection

The bottom of the basin may be vegetated with grass or covered with a layer of sand. If sand was used, it should form a uniform cover of at least 4 inches. The basin's interior and exterior side slopes, and all areas surrounding the basin should be stabilized with a uniform cover of turfgrass. Inspect grass to ensure that it is being mowed at a frequency to maintain a desired height of 6 to 15 inches.

Inspect the basin for structural integrity. Note any signs of erosion, burrowing animals, or undesirable vegetation. Inspect the embankment for settling, scouring, cracking, sloughing, and furrowing, and for shrubs or trees. Also, inspect the downstream toe of the embankment for seepage (NCDWQ, 2007). Note all trash and debris found in the basin and surrounding areas.

The basin bottom should be relatively flat; standing water can accumulate in localized low areas. Inspect for evidence that excessive ponding is occurring. Water should drain from the basin within five days. Cattails and other wetland vegetation are indicators that water is remaining in the basin longer than intended. If this is the case, try to determine the cause of the standing water. For example, the soil may no longer be capable of percolating stormwater because of sedimentation or compaction. A high groundwater table or shallow bedrock can also inhibit infiltration. NCDOT's Geotechnical Unit may be able to assist in determining the cause of a malfunctioning infiltration basin.

If the basin appears to be retaining water longer than 5 days, it may need to be pumped out to correct the problem. If this is the case, the captured runoff must first be visually inspected for obvious signs of pollutants. Check for an oily sheen or excessive suspended solids. If either of these is present, do not drain the basin. Call the NCDOT Division Safety Officer or the NCDOT Roadside Environmental Unit (REU) for guidance.

Maintenance

Remove all undesirable vegetation (using mechanical or herbicidal treatment) and mow grass to the ideal height. Reestablish turfgrass where erosion has occurred (seed or sod). Refer to Chapter 3 when considering the use of fertilizer, which may be restricted at some locations. Replace sand where needed and repair all animal burrows. If there is channelization, reestablish the proper grade of the basin bottom by removing sediment and filling in, then reestablishing vegetation if applicable. Sediment should be removed as necessary to minimize clogging (NCDOT, 2008b). Soil clogged with sediment should be removed and the basin bottom tilled.

To minimize compaction, heavy equipment should not be used in the basin. Refer to Chapter 3 for additional information.

7.3.7 EMERGENCY OUTLET CONTROL STRUCTURE (IF PRESENT)

Function

An emergency outlet control structure may have been installed to release excess stormwater during large storm events. The emergency outlet control structure is composed of a riser and a discharge pipe. See Section 7.3.9 for information regarding the discharge pipe. The riser is typically made of concrete for durability. Many risers have an open top with a trash rack over the opening. Some outlet structures may have sluice gates that enable the basin to be drained for maintenance purposes. If this is the case and standing water is present, drain the basin and return the sluice gate to the closed position. Perform inspection and maintenance tasks for components that were previously inaccessible.

Inspection

Inspect the emergency outlet control structure thoroughly for any sign of damage such as cracking, holes, or leakage. Inspect to ensure that the outlet box remains covered with a trash rack and that the trash rack is not excessively corroded. Note the amount of trash and debris buildup on the trash rack. If a sluice gate is present, open and close it to ensure that it can be operated through its entire range of motion. Inspect the sluice gate for excessive corrosion. Verify that there is no sediment or debris below the sluice gate that could prevent it from being fully closed.

Maintenance

Repair any damaged areas of the emergency outlet control structure, and remove sediment and debris if it is accessible. Replace metal components if necessary. Lubricate sluice gates with a marine-type grease. It is recommended that a cover be fabricated to protect the sluice gate's worm gear from corrosion and increase the visibility of the device. The cover can be made by placing a cap on one end of a section of PVC pipe (see Figure 7-5). If the sluice gate is damaged beyond repair, replace it with one that meets the requirement presented in NCDOT Standard Drawing No. 838.02 (NCDOT, 2006). Perform additional maintenance and repairs as described in the manufacturer's instructions. If the outlet is clogged or blocked and standing water prevents access to the structure, hip waders or a small boat may be needed to make the necessary repairs. Ensure that the proper NCDOT safety procedures are followed when working in or around standing water.

Figure 7-5. Two large sluice gates with PVC covers

7.3.8 EMERGENCY SPILLWAY (IF PRESENT)

Function

An emergency spillway may be present as an alternative to the emergency outlet control structure. An emergency spillway is an overflow channel, typically constructed in natural ground.

Inspection

The emergency spillway should remain free of trash and debris at all times. Emergency spillways are typically covered with grass, but concrete and riprap are also used. For grass channels, verify that grass is maintained between 6 and 15 inches. Inspect concrete to verify that it is in good condition, or verify that adequate riprap is present. Note all erosion and undesirable vegetation.

Maintenance

Emergency spillways must be free of trash, debris, and undesirable vegetation at all times to function properly. Remove these if present. Grass should be carefully maintained at a height of 6 to 15 inches. If applicable, repair concrete or replace riprap as necessary. Repair areas of erosion.

7.3.9 OUTLET DRAINAGE SYSTEM

Function

The outlet drainage system conveys water from the SC to the downstream drainage system or receiving water. The outlet drainage system includes conveyance facilities downstream of the emergency outlet control structure, the emergency spillway, and/or the flow bypass system.

Inspection

Inspect the inside of pipes (where feasible) to ensure that they are free of sediment and debris. Inspect the ground surface above buried pipes and structures for depressions and other signs of

pipe breakage or separation. If the outlet drainage system consists of an earthen ditch, inspect for signs of erosion and undesirable vegetation. If outlet protection materials are present, verify that these materials are adequate.

Maintenance

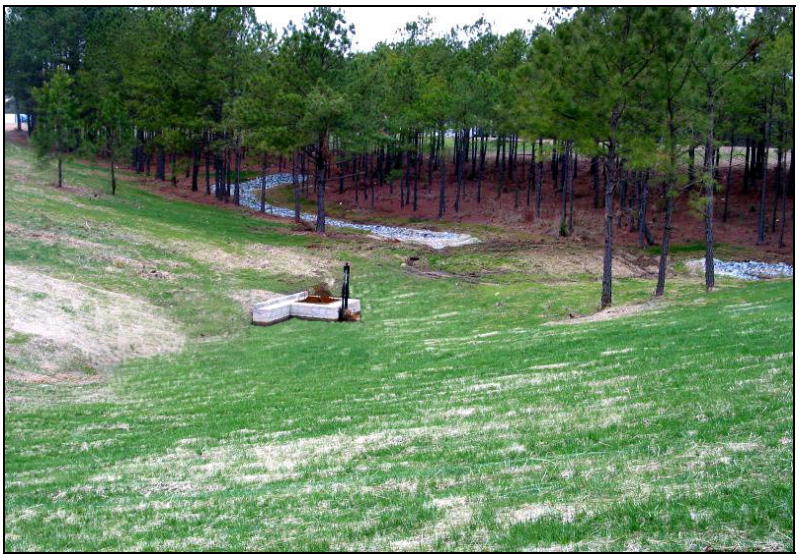
Remove and properly dispose of debris, unwanted vegetation, and major sediment accumulations. Repair all eroded areas and damaged pipes. Replace outlet protection materials (i.e., riprap) as necessary. Refer to Chapter 3 for additional guidance on maintenance techniques.

7.4 Inspection and Maintenance Summary

Observations made while inspecting stormwater controls must be documented on the appropriate SC inspection report form and entered into SCMS. Observations recorded would include a general description of the SC and those maintenance needs identified such as the removal of accessible trash, sediment, and unwanted vegetation.

If during an inspection emergency maintenance needs are identified (i.e., a sluice gate frozen in the open position), the inspector should either correct the problem at that time or contact the party(s) responsible for emergency maintenance repairs. If emergency maintenance needs are not corrected at the time of the inspection, a follow-up inspection should be conducted to verify that the responsible party(s) has taken action and all needs have been addressed. Observations made during the follow-up inspection must be documented on the appropriate SC inspection report form and entered into SCMS.

CHAPTER 8 Dry Detention Basin



Overview

A DRY DETENTION BASIN (DDB) is a stormwater control (SC) that reduces peak stormwater flows, promotes the settling of suspended pollutants, and minimizes erosive velocities downstream of the outlet structure.

PURPOSE AND DESCRIPTION

- Dry detention basins are structural SCs designed to temporarily capture stormwater runoff and reduce flow velocity.
- Inflow to the SC is detained and released slowly from a primary outlet control structure over a period of 48 – 72 hours.
- Dry detention basins are designed with a drawdown component that keeps the basin dry between storm events.

INSPECTION

- Dry detention basins should be dry between storm events; standing water in the basin may indicate that maintenance is needed.
- The outlet control structure is critical to the proper function of the dry detention basin and should be inspected carefully.
- Inspections should occur annually, unless otherwise required by environmental permits or more frequent inspections are deemed necessary.

TYPICAL MAINTENANCE

- Trash and debris should be removed from inlet grates, trash racks, orifices, and forebays.
- Any structural deficiencies should be repaired or the components replaced.
- Undesirable vegetation, especially woody vegetation on the embankment, should be removed.

8.1 Stormwater Control Overview

A Dry Detention Basin (DDB) is a stormwater device whose outlet has been designed to temporarily detain contaminated runoff and release it slowly over a period of 48-72 hours. It is during this time that runoff velocities are lowered and physical processes work to remove pollutants. As stormwater is detained and runoff velocities are lowered, suspended solids and other associated pollutants settle out and are removed from the runoff before it exits the basin and enters the nearest stream, river, or lake.

The primary pollutant removal process is sedimentation. Vegetation in the dry detention basin can also filter out and take up pollutants. Additionally, some water may infiltrate through the bottom of the basin, which recharges aquifers.

The basin's main outlet is small and is located near the bottom of the basin. This outlet is referred to as the drawdown orifice, and it allows the basin to temporarily hold water during storm events and drain completely afterward. One or more additional outlets allow water to overflow during large storms.

Figure 8-1 illustrates flow entering the basin, being detained, and exiting the basin. The figure also shows the treatment processes that occur in a typical dry detention basin.

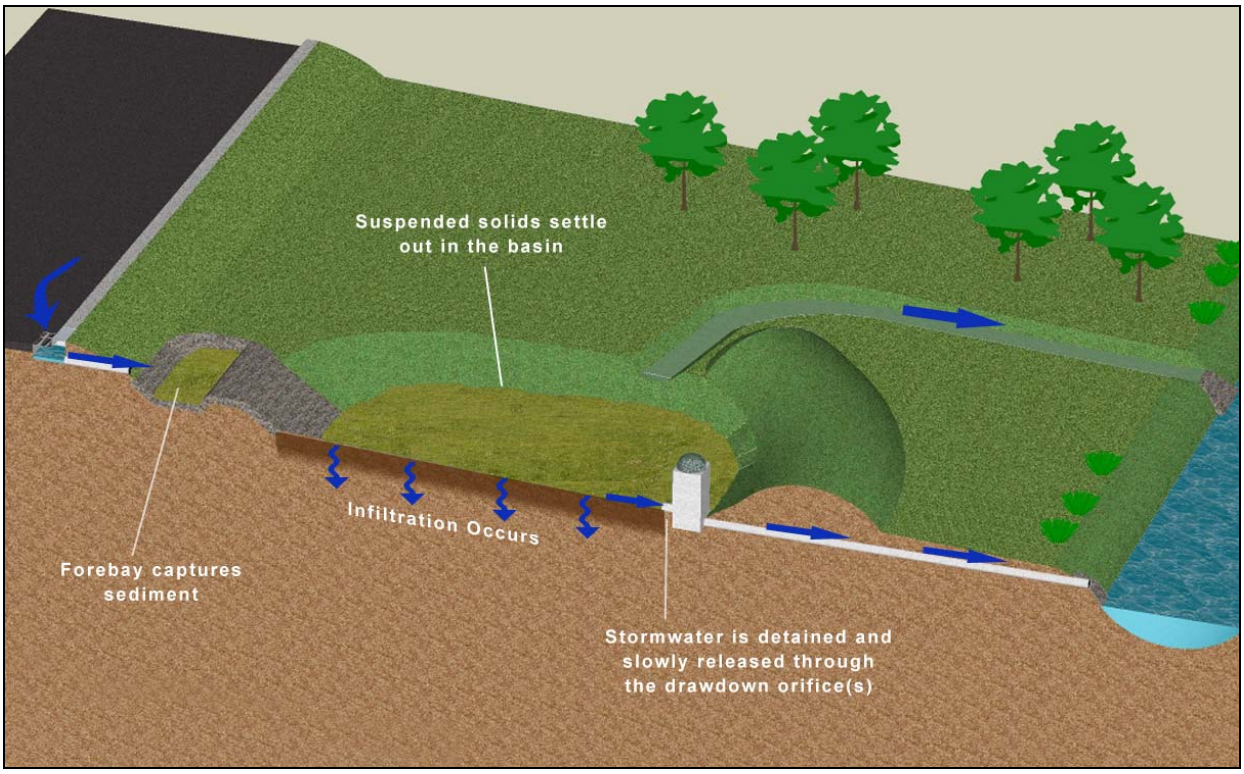


Figure 8-1. Cutaway of a dry detention basin flow diagram and treatment processes

8.2 Dry Detention Basin Components

Figure 8-2 illustrates the various components of a typical dry detention basin. Note that layouts vary. Some systems will have additional components, whereas others may lack certain components. Dry detention basins may include the following:

- Inlet Drainage System
- Forebay
- Basin
- Outlet Control Structure
- Drawdown Orifice
- Outlet Drainage System
- Emergency Spillway

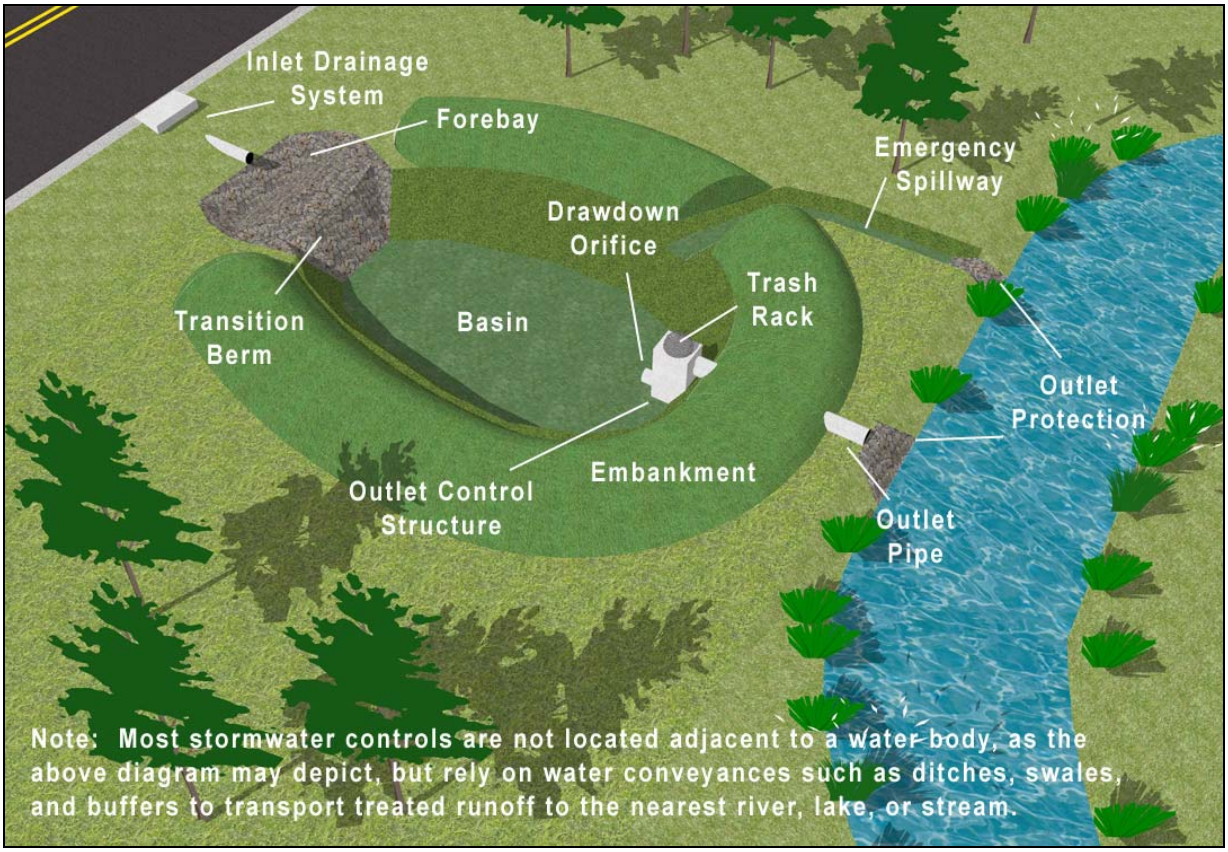


Figure 8-2. Components of a typical dry detention basin

8.3 Inspection and Maintenance

Dry detention basins should be inspected at least annually to determine whether they are functioning as intended. If a dry detention basin is found to not be functioning properly, determine the cause and restore to working order as soon as possible. Figures 8-3 and 8-4 illustrate a plan and profile view of the areas that should be inspected and maintained in a typical dry detention basin configuration.

All inspection findings and maintenance activities should be noted on the inspection form (see Appendix A) and then entered into the Stormwater Control Management System (SCMS). Photos should be taken to track the status of the stormwater control (SC) and document the maintenance activities conducted. These, too, can be uploaded to SCMS. Refer to Chapter 4 for further guidance.

The following sections describe the function of a dry detention basin, and provide inspection and maintenance guidance for its major components.

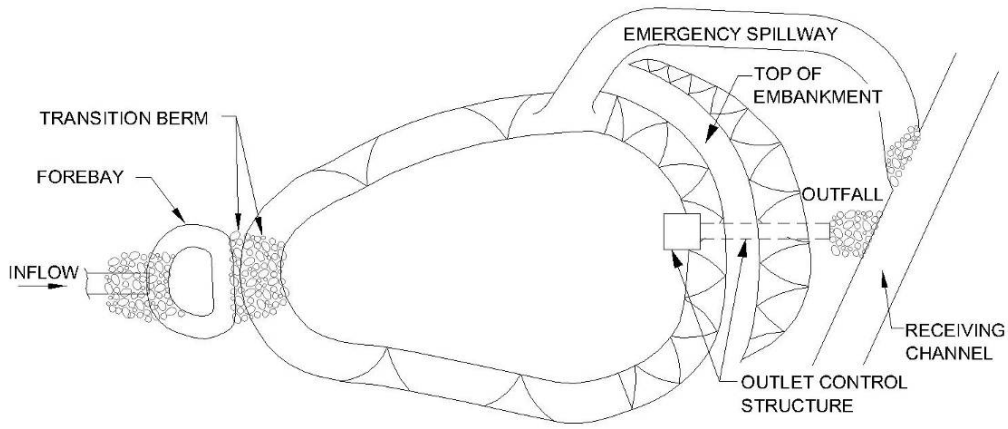


Figure 8-3. Plan view of a dry detention basin and its components

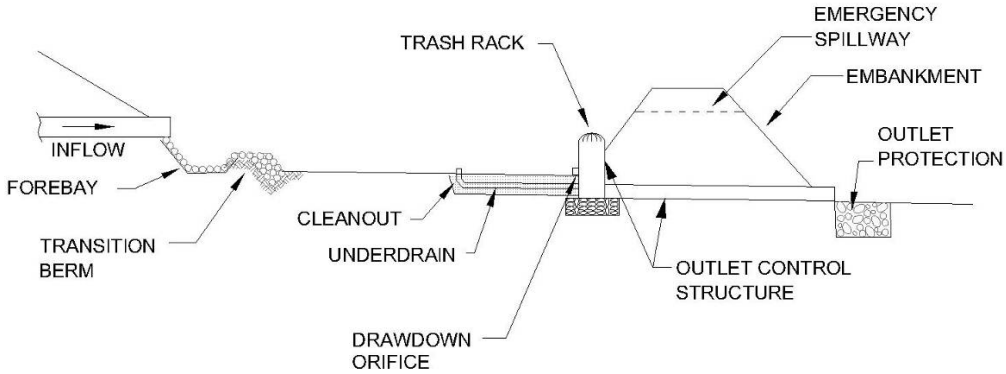


Figure 8-4. Profile view of a dry detention basin and its components

8.3.1 INLET DRAINAGE SYSTEM

Function

The inlet drainage system collects and conveys water to the dry detention basin. Inlet drainage systems can consist of open channels, pipes, curb and gutter, and catch basins.

Inspection

Stormwater runoff should be allowed to flow freely into the basin. Inspect ditches, pipes, and/or catch basins draining to the dry detention basin for trash, sediment, and debris. Inspect the ground surface above buried pipes and structures for depressions and other signs of pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation. Desirable vegetation includes grass cover in an open ditch to prevent soil erosion. Undesirable vegetation includes any woody plants or invasive species that may impede the inlet drainage system.

Maintenance

Remove and properly dispose of debris, unwanted vegetation, and major sediment accumulations. Repair eroded areas and damaged pipes. Refer to Chapter 3 for additional guidance on maintenance techniques.

8.3.2 FOREBAY

Function

A forebay is a basin located at the inlet of an SC that pretreats stormwater. Forebays reduce the runoff velocity of stormwater, which in turn allows sediment in the runoff to settle before the stormwater enters the dry detention basin. A transition berm is the component located at the downstream end of the forebay that acts as a weir and releases runoff to the stormwater control. The presence of a forebay reduces the risk of SC failure.

Inspection

Inspect forebays for trash, debris, and undesirable vegetation. Inspect to determine whether forebays are structurally sound and that they do not contain excessive amounts of accumulated sediment. Inspect the embankment and transition berm to determine whether it is structurally sound and shows signs of erosion. Forebays may have grass-covered embankments and berms, but they are not designed to support vegetation in the basin. Minimal plant growth is tolerable, but if it becomes excessive, the storage volume for sediment is reduced and dredging becomes more difficult. If any invasive species are present, it is generally preferable to remove them before they become well-established.

Maintenance

Remove trash, debris, and undesirable vegetation and properly dispose of it off-site. Remove sediment and dispose of it off-site if it appears to occupy more than 50% of the forebay's storage capacity. Replace erosion protection materials (i.e., riprap) as needed. If the surrounding soil is disturbed during cleanout of the forebay, or at any other time, reseed any areas of bare soil with

grass to prevent erosion. Repair the transition berm as necessary, taking care to maintain the original elevation of the berm. Refer to Chapter 3 for additional guidance on sediment disposal. Consult the North Carolina Department of Transportation *Stormwater Best Management Practices Toolbox* (NCDOT, 2008b) if major repairs or design changes are required.

8.3.3 Basin and Surrounding Area

Function

The basin is the component of the dry detention basin that reduces the rate of runoff and allows suspended solids to settle.

Inspection

The floor of the basin, its interior and exterior side slopes, and the area surrounding the basin should be stabilized with at least a cover of turf-type grass. Verify that grass is being mowed at a frequency to maintain a height of 6 to 15 inches. Inspect the basin for structural integrity. Note any signs of erosion, burrowing animals, or undesirable vegetation. Inspect the embankment for settling, scouring, cracking, sloughing, and furrowing, and for invading shrubs and trees. Also, inspect the downstream toe of the embankment for seepage (NCDWQ, 2007). Note all trash and debris found in the basin or in surrounding areas. Also, inspect the basin for evidence that water remains in the basin longer than 5 days. Cattails and other wetland vegetation are good indicators that water is remaining in the basin longer than intended. If this is the case, try to determine the cause of the standing water. Possible causes include a high groundwater table, clogged drawdown orifice(s), and localized low areas.

Some dry detention basins have been planted with certain grasses, trees, shrubs, and herbaceous plant material to enhance their aesthetic appeal and increase their pollutant removal ability (See Figure 8-5). If applicable, verify that this plant material remains healthy and uniformly established. A layer of mulch should be present to help maintain soil moisture, protect against surface sealing, prevent soil erosion, and provide a suitable microclimate for microorganisms. The mulch layer should be approximately 3-4 inches thick and relatively level, with no exaggerated channels cut through as a consequence of concentrated water flow.

It is important to note that dry detention basins with special plant material are not as common as grassed dry detention basins and can be easily confused with bioretention basins. However, dry detention basins do not typically have underdrain systems and cleanouts will not be present. All dry detention basins have a distinct outlet control structure with a restrictive outlet (drawdown orifice or slightly opened sluice gate) near the bottom of the basin.

Baffles may have been installed to increase the effective flow length in the basin. If this is the case, verify that the baffles are undamaged.

Figure 8-5. Dry detention basin with planted landscaped vegetation

Maintenance

Remove undesirable vegetation (using a mechanical or herbicidal treatment) and mow grass to the ideal height. Turfgrass is typically mowed at a frequency to maintain a maximum height of 4 inches for warm-season grasses and 6 inches for cool-season grasses. However, on highway right-of-way facilities, it is more practical to maintain a grass height between 6 and 15 inches.

If erosion has occurred, reestablish turfgrass (seed or sod) or replace mulch with double-shredded hardwood bark. Replace dead or unhealthy plant material, and fertilize turfgrass and/or plant material upon reestablishment. The use of fertilizer may be restricted at some locations. Refer to Chapter 3 when considering the use of fertilizer. Contact the NCDOT Roadside Environmental Unit (REU) if guidance is needed in maintaining landscaped dry detention basins.

Repair all animal burrows. If there is channelization, reestablish the proper grade of the basin bottom by removing sediment and filling in, then reestablishing vegetation. Repair damaged baffles if applicable. Sediment should be removed if it occupies more than 25% of the basin's original storage capacity.

8.3.4 UNDERDRAIN SYSTEM (IF PRESENT)

Function

Some large dry detention basins are equipped with underdrain systems to ensure that the basin is properly drained between storm events. In these systems, the drawdown orifice is still the primary outlet while the underdrain system is used to prevent small pools from holding water for periods longer than intended. Underdrain systems are usually constructed using perforated PVC pipe. The perforated pipe is wrapped in filter fabric to prevent clogging and installed in a

shallow layer (typically 12 inches) of No. 57 stone. To avoid crushing the underdrain system, heavy equipment should not be driven in the basin. Refer to Chapter 3 for additional information. Cleanouts are typically visible from the surface if an underdrain system is present.

Inspection

Verify that cleanout caps are in place and undamaged. Damaged or missing caps will allow stormwater to exit the basin untreated. Remove the caps from the cleanouts and inspect the inside for sediment or standing water using a flashlight. If water is available, pour water in the cleanouts using a bucket or hose and observe the outlet control structure or outlet pipe for flow. If the water does not exit freely, this indicates the underdrain system is clogged. If sediment is flushed from the underdrain system, it may be an indication that the filter fabric has been damaged and will need to be excavated and repaired. The basin should be inspected for depressions that are another indication that soil is entering the underdrain system.

If the basin is holding water longer than 5 days, (NCDWQ, 2007) the under drain system (if present) can be used to drain the basin via its cleanouts so that any plant or soil material which may be preventing infiltration can be remediated. Before doing so, the water must first be visually inspected for obvious signs of pollutants. Check for an oily sheen or excessive suspended solids. If either of these is present, do not drain the basin. Call the NCDOT Division Safety Officer or the NCDOT REU for guidance.

Maintenance

A high-pressure hose can be used to flush out underdrain systems by spraying water into cleanouts. Replace cleanout caps that are missing, cracked, or otherwise damaged. Consider flushing underdrain systems annually if it appears that they have a tendency to plug. Repair or replace underdrain systems in accordance with the original design specifications. If additional guidance is needed, consult the North Carolina Division of Water Quality *Stormwater Best Management Practices Manual* (NCDWQ, 2007).

8.3.5 OUTLET CONTROL STRUCTURE (BOX)

Function

The outlet control structure is used to drain the dry detention basin. Outlet control structures can have several components, including a trash rack, a trash screen, one or more drawdown orifices, a sluice gate, and an outlet pipe. Inspection and maintenance guidance for these specific components is provided in subsequent sections of this chapter. Figure 8-6 illustrates the configuration of a typical outlet control structure. The drawdown orifice(s) is located at the bottom of the outlet control structure and slowly drains the basin, reducing peak flow and allowing solids to settle. Typically, the outlet control structure has a second, larger opening that allows flow from large rainfall events to escape without overtopping the basin. Usually, this is in the form of an open-top outlet structure with a trash rack. Figure 8-7 offers a photograph of a typical outlet control structure.

Standing water in the basin may conceal parts of the outlet structure. If access to submerged components is needed, the basin can be drained or pumped out; however, the water must first be

visually inspected for obvious signs of pollutants. Check for an oily sheen or excessive suspended solids. If either of these is present, do not drain the basin. Call the NCDOT Division Safety Officer or the NCDOT REU for guidance.

Inspection

Treated water should be allowed to flow freely upon entering the outlet control structure. Inspect the outlet control structure thoroughly for any signs of damage such as cracking, holes, or leakage. Verify that the outlet box remains covered with a trash rack. See subsequent sections for guidance on specific components.

Maintenance

Repair any damaged areas of the outlet control structure, and remove sediment and debris if it is accessible. If the outlet is clogged or blocked and standing water prevents access to the structure, hip waders or a small boat may be needed to make the necessary repairs. Ensure that the proper NCDOT safety procedures are followed when working in or around standing water.

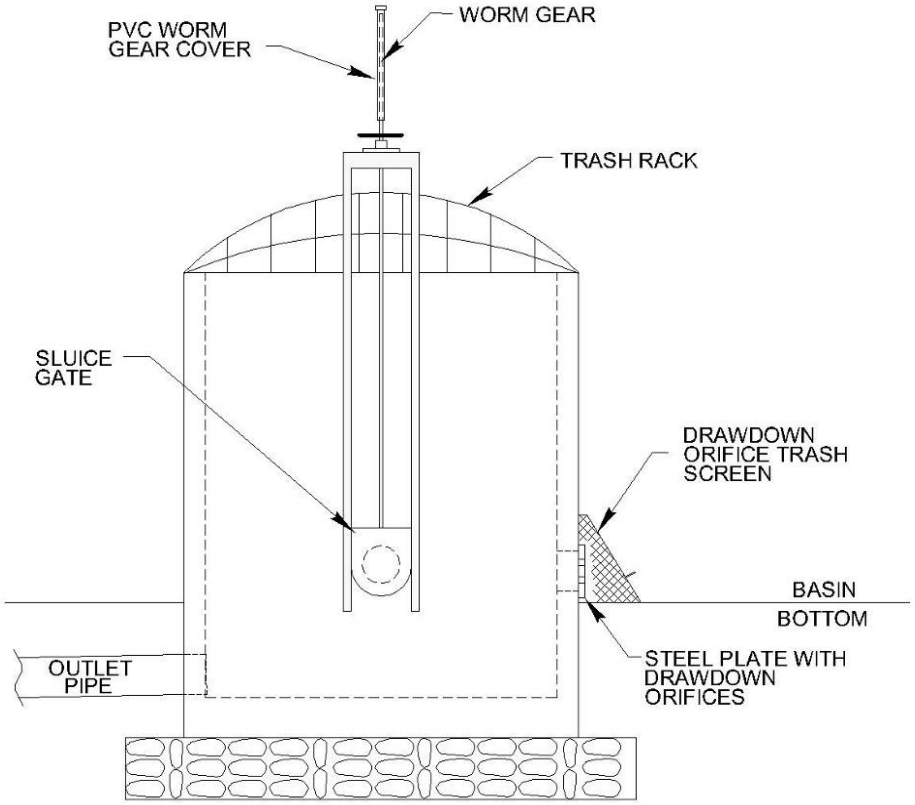


Figure 8-6. Components of an outlet control structure

Figure 8-7. An outlet control structure

8.3.6 TRASH RACK

Function

Positioned atop the outlet control structure (box), the trash rack protects the overflow of the outlet structure from becoming clogged with debris.

Inspection

Inspect the trash rack for debris and excessive corrosion.

Maintenance

Remove trash and debris. Replace the trash rack if it is corroded or otherwise damaged. The replacement trash rack should be consistent with the design specifications for the SC. If drawings or specifications are not available, contact the NCDOT Hydraulics Unit to obtain standard trash rack specifications or details.

8.3.7 TRASH SCREEN

Function

Positioned near the base of the outlet control structure, the trash screen helps keep the orifice from becoming clogged.

Inspection

If it is accessible, inspect the trash screen for accumulated sediment and debris. If the basin is holding water above the level of the orifice and water is not flowing into the outlet control structure, this is a good indication that the trash screen may be clogged.

Maintenance

If there is evidence that the trash screen is clogged, open the sluice gate to drain the basin or pump it out after properly inspecting the water for pollution. Once the basin is drained, remove any sediment, trash, or debris from the trash screen. Remember to return the sluice gate to its original position.

8.3.8 DRAWDOWN ORIFICE

Function

Positioned near the base of the outlet control structure, the drawdown orifice is a restricting device that allows stormwater to slowly enter the outlet box. In most cases, the drawdown orifice consists of either one or more 2- to 3-inch holes drilled directly into the side of the box or a predrilled steel plate attached to the side of the outlet control structure covering a manufactured outlet opening.

Inspection

If the orifice is accessible, verify that stormwater flows freely through it into the outlet structure. If a steel plate was used to restrict flow, check the plate for excessive corrosion. Standing water above the level of the orifice is an indication that the orifice may be blocked.

Maintenance

Remove sediment and debris blocking the flow into the orifice. If the water level in the basin is above the orifice, follow proper precautions before opening the sluice gate or pumping out the basin. After the basin has been drained, lift the trash screen to gain access to the orifice. Remember to return the sluice gate to its original position. Replace the steel orifice plate if necessary.

8.3.9 SLUICE GATE (IF PRESENT)

Function

Sluice gates are typically installed for emergency maintenance needs or to prevent spills from entering water bodies. In these cases, the sluice gate covers an additional opening that is larger than the drawdown orifice. The sluice gate can be opened to rapidly drain the basin. **In some instances, sluice gates are used in place of drawdown orifices. If a basin's outlet control structure is equipped with both an orifice and a sluice gate, the sluice gate should remain closed at all times. If a sluice gate is used to restrict water flow, it should be left open to provide a 1-inch opening.**

Inspection

Two types of sluice gates are currently in use: (1) a screw-type gate and (2) a lift-type gate. Figures 8-8 and 8-9 show a screw-type sluice gate and a lift-type sluice gate, respectively. Open and close the sluice gate to verify that it is operable through its entire range of motion. Inspect the sluice gate for excessive corrosion. Verify that there is no sediment or debris below the sluice gate that could prevent it from being fully closed.

Maintenance

If lubrication is necessary, lubricate with a marine-type grease. It is recommended that a cover be fabricated to protect the sluice gate's worm gear from corrosion and increase the visibility of the device. The cover can be made by placing a cap on one end of a section of PVC pipe (see Figure 8-10). Remove any sediment and debris near the sluice gate. If the sluice gate is damaged beyond repair, replace it with one that meets the requirements presented in NCDOT Standard Drawing No. 838.02 (NCDOT, 2006). Perform additional maintenance and repairs as described in the manufacturer's instructions.

Figure 8-8. An open screw-type sluice gate

Figure 8-9. A lift-type sluice gate

Figure 8-10. Two large sluice gates with PVC covers

8.3.10 Outlet Drainage System

Function

The outlet drainage system conveys water from the SC to the downstream drainage system. Typically, a pipe conveys water from the outlet control structure through the embankment to a swale or other open channel.

Inspection

Inspect the inside of the outlet box and pipe(s) for sediment and debris. Inspect the ground surface above buried pipes and structures for depressions or other signs that might indicate pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation.

Maintenance

Remove any sediment or debris that is accessible. Repair eroded areas and damaged pipes. Replace outlet protection materials (i.e., riprap) as necessary. Refer to Chapter 3 for additional guidance on maintenance techniques.

8.3.11 Emergency Spillway (if present)

Function

The emergency spillway serves as an overflow structure that is typically constructed as a channel in natural ground. The emergency spillway is necessary to minimize the potential for overtopping the basin, which can damage the embankment and lead to SC failure and downstream flooding.

Inspection

The emergency spillway should remain free of trash and debris. Emergency spillways are typically covered with grass, but concrete and riprap are also used. For grass channels, verify that grass is maintained between 6 and 15 inches. Inspect concrete to verify that it is in good condition, or verify that adequate riprap is present. Note all erosion and undesirable vegetation.

Maintenance

Emergency spillways must be free of trash, debris, and undesirable vegetation to maintain their functionality. Remove these if present. Grass should be carefully maintained at a height of 6 to 15 inches. If applicable, repair concrete or replace riprap as necessary. Repair areas of erosion.

8.4 Inspection and Maintenance Summary

Observations made while inspecting stormwater controls must be documented on the appropriate SC inspection report form and entered into SCMS. Observations recorded would include a general description of the SC and those maintenance needs identified such as the removal of accessible trash, sediment, and unwanted vegetation.

If during an inspection emergency maintenance needs are identified (i.e., a sluice gate frozen in the open position), the inspector should either correct the problem at that time or contact the party(s) responsible for emergency maintenance repairs. If emergency maintenance needs are not corrected at the time of the inspection, a follow-up inspection should be conducted to verify that the responsible party(s) has taken action and all needs have been addressed. Observations made during the follow-up inspection must be documented on the appropriate SC inspection report form and entered into SCMS.

CHAPTER 9 Wet Detention Basin

OVERVIEW

A WET DETENTION BASIN (WDB) is a stormwater control that maintains a permanent pool of water, reduces peak stormwater flows, promotes the settling of suspended solids and biological uptake of pollutants, and reduces erosive velocities downstream of the outlet control structure.

PURPOSE AND DESCRIPTION

- Wet detention basins improve water quality by allowing sediment to settle and promoting the growth of wetland plants.
- The basin has additional capacity to detain and slowly release stormwater from a primary outlet control structure over a period of time.

INSPECTION

- The water level should remain near the drawdown device or orifice; low water level or frequent overflowing indicates that maintenance is necessary.
- The outlet control structure is critical to the proper function of the wet detention basin and should be inspected carefully.
- Inspections should occur annually, unless otherwise required by environmental permits or more frequent inspections are deemed necessary.

TYPICAL MAINTENANCE

- Trash and debris should be removed from inlet grates, forebays, orifices, and trash racks.
- Any structural deficiencies should be repaired or the components replaced.
- Undesirable vegetation, especially woody vegetation on the embankment, should be removed.

9.1 Stormwater Control Overview

A Wet Detention Basin (WDB) is a constructed basin with a permanent pool of water that is used to detain and treat contaminated runoff. During storm events, runoff is directed into the pond where it is detained until it is displaced by runoff from the next storm. It is during this detention period that suspended solids and other associated pollutants found in stormwater runoff settle-out.

Figure 9-1 illustrates flow entering the basin, being detained, and exiting the basin. The figure also shows the treatment processes that occur in a typical wet detention basin.

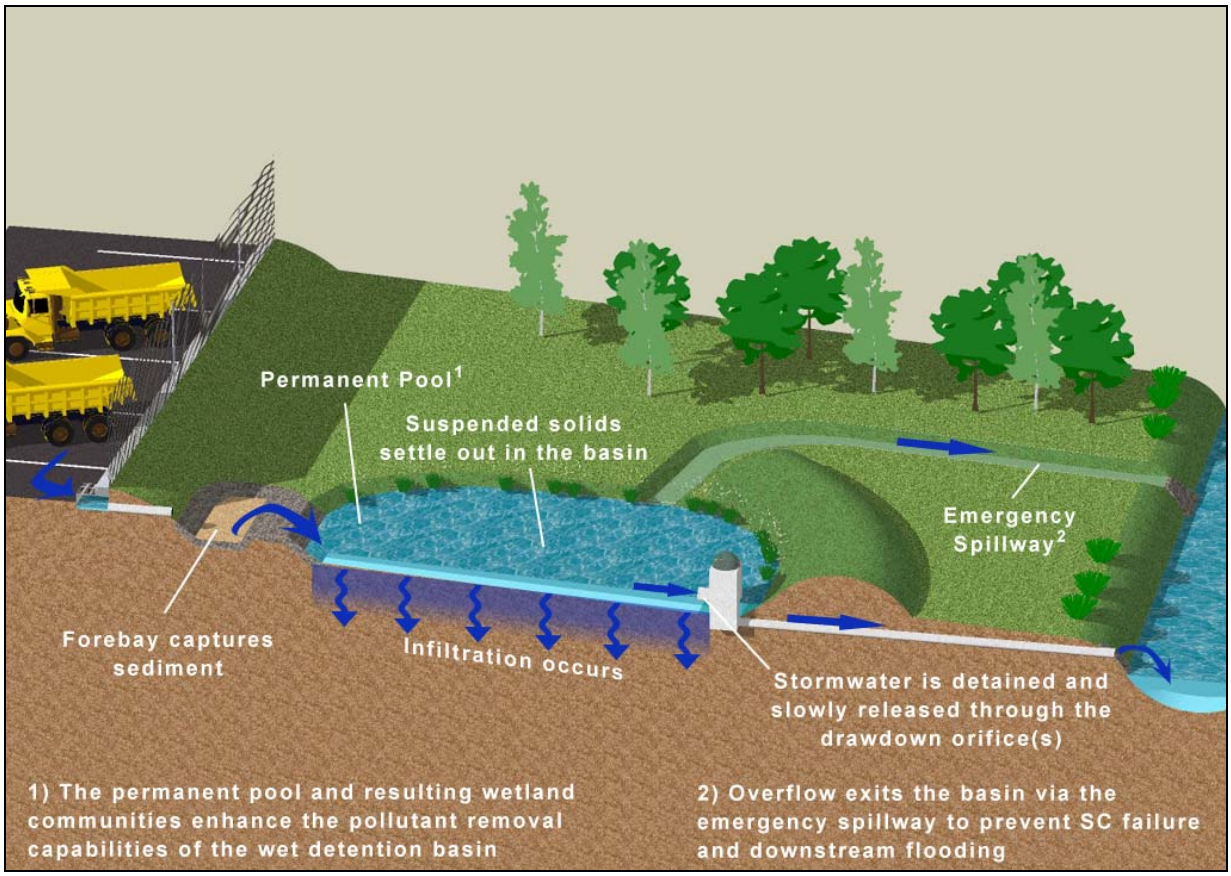


Figure 9-1. Cutaway of a wet detention basin flow diagram and treatment processes

9.2 Wet Detention Pond Components

Figure 9-2 illustrates the various components of a typical wet detention basin. Note that layouts vary. Some systems will have additional components while others may lack certain components. Wet detention basins may include the following:

- Inlet Drainage System
- Forebay
- Basin
- Outlet Control Structure
- Outlet Drainage System
- Emergency Spillway

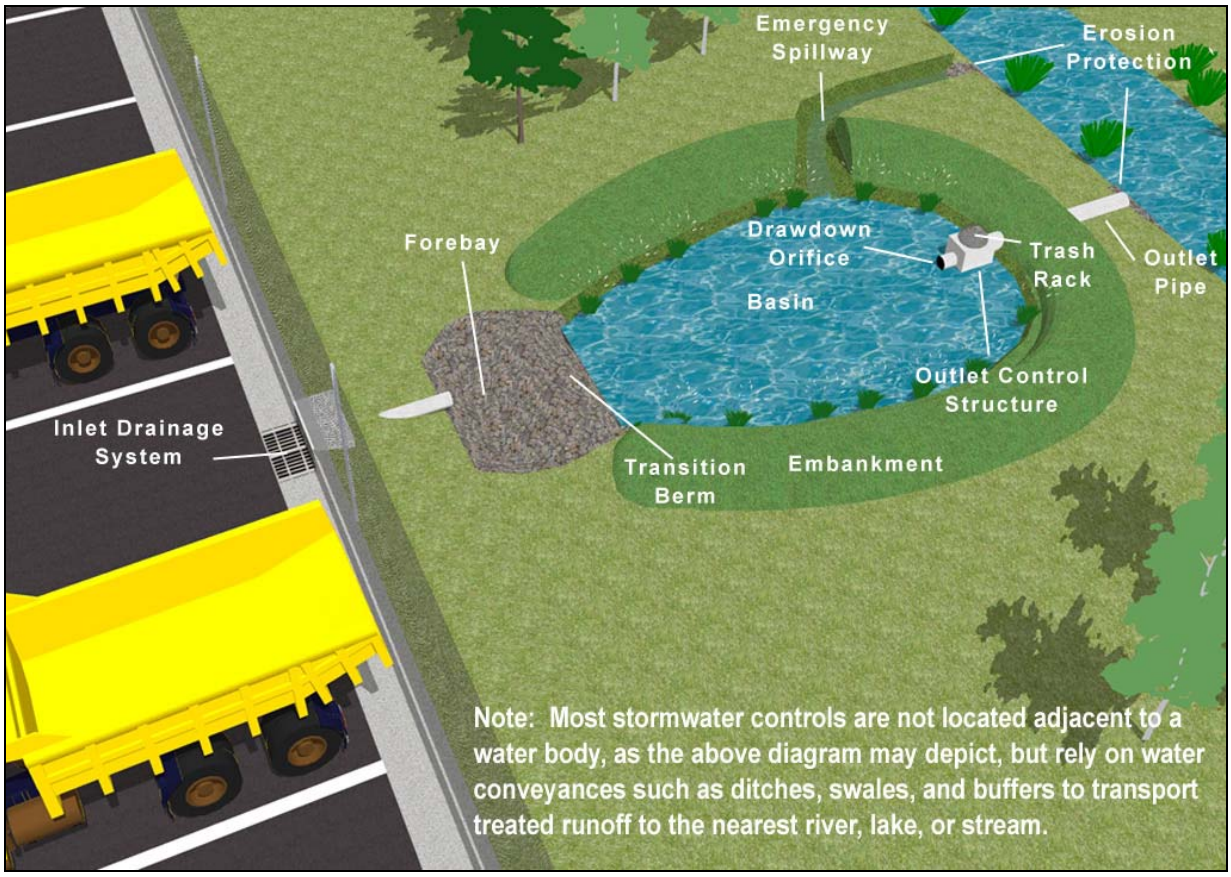


Figure 9-2. Components of a typical wet detention basin

9.3 Inspection and Maintenance

Wet detention basins should be inspected at least annually to determine whether they are functioning as intended. If a wet detention basin is found not to be functioning properly, determine the cause and restore to working order as soon as possible. Figures 9-3 and 9-4 illustrate a plan and profile view of the areas that should be inspected and maintained in a typical wet detention basin configuration.

All inspection findings and maintenance activities should be noted on the inspection form (see Appendix A), then entered into the Stormwater Control Management System (SCMS). Photos should be taken to track the status of the stormwater control (SC) and document the maintenance activities conducted. These, too, can be uploaded to SCMS. Refer to Chapter 4 for further guidance.

The following sections describe the function of a wet detention basin, and provide inspection and maintenance guidance for its major components.

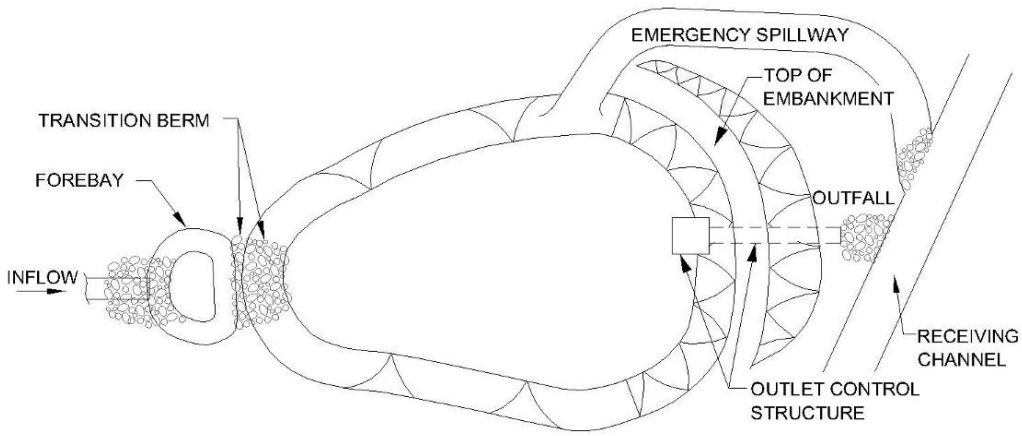


Figure 9-3. Plan view of a wet detention basin and its components

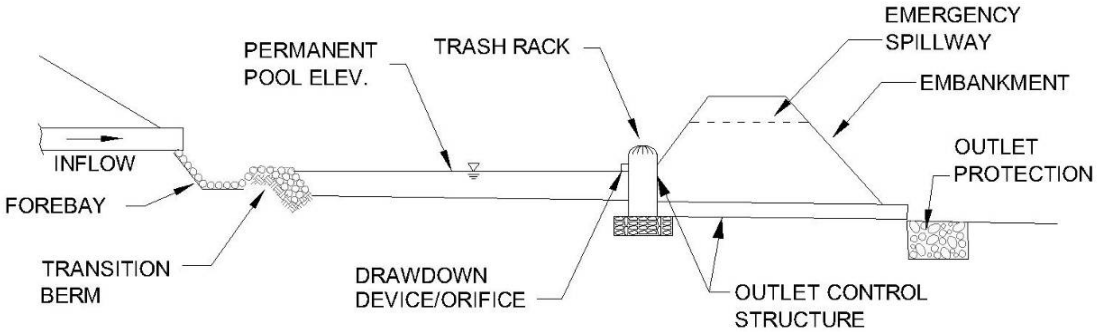


Figure 9-4. Profile view of a wet detention basin and its components

9.3.1 INLET DRAINAGE SYSTEM

Function

The inlet drainage system collects and conveys water to the wet detention basin. Inlet drainage systems can consist of open channels, pipes, curb and gutter, and catch basins.

Inspection

Stormwater runoff should be allowed to flow freely into the basin. Inspect ditches, pipes, and/or catch basins draining to the wet detention basin for trash, sediment, and debris. Inspect the ground surface above buried pipes and structures for depressions and other signs of pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation.

Maintenance

Remove and properly dispose of debris, unwanted vegetation, and major sediment accumulations. Repair eroded areas and damaged pipes. Refer to Chapter 3 for additional guidance on maintenance techniques.

9.3.2 FOREBAY

Function

A forebay is a basin located at the inlet of a SC that pretreats stormwater. A forebay reduces the runoff velocity of stormwater, which in turn allows sediment in the stormwater to settle before the stormwater enters the wet detention basin. A transition berm is the component located at the downstream end of the forebay that acts as a weir and releases runoff to the SC. The presence of a forebay reduces the risk of SC failure.

Inspection

Inspect forebays for trash, debris, and undesirable vegetation. Inspect to determine whether forebays are structurally sound and that they do not contain excessive amounts of accumulated sediment. Sediment accumulation should be less than 50% of the forebay's storage capacity. Inspect the embankment and transition berm for structural integrity and signs of erosion. Inspect the forebay for undesirable vegetation. Forebays may have grass-covered embankments and berms, but they are not designed to support vegetation in the basin. Minimal plant growth is tolerable, but if it becomes excessive, the storage volume for sediment is reduced and dredging becomes more difficult. If any invasive species are present, it is generally preferable to remove them before they become well established.

Maintenance

Remove trash, debris, and undesirable vegetation and properly dispose of it off-site. Remove sediment and dispose of it off-site if it appears to occupy more than 50% of the forebay's storage capacity. Replace erosion protection materials (i.e., riprap) as needed. If the surrounding soil is disturbed during cleanout of the forebay, or at any other time, reseed any areas of bare soil with grass to prevent erosion. Repair the transition berm as necessary, taking care to maintain the original elevation of the berm. Refer to Chapter 3 for additional guidance on sediment disposal.

Consult the NCDOT *Stormwater Best Management Practices Toolbox* (NCDOT, 2008b) or the Hydraulics Unit if major repairs are required.

9.3.3 Basin and Surrounding Area

Function

The basin is the component of the wet detention basin in which sedimentation and biological uptake of pollutants occurs. A permanent pool of water is maintained in the basin. The basin is designed with additional capacity, above the permanent pool, for detaining and slowly releasing runoff from storm events. The sides of the basin may be covered with grass, riprap, and/or wetland vegetation.

If sediment removal or access to submerged components is necessary, the basin can be drained or pumped out; however, the water must first be visually inspected for obvious signs of pollutants. Check for an oily sheen, any unusual odors, or excessive suspended solids. If any of these are present, do not drain the basin. Call the Division Safety Officer or the Roadside Environmental Unit for guidance.

Inspection

Inspect the sides of the basin and the surrounding area for structural integrity, noting any signs of burrowing animals, erosion, inadequate vegetative cover, or undesirable vegetation. Verify that grass is being mowed at a frequency to maintain a height of 6 to 15 inches. Inspect the embankment for settling, scouring, cracking, sloughing, and furrowing, and for invading shrubs and trees. Also, inspect the downstream toe of the embankment for seepage (NCDWQ, 2007). Note trash and debris found in the basin or in surrounding areas.

The water level should be at or near the invert of the drawdown device/orifice except after storm events and during prolonged dry periods. If the water level appears to be too high given recent weather conditions, one or more components are likely clogged. Follow the inspection procedures outlined previously before draining or pumping out the basin, then follow the maintenance guidance given in subsequent sections of this chapter to correct the problem. Low water levels when there is adequate rainfall indicates that the infiltration rate in the basin is higher than originally anticipated. If this is an aesthetic problem or causing adverse affects on the vegetation, a liner can be installed (NCDWQ, 2007). Contact the Hydraulics Unit if there are chronic problems with low water levels.

Try to determine the depth of sediment that has accumulated in the basin. If levels are approaching the drawdown orifice, it is likely that sediment needs to be removed before it impedes the functionality of the basin.

Algae is going to occur in wet detention basins as a result of: 1) nutrient enriched water, 2) shallow water, and 3) intense sun light. When the algal population is controlled, algae provide nutrient removal. Generally, if the algae mats are not so thick as to provide mosquito refuge, they should not require removal. However, unhealthy algal growth can occur when poor vegetative density increases the temperature of the water in the basin or when the basin receives excessive

nutrient inputs. If algal growth covers more than 50% of the basin, develop a management plan to remove and prevent reoccurrence of such growth (NCDWQ, 2007). Physical removal is one option. Available chemical control options are discussed in the 2009 N.C. Agricultural Chemicals Manual (NCSU, 2009). Applicators require a commercial pesticide applicators license with an aquatic endorsement. Contact the Roadside Environmental Unit for guidance.

Some wet detention basins have a vegetated shelf at the perimeter that is planted with wetland vegetation to increase pollutant removal. Consult the design drawings or landscaping plan to determine whether the appropriate vegetation is present. Note any undesirable vegetation and verify that plants remain healthy and uniformly established. Cattails or other invasive plants should be removed if they cover more than 50% of the basin area (NCDWQ, 2007).

Baffles may have been installed to increase the effective flow length in the basin. If this is the case, verify that the baffles are undamaged.

Maintenance

Remove undesirable vegetation by hand if possible or by wiping them with pesticide. Use aquatic herbicides and other appropriate products per label instructions in and around the basin. Mow grass to the ideal height. Turfgrass is typically mowed at a frequency to maintain a maximum height of 4 inches for warm-season grasses and 6 inches for cool-season grasses. However, on highway right-of-way facilities, it is more practical to maintain a grass height between 6 and 15 inches.

If erosion has occurred, reestablish grass, wetland vegetation, or riprap as appropriate. Replace dead or unhealthy plant material. Fertilize upon reestablishment only if needed. The use of fertilizer may be restricted at some locations. Refer to Chapter 3 when considering the use of fertilizer. Contact the Roadside Environmental Unit if further guidance is necessary to maintain vegetation in wet detention basins.

Repair all animal burrows. Repair damaged baffles if applicable. Remove sediment if it is suspected to have exceeded the original design sediment storage depth or if it is impeding the function of the basin.

9.3.4 OUTLET CONTROL STRUCTURE (BOX)

Function

The outlet control structure regulates the water level and slowly releases stormwater. Outlet control structures can have several components, including a trash rack, a drawdown device or orifice, a sluice gate, and an outlet pipe. Inspection and maintenance guidance for these specific components is provided in subsequent sections of this chapter. Figure 9-5 illustrates the configuration of a typical outlet control structure. Drawdown devices or orifices are located a few inches to a few feet below the top of the outlet control structure. The outlet control structure often has a second, larger opening at the top that allows flow from large rainfall events to escape without overtopping the basin. Usually, this is in the form of an open-top outlet structure with a trash rack.

Inspection

Treated water should be allowed to flow freely upon entering the outlet control structure. Inspect the outlet control structure thoroughly for any signs of damage such as cracks, holes, or leaks. Verify that the outlet box remains covered with a trash rack. See subsequent sections for guidance on specific components.

Maintenance

Repair any damaged areas of the outlet control structure, and remove sediment and debris if it is accessible. If the outlet is clogged or blocked, hip waders or a small boat may be needed to make the necessary repairs. Ensure that the proper NCDOT safety procedures are followed when working in or around standing water.

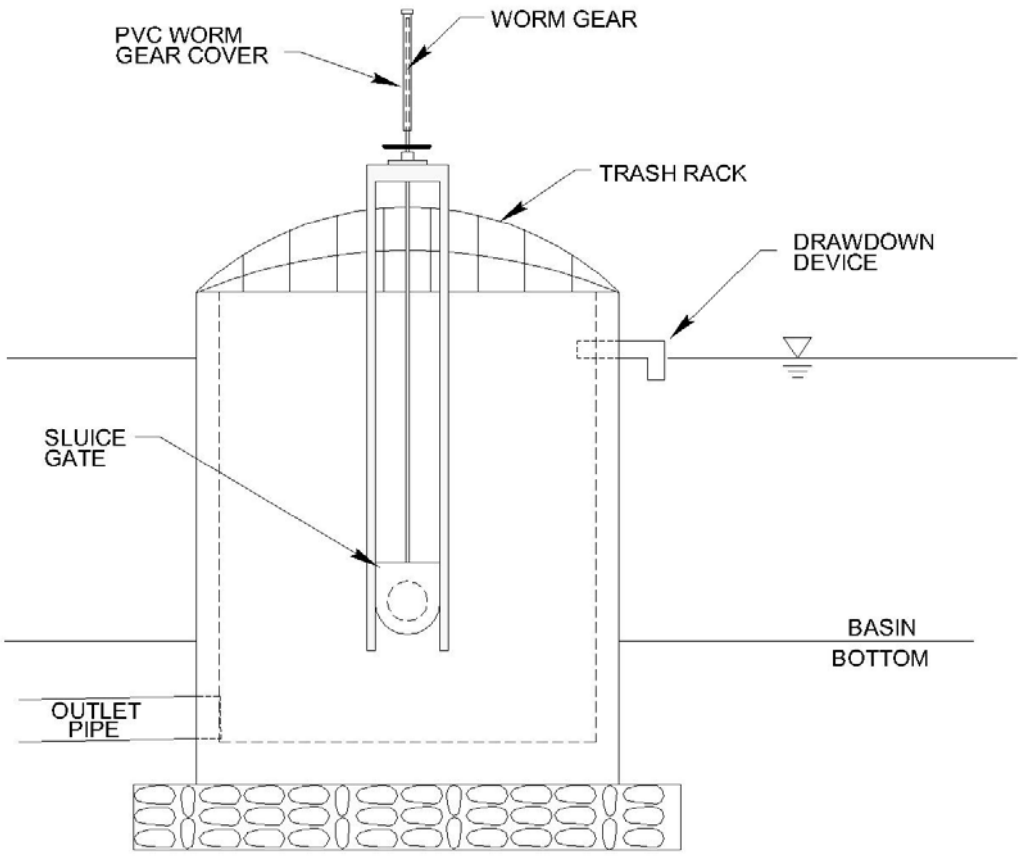


Figure 9-5. Components of an outlet control structure

Figure 9-6. Two views of an outlet control structure

9.3.5 TRASH RACK

Function

Positioned atop the outlet control structure (box), the trash rack protects the overflow of the outlet structure from becoming clogged with debris (see Figures 9-5 and 9-6).

Inspection

Inspect the trash rack for debris and excessive corrosion.

Maintenance

Remove trash and debris. Replace the trash rack if it is corroded or otherwise damaged. The replacement trash rack should be consistent with the design specifications for the SC. If drawings or specifications are not available, contact the NCDOT Hydraulics Unit to obtain standard trash rack specifications or details.

9.3.6 DRAWDOWN DEVICE OR ORIFICE

Function

Positioned a few inches below the top of the outlet control structure, the drawdown device or orifice is a restricting device that allows stormwater to slowly enter the outlet box. Several configurations exist. The simplest type is one or more orifices in the shape of slots or holes directly in the side of the outlet control structure.

Figure 9-7. Outlet control structures showing two types of drawdown devices, slotted (left) and PVC elbow (right).

Drawdown devices have been installed on some outlet control structures to protect the orifice from becoming clogged with floating debris. For example, a small baffle, a wall constructed around the portion of the riser with the orifice(s), can protect the orifice(s) from floating debris while allowing runoff to flow under the baffle and out through the orifices. Another type of drawdown device has a PVC elbow or tee that maintains the entrance to the orifice below the water level so it does not become clogged with floating debris. Figure 9-5 illustrates this configuration.

Inspection

If it is accessible, inspect the drawdown device to ensure that stormwater can freely enter the outlet control structure. If metal components were used to restrict flow or guard against floating debris, check them for excessive corrosion. If the drawdown device is not visible and is suspected to be submerged after the 2 – 5 day drawdown period (check design specifications), it is likely clogged.

Maintenance

Remove sediment and debris blocking the flow into the orifice. If the orifice is submerged, follow guidance given in Section 9.3.4 before pumping out or draining the basin. Replace damaged or corroded components.

9.3.7 SLUICE GATE (IF PRESENT)

Function

Sluice gates are installed for emergency maintenance needs. The sluice gate covers an additional opening at the invert of the basin that is larger than the drawdown orifice. The sluice gate can be opened to rapidly drain the basin. Figure 9-7 is a photograph of a screw-type sluice gate. Figure 9-8 shows a lift-type sluice gate.

Figure 9-8. An open screw-type sluice gate

Figure 9-9. A Lift-type sluice gate

Inspection

Two types of sluice gates are currently in use: (1) a screw-type gate and (2) a lift-type gate. Make sure the sluice gate has not frozen shut by slightly testing the functionality, taking care not to open it, which could allow sediment or debris to escape or get lodged in the outlet. Inspect the sluice gate for excessive corrosion. Verify that there is no sediment or debris below the sluice gate that could prevent it from being fully closed.

Maintenance

If lubrication is necessary, lubricate with a marine-type grease. It is recommended that a cover be fabricated to protect the sluice gate's worm gear on a screw-type gate from corrosion and to increase the visibility of the device. The cover can be made by placing a cap on one end of a section of PVC pipe (see Figure 9-9). If accessible, remove any sediment and debris near the sluice gate. If the sluice gate is damaged beyond repair, replace it with one that meets the requirements presented in NCDOT Standard Drawing No. 838.02 (NCDOT, 2006). Perform additional maintenance and repairs as described in the manufacturer's instructions.

Figure 9-10. Two large sluice gates with PVC covers

9.3.8 OUTLET DRAINAGE SYSTEM

Function

The outlet drainage system conveys water from the SC to the downstream drainage system or receiving water. Typically, a pipe conveys water from the outlet control structure through the embankment to a swale or other open channel.

Inspection

Inspect the inside of structures and pipe(s) to verify that they are free of sediment and debris. Inspect the ground surface above buried pipes and structures for depressions or other signs that might indicate pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation.

Maintenance

Remove any sediment or debris that is accessible. Repair eroded areas and damaged pipes. Replace outlet protection materials (i.e., riprap) as necessary. Refer to Chapter 3 for additional guidance on maintenance techniques.

9.3.9 EMERGENCY SPILLWAY (IF PRESENT)

Function

The emergency spillway serves as an overflow structure that is typically constructed as a channel in natural ground. The emergency spillway is necessary to minimize the potential for overtopping the basin, which can damage the embankment and lead to SC failure and downstream flooding.

Inspection

The emergency spillway should remain free of trash and debris. Emergency spillways are typically covered with grass, but concrete and riprap are also used. For grass channels, verify that grass is maintained between 6 and 15 inches. Inspect concrete channels to verify that they are in good condition, or verify that adequate riprap is present. Note all erosion and undesirable vegetation. Observe the point of discharge to evaluate if erosion protection is adequate.

Maintenance

Emergency spillways must be free of trash, debris, sediment and undesirable vegetation to maintain proper function. Remove these if present. Grass should be carefully maintained at a height of 6 to 15 inches. Repair concrete or replace riprap as necessary. Repair areas of erosion.

9.4 Inspection and Maintenance Summary

Observations made while inspecting stormwater controls must be documented on the appropriate SC inspection report form and entered into SCMS. Observations recorded would include a general description of the SC and those maintenance needs identified such as the removal of accessible trash, sediment, and unwanted vegetation.

If during an inspection emergency maintenance needs are identified (i.e., a sluice gate frozen in the open position), the inspector should either correct the problem at that time or contact the party(s) responsible for emergency maintenance repairs. If emergency maintenance needs are not corrected at the time of the inspection, a follow-up inspection should be conducted to verify that the responsible party(s) has taken action and all needs have been addressed. Observations made during the follow-up inspection must be documented on the appropriate SC inspection report form and entered into SCMS.

CHAPTER 10 Hazardous Spill Basin

OVERVIEW

A HAZARDOUS SPILL BASIN (HSB) is a stormwater control designed to temporarily detain hazardous material that has been spilled on roads and parking areas until it can be removed.

PURPOSE AND DESCRIPTION

- HSBs protect water quality by detaining hazardous materials that have been spilled on roadways near designated sensitive water supplies, other environmentally sensitive areas, and areas with concentrated truck parking.
- Under normal operation, hazardous spill basins do not restrict the free flow of runoff.

INSPECTION

- The area should first be inspected for any evidence that a spill has occurred. If hazardous material is present, abandon the inspection, and notify the proper authorities.
- The outlet should remain unobstructed during normal operation.
- Inspections should occur annually, unless otherwise required by environmental permits or more frequent inspections are deemed necessary.

TYPICAL MAINTENANCE

- Vegetation should be controlled so that the outlet is visible and easily accessible.
- Sediment and debris should be removed from the device and outlet to retain capacity and to ensure that the sluice gate or other obstruction method can be properly sealed during a spill.
- The sluice gate should be exercised and lubricated to prevent corrosion and seizing.

10.1 Stormwater Control Overview

A Hazardous Spill Basin (HSB) is a containment structure installed at stream crossings and rest area parking lots that aids in the temporary storage and clean up of accidental spills. Under normal conditions runoff flow is allowed to enter and pass freely through the basin. When a spill occurs, the basin's drainage outlet structure is closed using a mechanical control valve (sluice gate). This helps contain the hazardous material and prevents it from reaching and contaminating the nearest river, lake, or stream.

Before inspecting any hazardous spill basin, the inspector should first check the site for the presence of a spill. If the basin already contains a spill or a spill has just occurred, the inspection should be cancelled and rescheduled sometime after 'clean-up' has taken place. If it is safe to do so, the inspector should close the sluice gate, contact the Division's Safety Engineer or Hazardous Materials Manager, and call 911 and any other proper authorities if this has not already been done. **At no time should an inspector attempt any hazardous material cleanup, or enter a spill area unless he or she is properly trained.**

At a minimum, HSBs should be inspected on an annual basis unless otherwise specified by environmental permits. Figure 10-1 illustrates the function of an HSB.

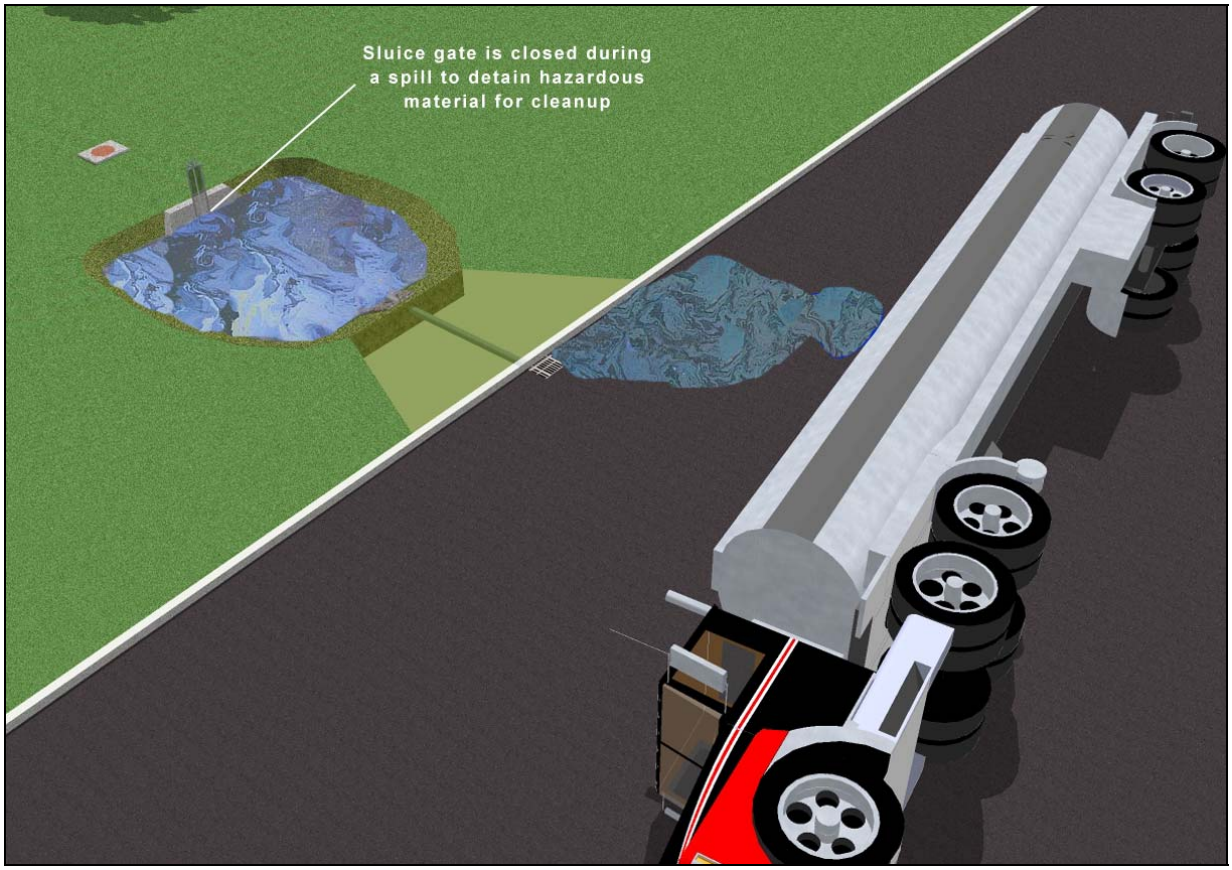


Figure 10-1. Function of a hazardous spill basin

10.2 Hazardous Spill Basin Components

Figure 10-2 illustrates the various components of a typical HSB. Note that layouts vary. The outlet structure shown is one of several configurations. Also, many HSBs are lined with riprap. HSBs may include the following:

- Inlet Drainage System
- Erosion Protection at the Inlet
- Basin
- Outlet Structure
- Sluice Gate or Obstruction Materials
- Outlet Drainage System

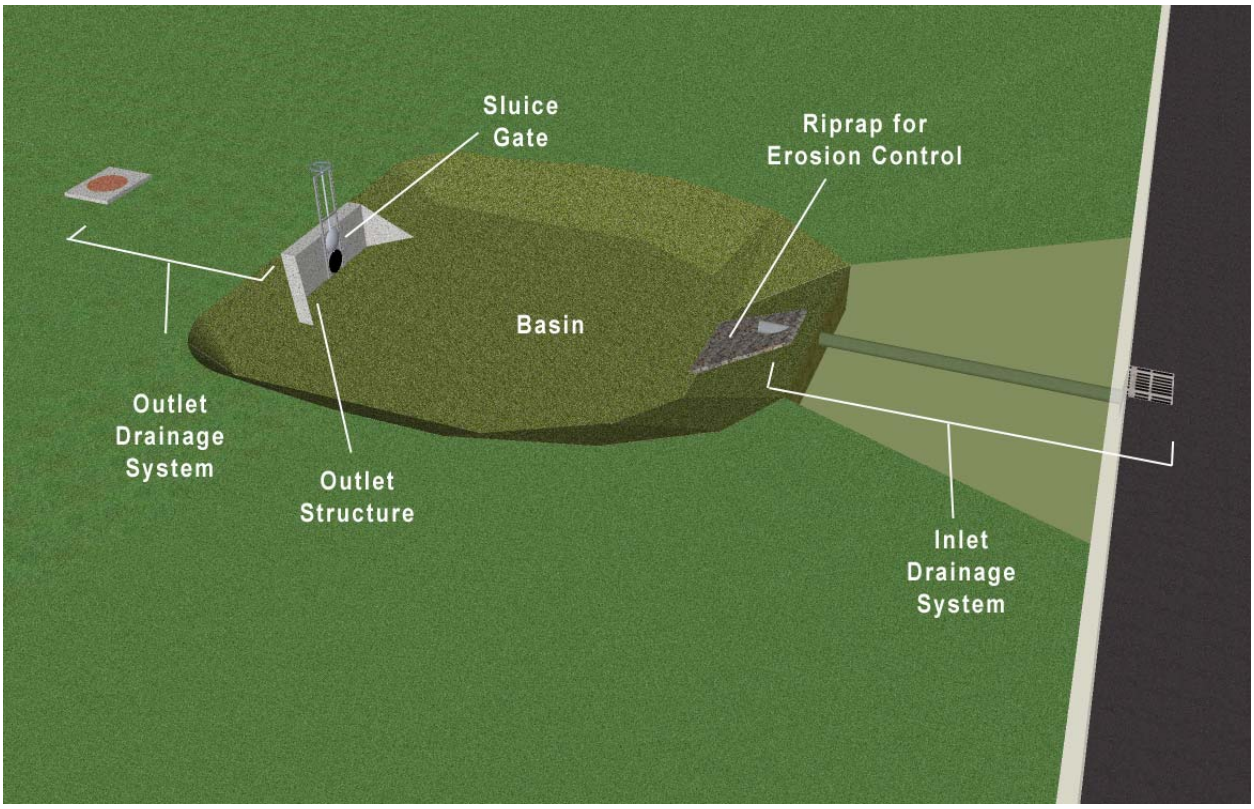


Figure 10-2. Components of a typical hazardous spill basin

10.3 Inspection and Maintenance

HSBs are sometimes difficult to locate due to their low elevation or overgrown vegetation. If this is the case, the sluice gate's worm gear is often visible from the road, even through thick vegetation. Refer to Section 10.3.5 for photos and additional information.

Before inspecting any HSB, the inspector should first check the site for the presence of a spill. If the basin already contains a spill, the inspection should be cancelled and rescheduled for a later date. If a spill has just occurred and it is safe to do so, the inspector should close the sluice gate, and call 911 and the Division's Safety Engineer or Hazardous Materials Manager. **At no time should an inspector attempt any hazardous material cleanup.**

If there is no evidence of a spill, the inspection can continue. HSBs should be inspected at least annually to determine whether they are functioning as intended. Most importantly, it should be verified that the outlet structure and sluice gate or obstruction materials can adequately block the flow should a spill occur. If an HSB is found to be functioning improperly, determine the cause and restore to working order as soon as possible. Figures 10-3 and 10-4 illustrate a plan and profile view of the areas that should be inspected and maintained for a typical HSB. Figure 10-3 also illustrates the flow path under normal conditions.

All inspection findings and maintenance activities should be noted on the inspection form (see Appendix A) and then entered into the Stormwater Control Management System (SCMS). Photos should be taken to track the status of the stormwater control (SC) and document the maintenance activities conducted. These, too, can be uploaded to SCMS. Refer to Chapter 4 for further guidance.

The following sections describe the function of a hazardous spill basin, and provide inspection and maintenance guidance for its major components.

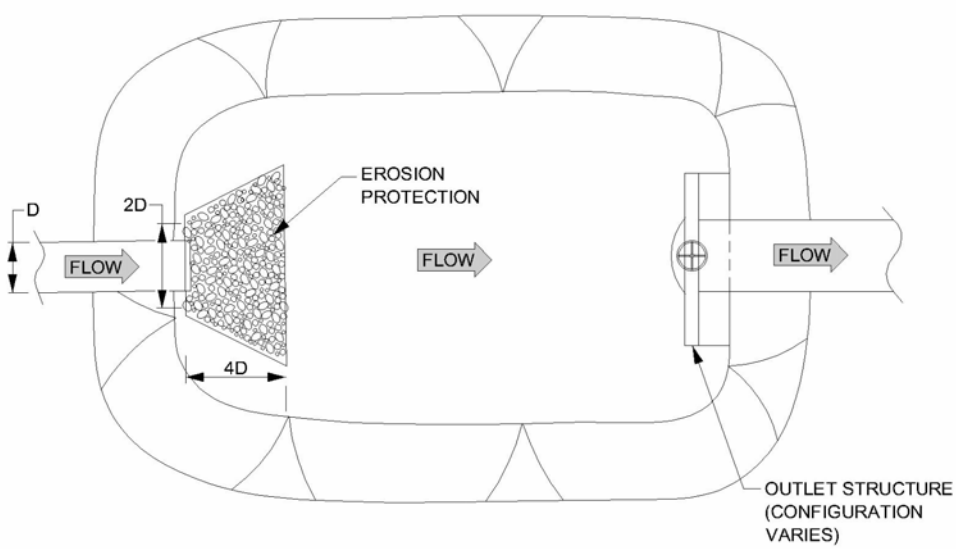


Figure 10-3. Plan view of a hazardous spill basin and its components

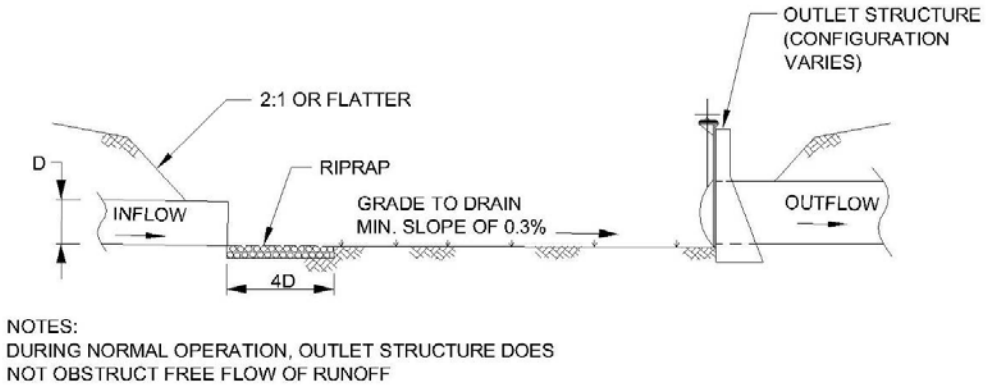


Figure 10-4. Profile view of a hazardous spill basin and its components

10.3.1 Inlet Drainage System

Function

The inlet drainage system collects and conveys water to the SC. Inlet drainage systems can consist of open channels, pipes, curb and gutter, and catch basins.

Inspection

Stormwater runoff should be allowed to flow freely into the basin. Inspect all ditches, pipes, and/or catch basins draining to the hazardous spill basin for trash, sediment, and debris. Inspect the ground surface above buried pipes and structures for depressions and other signs of pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation.

Maintenance

Remove and properly dispose of debris, undesirable vegetation, and major sediment accumulations. Repair all eroded areas and damaged pipes. Refer to Chapter 3 for additional guidance on maintenance techniques.

10.3.2 Erosion Protection at the Inlet

Function

Erosion protection materials (i.e., riprap and filter fabric) may have been placed at the inlet to the HSB to protect this area from erosion. For some HSBs, the entire basin is lined with riprap. If this is the case, refer to Section 10.3.3.

Inspection

Verify that the erosion protection measures are undamaged, remain in place, and are adequate to protect the inlet of the basin. Figure 10-3 shows the basic dimensions for erosion protection at the basin inlet. Refer to NCDOT Standard Drawing No. 876.02 for additional guidance (NCDOT, 2006). Inspect the riprap for sediment, trash, debris, and undesirable vegetation.

Maintenance

Remove sediment, trash, debris, and undesirable vegetation and properly dispose of it off-site. Replace riprap as needed.

10.3.3 Basin and Surrounding Area

Function

The basin is the component of the HSB that stores contaminants in the event of a spill. Normally, runoff flows freely through the basin.

Inspection

The floor of the basin, its interior and exterior side slopes, and all areas surrounding the basin should be stabilized with a uniform cover of turfgrass or adequate erosion protection materials, such as riprap. Inspect grass to ensure that it is being mowed at a frequency to maintain a height of 6 to 15 inches.

Inspect the basin for structural integrity. Note any signs of erosion, burrowing animals, or undesirable vegetation. Inspect the embankment for settling, scouring, cracking, sloughing, and furrowing, and for shrubs and trees. Also, inspect the downstream toe of the embankment for seepage (NCDWQ, 2007). Note all trash and debris found in the basin or in surrounding areas.

Some hazardous spill basins may be lined with riprap to slow flow and protect against erosion. Note whether the riprap is heavily stained or covered with sediment buildup. The source of the sediment should be identified and corrected if possible.

Inspect the basin for standing water. If standing water is present, determine whether the cause is (1) a clogged outlet structure, (2) the elevation at the bottom of the basin is below the invert of the outlet structure, or (3) slow flowing water due to a constant upstream source. No maintenance is required if there is a constant stream of water. **However, vegetative growth will have to be monitored more closely if there is a constant supply of water, such as a spring.**

Maintenance

Remove all undesirable vegetation (using a mechanical or herbicidal treatment) and mow grass to the ideal height. Turfgrass is typically mowed at a frequency to maintain a maximum height of 4 inches for warm-season grasses and 6 inches for cool-season grasses. However, within the NCDOT right-of-way, it is more practical to maintain a grass height between 6 and 15 inches. If erosion has occurred, reestablish turfgrass (seed or sod), replace riprap, and fertilize turfgrass upon reestablishment. The use of fertilizer may be restricted at some locations. Refer to Chapter 3 when considering the use of fertilizer. Repair animal burrows. If there is channelization or standing water, reestablish the proper grade of the basin bottom by removing sediment and filling in, then reestablishing vegetation. Sediment should be removed as necessary to minimize outlet clogging. Remove and replace riprap as necessary.

10.3.4 OUTLET STRUCTURE

The most typical outlet configuration is a sluice gate fixed to a concrete headwall that blocks the outlet pipe when closed, as shown in Figure 10-4. Obstruction materials, such as sand bags, are another means of blocking the outlet pipe. Inspection and maintenance guidance for these two options follows. Refer to Section 10.3.6 on Obstruction Materials. If an alternative design was used, follow the general guidance given in this chapter and in Chapters 2 and 3 to inspect the outlet and maintain its function.

Figure 10-4. Components of an outlet structure

The outlet must be clearly visible and easy to access. Remove undesirable vegetation as necessary to increase visibility and ease of access. Figure 10-5 is an example of an overgrown hazardous spill basin.

Figure 10-5. A sluice gate barely visible due to overgrown vegetation

10.3.5 SLUICE GATE

Function

In HSBs, sluice gates are used to block the flow and contain pollutants during a spill. Two types of sluice gates are currently in use: (1) a lift-type gate and (2) a screw-type gate. Figures 10-6 and 10-7 show a lift-type sluice gate and a, screw-type sluice gate respectively. **Under normal conditions, the sluice gate should be left in the open position.** The sluice gate is also a good means for locating an HSB. The sluice gate's worm gear is often visible through overgrown vegetation. In addition, many sluice gate worm gears have been fitted with a capped section of white PVC pipe to increase visibility and protect against corrosion. The sluice gates in Figure 10-7 have worm gear covers. Sluice gates may also be mounted on the downstream end of the outlet pipe (see Figure 10-8).

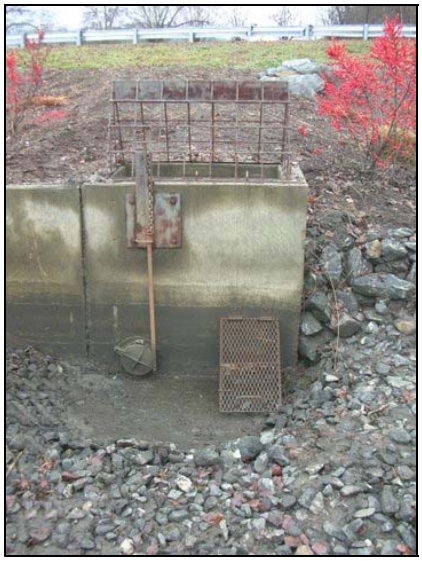


Figure 10-6. Lift-type sluice gate

Figure 10-7. Large, screw-type sluice gates with PVC cover and cap over worm gear

Figure 10-8. A sluice gate mounted on the downstream end of the outlet pipe

Inspection

Open and close the sluice gate to ensure that it is operable through its entire range of motion. Inspect the sluice gate for excessive corrosion. Verify that there is no sediment or debris below the sluice gate that could prevent it from being fully closed.

Maintenance

Lubricate the sluice gate worm gear with a marine-type grease. Remove any sediment and debris near the sluice gate. It is recommended that a cover be fabricated to protect the sluice gate's worm gear from corrosion and increase the visibility of the device. The cover can be made by placing a cap on one end of a section of PVC pipe. If the sluice gate is damaged beyond repair, replace it with one that meets the requirement presented in NCDOT Standard Drawing No. 838.02 (NCDOT, 2006). Perform additional maintenance and repairs as described in the manufacturer's instructions.

10.3.6 OBSTRUCTION MATERIALS

Function

Obstruction materials are sometimes used as a means to block the outlet during a spill. These materials are stored on site and should be ready to use at all times. The mini-hazardous spill basin (driveway type) barrier with sandbags and sandbags (alone) in open ditches are two alternative hazardous spill types of barriers used along with the regular type of hazardous spill basin. These two new types of hazardous spill barriers were first installed along the US-1 Vass Bypass in Moore and Lee Counties during 2007. (See Figures 10-9 and 10-10).

Figure 10-9. Driveway-type mini-hazardous spill basin

Figure 10-10. Open-ditch hazardous spill basin with sandbags

Inspection

If a sluice gate or similar method is not used, verify that obstruction materials are present. Obstruction materials should be easy to find and easy to physically place inside or in front of the outlet of the hazardous spill basin. Verify that obstruction materials are undamaged and sufficient to block the outlet. Be sure the outlet pipe or ditch is free of debris and heavy vegetation buildup.

Maintenance

Replace damaged or inadequate obstruction materials. Sandbag materials should be resistant to sunlight damage (i.e., black carbon fiber bags). Relocate materials if they are not clearly visible or easy to access and move into place. Clean out outlet pipe or ditch that is blocked with debris and heavy vegetation buildup.

10.3.7 Outlet Drainage System

Function

The outlet drainage system conveys water from the SC to the downstream drainage system or receiving water. Components of this system can include channels, pipes, catch basins, manholes, culverts, and other structures. Headwalls are also a common component of the outlet drainage system.

Inspection

Inspect the headwall, pipes, and drainage structures for cracks or leaks. Inspect the ground surface above buried pipes and structures for depressions or other signs that might indicate pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation. If outlet protection materials such as riprap are present, verify that these materials are adequate and in good shape.

Maintenance

Remove and properly dispose of debris, undesirable vegetation, and major sediment accumulations. Repair all eroded areas and damaged pipes. Replace outlet protection materials (i.e., riprap) as necessary. Refer to Chapter 3 for additional guidance on maintenance techniques.

10.3.8 Signage (if present)

Many hazardous spill basins have signage that describes the actions necessary to contain a spill. Note any damage to the sign as well as obstructions that hide the sign or make it difficult to read (i.e., overgrown vegetation). Make repairs and remove obstructions to the sign as necessary. Figure 10-11 shows some examples of signage associated with HSBs.

Figure 10-11. Signage associated with hazardous spill basins

10.4 Inspection and Maintenance Summary

Observations made while inspecting stormwater controls must be documented on the appropriate SC inspection report form and entered into SCMS. Observations recorded would include a general description of the SC and those maintenance needs identified such as the removal of accessible trash, sediment, and unwanted vegetation.

If during an inspection emergency maintenance needs are identified (i.e., a sluice gate frozen in the open position), the inspector should either correct the problem at that time or contact the party(s) responsible for emergency maintenance repairs. If emergency maintenance needs are not corrected at the time of the inspection, a follow-up inspection should be conducted to verify that the responsible party(s) has taken action and all needs have been addressed. Observations made during the follow-up inspection must be documented on the appropriate SC inspection report form and entered into SCMS.

If a hazardous spill basin already contains a spill, the inspection should be cancelled and rescheduled for a later date. If a spill has just occurred and it is safe to do so, the inspector should close the sluice gate, and call 911 and the NCDOT Division's Safety Engineer or Hazardous Materials Manager. **At no time should an inspector attempt any hazardous material cleanup.**

CHAPTER 11 Stormwater Wetland

OVERVIEW

A STORMWATER WETLAND (SW) is an engineered marsh or swamp with dense wetland vegetation designed to remove stormwater pollutants primarily through biological processes.

PURPOSE AND DESCRIPTION

- Stormwater wetlands, as opposed to naturally occurring wetlands, have distinct inlet and outlet structures.
- Vegetation grows throughout the wetland.
- Pools of standing water are usually present, although some wetlands are designed to treat runoff below ground.

INSPECTION

- The density and diversity of vegetation is critical to the success of the stormwater wetland. During inspection, vegetation should be compared to the landscaping plan.
- The water level should remain near the drawdown device, except under drought conditions.
- Inspections should occur annually, unless otherwise required by environmental permits or more frequent inspections are deemed necessary.

TYPICAL MAINTENANCE

- Trash and debris should be removed from inlet grates, forebays, orifices, and trash racks.
- Undesirable vegetation should be removed, and diseased or dying vegetation should be replanted.
- If an algae bloom is present, an action plan should be developed and followed.

Note: This is a specialized device and if any major maintenance is needed, contact the Hydraulics or Roadside Environment Units in Raleigh for guidance.

11.1 Stormwater Control Overview

Stormwater Wetlands (SW) are constructed stormwater controls that mimic natural wetlands, and are designed with multiple treatment zones of different water depths. Each treatment zone supports a diverse aquatic ecosystem. The primary treatment zones are deep pools, shallow water, and shallow land. Deep pools (18-36 inches deep) dissipate flow energy, trap sediment, remove nitrogen, and promote infiltration. Deep pools are also important for mosquito control by providing habitat for fish. The shallow water zone (2-4 inches) provides habitat for diverse wetland plants that provide additional nitrogen and phosphorus removal. The shallow land zone (also referred to as the temporary inundation zone) is submerged only for a short period of time as a result of storm events. Otherwise this area is dry and should be 0-12 inches above the normal pool elevation. This area supports a wide variety of vegetation that grows in wet or dry conditions and increases the diversity of the wetland.

A constant supply of water, generally provided by groundwater in addition to stormwater, is needed to maintain a shallow water level. Therefore, most stormwater wetlands are located in low-lying, typically wet areas. Figure 11-1 illustrates the treatment processes that occur in a typical stormwater wetland.

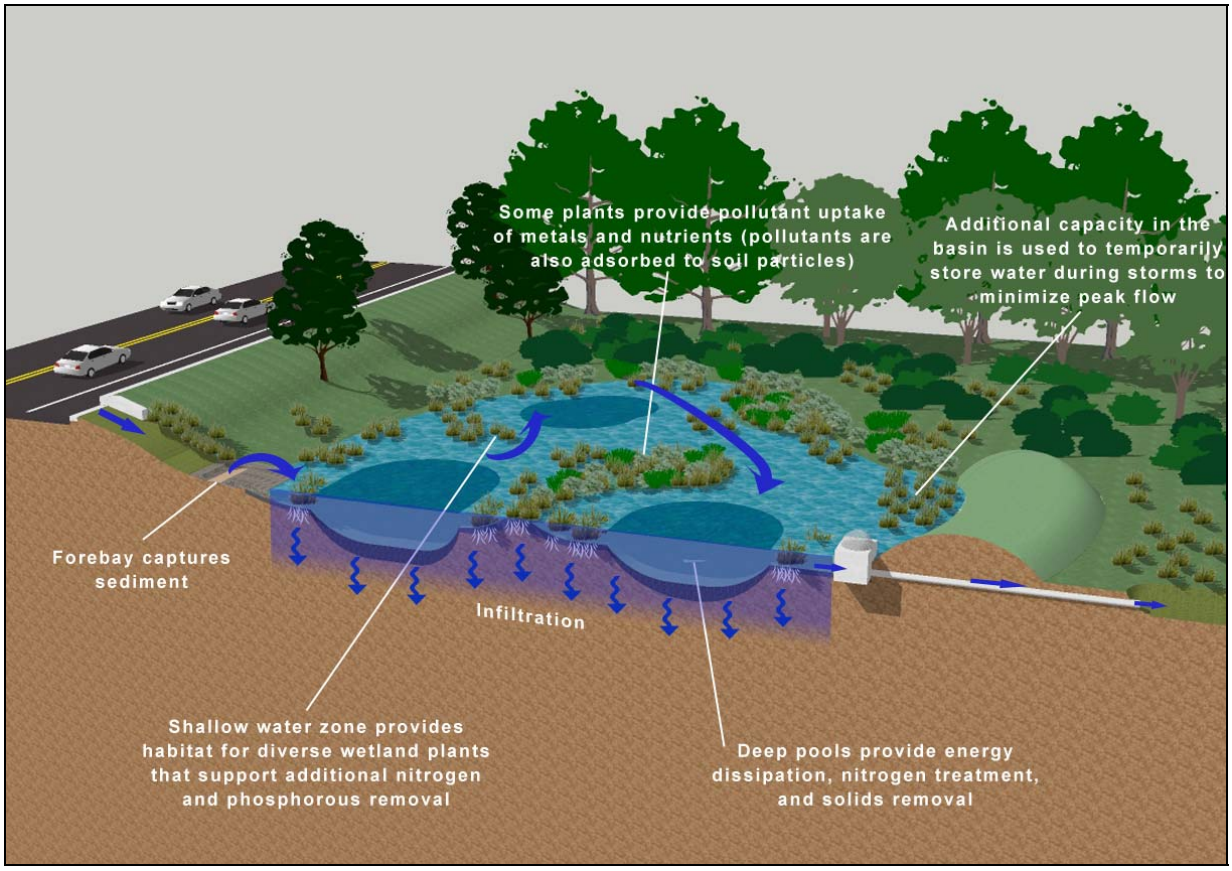


Figure 11-1. Cutaway of a stormwater wetland flow diagram and treatment processes

11.2 Stormwater Wetland Components

Stormwater wetlands include, but are not limited to, the following components:

- Inlet Drainage System
- Forebay(s)
- Basin
- Outlet Control Structure
- Outlet Drainage System
- Emergency Spillway

A typical stormwater wetland layout and its components are shown in Figure 11-2.

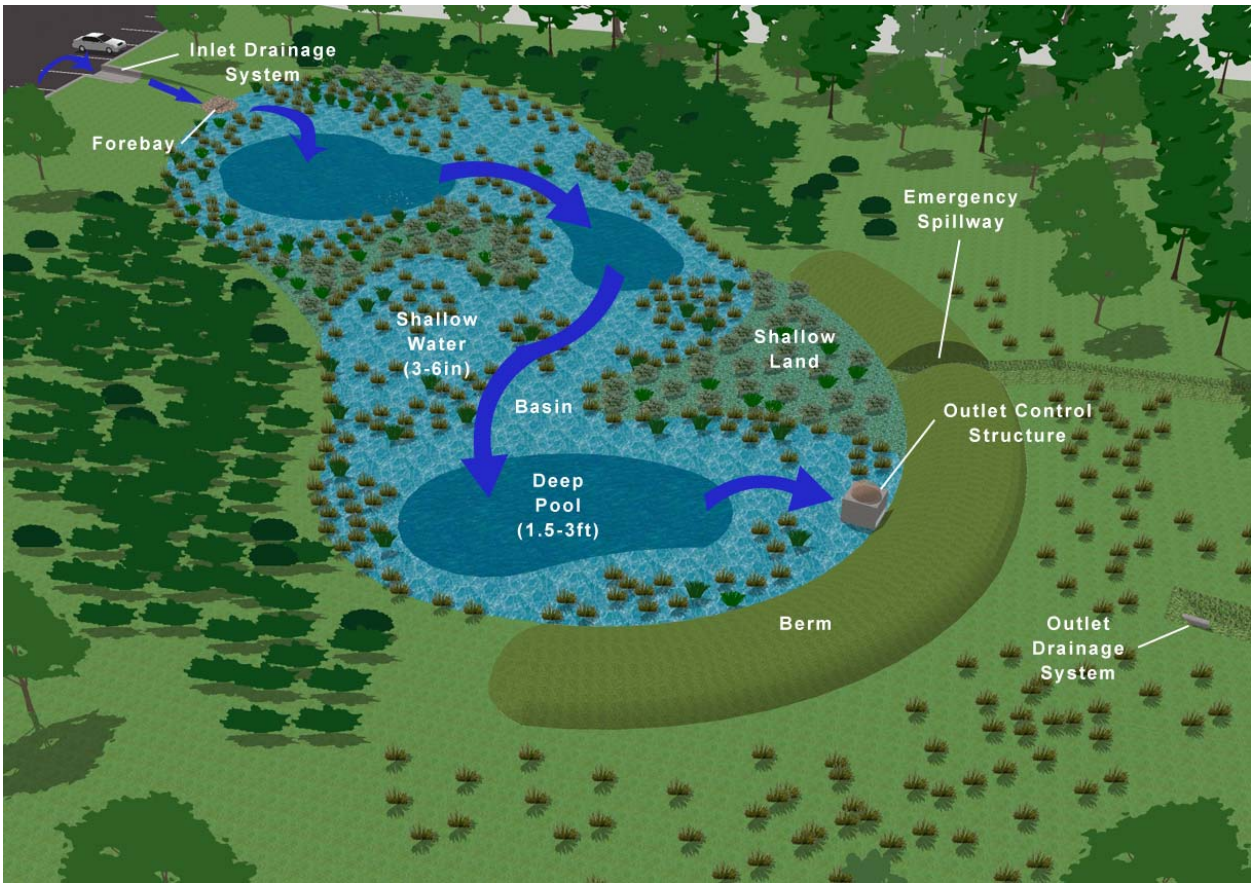


Figure 11-2. Components of a typical stormwater wetland

As runoff enters the stormwater wetland forebay, the runoff velocity is quickly reduced allowing large trash, debris, and solids to be removed. After runoff leaves the forebay, runoff moves slowly through the wetland vegetation in the shallow water zone. Contact with vegetation allows for biological treatment of metals and nutrients primarily through microbial processes (NCHRP, 2006). As runoff continues through the wetland, it enters the deep pools. Because the deep

pools tend to be stagnant, they provide oxygen-free environments for additional nutrient removal by anaerobic microbes (Hunt et al., 2007).

As opposed to natural systems, stormwater wetlands have distinct inlet and outlet control systems to manage the shallow water elevation. The outlet control structure is typically a riser structure composed of low-flow and high-flow options. A low-flow orifice maintains the shallow water level in the wetland. High-flow options (e.g., an open-throat riser, broad-crested weir) detain and slowly release stormwater from large storm events over a period of 2-5 days. This reduces the runoff velocity of the discharge, and allows additional physical and chemical processes to remove pollutants while the water is detained in the stormwater wetland.

11.3 Inspection and Maintenance

Stormwater wetlands should be inspected at least annually to determine whether they are functioning as intended. Most important, it should be verified that the outlet control structure is functioning properly and that the shallow water level is being maintained. If a stormwater wetland is found not to be functioning properly, determine the cause and restore to working order as soon as possible. Figures 11-3 and 11-4 illustrate a plan and profile view of the areas that should be inspected and maintained in a typical stormwater wetland configuration.

All inspection findings and maintenance activities must be noted on the inspection form (see Appendix A) and then entered into the Stormwater Control Management System (SCMS). Photos should be taken to track the status of the stormwater control (SC) and document the maintenance activities conducted. These, too, should be uploaded to SCMS. Refer to Chapter 4 for further guidance.

The following sections describe the function of a stormwater wetland, and provide inspection and maintenance guidance for its major components.

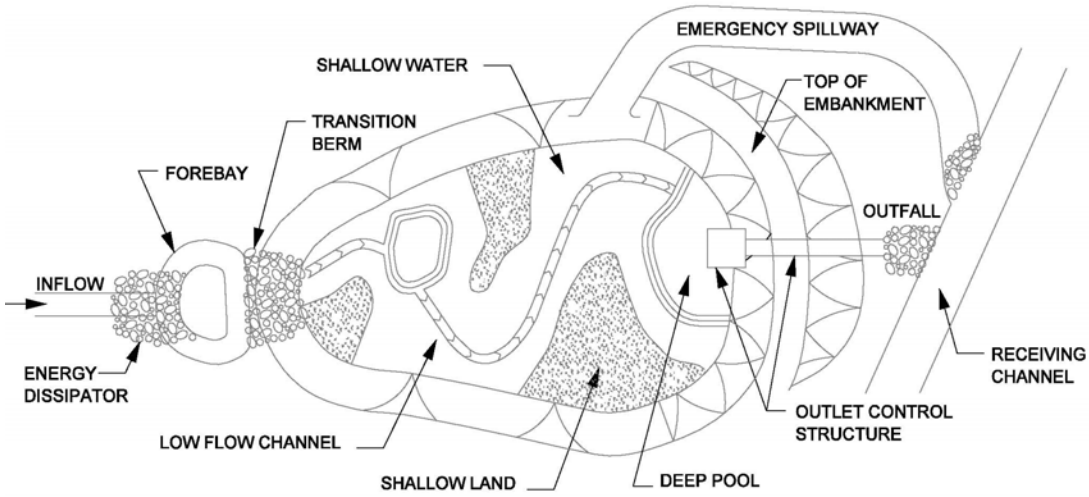


Figure 11-3. Plan view of a stormwater wetland and its components

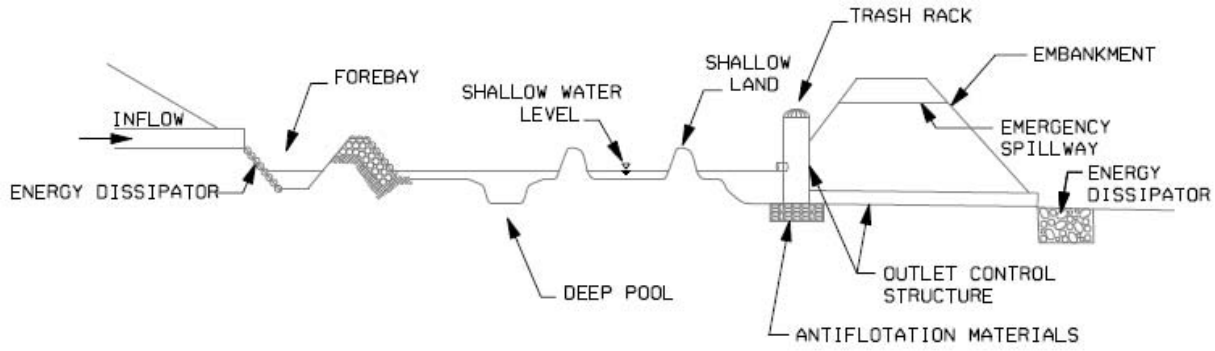


Figure 11-4. Profile view of a stormwater wetland and its components

11.3.1 Inlet Drainage System

Function

The inlet drainage system collects and conveys water to the stormwater wetland. Inlet drainage systems can consist of open channels, pipes, curb and gutter, and catch basins.

Inspection

Stormwater runoff should be allowed to flow freely into the basin. Inspect ditches, pipes, and/or catch basins draining to the stormwater wetland for trash, sediment, and debris. Inspect the ground surface above buried pipes and structures for depressions and other signs of pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation. Desirable vegetation includes grass cover in an open ditch to prevent soil erosion. Undesirable vegetation includes any woody plants or invasive species that may impede the inlet drainage system.

Maintenance

Remove and properly dispose of debris, undesirable vegetation, and major sediment accumulations. Repair eroded areas and damaged pipes. Refer to Chapter 3 for additional guidance on maintenance techniques.

11.3.2 Forebay

Function

A forebay is a basin located at the inlet of a SC that pretreats stormwater. A forebay reduces the velocity of stormwater, which in turn allows sediment in the runoff to settle before the stormwater enters the stormwater wetland. A transition berm is the component located at the downstream end of the forebay that acts as a weir and releases runoff to the SC. The presence of a forebay reduces the risk of SC failure.

Inspection

Inspect forebays for trash and debris. Inspect to determine whether forebays are structurally sound and that they do not contain excessive amounts of accumulated sediment. Inspect the embankment and transition berm for structural integrity and signs of erosion. Inspect the forebay for undesirable vegetation. Forebays may have grass-covered embankments and berms, but they are not designed to support vegetation in the basin. Minimal plant growth is tolerable, but if it becomes excessive, the storage volume for sediment is reduced and dredging becomes more difficult. If any invasive species are present, it is generally preferable to remove them before they become well established.

Maintenance

Remove trash, debris, and undesirable vegetation and properly dispose of it off-site. Remove sediment and dispose of it off-site if it appears to occupy more than 50% of the forebay's storage capacity. Replace erosion protection materials (i.e., riprap) as needed. If the surrounding soil is disturbed during cleanout of the forebay, or at any other time, reseed any areas of bare soil with a turf-type grass to prevent erosion. Repair the transition berm as necessary, taking care to maintain the original elevation of the berm. Refer to Chapter 3 for additional guidance on sediment disposal. Consult the NCDOT *Stormwater Best Management Practices Toolbox* (NCDOT, 2008b) or the Hydraulics Unit if major repairs are required.

11.3.3 Basin and Surrounding Area

Function

The basin is the component of the stormwater wetland in which wetland plants and aquatic organisms remove nutrients and other pollutants. Generally, the wetland supports a shallow water elevation interspersed with deep pools. The wetland is also designed with additional capacity, above the shallow water elevation, for detaining and slowly releasing runoff from storm events. The interior and side slopes of the stormwater wetland are covered with very specific wetland and nonwetland vegetation, depending on the water level in that area of the SC.

If access to submerged components is necessary, the stormwater wetland can be drained or pumped out; however, the water must first be visually inspected for obvious signs of pollutants. Check for an oily sheen, any unusual odors, or an excessive amount of suspended solids. If any of these are present, do not drain the basin. Call the Division Safety Officer or the Roadside Environmental Unit for guidance.

Inspection

Inspection of the stormwater wetland basin should focus particularly on the health, density, and diversity of wetland vegetation. The design planting plan should be obtained and referenced during the inspection. The plants in the planting plan are chosen to provide one or more specific functions such as pollutant uptake, shade, or mosquito control. If over 30% of the wetland vegetation appears to be dead or dying, determine the source of the problem (i.e., inadequate water supply, disease) and record it on the inspection form (Appendix A). Ideal vegetation density should be greater than 90% in planted areas (NCDWQ, 2007). If the vegetation density

is clearly reduced from the intended design, provide a note on the inspection form, including the general location within the stormwater wetland.

Aquatic weeds and other invasive species can be detrimental to a stormwater wetland because they will very quickly take over the desirable wetland plants. Once established, it can be impossible to remove the invasive species without also harming the native plants. Therefore, early intervention is important. Invasive or aggressive species should be removed as soon as they are noticed, because by the following year they will be much more difficult to kill. Examples of exotic invasive species that can be problems for stormwater wetlands include hydrilla, phragmites, and purple loosestrife. Cattails can also be a problem species. Although they are native and provide some pollutant removal, cattails multiply quickly and can reduce the device's storage capacity, crowd out other desirable species, and create a breeding habitat for mosquitoes (Hunt et al., 2007).

Many stormwater wetlands contain some algae. Algae is going to occur in stormwater wetlands as a result of: 1) nutrient enriched water, 2) shallow water, and 3) intense sun light. When the algal population is controlled, algae provide nutrient removal. Generally, if the algae mats are not so thick as to provide mosquito refuge, they should not require removal. However, unhealthy algal growth can occur when poor vegetative density increases the temperature of the water in the wetland or when the wetland receives excessive nutrient inputs. If algal growth covers more than 50% of the stormwater wetland, develop a management plan to remove and prevent reoccurrence of such growth (NCDWQ, 2007). Physical removal is one option. Approved chemical control options are discussed in the N.C. Agricultural Chemicals Manual (NCSU, 2009). Applicators are required to have a commercial pesticide applicators license with an aquatic endorsement. Contact the Roadside Environmental Unit for guidance.

Inspect the sides of the stormwater wetland and the surrounding area for structural integrity, noting any signs of burrowing animals, erosion, or inadequate cover. If areas around the stormwater wetland are grassed, verify that grass is being mowed at a frequency to maintain a height of 6 to 15 inches. Inspect the embankment for settling, scouring, cracking, sloughing, and furrowing, and for invasive shrubs and trees. Also, inspect the downstream toe of the embankment for seepage (NCDWQ, 2007). Note trash and debris found in the stormwater wetland or in surrounding areas.

The water level should be at or near the invert of the drawdown device/orifice except after storm events and during prolonged dry periods. Generally, the deep pools of the wetland should not dry out during prolonged dry periods, except for significant droughts. If the deep pools are dry and the region is not undergoing an extreme drought, the stormwater wetland may be experiencing excessive infiltration. Make a note of the condition on the inspection form. The underlying soils may need to be tamped down or a clay soil supplement added to the wetland (Hunt et al., 2007).

Maintenance

Avoid spraying nonaquatic chemicals in and around the basin. Remove undesirable vegetation by hand if possible or by wiping plants with pesticide. It is important to dispose of vegetative cuttings off-site so they do not contribute additional nutrients to the stormwater wetland.

Mow grass to the ideal height around the wetland and on the embankment. Turfgrass is typically mowed at a frequency to maintain a maximum height of 4 inches for warm-season grasses and 6 inches for cool-season grasses. However, on highway right-of-way facilities, it is more practical to maintain a grass height between 6 and 15 inches.

If inadequate plant density is noted in the inspection, replace vegetation according to the planting plan. Fertilize upon establishment, following best practices to avoid excessive input of nutrients into the wetland. The use of fertilizer may be restricted at some locations. Refer to Chapter 3 when considering the use of fertilizer. If inadequate wetland vegetation is a widespread problem throughout the SC or if the wetland is dry during nondrought periods, contact the Division Environmental Officer or the Roadside Environmental Unit for guidance. In this event, it may be necessary to perform soil amendments or to regrade the basin.

If excessive algae is noted during the inspection, refer to the information under "Inspection" of this section and/or follow any appropriate actions in the algae management plan for the SC.

Repair animal burrows.

Unlike most other stormwater controls, solids that have settled in the stormwater wetland cannot be removed by dredging. Any dredging of the wetland risks negatively impacting the vegetative cover. Solids should be removed from the stormwater wetland only if it is deemed critical to the functioning of the stormwater wetland. The top layer of dredged material should be replaced over the wetland to reestablish vegetation (NCDWQ, 2007). Proper maintenance of the forebay should prevent more costly dredging of the stormwater wetland basin.

11.3.4 Outlet Control Structure (Box)

Function

The outlet control structure maintains the shallow water level in the wetland and regulates the slow release of stormwater. Outlet control structures can have several components, including a trash rack, a drawdown device or orifice, a sluice gate, and an outlet pipe. Inspection and maintenance guidance for these specific components is provided in subsequent sections of this chapter. Figure 11-5 illustrates the configuration of a typical outlet control structure.
Figure 11-6 illustrates the configuration of a flashboard riser, sometimes used on stormwater wetlands to provide more flexibility with water levels. Generally, a drawdown device, such as an orifice installed directly into the riser or an inverted pipe, controls the elevation of the shallow pool. The outlet control structure often has a second, larger opening at the top that allows flow from large rainfall events to escape without overtopping the basin. Usually, this is in the form of an open-top outlet structure with a trash rack. Flashboard risers consist of a riser with one wall or edge composed of movable boards to create adjustable water levels. With this type of riser, the shallow water level and large rainfall elevations may be adjusted in a variety of ways to handle maintenance needs. Figure 11-7 shows photos of the two outlet control structures.

Inspection

Treated water should be allowed to flow freely upon entering the outlet control structure. Inspect the outlet control structure thoroughly for any signs of damage such as cracks, holes, or leaks. Verify that the outlet box remains covered with a trash rack. See subsequent sections for guidance on specific components. For flashboard riser structures, check the connection between boards for any signs of leaks or seepage.

Maintenance

Repair any damaged areas of the outlet control structure, and remove sediment and debris if it is accessible. If the outlet is clogged or blocked, hip waders or a small boat may be needed to make the necessary repairs. Ensure that the proper NCDOT safety procedures are followed when working in or around standing water.

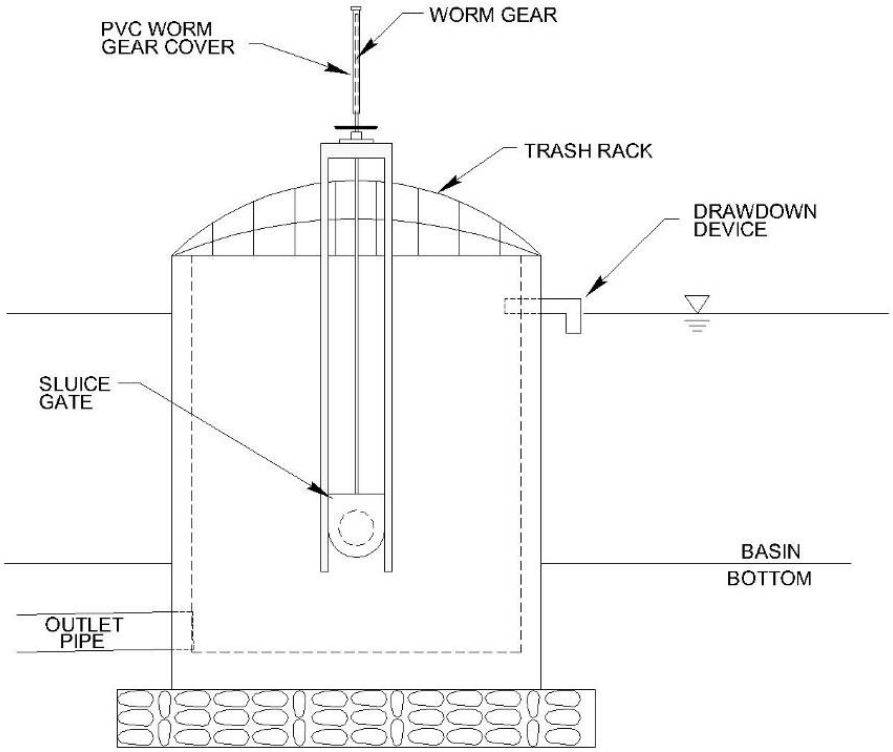


Figure 11-5. Components of a typical outlet control structure for a stormwater wetland

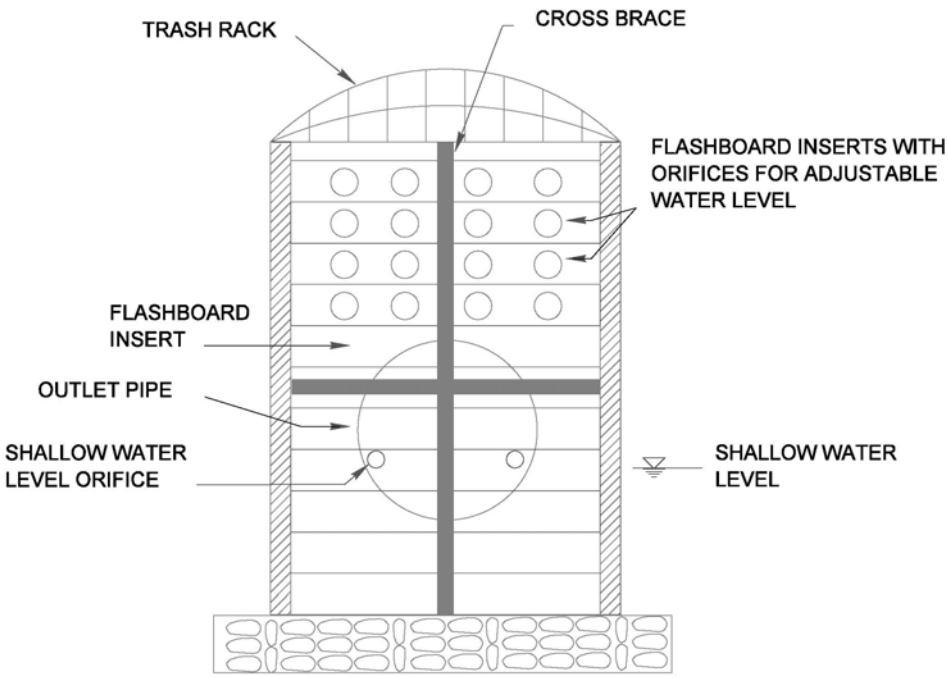


Figure 11-6. Components of a flashboard riser outlet control structure for a stormwater wetland

Figure 11-7. Two examples of outlet control structures: a standard riser (left) and a flashboard riser (right)

11.3.5 Trash Rack

Function

Positioned atop the outlet control structure, the trash rack protects the overflow of the outlet control structure from becoming clogged with debris (see Figures 11-5 and 11-6).

Inspection

Inspect the trash rack for debris and excessive corrosion.

Maintenance

Remove trash and debris. Replace the trash rack if it is corroded or otherwise damaged. The replacement trash rack should be consistent with the design specifications for the SC. If drawings or specifications are not available, contact the NCDOT Hydraulics Unit to obtain standard trash rack specifications or details.

11.3.6 Drawdown Device or Orifice

Function

The drawdown device or orifice is a restricting device that allows stormwater to slowly enter the outlet box. Several configurations exist. The simplest type is one or more orifices in the shape of slots or holes directly in the side of the outlet control structure. Another type of drawdown device has a PVC elbow or tee that maintains the invert to the outlet control structure below the water level so it does not become clogged with floating debris.

Inspection

If it is accessible, inspect the drawdown device to ensure that stormwater can freely enter the outlet control structure. If metal components were used to restrict flow or guard against floating debris, check them for excessive corrosion. If the drawdown device is not visible, it is likely submerged due to being clogged.

Maintenance

Remove sediment and debris blocking the flow into the orifice. If the water level in the basin is above the orifice, open the sluice gate and drain the basin until the drawdown device/orifice is accessible, then clean it out. Replace damaged or corroded components.

11.3.7 Sluice Gate (if present)

Function

Sluice gates are installed for emergency maintenance needs. The sluice gate covers an additional opening at the invert of the basin that is larger than the drawdown orifice. The sluice gate can be opened to rapidly drain the basin. Figure 11-8 is a photograph of a screw-type sluice gate. Figure 11-9 shows a lift-type sluice gate.

Inspection

Two types of sluice gates are currently in use: (1) a screw-type gate and (2) a lift-type gate. Make sure the valve has not frozen shut by slightly testing the functionality, taking care not to open it, which could allow sediment or debris to escape or get lodged in the outlet. Inspect the sluice gate for excessive corrosion. Verify that there is no sediment or debris below the sluice gate that could prevent it from being fully closed.

Figure 11-8. An open screw-type sluice gate

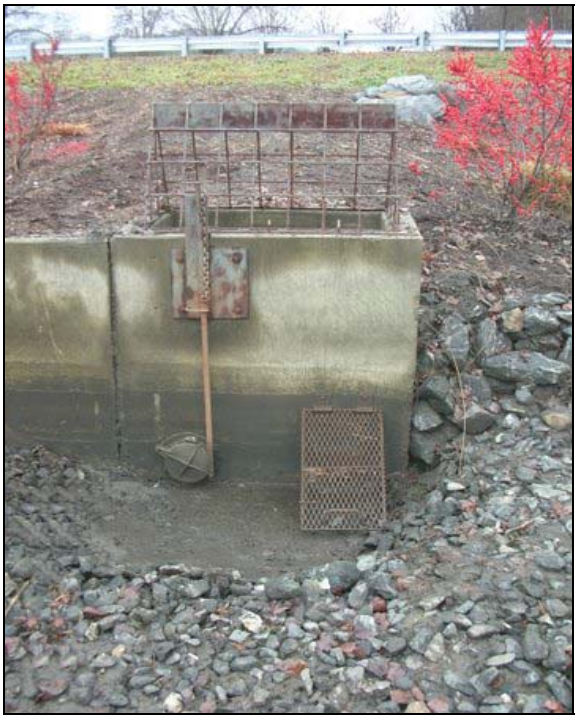


Figure 11-9. A lift-type sluice gate

Maintenance

If lubrication is necessary, lubricate with a marine-type grease. It is recommended that a cover be fabricated to protect the sluice gate's worm gear from corrosion and to increase the visibility of the device. The cover can be made by placing a cap on one end of a section of PVC pipe (see Figure 11-10). Remove any sediment and debris near the sluice gate. If the sluice gate is damaged beyond repair, replace it with one that meets the requirements presented in NCDOT Standard Drawing No. 838.02 (NCDOT, 2006). Perform additional maintenance and repairs as described in the manufacturer's instructions.

Figure 11-10. Two large sluice gates with PVC covers

11.3.8 OUTLET DRAINAGE SYSTEM

Function

The outlet drainage system conveys water from the SC to the downstream drainage system or receiving water. Typically, a pipe conveys water from the outlet control structure through the embankment to a swale or other open channel.

Inspection

Inspect the inside of structures and pipe(s) to verify that they are free of sediment and debris. Inspect the ground surface above buried pipes and structures for depressions or other signs that might indicate pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation.

Maintenance

Remove any sediment or debris that is accessible. Repair eroded areas and damaged pipes. Replace outlet protection materials (i.e., riprap) as necessary. Refer to Chapter 3 for additional guidance on maintenance techniques.

11.3.9 EMERGENCY SPILLWAY (IF PRESENT)

Function

The emergency spillway serves as an overflow structure that is typically constructed as a channel in natural ground. The emergency spillway is necessary to minimize the potential for overtopping the basin, which can damage the embankment and lead to SC failure and downstream flooding.

Inspection

The emergency spillway should remain free of trash and debris. Emergency spillways are typically covered with grass, but concrete and riprap are also used. For grass channels, verify that grass is maintained between 6 and 15 inches. Inspect concrete channels to verify that they are in good condition, or verify that adequate riprap is present. Note all erosion and undesirable vegetation.

Maintenance

Emergency spillways must be free of trash, debris, and undesirable vegetation to maintain their functionality. Remove these if present. Grass should be carefully maintained at a height of 6 to 15 inches. Repair concrete or replace riprap as necessary. Repair areas of erosion.

11.4 Inspection and Maintenance Summary

Observations made while inspecting stormwater controls must be documented on the appropriate SC inspection report form and entered into SCMS. Observations recorded would include a general description of the SC and those maintenance needs identified such as the removal of accessible trash, sediment, and unwanted vegetation.

If during an inspection emergency maintenance needs are identified (i.e., a sluice gate frozen in the open position), the inspector should either correct the problem at that time or contact the party(s) responsible for emergency maintenance repairs. If emergency maintenance needs are not corrected at the time of the inspection, a follow-up inspection should be conducted to verify that the responsible party(s) has taken action and all needs have been addressed. Observations made during the follow-up inspection must be documented on the appropriate SC inspection report form and entered into SCMS.

CHAPTER 12 Swale

OVERVIEW

A SWALE (S) is a vegetated channel that treats and conveys runoff from small drainage areas.

PURPOSE AND DESCRIPTION

- Swales are broad and shallow so that water will flow slowly.
- Swales remove suspended solids, metals, and nutrients through sedimentation, vegetated filtration, infiltration, and biological uptake.

INSPECTION

- Swales should be carefully monitored for erosion so they do not contribute sediment to receiving waters.
- Swales should be inspected periodically to verify that the ideal vegetation type is maintained at the proper density and height.
- Inspections should occur annually, unless otherwise required by environmental permits or more frequent inspections are deemed necessary.

TYPICAL MAINTENANCE

- Sediment and debris should be removed before it negatively impacts vegetation growth or inhibits infiltration.
- Mowing should be done at a frequency that maintains aesthetics and prevents the growth of undesirable vegetation.
- Eroded areas in and around the swale should be repaired as needed.

12.1 Stormwater Control Overview

Swales (S) convey and treat peak runoff from small drainage areas. Swales decrease runoff velocity to promote infiltration and physical filtration. Swales also increase contact time between runoff and vegetation to promote biological uptake of pollutants.

Swales are similar to roadside ditches in appearance and function. During storm events, swales collect water from roadways and transport it downstream. The main difference between a swale and a roadside ditch is that swales are especially broad and shallow. The broad and shallow design and the vegetation in the swale help to slow the speed of the runoff.

The reduction in speed enhances both the pollutant filtering and runoff infiltration processes. Suspended solids and other associated pollutants can be filtered and settle-out, contact with vegetation allows for biological treatment of metals and nutrients through primarily microbial processes, and the potential for downgrade erosion is greatly reduced. Figure 12-1 illustrates the treatment processes and flow paths in two different swale configurations.

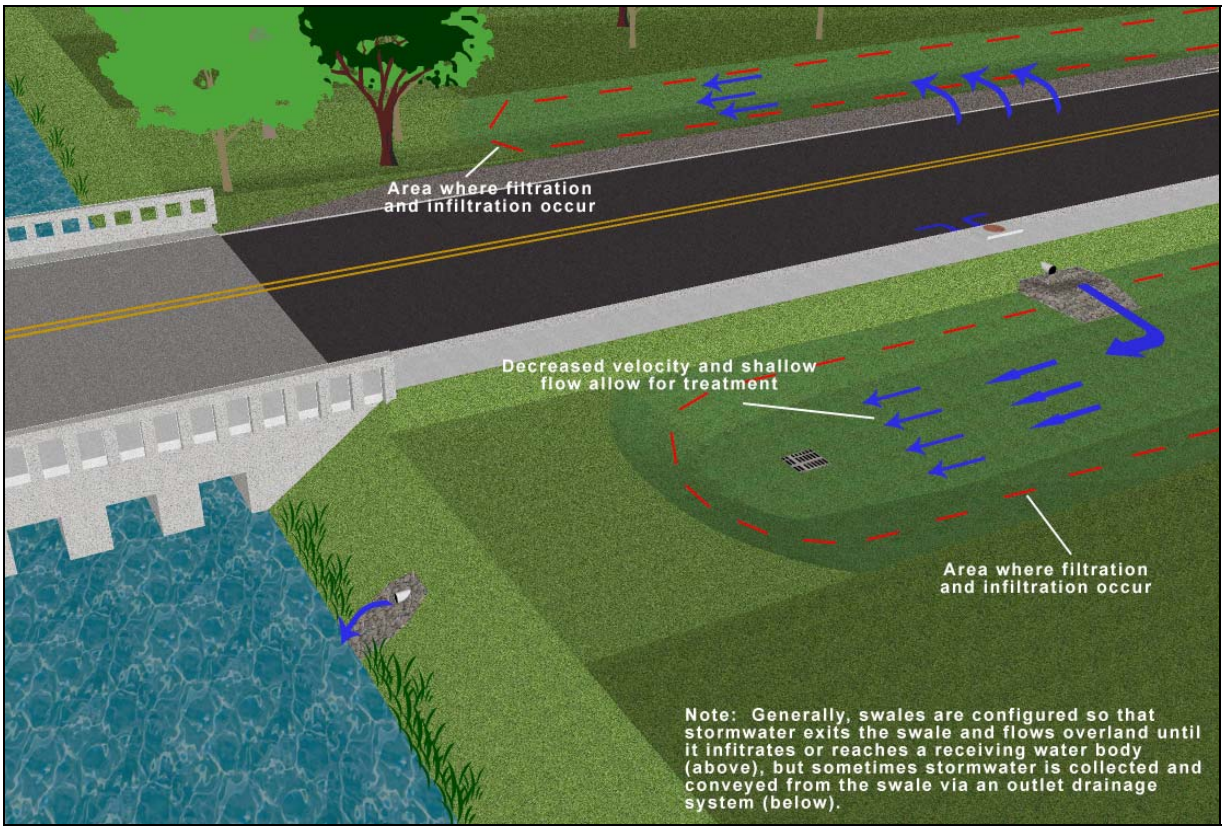


Figure 12-1. Swale treatment processes and flow paths

12.2 Swale Components

Figure 12-2 illustrates the various components of a typical swale. Note that layouts vary. Some systems will have additional components while others may lack certain components. Swale systems may include the following:

- Inlet Drainage System
- Forebay, Preformed Scour Hole, or Splash Pad
- Swale
- Check Dams (not illustrated in Figure 12-2)
- Outlet Drainage System

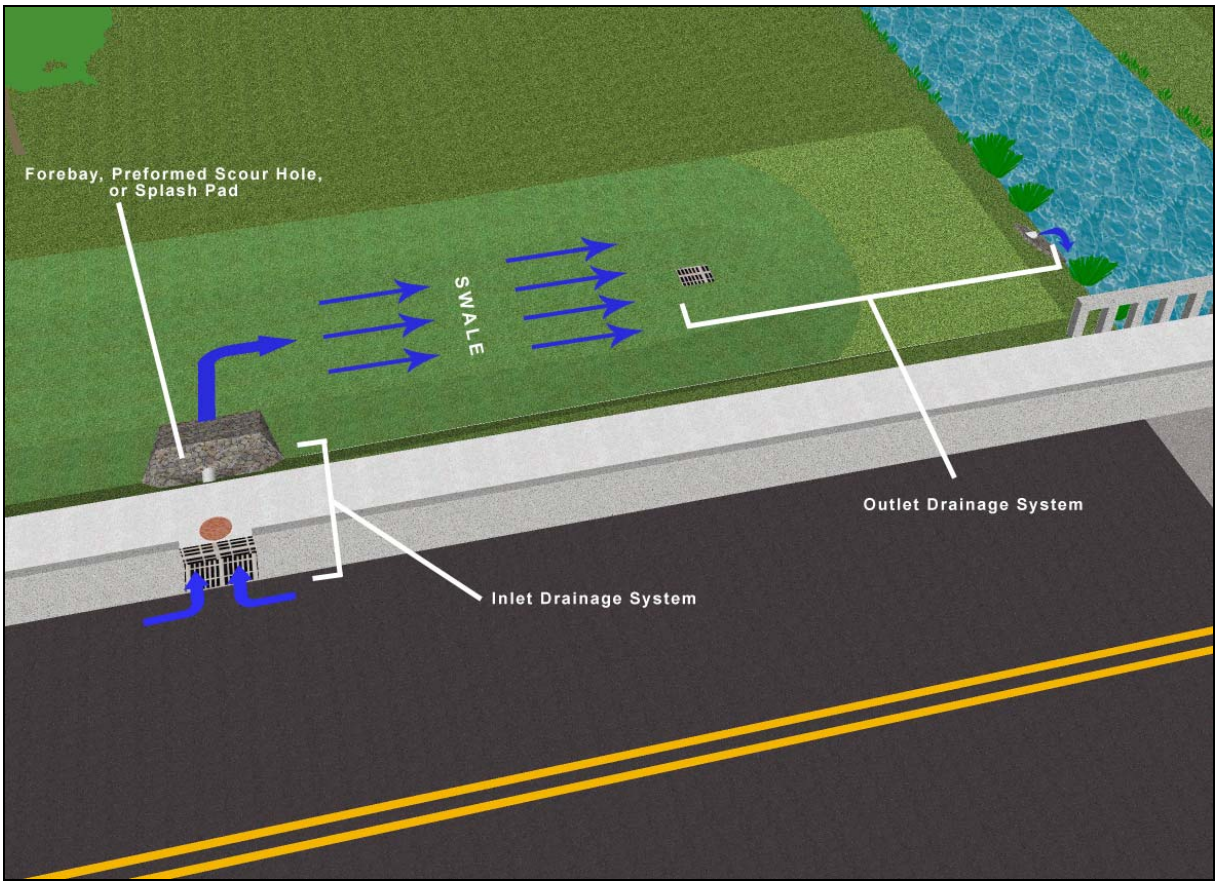


Figure 12-2. Components of a typical swale system

12.3 Inspection and Maintenance

Swales and the drainage structures associated with them should be inspected at least annually to determine whether they are functioning as intended. If the system is found to not be functioning properly, determine the cause and restore to working order as soon as possible.

All inspection findings and maintenance activities should be noted on the inspection form (see Appendix A) and then entered into the Stormwater Control Management System (SCMS) on NCDOT's Intranet. Photos should be taken to track the status of the stormwater control (SC) and document the maintenance activities conducted. These, too, can be uploaded to SCMS. Refer to Chapter 4 for further guidance.

The following sections describe the function of a swale, and provide inspection and maintenance guidance for its major components.

12.3.1 Inlet Drainage System (if present)

Function

The inlet drainage system collects and conveys water to the SC. Inlet drainage systems can consist of open channels, pipes, curb and gutter, and catch basins. An inlet drainage system may not be present if the swale receives runoff directly from the source via overland flow.

While swales sometimes include a forebay at the inlet, riprap and filter fabric are often used for erosion protection.

Inspection

Stormwater runoff should be allowed to flow freely into the swale. Inspect ditches, pipes, and/or catch basins draining to the swale for trash, sediment, and debris. Inspect the ground surface above buried pipes and structures for depressions and other signs of pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation.

Maintenance

Remove and properly dispose of debris, unwanted vegetation, and major sediment accumulations. Repair eroded areas and damaged pipes. If riprap has been placed at the inlet, inspect for undercutting or erosion. Refer to Chapter 3 for additional guidance on maintenance techniques.

12.3.2 Forebay, Preformed Scour Hole, or Splash Pad (if present)

Function

Forebays, splash pads, and/or preformed scour holes (PSHs) are energy dissipaters that may all be used at the inlet(s) of a swale to pretreat stormwater and protect against erosion. A forebay reduces the flow velocity, which in turn allows suspended solids in the stormwater to settle before the stormwater enters the swale. Forebays facilitate maintenance by collecting sediment in one area where it can be removed easily, increasing the life of the swale. Splash pads simply protect against erosion where runoff exits a pipe, in this case, at the inlet to the swale. Preformed

scour holes resemble forebays, but are designed to dissipate flow as it exits the PSH, similar to a level spreader. PSHs are square or round in shape, and use riprap and permanent soil reinforcement matting to protect against erosion. Figure 12-3 gives a side-by-side comparison of a forebay and a PSH. Guidance for forebays and splash pads follows.

Inspection

Inspect forebays and splash pads for trash, debris, and undesirable vegetation. Inspect to determine whether these facilities are structurally sound and that they do not contain excessive amounts of accumulated sediment. Splash pads are not typically designed to store sediment; however, any sediment accumulations that have the potential to wash downstream or cause problems in the swale should be removed.

Maintenance

Remove sediment, trash, debris, and undesirable vegetation and properly dispose of it off-site. Sediment should be removed from a forebay when it exceeds 50% of a forebay's storage capacity. Correct any structural deficiencies and replace erosion protection materials (i.e., riprap) as needed. If necessary, reestablish vegetation for earthen forebays. Refer to Chapter 3 for further guidance on sediment disposal.

Figure 12-3. A well maintained forebay (left) and a newly constructed preformed scour hole (right)

12.3.3 SWALE

Function

A swale decreases runoff velocity to promote infiltration and filtration of stormwater runoff. By slowing runoff, suspended solids and associated pollutants settle out of stormwater before being conveyed downstream. Typically, swales work best on relatively flat grades. However, check dams (see section 12.3.4) may be installed in areas with steep slopes to help slow the flow. Swales often drain directly into receiving waters and other stormwater controls. For this reason, it is important that swales are carefully inspected and maintained to prevent excessive pollutants from being conveyed downstream. Figure 12-4 shows two photos of typical swales in a highway setting.

Inspection

The base of the swale, its interior and exterior side slopes, and areas surrounding the swale should be stabilized with a dense cover of turf-type grass. Inspect the swale and surrounding areas for erosion. Inspect for undercutting of swale side slopes, which can cause the slopes to become steeper than 3:1, the maximum allowed. Steep side slopes can cause excessive channelization and an increase in flow velocity, which decreases the effectiveness of the swale.

Figure 12-4. Linear highway applications of swales

Verify that grass is being mowed at a frequency to maintain the desired height. Ideally, turf grasses should be mowed at a frequency to maintain a maximum height of 4 inches for warm-season grasses and 6 inches for cool-season grasses. However, within the NCDOT right-of-way, it is more practical to maintain grass height between 6 and 15 inches.

Inspect the swale and surrounding areas for bare soil, sediment deposition, trash, debris, and undesirable vegetation.

Maintenance

Trash, debris, and undesirable vegetation should be removed from the swale. Excessive accumulations of sediment should be removed when typical flow is altered or grass can no longer be seen. Stabilize any eroding surfaces in or around the swale, and repair undercut slopes by restoring the proper grade and reseeding. Refer to Chapter 3 for further guidance.

12.3.4 CHECK DAMS (IF PRESENT)

Function

Checks dams are small riprap dams constructed to enhance the water quality benefits of swales. Checks dams, are installed in swales to create storage volume or to slow flow in areas with steep slopes. Figure 12-5 shows an example of check dams implemented in a swale. Check dams are permanent riprap dams constructed to enhance water quality and should not be confused with a sediment and erosion control temporary device used during roadway construction.

Inspection

Inspect check dams for trash, debris, undesirable vegetation, excessive sediment, and erosion around the sides of the rock check. Verify that check dams retain the proper dimensions. Check dams should be approximately one foot high along the base and sides of the swale and approximately 4.5 feet in width (in the direction of flow). The main structure of the check dam should be composed of Class B riprap. A 12-inch (approximate) layer of No. 57 stone should be located on the upstream side of the check dam to capture sediment. Figure 12-6 shows the basic configuration of a check dam.

Figure 12-5. Swale with check dams

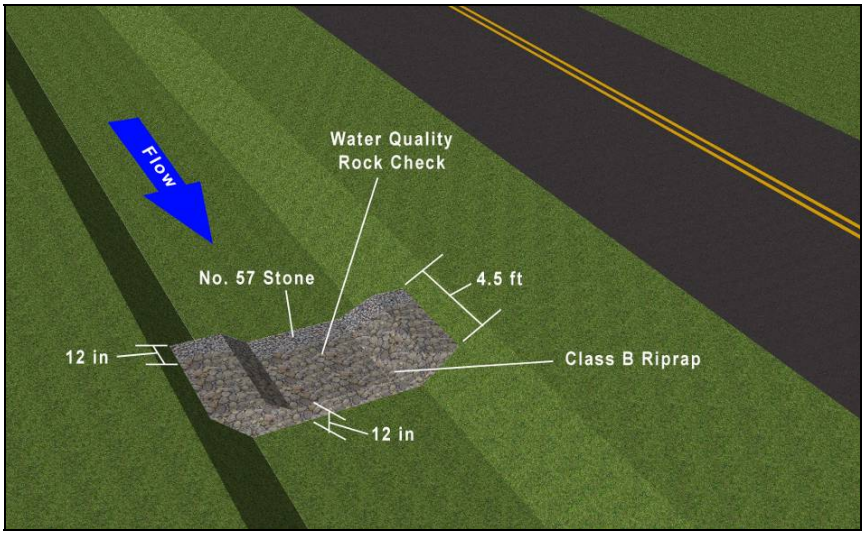


Figure 12-6. Check dam

Maintenance

If possible, maintenance on the permanent check dam should be performed when the swale is dry so as not to allow accumulated sediment to wash downstream. Remove and properly dispose of trash, debris, undesirable vegetation, and sediment. Replace riprap and No. 57 stone, repair erosion, and rebuild or reshape check dams as necessary. When mowing swales, be sure not to damage the check dam's structure. Handheld equipment should be used when mowing around check dams.

12.3.5 Outlet Drainage System (if present)

Function

The outlet drainage system conveys water from the SC to the downstream drainage system or receiving water. Components of this system can include channels, pipes, catch basins, manholes, culverts, and other structures. Swales often end at a grassy, open area or forested buffer. An outlet drainage system will not be present in these situations.

Inspection

Inspect pipes and drainage structures for cracks or leaks. Inspect the ground surface above buried pipes and structures for depressions or other signs of pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation. If outlet protection materials are present, verify that these materials are adequate.

Maintenance

Remove and properly dispose of debris, unwanted vegetation, and major sediment accumulations. Repair eroded areas and damaged pipes. Replace outlet protection materials (i.e., riprap) as necessary. Refer to Chapter 3 for additional guidance on maintenance techniques.

12.4 Inspection and Maintenance Summary

Observations made while inspecting stormwater controls must be documented on the appropriate SC inspection report form and entered into SCMS. Observations recorded would include a general description of the SC and those maintenance needs identified such as the removal of accessible trash, sediment, and unwanted vegetation.

If during an inspection emergency maintenance needs are identified (i.e., a sluice gate frozen in the open position), the inspector should either correct the problem at that time or contact the party(s) responsible for emergency maintenance repairs. If emergency maintenance needs are not corrected at the time of the inspection, a follow-up inspection should be conducted to verify that the responsible party(s) has taken action and all needs have been addressed. Observations made during the follow-up inspection must be documented on the appropriate SC inspection report form and entered into SCMS.

CHAPTER 13 Level Spreader

OVERVIEW

A LEVEL SPREADER (LS) is a structural stormwater control that redistributes concentrated stormwater flow into sheet flow.

PURPOSE AND DESCRIPTION

- A level spreader provides a nonerosive outlet for concentrated runoff by diffusing the water uniformly across a stable slope.
- A level spreader consists of a trough with a level, nonerosive lip.

INSPECTION

- Level spreaders are designed to convert concentrated flow to sheet flow before it enters a buffer or filter strip; erosion within the buffer or filter strip is an indication that the level spreader is not functioning properly.
- The level spreader lip must be level to promote uniform, diffuse flow along its entire length.
- Inspections should occur annually, unless otherwise required by environmental permits or more frequent inspections are deemed necessary.

TYPICAL MAINTENANCE

- Sediment, trash, and debris should be removed from the level spreader trough and other components as applicable.
- Any structural deficiencies, especially pertaining to the level spreader lip, should be repaired or the components replaced.
- Repair eroded areas within the buffer or filter strip after determining the root cause of the erosion.

13.1 Stormwater Control Overview

A Level Spreader (LS) is a stormwater device used to slow runoff velocities, trap sediment and promote infiltration. It works by dispersing concentrated runoff uniformly over the ground's surface. During storm events concentrated runoff from parking lots, roadways, or ditches is directed into the level spreader where it is spread out and released as sheet flow over a vegetated area (filter strip). The resultant sheet flow helps reduce the erosion potential and enhances the pollutant filtering and runoff infiltration processes. Suspended solids and other associated pollutants are filtered and settle-out, while dissolved metals and nutrients are taken-up by the soil and plant roots. Figure 13-1 illustrates concentrated water flow entering a level spreader and sheet water flow exiting a level spreader.

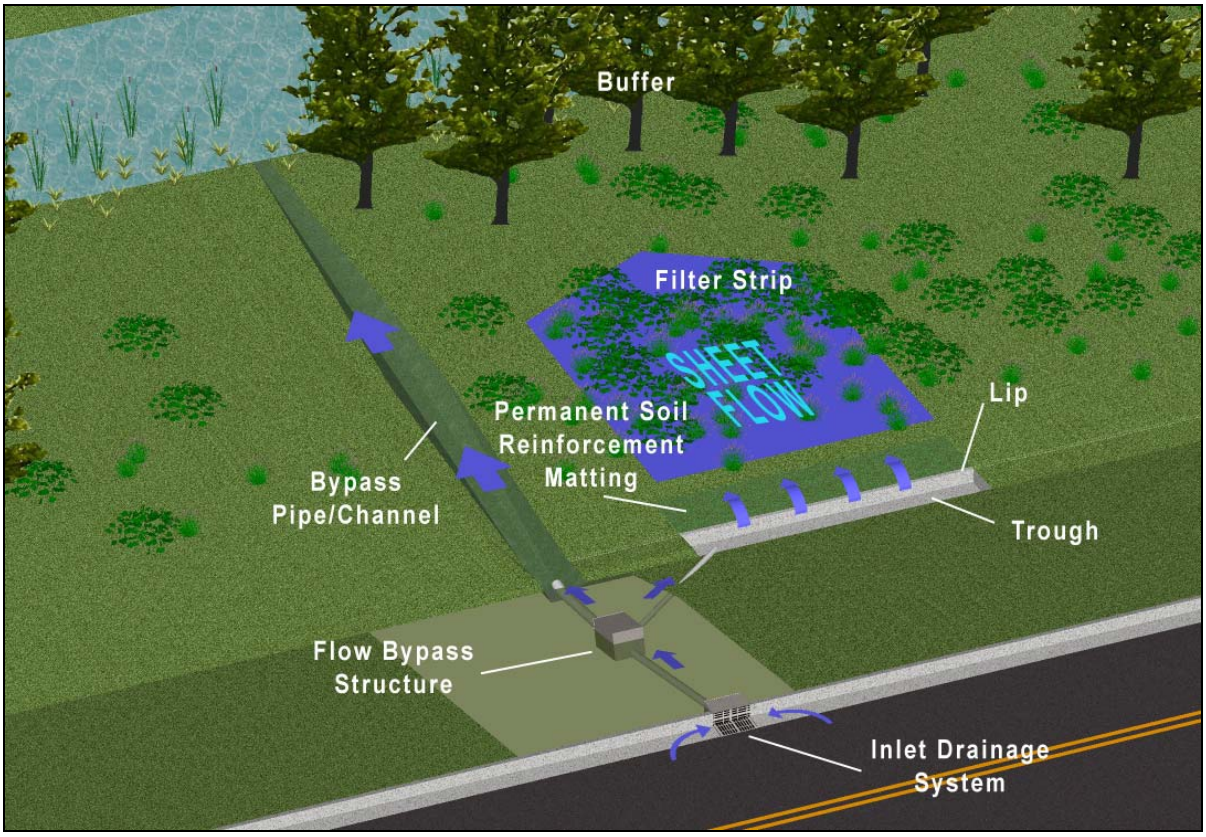


Figure 13-1. Water flow through a level spreader

Figure 13-2 illustrates the treatment processes that occur in a typical level spreader system.

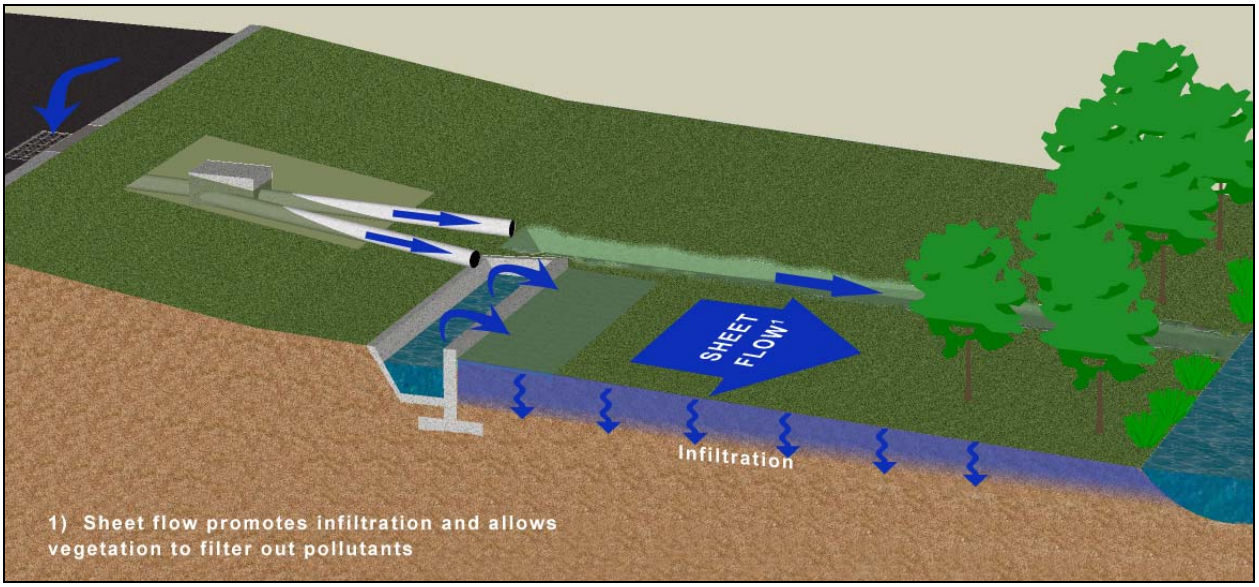


Figure 13-2. Level spreader treatment processes

13.2 Level Spreader Components

Figure 13-3 illustrates the various components of a typical level spreader system. Currently, level spreaders are designed to include a flow bypass structure (NCDOT, 2008b). For these systems, runoff enters the level spreader via a flow bypass structure, which is designed to divert a set amount of runoff to the trough of the level spreader. Excess flow bypasses the level spreader and is conveyed by ditch or pipe directly downstream. Level spreaders constructed before the flow bypass system requirement was in place may not include a flow bypass system. For these level spreaders, all runoff will enter the level spreader regardless of the flow rate.

Level spreader systems may include, but are not limited to, the following components:

- Inlet Drainage System
- Flow Bypass Structure/System
- Level Spreader Trough and Lip
- Filter Strip and/or Buffer
- Bypass Swale/Pipe or Outlet Ditch

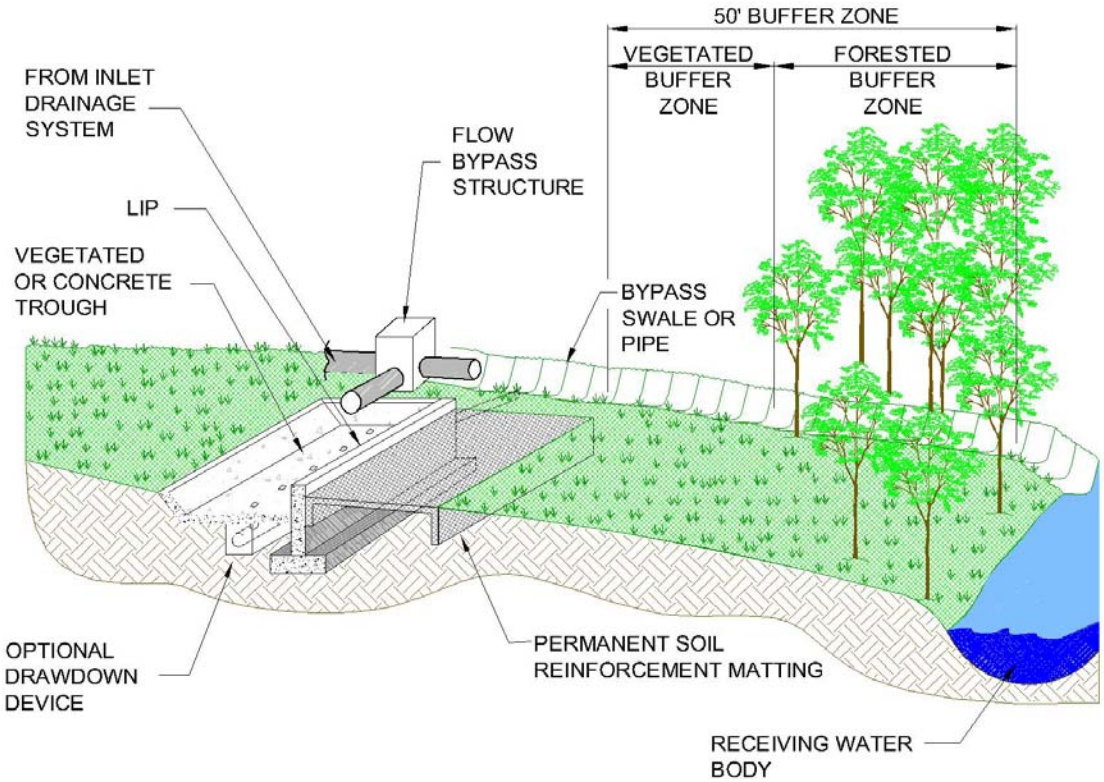


Figure 13-3. Components of a typical level spreader system (not all components may be present)

13.3 Inspection and Maintenance

Level spreaders should be inspected periodically to determine whether they are functioning as intended. Most importantly, it should be verified that the level spreader is distributing flow evenly. If a level spreader is found not to be functioning properly, determine the cause and restore to working order as soon as possible.

All inspection findings and maintenance activities should be noted on the inspection form (see Appendix A) and then entered into the Stormwater Control Management System (SCMS). Photos should be taken to track the status of the stormwater control (SC) and document the maintenance activities conducted. These, too, can be uploaded to SCMS. Refer to Chapter 4 for further guidance.

The following sections describe the function of a level spreader, and provide inspection and maintenance guidance for its major components.

13.3.1 Inlet Drainage System

Function

The inlet drainage system collects and conveys water to the SC. Inlet drainage systems can consist of open channels, pipes, curb and gutter, and catch basins.

Inspection

Stormwater runoff should be allowed to flow freely into the level spreader or flow bypass structure. Inspect ditches, pipes, and/or catch basins draining to the level spreader for trash, sediment, and debris. Inspect the ground surface above buried pipes and structures for depressions and other signs of pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation.

Maintenance

Remove and properly dispose of debris, unwanted vegetation, and major sediment accumulations. Repair eroded areas and damaged pipes. Refer to Chapter 3 for additional guidance on maintenance techniques.

13.3.2 Forebay (if present)

Function

A forebay is a basin located at the inlet of a SC that pretreats stormwater. A forebay reduces the runoff velocity of stormwater, which in turn allows suspended particles in the stormwater to settle before the stormwater enters the level spreader. The presence of a forebay reduces the risk of SC failure due to clogging of the filter strip and sediment accumulation in the trough.

Inspection

Inspect the forebay for trash, debris, and undesirable vegetation. Inspect to determine whether forebays are structurally sound and that they do not contain excessive amounts of accumulated sediment.

Maintenance

Remove trash, debris, and undesirable vegetation and properly dispose of it off-site. Remove sediment and dispose of it off-site if it appears to occupy more than 50% of the forebay's storage capacity. Reestablish vegetation in earthen forebays. Refer to Chapter 3 for further guidance.

13.3.3 Flow Bypass Structure (if present)

Function

Level spreaders can easily become overwhelmed during large rainfall events. If flow in excess of the design amount is allowed to pass through the level spreader, it will likely reconcentrate and erode areas of the filter strip or buffer. Flow bypass structures allow excess flows from large storm events to bypass the level spreader via a bypass swale or pipe and discharge directly to the receiving stream.

Inspection

The flow bypass structure should be free of any sediment, trash, and debris. Inspect the flow bypass structure for holes and cracks, and for any erosion that would allow runoff to flow around the structure. Note any undesirable vegetation that might prevent the flow bypass structure from performing its function. If applicable, inspect metal components for excessive corrosion. Check the level spreader and buffer/filter strip for visual signs that it is receiving flow and has not been overwhelmed. If the level spreader does not appear to be receiving flow or if there is evidence of excessive flow, the flow bypass structure is not functioning properly.

Maintenance

Remove undesirable vegetation, sediment, trash, and debris. If the flow bypass structure becomes clogged, remove sediment and dispose of it off-site. Repair any cracks and holes, and eroded areas associated with the flow bypass structure. Replace components as necessary.

13.3.4 Level Spreader Trough and Lip

Function

The level spreader trough collects stormwater runoff, and the nonerosive lip evenly distributes the runoff to downgrade areas as diffuse flow. The trough may be vegetated or concrete. The lip may be constructed of various materials. The level spreader may also be equipped with a drawdown system (e.g., weep holes leading to a drainage system) if prolonged periods of standing water are not desired.

Inspection

The level spreader trough and lip should be level and remain relatively free of sediment and debris or the level spreader will quickly become overwhelmed and lose its effectiveness. Inspect the lip for erosion, undesirable vegetation, and other impairments that could render it uneven or otherwise ineffective. Verify that the area immediately downstream of the level spreader lip is free of woody vegetation, which can cause reconcentration of flows and reduce flow across the filter strip. If a drawdown system is present, check to make sure it is not clogged with sediment or debris. Pervious bags filled with stone may have been placed over the drawdown system's inlets to keep sediment from entering. If sand bags are present, inspect them for damage.

Maintenance

Repair any areas of the level spreader trough that are damaged or, in the case of vegetated troughs, eroded. If there is erosion around the ends of the level spreader, regrade the soil, build a berm that is higher than the lip, and stabilize the area with vegetation (NCDWQ, 2007). Sediment should be removed before it interferes with the level spreader's ability to distribute flow evenly. Repair the lip if it has eroded or has become cracked or otherwise damaged. Remove any vegetation growing over the lip or any woody vegetation that could channelize flow. If there is a drawdown system and it has become clogged, remove any sediment and debris. Replace damaged pervious rock bags. See Figure 13-4 for examples of level spreaders with typical maintenance needs.

Figure 13-4. Typical maintenance concerns: erosion at the level spreader lip and channelization in the filter strip (left), and woody debris in need of removal (right)

13.3.5 Filter Strip and Buffer

Function

Stormwater treatment processes occur in the filter strip and buffer. Filter strips and buffers promote infiltration and biological uptake of pollutants, and filter out sediment. Permanent soil reinforcement matting (PSRM) may have been installed just downstream of the level spreader lip to prevent erosion. An example of a level spreader and filter strip is shown in Figure 13-5. This level spreader was designed with a drawdown device consisting of weep holes. The placement of pervious bags of stone prevents sediment from clogging the weep holes.

Inspection

The filter strip should be vegetated with a uniform, dense cover of desirable vegetation. Inspect for signs of erosion and channelization. Also, verify that the vegetation is being mowed at the proper frequency. Ideally, turfgrasses should be mowed at a frequency to maintain a maximum height of 4 inches for warm-season grasses and 6 inches for cool-season grasses. However, on highway right-of-way facilities, it is more practical to maintain grass height between 6 and 15 inches. Note any undesirable vegetation growing in the filter strip.

Buffers may be used instead of a grassed filter strip. Buffer areas, which are typically forested, are particularly susceptible to channelized flow and erosion. Carefully inspect the buffer for evidence of these processes, which indicates that the level spreader is not functioning properly. Also, verify that sediment has not accumulated in the filter strip or buffer to the degree that vegetation is dying (NCDWQ, 2007). If PSRM has been installed, inspect it for damage and verify that it is properly toed in and anchored.

Maintenance

Remove trash and undesirable vegetation. Remove debris that could cause channelization. Repair areas affected by erosion or channelization. Mow grass to the appropriate height. Repair or replace PSRM as necessary. Note that PSRM may not be visible and should not be disturbed

if vegetation is well established and adequate to protect against erosion. Ensure that grass remains dense and thick for optimum removal of pollutants. If excessive sediment has accumulated, remove the sediment, reestablish vegetation, and regrade if necessary (NCDWQ, 2007).

Figure 13-5. Example of a level spreader and filter strip with a drawdown device consisting of weep holes with rock bags

13.3.6 Bypass Swale /Pipe or Outlet Ditch

Function

A level spreader equipped with a flow bypass system has a swale or pipe that conveys runoff from the flow bypass structure to the receiving stream during large rainfall events. Conversely, a level spreader with a filter strip, but no bypass system, will discharge flow into an outlet ditch. If the ditch or pipe empties directly into a stream, it should do so in a manner that does not degrade the stream channel or banks. Typically, this requires the use of riprap or another type of protection/energy dissipation.

Inspection

Stormwater should be allowed to flow freely from the flow bypass structure or filter strip. All conveyances should be inspected for trash, sediment, and debris. For vegetated, open channels, inspect the area for erosion and undesirable vegetation. Also, note the mowing frequency, as mentioned previously. For other open channels, verify that the channel is properly protected from erosion. If a pipe is used, inspect the surface above the buried pipe for signs of pipe breakage or separation. When applicable, inspect the area where the bypass swale or pipe discharges to the stream.

Maintenance

Remove and properly dispose of debris, unwanted vegetation, and major sediment accumulations. Repair eroded areas and damaged pipes. Replace or repair any material (i.e., riprap) or structure used to prevent the discharge to the stream from causing erosion. Refer to Chapter 3 for additional guidance on maintenance techniques.

13.4 Inspection and Maintenance Summary

Observations made while inspecting stormwater controls must be documented on the appropriate SC inspection report form and entered into SCMS. Observations recorded would include a general description of the SC and those maintenance needs identified such as the removal of accessible trash, sediment, and unwanted vegetation.

If during an inspection emergency maintenance needs are identified (i.e., a sluice gate frozen in the open position), the inspector should either correct the problem at that time or contact the party(s) responsible for emergency maintenance repairs. If emergency maintenance needs are not corrected at the time of the inspection, a follow-up inspection should be conducted to verify that the responsible party(s) has taken action and all needs have been addressed. Observations made during the follow-up inspection must be documented on the appropriate SC inspection report form and entered into SCMS.

CHAPTER 14 Permeable Pavement

OVERVIEW

PERMEABLE PAVEMENT is an alternative to conventional concrete and asphalt paving materials that allows for infiltration of stormwater into a storage area, with void spaces that provide temporary detention (NCDENR, 2012)

PURPOSE AND DESCRIPTION

- Permeable pavement is a Best Management Practice (BMP) that promotes the infiltration of stormwater into void spaces that filters pollutants, decreases runoff rate, and reduces pollutant loads (NCDENR, 2012 and ICPI, 2008).

INSPECTION

- Inspection should occur annually unless otherwise more frequent inspections are deemed necessary. Monitor the permeable pavers in parking lots and driveway areas periodically for accumulation of sediment or debris;
- Monitor planted areas adjacent to pavement and areas upstream of pavement for erosion;
- Do not allow construction staging or soil mulch storage on unprotected pavement; and
- Do not pull weeds that grow in permeable pavement as this could damage the joint/opening filler material. A licensed pesticide applicator should spray weeds.

TYPICAL MAINTENANCE

- The most prevalent maintenance concern is the potential clogging of the pervious pavement pores (EPA, 2014).
- Vacuum permeable pavement surface in parking lot and driveway areas1 to 2 times per year. Do not vacuum the sidewalks that receive routine maintenance.

- Maintain permanent stable surface cover adjacent to the pavement.
- Immediately remove any soil or debris deposited on the pavement.

14.1 Stormwater Control Overview

Permeable interlocking concrete pavement (PICP) consists of manufactured concrete units that reduce stormwater runoff volume, rate, and pollutants. The concrete has small openings between permeable joints that typically comprise 5% to 15% of the paver surface area and are filled with highly permeable, small-sized aggregates (EPA, 2014). The joints allow stormwater to enter a bedding course of highly permeable open-graded aggregate. The pavers and bedding layer are placed over an open-graded base and subbase which creates a reservoir for stormwater storage and increases infiltration. PICP's ability to reduce or eliminate stormwater runoff, even in intense rain events, also reduces pollution (ICPI, 2014). PICPs are highly aesthetic, durable, easily repaired, require low maintenance, and can withstand heavy vehicle loads (EPA, 2014). Figure 14.1 below shows a typical NCDOT PICP installation at a non-roadway facility.

Figure 14.1 - Typical NCDOT PICP sidewalk installation at a Rest Area.

PICP is typically intended for sidewalks (Figure 14.1), parking lots and driveway areas. Figure 14.2 shows a cross-section of a typical PICP installation.

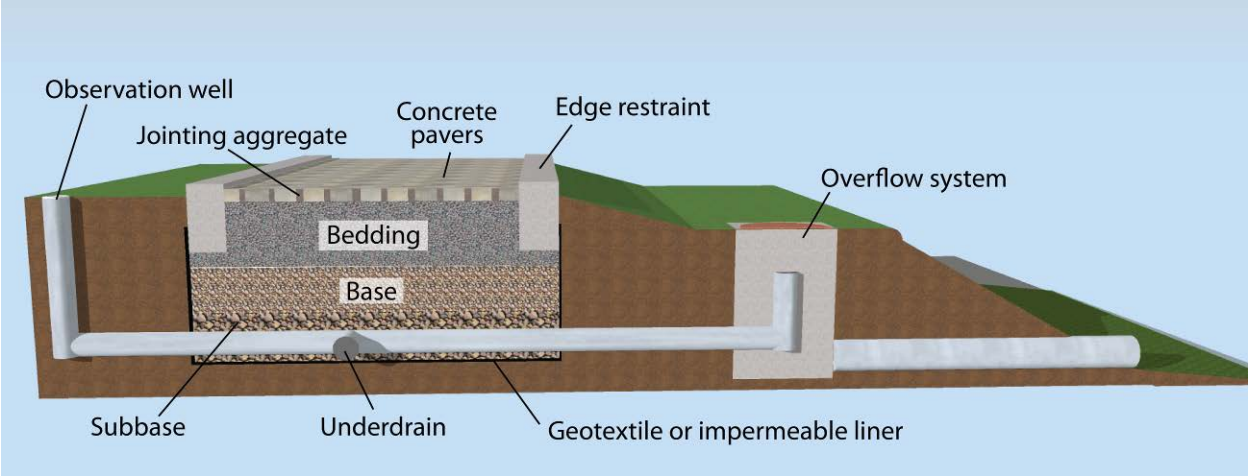


Figure 14-2. - A cross-section of a permeable interlocking concrete paver installation.

14.2 PICP Components

A previous NCDOT project included a PICP sidewalk that was designed to include 3 1/8 in. thick pavers with permeable joints over an open-graded bedding course (1 ½ to 2 in. thick #8 stone), open-graded base course (minimum 4 in. thick #57 stone), and open-graded subbase (minimum 6 in. thick #2 stone) on non-compacted soil subgrade. For these systems, perforated pipes (4 in. minimum) inside socks will serve as underdrains (as required) that are spaced and sloped to drain all stormwater. Excess flow turns into surface runoff that enters overflow structures (as equipped).

PICP systems may include, but are not limited to, the following components:

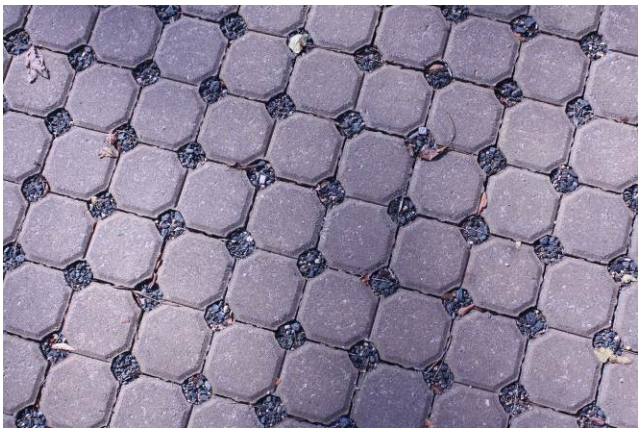
- Concrete Pavers
- Subbase, Base, Bedding, and Jointing Aggregates
- Underdrain/Observation Wells
- Geotextile Liner or Impermeable Liner
- Drainage Swales or Storm Sewer Inlets for Emergency Overflow
- Overflow System

14.3 Inspection and Maintenance

PICP should be inspected periodically to determine whether it is functioning as intended. Parking lot and driveway surfaces should be vacuumed 1 to 2 times annually (typically spring/fall) Vacuuming schedule should be adjusted as needed to prevent clogging. If PICP is found not to be functioning properly, determine the cause and restore to working order as soon as possible.

All inspection findings and maintenance activities should be noted on the inspection form (see Appendix A) and then entered into the Stormwater Control Management System (SCMS). Photos should be taken to track the status of the stormwater control (SC) and document the maintenance activities conducted. These, too, can be uploaded to SCMS. Refer to Chapter 4 for further guidance.

The following sections describe the function of PICP, and provide inspection and maintenance guidance for its major components.



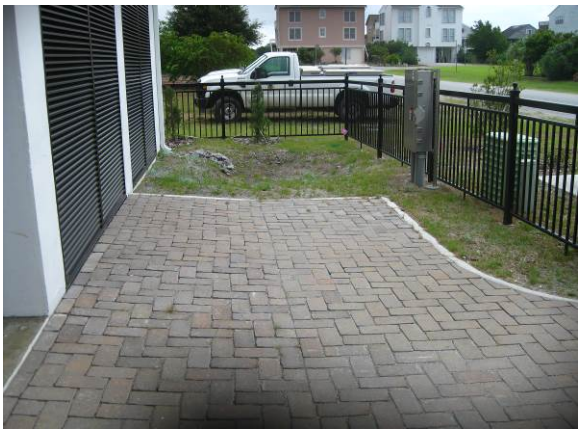


Figure 14-3. – Plan view of permeable interlocking concrete pavers.

14.3.1 Concrete Pavers

Function

Provide permeability to a paved surface and provide stability for traffic (vehicles, machinery, pedestrians, bicyclists, etc.).

Inspection

Inspect paver surface for deformities exceeding ½ in., cracks, offsets more than ¼ in. above/below adjacent units or curbs, inlets, etc. Look for staining due to oil and grease drips/spills.

Edge restraints keep the pavers in place. Inspect edge restraints for cracks or other damage.

Maintenance

Replace deformed or cracked pavers. Correct any paver offsets greater than ¼ inch above/below adjacent units or curbs, inlets, etc. To remove oil and grease, add stain remover, let it soak and then rinse. During the winter, remove snow with standard plow/snow blowing equipment and monitor salt use for treating icy conditions. Do not apply sand or gravel on or around permeable pavement for winter maintenance. Instead use jointing material for traction. Do not store piles of snow or soil on pavement. Repair/replace edge restraint as necessary.

14.3.2 Subbase, Base, Bedding, and Jointing Aggregates

Function

The subbase, base, bedding, and jointing aggregates provide subsurface structure and pore space (permeability) within PICP. Reduces runoff volume, decreases runoff rate, filters storm water, and reduces pollutant loads.

Inspection

Stormwater runoff should be allowed to flow freely through the PICP. Inspect paver joints for trash, sediment, debris, and oil and grease. Examine the pavement surface for sagging or depressions, as this can indicate failure of the subbase and require corrective action. Inspect the vegetation around PICP perimeter for cover and soil stability repairing/replanting as necessary. Monitor areas upstream of the PICP for evidence of erosion and/or construction activities. Do not allow construction staging or mulch storage on unprotected PICP. Aggregate depth below chamfer bottoms on paver surfaces should be measured after vacuuming. If the permeable pavement is suspected to be sufficiently clogged, then an infiltration rate test should be performed using an industry standard practice, such as ASTM C1701 or ASTM D3385.

Maintenance

Permeable pavement in sidewalk applications (e.g., at rest areas) receive a higher level of routine maintenance, which includes sweeping, blowing, and litter removal. Furthermore, maintenance practices such as vacuuming sidewalk areas may cause the lightly compacted aggregate in the voids to be removed. Thus, the maintenance recommendations in this section are **intended for parking lots and driveway areas** where higher traffic volume occurs resulting in higher compaction and potential pollutants.

Vacuum surface 1 to 2 times annually (typically spring/fall) using a regenerative air vacuum sweeper to remove trash, sediment, and debris and properly dispose of it off-site. Use a true vacuum sweeper for restoring highly clogged surfaces. Do not use pressure washing to unclog surface joints. Replenish aggregate in joints when more than ½ in. from chamfer bottoms on paver surfaces exists. Do <u>not</u> pull up unwanted vegetation! Use an approved systematic herbicide, such as Glyphosate, and then return within the week to remove them by hand.

14.3.3 Underdrain/Observation Wells (if present)

Function

Underdrains prevent saturation of aggregate layers over lower-infiltration soils and convey stormwater to downstream swale, stream, or outlet structure. Observation wells allow the inspection of water level within the aggregate area.

Inspection

The underdrain outfalls should be free of any sediment, trash, and debris. Inspect the underdrain outfalls for free flow and the observation wells for outflow following storm events. Check outfall areas for erosion and undercutting. Inspect the surface above the buried pipe for signs of pipe breakage or separation. When applicable, inspect the area where the pipe discharges to the stream.

Maintenance

Remove sediment, trash, and debris around underdrain outfalls. Use a bucket or hose to pour water into the underdrain cleanout and observe the outlet structure for flow. If the underdrain becomes clogged, remove sediment and dispose of it off-site. A high-pressure hose can be used to flush out the underdrain system by spraying directly into the cleanouts. Repair or replace underdrain system in accordance with the original design specifications. Consider flushing the underdrain system annually if it appears it has a tendency to plug.

Replace/repair broken or separated pipes and missing or damaged well caps. Fill-in and re-stabilize outfall areas if erosion and undercutting occur.

14.3.4 Geotextile Liner (if present)

Function

A geotextile liner prevents the lateral migration of soil into the base/subbase aggregates when soil is restraining the sides of the base/subbase at the PICP perimeter.

Inspection

The soil around the perimeter of the PICP should retain the aggregate layers in place. Inspect the geotextile liner for tears, holes, and wrinkles. Check for erosion and signs of loose aggregates on the embankments around the perimeter of the PICP.

Maintenance

Replace/repair geotextile liner as needed. Replace aggregates, backfill soil embankment, stabilize with matting, and seed with grass as needed following geotextile failures.

14.3.5 Impermeable Liner (if present)

Function

Prevents toxic pollutants from leaching into the underlying soil layer and subsequently contaminating the groundwater at sites where there is higher risk of spills and contamination.

Inspection

The impermeable liner forces water to leave the system through the porous underdrain pipe. Inspect to ensure that there is flow from the underdrain outlet during storm events.

Maintenance

Replace impermeable liner as necessary.

14.3.6 Drainage Swales or Storm Sewer Inlets for Emergency Overflow (if present)

Function

PICP that has underlying soil with a moderate to low infiltration rate can be equipped with a swale that conveys surface runoff to the receiving stream during large rainfall events. Conversely, PICP with a storm sewer inlet will discharge surface runoff into the municipal storm sewer system. If the swale empties directly into a stream, it should do so in a manner that does not degrade the stream channel or banks. Typically, this requires the use of riprap or another type of protection/energy dissipation.

Inspection

All conveyances should be inspected for trash, sediment, and debris. For vegetated swales, inspect the area for erosion and undesirable vegetation. Also, note the mowing frequency to ensure that the proper vegetation height is maintained. For non-vegetated swales, verify that the channel is properly protected from erosion. If a storm sewer inlet is used, inspect the grates for debris, sediment, and trash build-up. When applicable, inspect the area where the swale discharges to the stream.

Maintenance

Remove and properly dispose of debris, unwanted vegetation, and major sediment accumulations. Repair eroded areas. Replace or repair any damaged material (i.e., riprap) or structure used to prevent erosion at the outfall.

14.3.7 Overflow System

Function

Prevents system flooding during larger storm events and may provide detention during smaller storm events.

Inspection

Overflow systems should be inspected for sediment and debris. Check for the presence of standing water several days after a large storm event, which could indicate plugging in the outlet pipe. Inspect the outlet area for signs of erosion. Check for damaged or corroded pipes or other structural components.

Maintenance

Remove and properly dispose of debris and sediment accumulations. Repair or replace damaged components. Repair eroded areas at outlet pipe. Replace or repair any material (i.e., riprap) or structure used to prevent the erosion at the outfall.

14.4 Inspection and Maintenance Summary

Observations made while inspecting stormwater controls must be documented on the appropriate SC inspection report form and entered into SCMS. Observations recorded would include a general description of the SC and those maintenance needs identified such as the removal of accessible trash, sediment, and unwanted vegetation.

If during an inspection, emergency maintenance needs are identified (i.e., failure of the stormwater control system), the inspector should either correct the problem at that time or contact the party(s) responsible for emergency maintenance repairs. If emergency maintenance needs are not corrected at the time of the inspection, a follow-up inspection should be conducted to verify that the responsible party(s) has taken action and all needs have been addressed. Observations made during the follow-up inspection must be documented on the appropriate SC inspection report form and entered into SCMS.

CHAPTER 15 Preformed Scour Holes

OVERVIEW

A PREFORMED SCOUR HOLE (PSH) is a structural stormwater control designed to dissipate energy and promote diffuse flow.

PURPOSE AND DESCRIPTION

- Preformed scour holes are riprap depressions constructed at the outlet of a point discharge.
- By providing a stable impact point for peak flows, a preformed scour hole dissipates energy and diffuses flow for specific applications.

INSPECTION

- Preformed scour holes are inspected by the Division Roadside Environmental Engineers (DREEs) for downstream erosion, improper construction, and structural damage 1 year after project acceptance by NCDOT.
- If the preformed scour hole is considered functional during the inspection, no further inspection or maintenance activities are performed.
- If the preformed scour hole is considered non-functional at the inspection, repairs are made, and the scour hole is reinspected 1 year after the repair.
- If the preformed scour hole is considered functional at the second inspection, no further inspection and maintenance activities are performed.

TYPICAL MAINTENANCE

- Most PSH locations are difficult to access. For any maintenance work where heavy equipment is needed, minimize tracking, excavation, and re-grading, which may create an increased potential of erosion.
- The most prevalent maintenance concern with PSH is the potential of downgrade erosion. Reseed and/or replant downgrade vegetation to minimize erosion, if necessary.
- Verify that the riprap consists of a well-graded mixture of stone. Replace and/or reset riprap to maintain designed structural components for dissipating energy and promoting diffuse flow. The top of the scour hole is required to be level such that even diffuse flow is leaving the device.
- Clear the scour hole of any unwanted debris or trash. .
- Repair or replace filter fabric and permanent soil reinforcement matting to minimize downstream erosion.

15.1 Stormwater Control Overview

Preformed scour holes are preshaped, riprap plated areas located directly downgrade of a discharge point. The man-made structure mimics the natural scour hole that would otherwise form at the conveyance outlet if no energy dissipation were provided. The basin is stabilized with filter fabric and riprap to absorb the impact of the discharge and to prevent additional erosion. Once runoff has filled the shallow basin, it overtops the preformed scour hole and is redistributed as diffuse flow to the surrounding area.

Figure 15-1. Standard Preformed Scour Hole Installation

To prevent erosion immediately downgrade of the preformed scour hole, an apron of permanent soil reinforcement mat (PSRM) is required around and downgrade of the BMP. Preformed scour holes absorb the impact of high velocities and reduce the potential for downgrade erosion from point discharges by reducing flow velocities. When preformed scour holes are implemented under small peak flow conditions and installed on level ground, they redistribute concentrated inflow as diffuse outflow to adjacent land. **The top of the scour hole is required to be level such that even diffuse flow is leaving the device.** Figure 15.1 shows a typical Preformed Scour Hole installation. Preformed scour holes provide a water quality benefit by dispersing flow, which achieves the following:

- Prevents scour at the pipe discharge,
- Promotes runoff infiltration, and
- Reduces soil erosion.

Preformed scour holes are typically intended for small drainage areas receiving flows from 15 to 18-inch diameter pipes. The maximum allowable discharge is 6 ft^3/s and 10 ft^3/s for a 15-inch and 18-inch pipe, respectively.

15.2 Preformed Scour Hole Components

Preformed scour holes must be installed in a flat area and should be stabilized with filter fabric and riprap to absorb the impact of the discharge and to prevent additional erosion. The base of the preformed scour hole is square. The base width is calculated as 3 times the discharge pipe size. The minimum design depth of the scour hole is 1 foot and the maximum design depth is 3 feet. Side slope for all four sides of the scour hole is 2H:1V. Class B riprap (d_{50} of 8 inches) should be used on top of the filter fabric to line the preformed scour hole. The minimum and maximum stone sizes for Class B riprap are 5 inches and 12 inches, respectively.

To prevent erosion immediately downgrade, an apron of PSRM is required downgrade of the preformed scour hole. The minimum width of the PSRM apron is the standard roll width. PSRM must be buried a minimum of 1 foot underneath the filter fabric and natural ground around the perimeter of the scour hole. Ensure that the apron is flush with natural ground. The elevation of the top of the preformed scour hole should be the same as the elevation of the PSRM. Figures 15.2 and 15.3 show a typical layout and cross-section of a preformed scour hole installation.

Preformed scour holes may include, but are not limited to, the following components:

- Scour Hole
- Filter fabric
- Riprap
- PSRM

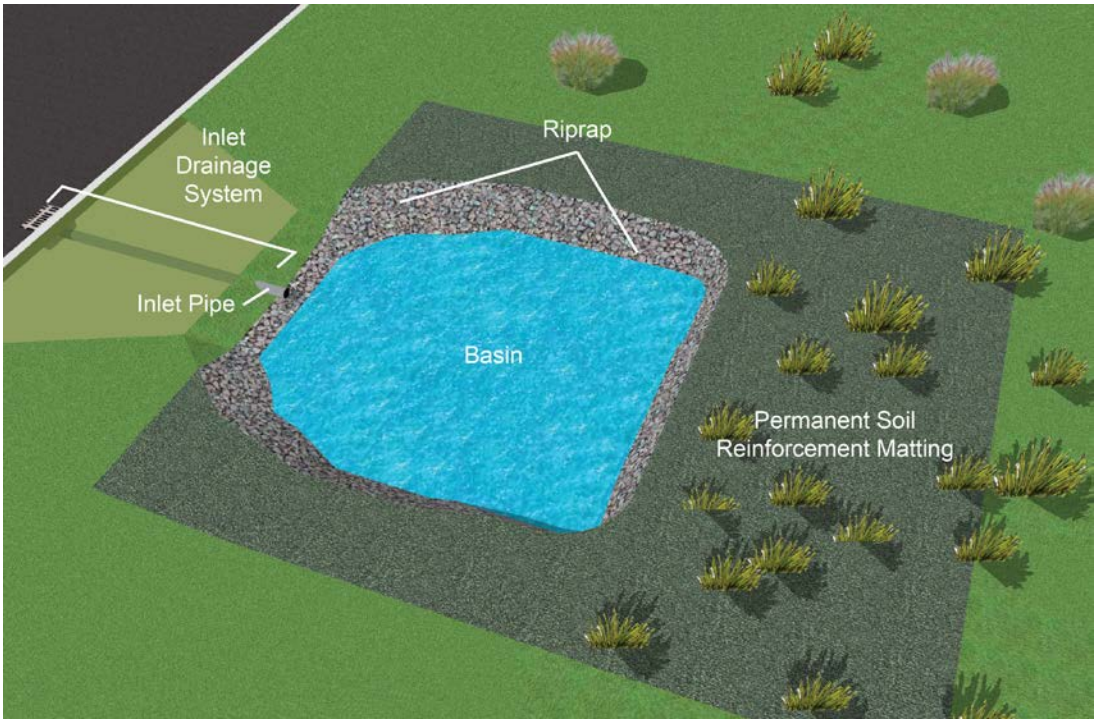


Figure 15-2. Typical Preformed Scour Hole layout and components

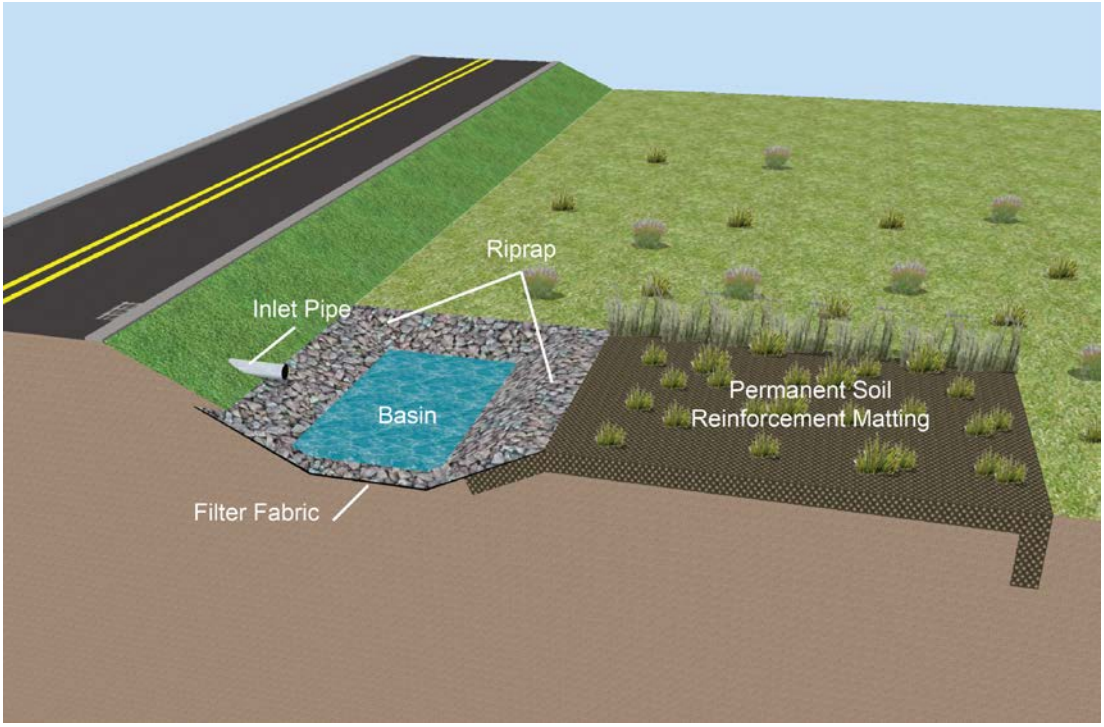


Figure 15-3. Cross-section of a Preformed Scour Hole

15.3 Inspection and Maintenance

Preformed Scour Holes are inspected 1 year after project acceptance to determine their functionality and overall condition. If the PSH receives a Level of Service (LOS) rating of C or better, the device is considered to be functional and no further inspection or maintenance is required for the device. If during the 1-year inspection, PSH receives a LOS rating of D or F, the device is considered nonfunctional and corrective maintenance and/or repair is required. Once the maintenance and repair is completed, a follow-up inspection is conducted after 1 year and if the device is considered functional (rating C or better), then no further inspection or maintenance is conducted.

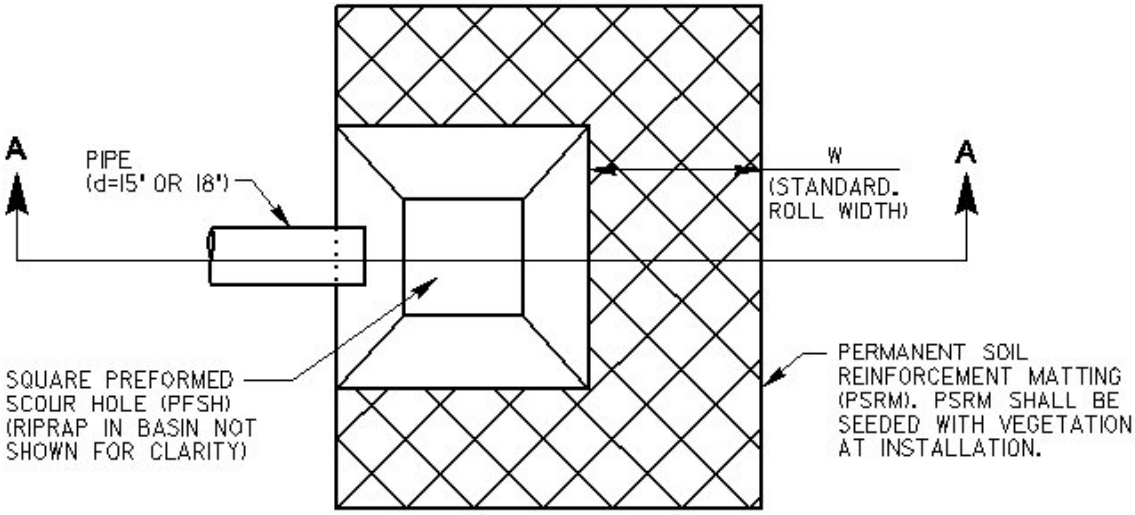


Figure 15-4. Plan view of Preformed Scour Holes

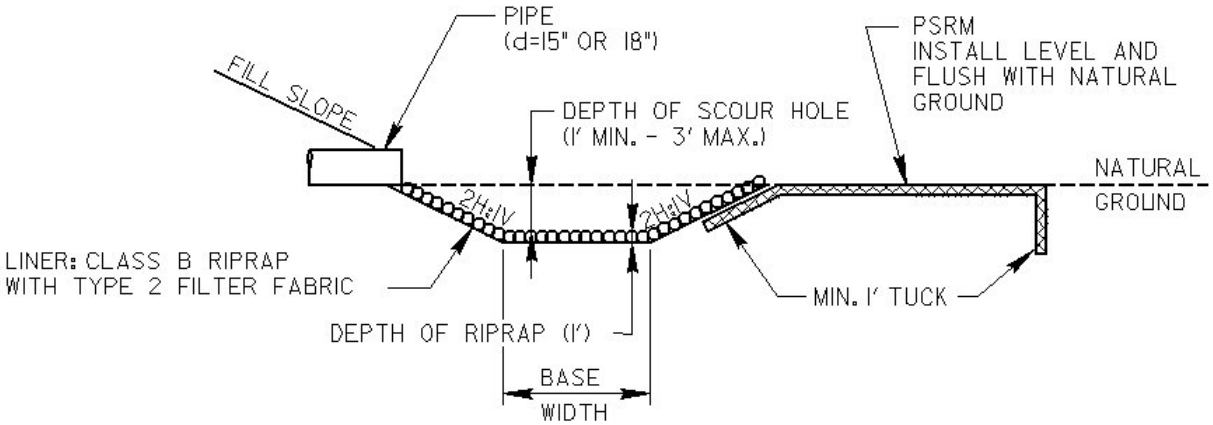


Figure 15-5. Profile view of Preformed Scour Holes

The following sections describe the function of preformed scour holes and provide inspection and maintenance guidance for its major components.

15.3.1 Scour Hole

Function

The scour hole is the principal structural component of the device that provides energy dissipation for peak runoff flows. The scour hole basin is lined with filter fabric and riprap (discussed in the following sections), and is representative of a natural scour hole that would develop at the pipe outlet in absence of an energy dissipater.

Inspection

Stormwater runoff should be able to flow in and out of the scour hole. Verify that there is a depression within the scour hole and it is not filled with unwanted trash or debris. Inspect the riprap for a well-graded mixture.

Maintenance

Typically, the device should need minimal maintenance. However, if any unwanted trash or debris is noted, it should be removed promptly. Refer to the riprap section if it requires maintenance.

15.3.2 Filter Fabric

Function

The filter fabric is an erosion protection and stabilization material, which may be made of woven or nonwoven monofilament yarns. It is used to line the stone plated basin for absorbing the impact of the discharge and preventing erosion. The filter fabric also prevents soil movement into or through the riprap.

Inspection

Verify that the filter fabric is undamaged, remains in place as installed, and appears adequate to protect the area from erosion. Check to ensure that the filter fabric is buried below ground and if any wire staples or anchor pins have been removed causing the edges to be exposed.

Maintenance

If there is damage to the filter fabric and erosion is visible underneath the riprap plated portion of the scour hole, restore the compacted fill and repair filter fabric. Any damage to the filter fabric should be repaired by removing the riprap and placing another piece of filter cloth over the damaged area and securing it using wire staples or anchor pins. Once repair is completed, replace the riprap. If the wire staples or anchor pins are missing exposing the edges, pull the edge of the filter fabric underground and place new wire staples or anchor pins to provide stability.

15.3.3 RIPRAP

Function

Riprap is a layer of stone designed to protect and stabilize areas that are subject to erosion. Riprap is a highly erosion-resistant material which is effective in many locations to dissipate energy and reduce flow velocity of the runoff water. The riprap may be field stone or rough quarry stone and should be hard, angular, highly weather resistant, and well-graded. Larger stones predominate and smaller size stones fill the voids between larger stone.

Inspection

During the scheduled inspections, examine riprap plating to see if any erosion has occurred around or below the riprap or if stones appear to be dislodged. Verify that the riprap consists of well-graded mixture of large and small size stone.

Maintenance

For routine maintenance items, remove any debris from the scour hole and check the exit areas for any potential obstructions that could hinder diffuse flow. If the stone gradation seems inadequate use the smaller-sized stones to fill voids. If the riprap appear moved or erosion is visible, schedule maintenance to make repairs and prevent further damage.

15.3.4 PERMANENT SOIL REINFORCEMENT MATTING

Function

The Permanent Soil Reinforcement Matting is installed to prevent soil erosion from flows and assist the vegetation

to grow and establish in the areas receiving diffuse flows from the scour hole. The matting is installed flush with natural ground and buried below the filter fabric immediately downgrade of the scour hole.

Inspection

If there are signs of erosion and/or poor vegetation growth downgrade of the scour hole, look for nearby vegetation to determine if it is blocking sunlight and vegetation establishment. Verify that the PSRM is buried firmly below ground, overlain by the filter fabric, and the edges are not exposed.

Maintenance

Reseed areas with erosion or poor vegetation downgrade of the scour hole if the PSH had been installed recently and is in the establishment phase. If the PSRM edges are unburied and exposed, use wire staples to provide stability. If adjacent dense vegetation is causing impaired growth, consider minimal pruning to allow sunlight penetration.

Note: In addition to these major components discussed above, **the area surrounding the preformed scour hole, especially downgrade, should also be inspected for signs of sparse**

vegetation and erosion, since this is the most common maintenance issue in PSHs. Repair eroded areas by resodding or reseeding, if the erosion warrants intervention. If the practice is new and in the establishment phase, consider delaying the repair until the next inspection cycle.

15.4 Inspection and Maintenance Summary

Observations made while inspecting stormwater controls must be documented on the appropriate SC inspection report form and entered into the SCMS database system. Observations recorded would include a general description of the SC, its location, and the maintenance needs identified.

Maintenance needs can be routine or non-routine. Removal of accessible unwanted trash and debris, which the crews may be able to perform during the same day are examples of routine maintenance activities. Any maintenance activities performed should be recorded on the maintenance report form. Non-routine maintenance needs often require specialized equipment and trained personnel. If during an inspection, non-routine maintenance needs are identified (i.e., failure of the stormwater control system), the inspector should either correct the problem at that time or contact the party(s) responsible to schedule non-routine maintenance repairs.

If non-routine maintenance needs are not corrected at the time of the inspection, a follow-up inspection should be conducted to verify that the responsible party(s) has taken action and all maintenance needs have been addressed. Observations made during the follow-up inspection must be documented on the appropriate SC maintenance report form and entered into SCMS.

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APPENDIX A Inspection Checklists

LOS RANKING: _____

STORMWATER BMP: BIORETENTION BASIN
BMP ID#: _____
DIVISION: _____
COUNTY: _____
DATE INSTALLED: _____
LOCATION: _____

Inspector(s): _____
_____
_____

Inspection Date: _____

Structural Components

Y	N	N/A	
☐	☐	☐	**Inlet/outlet drainage systems are structurally sound and functional.**
☐	☐	☐	**Forebay and transition berm are structurally sound and functional.**
☐	☐	☐	**Basin, embankment, and emergency spillway are structurally sound and functional. (Sediment must be removed from the basin when it exceeds 50% or more of the forebay's storage capacity.)**
☐	☐	☐	**Filter media and underdrain, including cleanouts, appear to be structurally sound and functional.**
☐	☐	☐	**Outlet control structure and components are structurally sound and functional.**

Areas of Maintenance

Y	N	N/A	
☐	☐	☐	**Inlet and outlet ditches/pipes are free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Forebay is clean and free of sediment, leaves, trash, and other debris. (Sediment must be removed when it exceeds 50% or more of the forebay's storage capacity.)**
☐	☐	☐	**Grass has been mowed and undesirable vegetation removed.**
☐	☐	☐	**Plants are healthy and mulch layer is adequate (at least 3 inches).**
☐	☐	☐	**Basin is free of standing water.**
☐	☐	☐	**Areas of erosion have been repaired.**
☐	☐	☐	**Trash rack is unobstructed and free of sediment, leaves, trash, and other debris.**

Y	N	
☐	☐	**Are structural repairs needed at this site? (If yes, describe in Comments.)**
☐	☐	**Is any maintenance necessary at this site? (If yes, describe in Comments.)**
☐	☐	**Were maintenance activities conducted at the time of inspection? (If yes, describe in Comments.)**

Comments/Recommendations/Actions Taken:

_____
_____
_____
_____

LOS Category	LOS Description
A	Some aging and wear has occurred, but no structural deterioration or maintenance needs were found. Device is functioning properly.
B	Minor structural deterioration and/or maintenance needs were found, but function of the device has not been affected.
C	Moderate structural deterioration and/or maintenance needs were found, but function of the device has not been significantly affected.
D	Serious deterioration in at least one structural component and/or major maintenance needs were found. Function of the device is inadequate.
F	Device is no longer functional due to the general or complete failure of a major structural component and/or the lack of adequate maintenance.

LOS Ranking: _____

STORMWATER BMP: DRY DETENTION BASIN
BMP ID#: _____
DIVISION: _____
COUNTY: _____
DATE INSTALLED: _____
LOCATION: _____

Inspector(s): _____
_____
_____

Inspection Date: _____

Structural Components

Y	N	N/A	
☐	☐	☐	**Inlet drainage system is structurally sound and functional.**
☐	☐	☐	**Sluice gate is in place, structurally sound, and functional.**
☐	☐	☐	**Drawdown orifice plate is in place, structurally sound, and functional.**
☐	☐	☐	**Trash rack is in place, structurally sound, and functional.**
☐	☐	☐	**Trash screen is in place, structurally sound, and functional.**
☐	☐	☐	**Forebay and transition berm are structurally sound and functional.**
☐	☐	☐	**Basin, embankment, and emergency spillway are structurally sound and functional. (Sediment must be removed when it reduces the design depth by 50%)**
☐	☐	☐	**Outlet control structure is in place, structurally sound, and functional.**

Areas of Maintenance

Y	N	N/A	
☐	☐	☐	**Trash rack is unobstructed and free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Openings in the drawdown orifice plate are unobstructed and free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Trash screen is unobstructed and free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Sluice gate is unobstructed and free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Forebay is clean and free of sediment, leaves, trash, and other debris. (Sediment must be removed when 50% or more of the capacity is reduced.)**
☐	☐	☐	**Inlet and outlet ditches/pipes are free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Grass has been mowed and undesirable vegetation removed**

Y	N	
☐	☐	**Do any components at this site need structural repairs? (If yes, describe below:)**
☐	☐	**Is any maintenance necessary at this site (i.e., areas of erosion, unwanted vegetation)? (If yes, describe in Comments section.)**
☐	☐	**Were maintenance activities conducted during the time of inspection? (If yes, describe in Comments section.)**

Comments/Recommendations/Actions Taken: _____
_____
_____
_____

LOS Category	LOS Description
A	Some aging and wear has occurred, but no structural deterioration or maintenance needs were found. Device is functioning properly.
B	Minor structural deterioration and/or maintenance needs were found, but function of the device has not been affected.
C	Moderate structural deterioration and/or maintenance needs were found, but function of the device has not been significantly affected.
D	Serious deterioration in at least one structural component and/or major maintenance needs were found. Function of the device is inadequate.
F	Device is no longer functional due to the general or complete failure of a major structural component and/or the lack of adequate maintenance.

LOS Ranking: _____

STORMWATER BMP: FILTRATION BASIN
BMP ID#: _____
DIVISION: _____
COUNTY: _____
DATE INSTALLED: _____
LOCATION: _____

Inspector(s): _____
_____
_____

Inspection Date: _____

Structural Components

Y	N	N/A	
☐	☐	☐	**Inlet/outlet drainage systems are structurally sound and functional.**
☐	☐	☐	**Forebay and transition berm are structurally sound and functional.**
☐	☐	☐	**Basin, embankment, and emergency spillway are structurally sound and functional. (Sediment must be removed from the basin when it exceeds 50% or more of the forebay's storage capacity.)**
☐	☐	☐	**Filter media and underdrain appear to be structurally sound and functional.**
☐	☐	☐	**Outlet control structure and components are structurally sound and functional.**

Areas of Maintenance

Y	N	N/A	
☐	☐	☐	**Inlet and outlet ditches/pipes are free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Forebay is clean and free of sediment, leaves, trash, and other debris. (Sediment must be removed when it exceeds 50% or more of the forebay's storage capacity.)**
☐	☐	☐	**Grass has been mowed and undesirable vegetation removed.**
☐	☐	☐	**Basin is free of standing water.**
☐	☐	☐	**Trash rack is unobstructed and free of sediment, leaves, trash, and other debris.**

Y	N	
☐	☐	**Are structural repairs needed at this site? (If yes, describe in Comments.)**
☐	☐	**Is any maintenance necessary at this site? (If yes, describe in Comments.)**
☐	☐	**Were maintenance activities conducted at the time of inspection? (If yes, describe in Comments.)**

Comments/Recommendations/Actions Taken: _____
_____
_____
_____
_____

LOS Category	LOS Description
A	Some aging and wear has occurred, but no structural deterioration or maintenance needs were found. Device is functioning properly.
B	Minor structural deterioration and/or maintenance needs were found, but function of the device has not been affected.
C	Moderate structural deterioration and/or maintenance needs were found, but function of the device has not been significantly affected.
D	Serious deterioration in at least one structural component and/or major maintenance needs were found. Function of the device is inadequate.
F	Device is no longer functional due to the general or complete failure of a major structural component and/or the lack of adequate maintenance.

LOS Ranking: _____

STORMWATER BMP: HAZARDOUS SPILL BASIN
BMP ID#: _____
DIVISION: _____
COUNTY: _____
DATE INSTALLED: _____
LOCATION: _____

Inspector(s): _____
_____
_____

Inspection Date: _____

Structural Components

Y	N	N/A	
☐	☐	☐	**Inlet and outlet drainage systems are structurally sound and functional.**
☐	☐	☐	**Sluice gate is in place, structurally sound, and functional.**
☐	☐	☐	**Concrete headwall/outlet structure is in place, structurally sound, and functional.**
☐	☐	☐	**Basin and side slopes are structurally sound and functional.**
☐	☐	☐	

Areas of Maintenance

Y	N	N/A	
☐	☐	☐	**Inlet and outlet pipe(s) are free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Basin is free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Grass has been mowed and undesirable vegetation removed as needed.**
☐	☐	☐	**Sluice gate opening is unobstructed and free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Outlet is accessible and free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Signage is undamaged, clear, and visible.**

Y	N	
☐	☐	**Are structural repairs needed at this site? (If yes, describe in Comments section.)**
☐	☐	**Are there maintenance needs at this site? (If yes, describe in Comments section.)**
☐	☐	**Does the basin pond water for excessive periods of time? (If yes, describe in Comments section.)**
☐	☐	**Are odors being emitted from the basin? (If yes, describe in Comments section.)**
☐	☐	**Were maintenance activities conducted at the time of inspection? (If yes, describe in Comments section.)**

Comments/Recommendations/Actions Taken: _____
_____
_____
_____
_____

LOS Category	LOS Description
A	Some aging and wear has occurred, but no structural deterioration or maintenance needs were found. Device is functioning properly.
B	Minor structural deterioration and/or maintenance needs were found, but function of the device has not been affected.
C	Moderate structural deterioration and/or maintenance needs were found, but function of the device has not been significantly affected.
D	Serious deterioration in at least one structural component and/or major maintenance needs were found. Function of the device is inadequate.
F	Device no longer functional due to the general or complete failure of a major structural component and/or the lack of adequate maintenance.

LOS Ranking: _____

STORMWATER BMP: INFILTRATION BASIN
BMP ID#: _____
DIVISION: _____
COUNTY: _____
DATE INSTALLED: _____
LOCATION: _____

Inspector(s): _____
_____
_____

Inspection Date: _____

Structural Components

Y	N	N/A	
☐	☐	☐	**Inlet and outlet drainage systems and flow bypass structure are structurally sound and functional.**
☐	☐	☐	**Pretreatment BMP and filter strip/swale are structurally sound and functional.**
☐	☐	☐	**Basin, embankment, and emergency spillway (if present) are structurally sound and functional.**
☐	☐	☐	**Emergency outlet control structure, sluice gate, and trash rack are structurally sound and functional if present.**

Areas of Maintenance

Y	N	N/A	
☐	☐	☐	**All components are free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Sediment was removed from forebay if capacity was reduced to 50% or less.**
☐	☐	☐	**Basin sidewalls and surrounding areas are stabilized with a dense cover of turf grass maintained at a height of 6–15 inches.**
☐	☐	☐	**Basin bottom has adequate cover (4" of sand or dense turf grass 6-15" in height).**
☐	☐	☐	**Sediment was removed from basin if soil media appeared to be clogged.**
☐	☐	☐	**Areas of erosion have been repaired.**

Y	N	
☐	☐	**Are there structural repairs needed at this site? (If yes, describe in Comments section.)**
☐	☐	**Are there maintenance needs at this site? (If yes, describe in Comments section.)**
☐	☐	**Were maintenance activities conducted at the time of inspection? (If yes, describe in Comments section.)**

Comments/Recommendations/Actions Taken: _____
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_____
_____
_____

LOS Category	LOS Description
A	Some aging and wear has occurred, but no structural deterioration or maintenance needs were found. Device is functioning properly.
B	Minor structural deterioration and/or maintenance needs were found, but function of the device has not been affected.
C	Moderate structural deterioration and/or maintenance needs were found, but function of the device has not been significantly affected.
D	Serious deterioration in at least one structural component and/or major maintenance needs were found. Function of the device is inadequate.
F	Device is no longer functional due to the general or complete failure of a major structural component and/or the lack of adequate maintenance.

LOS Ranking: _____

STORMWATER BMP: LEVEL SPREADER
BMP ID#: _____
DIVISION: _____
COUNTY: _____
DATE INSTALLED: _____
LOCATION: _____

Inspector(s): _____
_____
_____

Inspection Date: _____

Structural Components

Y	N	N/A	
☐	☐	☐	**Inlet pipe grate is in place, structurally sound, and functional.**
☐	☐	☐	**Sediment forebay is structurally sound and functional.**
☐	☐	☐	**Inlet and outlet ditches are structurally sound and functional.**
☐	☐	☐	**Inlet pipe or flow bypass system is in place, structurally sound and functional.**
☐	☐	☐	**Level spreader trough is in place, structurally sound, and functional.**
☐	☐	☐	**Level spreader lip is in place, structurally sound, and functional.**
☐	☐	☐	**Filter strip is structurally sound, and functional.**
☐	☐	☐	**Bypass swale or pipe is structurally sound and functional.**

Areas of Maintenance

Y	N	N/A	
☐	☐	☐	**Sediment forebay is clean, free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Inlet and outlet ditches are clean, free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Flow Bypass Structure is clean and free of sediment.**
☐	☐	☐	**Inlet drainage system is unobstructed, free of leaves, trash, and other debris.**
☐	☐	☐	**Weep holes are unobstructed, free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Rock filter bags protecting weep holes are not damaged or in need of replacing.**
☐	☐	☐	**Filter strip has a good stand of grassed vegetation. No erosion noted.**
☐	☐	☐	**Grass has been mowed and undesirable vegetation removed as needed.**
☐	☐	☐	**Bypass swale is well vegetated and free of sediment, leaves, trash, and other debris.**

Y	N	
☐	☐	**Are structural repairs needed at this site? (If yes, describe in Comments section.)**
☐	☐	**Are there maintenance needs at this site? (If yes, describe in Comments section.)**
☐	☐	**Were maintenance activities conducted at the time of inspection? (If yes, describe under Comments.)**

Comments/Recommendations/Actions Taken: _____
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_____
_____

LOS Category	LOS Description
A	Some aging and wear has occurred, but no structural deterioration or maintenance needs were found. Device is functioning properly.
B	Minor structural deterioration and/or maintenance needs were found, but function of the device has not been affected.
C	Moderate structural deterioration and/or maintenance needs were found, but function of the device has not been significantly affected.
D	Serious deterioration in at least one structural component and/or major maintenance needs were found. Function of the device is inadequate.
F	Device is no longer functional due to the general or complete failure of a major structural component and/or the lack of adequate maintenance.

LOS Ranking: _____

STORMWATER BMP: PERMEABLE PAVEMENT
BMP ID#: _____
DIVISION: _____
COUNTY: _____
DATE INSTALLED: _____
LOCATION: _____

Inspector(s): _____
_____
Latitude: _____
Longitude: _____
Inspection Date: _____

Structural Components

Y	N	N/A	
☐	☐	☐	**Concrete pavers are structurally sound and functional.**
☐	☐	☐	**Subbase, base, bedding, and joint aggregates are structurally sound and functional.**
☐	☐	☐	**Underdrain/ observation wells are structurally sound and functional.**
☐	☐	☐	**Geotextile or impermeable liner is structurally sound and functional.**
☐	☐	☐	**Drainage swales or storm sewer inlets for emergency overflow are structurally sound and functional.**
☐	☐	☐	**Overflow system is structurally sound and functional.**

Areas of Maintenance

Y	N	N/A	
☐	☐	☐	**Concrete pavers are free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Subbase, base, bedding, and jointing aggregates are free of sediment, leaves, trash, and other debris. (Joints should be refilled with jointing aggregate when more than ½ inch from chamfer bottom on paver surfaces exists).**
☐	☐	☐	**Underdrain/ observation wells are free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Geotextile or impermeable liner has been replaced.**
☐	☐	☐	**Drainage swales or storm sewer inlets for emergency overflow are free of sediment, leaves, trash, unwanted vegetation, and other debris.**
☐	☐	☐	**Overflow system is free of sediment, leaves, trash, and other debris.**

Y	N	
☐	☐	**Are structural repairs needed at this site? (If yes, describe in Comments section.)**
☐	☐	**Are there maintenance needs at this site? (If yes, describe in Comments section.)**

Comments/Recommendations/Actions Taken: _____

LOS Category	LOS Description
A	Some aging and wear has occurred, but no structural deterioration or maintenance needs were found. Device is functioning properly.
B	Minor structural deterioration and/or maintenance needs were found, but function of the device has not been affected.
C	Moderate structural deterioration and/or maintenance needs were found, but function of the device has not been significantly affected.
D	Serious deterioration in at least one structural component and/or major maintenance needs were found. Function of the device is inadequate.
F	Device is no longer functional due to the general or complete failure of a major structural component and/or the lack of adequate maintenance.

LOS Ranking: ☐

STORMWATER BMP: PREFORMED SCOUR HOLE
SCMS ID#: _____
DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐ Highway Right-of-Way
☐ Rest Area ☐ County Maintenance Yard (CMY)
☐ DOH Offices ☐ Ferry
☐DMV
☐Municipal (City/Town)
☐Other

Inspector(s): _____

Latitude: _____ (Decimal Degrees)

Longitude: _____ (Decimal Degrees)

Inspection Date: _____

Detailed Location: _____

Scour Hole and Rip Rap

Y	N	N/A	
☐	☐	☐	Scour Hole is free of sediment, leaves, trash, and other debris and the depression is maintained.
☐	☐	☐	Riprap has a gradation (varied sizes) of different stone size.

Filter Fabric and Permanent Soil Reinforcement Matting (PSRM)

Y	N	N/A	
☐	☐	☐	Filter Fabric is structurally sound and functional as lining of the scour hole.
☐	☐	☐	PSRM is structurally sound and functional, as installed below the filter fabric around the perimeter of scour hole.
☐	☐	☐	The filter fabric and PSRM edges are buried below ground and anchored as installed.

Inlet and Outlet Structures

Y	N	N/A	
☐	☐	☐	Drainage swale or inlet pipe into the Preformed Scour Hole is structurally sound and functional.
☐	☐	☐	Drainage swale or inlet pipe into the Preformed Scour Hole is free of sediment, leaves, trash, and debris.
☐	☐	☐	Outlet area is free of sediment, leaves, trash, unwanted vegetation, and debris.
☐	☐	☐	Surrounding vegetation is well established with no signs of erosion or bare areas.

Maintenance Needs

Check One
☐ None Needed
☐ Routine/ Normal
☐ Immediate Attention Required

Date	Inspection Description
	Initial Inspection
	Maintenance Conducted (if needed)
	Follow-up Inspection

Comments/Recommendations/Actions Taken: _____

LOS Category	LOS Description
A	**Some aging and wear has occurred, but no structural deterioration or maintenance needs were found. Device is functioning properly.**
B	**Minor structural deterioration and/or maintenance needs were found, but function of the device has not been affected.**
C	**Moderate structural deterioration and/or maintenance needs were found, but function of the device has not been significantly affected.**
D	**Serious deterioration in at least one structural component and/or major maintenance needs were found. Function of the device is inadequate.**
F	**Device is no longer functional due to the general or complete failure of a major structural component and/or the lack of adequate maintenance.**

LOS Ranking: _____

STORMWATER BMP: STORMWATER WETLAND
BMP ID#: _____
DIVISION: _____
COUNTY: _____
DATE INSTALLED: _____
LOCATION: _____

Inspector(s): _____
_____
_____

Inspection Date: _____

Structural Components

Y	N	N/A	
☐	☐	☐	**Inlet/outlet drainage systems are structurally sound and functional.**
☐	☐	☐	**Forebay and transition berm are structurally sound and functional.**
☐	☐	☐	**Basin, embankment, and spillway are structurally sound and functional.**
☐	☐	☐	**Drawdown device/orifice is in place, structurally sound, and functional.**
☐	☐	☐	**Outlet control structure and components are structurally sound and functional.**

Areas of Maintenance

Y	N	N/A	
☐	☐	☐	**Inlet and outlet ditches/pipes are free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Forebay is clean and free of sediment, leaves, trash, and other debris. (Sediment must be removed when it exceeds 50% or more of the forebay's storage capacity.)**
☐	☐	☐	**Pools are free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Algal growth covers less than 50% of the stormwater wetland.**
☐	☐	☐	**Wetland is well vegetated with the intended species; undesirable vegetation has been removed.**
☐	☐	☐	**Water level is at or near the elevation of the orifice.**
☐	☐	☐	**Drawdown device/orifice and trash rack are unobstructed and free of sediment, leaves, trash, and other debris.**

Y	N	
☐	☐	**Are there structural repairs needed at this site? (If yes, describe in Comments.)**
☐	☐	**Are there maintenance needs at this site? (If yes, describe in Comments.)**
☐	☐	**Were maintenance activities conducted during the time of inspection? (If yes, describe in Comments.)**

Comments/Recommendations/Actions Taken: _____
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_____
_____

LOS Category	LOS Description
A	Some aging and wear has occurred, but no structural deterioration or maintenance needs were found. Device is functioning properly.
B	Minor structural deterioration and/or maintenance needs were found, but function of the device has not been affected.
C	Moderate structural deterioration and/or maintenance needs were found, but function of the device has not been significantly affected.
D	Serious deterioration in at least one structural component and/or major maintenance needs were found. Function of the device is inadequate.
F	Device is no longer functional due to the general or complete failure of a major structural component and/or the lack of adequate maintenance.

LOS Ranking: _____

STORMWATER BMP: SWALE
BMP ID#: _____
DIVISION: _____
COUNTY: _____
DATE INSTALLED: _____
LOCATION: _____

Inspector(s): _____
_____
_____

Inspection Date: _____

Structural Components

Y	N	N/A	
☐	☐	☐	**Forebay is structurally sound and functional.**
☐	☐	☐	**Inlet and outlet drainage systems are structurally sound and functional.**
☐	☐	☐	**Side slopes and bottom of swale are structurally sound and functional.**
☐	☐	☐	**Water quality rock checks are structurally sound and functional if present.**

Areas of Maintenance

Y	N	N/A	
☐	☐	☐	**Forebay is clean, free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Inlet and outlet ditches/pipes are clean, free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Is erosion occurring within the swale? (If yes, describe in Comments section.)**
☐	☐	☐	**Swale is clean, free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Swale has an established stand of turf grass.**
☐	☐	☐	**Swale has been mowed and undesirable vegetation removed.**
☐	☐	☐	**If present, rock checks retain dimensions and have adequate riprap and No. 57 stone.**

Y	N	
☐	☐	**Are structural repairs needed at this site? (If yes, describe in Comments section.)**
☐	☐	**Are there maintenance needs at this site? (If yes, describe in Comments section.)**
☐	☐	**Were maintenance activities conducted at the time of inspection? (If yes, describe in Comments section.)**

Comments/Recommendations/Actions Taken: _____
_____
_____
_____

LOS Category	LOS Description
A	Some aging and wear has occurred, but no structural deterioration or maintenance needs were found. Device is functioning properly.
B	Minor structural deterioration and/or maintenance needs were found, but function of the device has not been affected.
C	Moderate structural deterioration and/or maintenance needs were found, but function of the device has not been significantly affected.
D	Serious deterioration in at least one structural component and/or major maintenance needs were found. Function of the device is inadequate.
F	Device is no longer functional due to the general or complete failure of a major structural component and/or the lack of adequate maintenance.

LOS Ranking: _____

STORMWATER BMP: WET DETENTION BASIN
BMP ID#: _____
DIVISION: _____
COUNTY: _____
DATE INSTALLED: _____
LOCATION: _____

Inspector(s): _____
_____
_____

Inspection Date: _____

Structural Components

Y	N	N/A	
☐	☐	☐	**Inlet/outlet drainage systems are structurally sound and functional.**
☐	☐	☐	**Forebay and transition berm are structurally sound and functional.**
☐	☐	☐	**Basin, embankment, and emergency spillway are structurally sound and functional.**
☐	☐	☐	**Drawdown device/orifice is in place, structurally sound, and functional**
☐	☐	☐	**Outlet control structure and components are structurally sound and functional.**

Areas of Maintenance

Y	N	N/A	
☐	☐	☐	**Inlet and outlet ditches/pipes are free of sediment, leaves, trash, and other debris.**
☐	☐	☐	**Forebay is clean and free of sediment, leaves, trash, and other debris. (Sediment must be removed when it exceeds 50% or more of the forebay's storage capacity.)**
☐	☐	☐	**Grass has been mowed and undesirable vegetation removed, and eroded areas repaired.**
☐	☐	☐	**Water level is at or near the invert of the orifice.**
☐	☐	☐	**Permanent pool does not contain excessive (covers more than 50% of permanent pool surface area) algae or invasive plants (i.e., cattails).**
☐	☐	☐	**Sediment accumulation is not impeding the function of the basin.**
☐	☐	☐	**Drawdown device/orifice and trash rack are unobstructed and free of sediment, leaves, trash, and other debris.**

Y	N	
☐	☐	**Are there structural repairs needed at this site? (If yes, describe in Comments.)**
☐	☐	**Are there maintenance needs at this site? (If yes, describe in Comments.)**
☐	☐	**Were maintenance activities conducted during the me of inspection? (If yes, describe in Comments.)**

Comments/Recommendations/Actions Taken: _____
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_____
_____

LOS Category	LOS Description
A	Some aging and wear has occurred but no structural deterioration or maintenance needs were found. Device is functioning properly.
B	Minor structural deterioration and/or maintenance needs were found but function of the device has not been affected.
C	Moderate structural deterioration and/or maintenance needs were found but function of the device has not been significantly affected.
D	Serious deterioration in at least one structural component and/or major maintenance needs were found. Function of the device is inadequate.
F	Device no longer functional due to the general or complete failure of a major structural component and/or the lack of adequate maintenance.

APPENDIX B NCDOT Stormwater Control Naming Convention

STORMWATER TERMS

Basin: This term signifies any depression that has a wider width than depth. According to this definition, all ponds are basins. Basins may be circular, oval, or channel-shaped. However, all basins are designed to detain the water quality volume before discharging that volume to surface water or groundwater. Any stormwater control that is designed based on a target stormwater volume will be referred to as a basin.

Best Management Practice (BMP): EPA defines a BMP as a nonstructural (technique, or measure) or structural control (engineered grass swale, dry detention basin, filtration basin, etc.) that is used for a given set of conditions to manage the quantity and improve the quality of storm water runoff in the most cost-effective manner (EPA-821-R-99-012 August 1999).

Detention: Many stormwater manuals use the term detention basin to mean a basin that temporarily holds stormwater then slowly releases it to the receiving stream. In contrast, retention basins, sometimes called wet ponds, can refer to basins that maintain a permanent pool of water. For simplicity, NCDOT will use the term wet detention basin to describe a basin with a permanent pool of water and dry detention basin to refer to a basin that is dry between storm events.

Filters: Some non-HSP references distinguish between stormwater controls that remove gross solids (screens) and those that remove suspended and settleable solids (filters). However, this naming convention is based on the relative size of the material being filtered, not on the actual physical separation process. The preferred term for the physical separation of water and solids using a porous media is filtration, and the structure is a filter, regardless of the porosity of the media.

Stormwater Control: Stormwater control is preferred over best management practice to refer to nonstructural and structural controls because it is a more accurate and precise descriptor of stormwater treatment practices.

Stormwater Control System: One or more stormwater controls implemented together is a system. The stormwater controls selected target different practices or pollutants to provide comprehensive stormwater treatment.

Stormwater Wetlands: The preferred term in the HSP for a stormwater treatment wetland is stormwater wetland. The term constructed wetland has been used by other agencies to mean a mitigation wetland that has been restored as compensation for unavoidable aquatic impacts and/or wetlands constructed to treat stormwater. This dual meaning can be confusing. Therefore, stormwater wetland will be used to denote wetlands designed for stormwater treatment as required by National Pollutant Discharge Elimination System (NPDES) permits. Constructed wetland will signify a mitigation wetland required for Clean Water Act Section 401 and Section 404 permits.

Swale: This term refers to a shallow, vegetated trough that conveys stormwater. Swales are designed based on a target flow rate for various design storms. Swales can be further classified by their vegetation type. For example, different types of swales include grass swales, landscaped swales, and wetland swales. The term vegetative or vegetated swale is too broad and will not be used by the HSP as an official stormwater control name. In addition, stormwater controls that are designed based on the water quality volume are basins and will not be referred to as swales. Swale signifies stormwater conveyance and rate-based design, not basin geometry.

STRUCTURAL STORMWATER CONTROL FIELD GUIDE

This field guide is intended to assist the user in identifying different types of post-construction stormwater controls used by NCDOT. Post-construction stormwater controls treat stormwater runoff from roadway surfaces and other NCDOT facilities. The photos and descriptions provided represent typical examples of NCDOT structural controls and their identifying characteristics. However, each structural control will vary depending on site-specific conditions.

Filtration Basin

A SHALLOW BASIN WITH ENGINEERED OR AMENDED SOIL AND AN UNDERDRAIN SYSTEM

Filtration basins function by detaining stormwater in the basin. As stormwater infiltrates through the amended soil, sand, or engineered media, pollutants are filtered and adsorbed onto soil particles. Treated stormwater is directed to the receiving stream via the underdrain system.

- Filtration basins may be shaped like ponds or channels.
- To improve pollutant removal, the basin may be covered with grass, wetland species, or landscaped vegetation (see Bioretention Basin).
- Sand filters are considered filtration basins.
- Filtration basins *may* have outlet control structures and emergency spillways. However, all filtration basins have underdrain systems.

Bioretention Basin

A TYPE OF FILTRATION BASIN WITH ENGINEERED MEDIA, AN UNDERDRAIN SYSTEM, AND LANDSCAPED VEGETATION

Bioretention basins use a landscaped mix of water-tolerant plants to improve pollutant removal. The vegetation is selected for its ability to physically filter and uptake stormwater pollutants. As with all filtration basins, stormwater is infiltrated through amended soil or an engineered media before it enters the underdrain system.

- Selected vegetation simulates various ecosystems such as forests, meadows, and hedgerows
- Bioretention basins are suited to drainage areas less than 1 acre.
- Bioretention basins may include outlet control structures and emergency spillways, but they will always have underdrain systems.

Dry Detention Basin

A SHALLOW, DRY BASIN WITH AN OUTLET PIPE OR ORIFICE AT THE INVERT OF THE BASIN

Dry detention basins attenuate peak discharges and temporarily detain runoff to promote sedimentation of solids and infiltration. Runoff is slowly released from an outlet control structure at a steady flow rate to increase detention time.

- Dry detention basins may be shaped like ponds or channels.
- The primary outlet control structure is located at the invert of the basin, allowing stormwater to drain slowly and completely between storm events.
- Dry detention basins are identified by the presence of an outlet control structure and an emergency spillway.

Wet Detention Basin

A SHALLOW BASIN THAT MAINTAINS A PERMANENT POOL OF WATER BY USING AN ELEVATED OUTLET CONTROL STRUCTURE

Wet detention basins treat stormwater through sedimentation and biological uptake of pollutants by plants, algae, and bacteria. Stormwater runoff in excess of the permanent pool is slowly released from the basin to prevent downstream erosion.

- Wet detention basins may be shaped like ponds or channels.
- The outlet control structure is elevated above the invert of the basin, allowing pollutant-laden solids to settle to the bottom and cleaner surface water to exit.
- The wet detention basin may have additional capacity for detaining and slowly releasing volumes greater than the permanent pool volume.
- Wet detention basins contain an emergency spillway to convey large events.
- Vegetation growing around the perimeter of the basin provides for biological uptake of nutrients from the water.

Infiltration Basin

A SHALLOW BASIN IN PERMEABLE SOILS THAT DETAINS AND INFILTRATES STORMWATER RUNOFF

Infiltration basins use porous soils to infiltrate stormwater. During infiltration, pollutants are physically filtered and adsorbed by the native soil. Infiltration basins provide total runoff volume control for all runoff equivalent to and smaller than the design storm and help to recharge groundwater.

- Infiltration basins may be shaped like ponds or channels.
- Infiltration basins *may* have outlet control structures and emergency spillways.
- Infiltration basins rarely have underdrain systems. The purpose of the underdrain system in an infiltration basin is to facilitate maintenance.

Hazardous Spill Basin

A SHALLOW BASIN WITH AN OUTLET CONTROL STRUCTURE THAT CAN BLOCK THE ENTIRE CROSS-SECTIONAL AREA OF FLOW

Hazardous spill basins (HSBs) are designed to contain hazardous materials in the event of an accidental spill. During normal operation, stormwater runoff flows unimpeded through the basin. In the event of a spill, the outlet control structure is manually activated, preventing discharge from the basin.

- HSBs may be shaped like a pond or a channel.
- Sluice gates or sand bags are typically used to block the basin outlet.
- Some HSBs are marked by a sign with instructions to personnel on how to contain a spill.
- The HSB outlet control structure may be designed to provide detention in some applications.

Stormwater Wetland

AN ENGINEERED MARSH OR SWAMP WITH DENSE WETLAND VEGETATION

Stormwater wetlands mimic the water treatment ability of natural wetlands. Stormwater wetlands remove a variety of pollutants, primarily through biological uptake via plants and microorganisms.

- Stormwater wetlands, as opposed to naturally occurring wetlands, have distinct inlet and outlet structures.
- Vegetation grows throughout the wetland.
- Shallow pools of standing water are usually present, although some wetlands are designed for subsurface flow.
- Thick vegetative growth around the edges of the wetland aids in the biological uptake of pollutants.

Swale

A BROAD AND SHALLOW CHANNEL WITH DENSE VEGETATION

Swales convey and treat peak runoff from small drainage areas. Swales decrease runoff velocity to promote infiltration and physical filtration. Swales also increase contact time between runoff and vegetation to promote biological uptake of pollutants.

- Swales are shaped like channels and are designed based on target flow rates.
- Swales require nearly flat longitudinal slopes to function. Some applications use water quality rock checks to reduce the effective slope.
- Swales do not incorporate underdrain systems. Channel-shaped stormwater controls that use underdrain systems are filtration basins, not swales.

Level Spreader

A TROUGH AND LEVEL LIP USED TO REDISTRIBUTE CONCENTRATED STORMWATER AS DIFFUSE FLOW

Level spreaders provide a nonerosive outlet for concentrated runoff by diffusing the water uniformly across a stable slope.

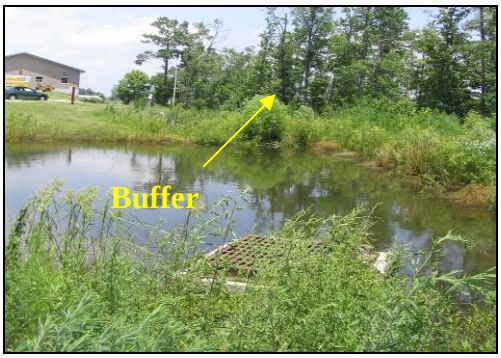
- Level spreaders are implemented upstream of buffers, swales, and basins to improve infiltration and biological uptake.
- Level spreaders are implemented downstream of stormwater controls to prevent stormwater from reconcentrating.
- Level spreaders are implemented on nearly flat grades to prevent reconcentration of runoff.
- The length of the level spreader trough will vary, depending on the stormwater discharge rate.

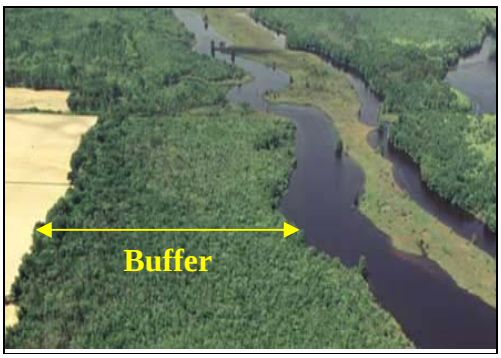
Filter Strip (component)

A LINEAR SECTION OF LAND, EITHER GRASSED OR FORESTED, THAT PHYSICALLY FILTERS AND INFILTRATES STORMWATER.

Filter strips intercept perpendicular, diffuse flow, much the same way a buffer does. As runoff enters the filter strip, dense foliage and thick root mats physically filter out solids while reducing the peak flow rate.

- Runoff must be in the form of diffuse flow for filter strips to function. Filter strips are often located downstream of level spreaders and preformed scour holes.
- Filter strips may consist of tree stands, shrubs, grass, or a combination thereof.
- Filter strips may be located along the perimeter of a water bodies as well as nonriparian areas.
- Unlike buffers, filter strips are regularly managed through mowing, trimming, and replanting.





Bottom Photo: North Carolina Department of the Environment and Natural Resources (NCDENR)

Buffer (component)

A SECTION OF DENSE WOODY OR GRASSY VEGETATION ALONG THE RIPARIAN CORRIDOR OF A WATER BODY

Buffers are constructed or natural strips of vegetation located along the banks of a water body. Buffers perform many of the same functions as filter strips. The buffer vegetation acts as a filter to remove pollutants from runoff and shallow groundwater.

- Thin buffers provide bank stabilization, whereas wider buffers remove solids and uptake dissolved pollutants.
- Unlike filter strips, buffers should require little or no management.
- Buffers may be configured according to the two-zone or three-zone model. In these models, the areas closest to the stream bank are undisturbed forest. Landward areas are made up of shrubs or grass.
- In some watersheds, riparian buffers are subject to Riparian Area Protection Rules (i.e., buffer rules) that restrict development.

Preformed Scour Hole (component)

A RIPRAP-LINED BASIN FORMED AT THE OUTLET OF A POINT DISCHARGE

By providing a stable impact point for peak flows, a preformed scour hole (PFSH) dissipates energy and diffuses flow. PFSHs prevent downgrade erosion and promote infiltration.

- The basins are reinforced with riprap to prevent erosion and scour.
- PFSH are used with pipe diameters of 18 inches or less.
- An apron of permanent soil reinforcement matting (PSRM) is required downgrade of PFSH to prevent scour.

Forebay (component)

A SMALL BASIN LOCATED UPSTREAM OF ANOTHER STORMWATER CONTROL

Forebays are pretreatment devices designed to remove large stormwater particles. Forebays are important components of stormwater control systems because they improve the pollutant removal efficiency and extend the life of downstream controls.

- Forebays are always located upstream of other stormwater controls, generally controls in the basin family.
- Stormwater usually transitions from the forebay to the downstream control via a weir.
- Forebays are typically lined with riprap and filter fabric.