NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

STORMWATER CONTROL MEASURE
INSPECTION AND MAINTENANCE MANUAL
(LAST UPDATED: OCTOBER 2022)

North Carolina
Department of Transportation

NCDOT HSP 2022-10

Revision History

Date	Description
May 2015	• Added Permeable Pavement and Preformed Scour Hole Chapters (14 and 15) and associated inspection checklists.
October 2022	• Updated terminology throughout the manual to current state of practice. • Added Catch-All Chapters (Chapters 16-A to 16-H) and associated inspection checklists. • Divided the Swale Chapter (Chapter 14) into 4 sub-classifications and added swale sub-classification inspection checklists. • Updated chapter figures to correspond with the 2014 BMP toolbox

Acronyms

BB	Bioretention Basin
BE	Bioembankment
BFC	Biofiltration Conveyance
BMP	Best Management Practice
BS	Bioswale
C	Cistern (both above- and underground)
DDB	Dry Detention Basin
DEO	Division Environmental Officer
DEQ	Department of Environmental Quality
DREE	Division Roadside Environmental Engineer
DSO	Division Safety Officer
FB	Filtration Basin
FEMA	Federal Emergency Management Agency
FWI	Floating Wetland Island(s)
GPS	Global Positioning System
GR	Green Roof
HDPE	High-Density Polyethylene
HSB	Hazardous Spill Basin
IB	Infiltration Basin
IC	Infiltration Chamber
IS	Infiltration Swale
IWS	Internal Water Storage
LOS	Level of Service
LS	Level Spreader
NCAC	North Carolina Administrative Code
NCDENR	North Carolina Department of Environment and Natural Resources
NCDEQ	North Carolina Department of Environmental Quality
NCDOT	North Carolina Department of Transportation
NCHRP	National Cooperative Highway Research Program
NCSU	North Carolina State University
NPDES	National Pollutant Discharge Elimination System
NRC	National Response Center
PICP	Permeable Interlocking Concrete Pavement
PP	Permeable Pavement
PSH	Preformed Scour Hole
PSRM	Permanent Soil Reinforcement Matting
PVC	Polyvinyl Chloride
REU	Roadside Environmental Unit
RFOE	Roadside Field Operations Engineer
ROW	Right-of-Way or Rights-of-Way
S	Swale, Grass Swale
SCM	Stormwater Control Measure
SCMS	Stormwater Control Management System

SW	Stormwater Wetland
USEPA	United States Environmental Protection Agency
WDB	Wet Detention Basin
WS	Wet Swale

Glossary

Accumulated Sediment	Sediment that has accumulated in the SCM, inlet or outlet drainage systems, or elsewhere that has migrated in via use of the SCM and is not part of the design.
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.
Biological Uptake	Ability of soil, plants, filter media, etc. to filter out pollutants from stormwater runoff.
Buffer	Zone between the SCM and the indicated critical area, typically sensitive waters, that requires minimal disturbance.
Bypass	A typically established flow pattern that is designed and installed to allow an overflow of water to pass around the established outlet to avoid erosion.
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 (e.g., tanks, vessels, silos, storage bins, hoppers, vaults, and pits); and (3) is not designed for continuous employee occupancy (29 CFR 1910.146).
Contaminants	Chemicals, sediment, oils, etc. that do not naturally belong in the environment. This typically refers to these substances in stormwater runoff that SCMs help contain or treat.
Conveyance	A channel or pipe that is designed to convey water (in most cases). A conveyance channel does not always provide runoff treatment but is installed to avoid erosion occurring from flows.
Dense Stand/Cover	When referring to a dense cover of turf-type grasses or other vegetation, the typical NCDOT standard is to have the vegetation covering 80% of the ground (also called 80% density) in the determined area, such as in and around an SCM.
Diffuse Flow	Another term used to describe sheet flow.
Dissipate Flow	Another term used to describe diffuse or sheet flow.
Downgrade Erosion	Erosion occurring downgrade/downstream/down the slope from the structure being discussed, such as an SCM or outlet pipe.
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), 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.
First Flush	The initial high flow from a storm event. The first flush typically includes a higher amount of litter, sediment, or other contaminants than the remainder of the storm event.
Frozen Sluice Gate	The term used to describe a sluice gate when it cannot turn. This could mean that the sluice gate is rusted too much to be moved, needs grease, or has something caught around the worm gear preventing the handle from turning.
Furrowing	A rut, groove, tire track, rill, or other channelized erosion.
Hazardous Spill	Accidental spills with materials that would pollute or contaminate the environment, particularly bodies of water.
Impervious Surface	A land cover through which water cannot infiltrate; examples include concrete, asphalt, rooftops.
Infiltration	The act of water percolating 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.
Internal Water Storage (IWS)	An SCM that is designed with an Internal Water Storage is meant to detain water for some period of time, typically used to treat the stormwater runoff by allowing it to filter through soil/media. An IWS is likely present if an SCM is meant to be wet most/all of the time or can be identified if an outlet structure or underdrain system has an upturned elbow in the design.
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.
Maintenance (Non-Routine)	Maintenance needed for an SCM that would not otherwise routinely happen, such as sediment removal, cleaning out an inlet or outlet drainage system, or repairing a breach in the berm.
Maintenance (Routine)	Maintenance that typically occurs in an SCM such as mowing or litter pickup.
Nutrients	Contaminants, typically nitrogen or phosphorus, that are often present in stormwater runoff. Excessive nutrients from runoff can accelerate unwanted plant growth, such as algae.
Overtopping	When the amount of water flowing into an SCM exceeds its volume, water overtops the banks, berms, etc. of the SCM.
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.
Permeability	A material that allows water to flow through it.
Pollutants	Contaminants present in stormwater runoff, such as nutrients, litter, and sediment, that are introduced to an environment where it alters the natural balance of the ecosystem.
Pretreatment	Treatment of stormwater that allows large sediment particles and litter to settle out before the runoff continues into the main part of the SCM, such as the basin.
Randleman Rules	Rule that prohibits any fertilizer application within 30 feet of any stream or water body that falls under certain protections, typically sensitive or high-quality water bodies.
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 Water Body	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. Refer to NCDEQ Stream Classifications for more information.
Scouring	Intense erosion that occurs due to heavy flows. This frequently results in the formation of a hole, berm failure, or major rut.
Sediment	Soil that has been eroded and deposited elsewhere; typically contains pollutants and has a negative impact on aquatic environments.
Sedimentation	A physical process that helps remove primary runoff pollutants such as sediment and particulate-bound heavy metals and nutrients due to particles falling out of the water column.
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.
Sloughing	Sheets, sections, or large segments of soil that shed from a slope. Sloughing usually occurs in larger clumps or quantities.
Stormwater	A term used to describe water that originates from precipitation; often used interchangeably with the term *runoff*.
Stormwater Control Measure (SCM)	A structural device designed, constructed, and maintained to manage and/or treat stormwater pollutants to reduce surface water pollution.
Suspended Solids	Small particles carried in stormwater because of erosion; regarded as an indicator of water quality.
Toe (of embankment)	The bottom of the embankment where it meets the natural ground.

Transition Berm	A small berm that is meant to transition one pool or basin to another; this is most often present between forebays and the SCM that follows downstream.
Trash Rack/Screen	A trash rack is a large metal cage-like component that is meant to protect the outlet structure or orifice from large debris or litter. A trash screen has the same purpose but typically has smaller openings, making it more mesh-like. Trash racks are usually on the top of an outlet structure, while trash screens are usually covering an orifice in the side of an outlet structure.
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 as 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; therefore, stormwater, in essence, becomes a transportation system for pollutants. As stormwater flows over hard surfaces, it picks up oil, antifreeze, salt, litter, and other pollutants. Stormwater also picks up soil and organic material as it flows overland. Pollutants transported by stormwater are deposited into streams, rivers, and other bodies of water where they can degrade 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 control measures (SCMs) across the state, typically within NCDOT rights-of-way or on NCDOT properties, 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 reduce pollutants before releasing the water to a stream. In some situations, depending on the type of device and soil types, the water can also be returned to the ground via infiltration, thus promoting groundwater recharge. SCMs can also be 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 temporary silt fences and silt basins).

1.2 Purpose

SCMs must be routinely inspected and maintained to make sure 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. Furthermore, lack of maintenance can cause reduced SCM functionality, and it may require significant costs to restore an improperly maintained SCM back to the original intended function.

In 1998, NCDOT was issued a National Pollutant Discharge Elimination System (NPDES) permit by the North Carolina Department of Environmental Quality (NCDEQ). The NPDES permit authorizes NCDOT to discharge stormwater runoff from its roadways and industrial facilities and borrow pit wastewater into North Carolina's waterways, following proper stormwater management methods. The NPDES Permit requires that NCDOT maintain and implement a SCM Inspection and Maintenance program. To support this requirement, NCDOT developed this SCM Inspection and Maintenance Manual which maintains written procedures outlining the inspection and maintenance requirements for various types of SCMs. This manual outlines the regular inspection frequency and includes inspection checklists, "how-to" instructions for regular maintenance, evaluation and reporting procedures for non-routine maintenance, and procedures for documenting inspection and maintenance data into NCDOT's tracking mechanism. Currently, the NCDOT's tracking mechanism is referred to as the Stormwater Control Management System (SCMS, pronounced "skims"). This manual is updated as modifications are needed or to reflect changes in inspection and maintenance techniques. Additionally, if any new SCM types are added to the NCDOT Toolbox, then a corresponding inspection and maintenance chapter or other guidance language is added to this manual.

This manual, entitled *North Carolina Department of Transportation Stormwater Control Measure 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 SCMs on NCDOT properties.

1.3 How to Use this Manual

This manual is intended to be a practical tool to aid in the inspection and maintenance of SCMs. As such, Chapters 1 through 4 include a general discussion of inspection requirements,

maintenance considerations, and reporting requirements for structural SCMs. The remainder of the manual contains chapters on individual SCMs.

CHAPTER 2 — INSPECTION

Chapter 2 lists some of the common inspection procedures required for most SCMs; 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 non-routine maintenance procedures that may be needed when maintaining SCMs.

CHAPTER 4 — REPORTING AND RECORD KEEPING

Chapter 4 discusses the procedure for reporting and documenting inspection and maintenance activities in NCDOT's tracking mechanism, NCDOT's SCMS.

CHAPTERS 5 THROUGH 16 — STORMWATER CONTROL MEASURES

Chapters 5 through 16 provide a more detailed overview of different types of SCMs. Included is a general description of the SCM and its components, guidance on inspection and maintenance requirements for each component of the SCM, photographs of the SCM, and detailed renderings and engineering diagrams of the SCM.

APPENDIX A — INSPECTION AND MAINTENANCE CHECKLISTS

Appendix A provides an inspection checklist for each type of SCM. Each inspection checklist, which covers structural components of the SCM, is to be filled out at the time of the inspection. A maintenance report is included for any non-routine maintenance that can be used for any SCM. The maintenance completed form is used to document what non-routine maintenance was performed at the SCM as a follow-up from the initial inspection.

APPENDIX B — NCDOT STORMWATER CONTROLS NAMING CONVENTION

Appendix B provides a list of acceptable terms used to describe SCMs, a field guide with images, and descriptions of the different types of SCMs used by NCDOT.

1.4 Disclaimer

This manual provides guidance for inspection and maintenance procedures for typical SCMs owned and/or operated by NCDOT. These guidelines are not intended to be a comprehensive reference on every aspect of SCM inspection and maintenance. Additional references should be consulted as needed to maintain a safe and functional structural SCM. Further, it would not be possible to properly address every configuration or issue that might arise. Unique circumstances may require deviation from the guidance contained in this manual. 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 inspecting and maintaining NCDOT SCMs. If a particular situation should require deviation from the methods, procedures, and/or criteria presented in this manual, contact the NCDOT Roadside Environmental Unit (REU) in Raleigh for additional guidance.

CHAPTER 2 Inspection

2.1 Inspections

Stormwater control measures (SCMs) must be routinely inspected and have the necessary maintenance performed on them, so they continually function as designed. Specific inspection details for each SCM are presented in Chapters 5–16 of this manual. Refer to the appropriate SCM chapter when completing an inspection checklist. The following is a list of common problems that may be encountered during an inspection, but this is not an exhaustive list, so refer to the individual SCM chapters.

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 inlets and outlets, filter strips, or forebays
- Cracks or settling (small sinkholes) in the embankment or berms
- Deterioration of downstream channels

Spills/Releases

- Hazardous spill
- Illicit discharge
- Illegal dumping

2.2 Frequency of Inspection

NCDOT SCMs shall be inspected annually at a minimum, unless specified otherwise by environmental permits or other policies and regulations. For example, Preformed Scour Holes (PSHs) are inspected one year post construction. If this inspection passes, no further inspections are required. See Chapter 15 for further information about this policy.

2.3 Site Visit Preparation

Before going into the field to conduct inspections, the person(s) conducting the inspection should be adequately prepared. The following items may be needed when conducting SCM inspections:

- Tablet computer with wireless access to SCMS database so the inspector can access and complete SCM inspection forms, reference past inspection and maintenance records, and view a copy of this manual
- If tablet computer is not available, then
    - A hardcopy of this manual
    - Hardcopies of SCM inspection checklists
    - Global positioning system (GPS) unit and local maps (if available)

- Digital camera
- Shovel, bush axe, and/or rake
- Hand pruners and/or loppers
- Waders or waterproof boots
- Sunscreen and insect repellent

2.4 Safety Considerations

Safety considerations must be a constant focus during SCM inspections. Prior to conducting the inspection, anticipate any potential hazards based on recent or current conditions (e.g., flooding after a heavy rain). Always avoid hazardous conditions and document them on the inspection checklist. Refer to the NCDOT *Workplace Safety Manual* (latest edition) for safety practices.

The following list highlights common safety concerns when performing SCM inspections:

- Never conduct inspections of confined spaces alone, or 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 roadway.
- 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 checklist.
- If toxic, hazardous, or unknown substances are discovered in the area, leave the vicinity and report the findings by contacting 911 and Division Safety Officer (DSO).
- 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.

2.5 Reporting and Record Keeping

Observations made at the time of inspection pertaining to the status of the SCM shall be documented according to the reporting procedures presented in Chapter 4 of this manual. Inspection findings and maintenance activities should be noted on the appropriate inspection checklist (see Appendix A) and then entered into NCDOT's Stormwater Control Management System (SCMS). Refer to Chapter 4 for further guidance on documentation and entering information into SCMS.

CHAPTER 3 Maintenance

3.1 Maintenance of Stormwater Control Measures

Stormwater control measures (SCMs) require two basic types of maintenance: (1) routine maintenance, and (2) non-routine maintenance where SCMs need immediate attention to restore the intended function. All non-routine 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 should be documented using the reporting procedures presented in Chapter 4 of this manual.

If immediate maintenance needs are identified, 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 make sure that corrective actions have been satisfactorily completed and normal operation has been restored. **Correspondence and corrective actions must be documented and entered into the SCMS database immediately after the inspection or maintenance activities are completed.**

This chapter describes the maintenance activities most commonly required when maintaining NCDOT SCMs. Actual maintenance needs may vary, depending on specific site conditions. A schedule for maintenance activities based on the SCM Level of Service (LOS) scores is provided in Section 3.4.

3.2 Routine Maintenance

Routine maintenance is any procedure performed on a regular basis to maintain the proper working order of an SCM. 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 from basins, pipes, orifices, and weirs
- Upkeep of mechanical and 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 personnel.

Care should be taken to avoid using equipment that could cause soil compaction in or around SCMs. 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 an SCM, 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 Chapter 2 Section 4 for a list of common safety concerns.

3.2.1 Desirable Vegetation Maintenance

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

Periodic maintenance of desirable vegetation is required to make sure 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 vegetation. Provisions may be needed to supplement or replace some vegetated areas due to plant loss. Supplemental and replacement plantings should occur during the appropriate planting season for the particular species being utilized. These new plantings require additional care until they are well 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 SCMs. Additional information and guidance can be found in NCDOT's *Vegetation Management Manual*.

Turf-Type Grasses

Turf-type grasses are common to most NCDOT SCMs. They can be the major component in an SCM's makeup or simply used to stabilize the areas surrounding an SCM.

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

Turf-Type Grasses

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

CENTIPEDE GRASS, 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, erosion, 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 in an unhealthy growing state should be evaluated to determine the maintenance needs (e.g., 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 (and any nearby storm inlets) so they do not add excess nutrients to the water.**

Herbaceous Plants and Native/Ornamental Grasses

Some SCMs have as a part of their makeup a carefully designed mixture of herbaceous plants and native/ornamental grasses. This vegetation is essential to the operation and function of the SCM. Planted within certain SCMs, this vegetation not only stabilizes the soil and prevents erosion, but also reduces 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 NCDOT SCMs.

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 SCM'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.

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 vegetation is very slow to recover when compromised, and the end result is often the death of the plant.

JUNCUS, SOURCE: NCDOT

Trees and Shrubs

Trees and shrubs are essential to the operation and function of certain SCMs. Often used on the floor of stormwater wetlands and wet detention basins, trees and shrubs provide valuable shade, which helps regulate water temperatures. High water temperature can be harmful to aquatic species, 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 SCMs that contain underdrain systems (e.g., bioretention basin). Trees and shrubs used in this capacity can increase safety by discouraging people from entering the SCM. They can also enhance the aesthetic appeal of the SCM, enabling it to blend in with the landscape. The following is a list of the tree and shrub species commonly used in association with NCDOT SCMs.

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. Remove trees and shrubs entirely if they are causing damage to the embankments.

Turf-type grasses, 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 an SCM. A mulch layer of aged, triple-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 any water within the SCM 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 the NCDOT Division Environmental Officer (DEO) 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 .0610, .0611, .0612, and .0714 of NCAC's Subchapter 02B Surface Waters and Wetlands Standards [NCAC 2020]) 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 in Raleigh or the Division Roadside Environmental personnel, or refer to NCDOT's *Vegetation Management Manual*. Some environmental permits might prohibit the use of fertilizers for maintenance purposes. For information pertaining to site-specific fertilizer restrictions, contact the DEO.

3.2.3 Undesirable Vegetation Removal

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

Desirable vegetation 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 SCMs that have underdrain piping.

The following is a list of the most common undesirable plant species found during NCDOT SCM 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	Annual 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

Annual Ragweed, Source: USDA

Broadleaf Weeds (continued)

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

Cyperus esculentus	Yellow Nutsedge
Cyperus rotundus	Purple Nutsedge
Microstegium vimineum	Japanese Stiltgrass
Typha sp.	Cattail

Trees

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

YELLOW NUTSEDGE, SOURCE: NCCES

Remove undesirable vegetation before it becomes established. Once established, this vegetation can have an adverse effect on the survivability of desirable plants and the aesthetic appeal of SCMs. 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 excess nutrients to the water. Additional information on removal of invasive species can be found in NCDOT's *Invasive Exotic Plants of North Carolina* (NCDOT, 2012).

3.2.4 TRASH AND DEBRIS REMOVAL

Trash and other debris can pollute surface waters and damage SCMs. The removal of floating trash and other debris will not only improve water quality, it will also reduce the potential for outlet clogging during storm events and improve the overall aesthetic appeal of an SCM. 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 beds, side slopes, and other components, as well as from the area surrounding the SCM.

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 fully 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 Non-Routine Maintenance

Non-routine or immediate maintenance is a repair performed to correct a problem and restore an SCM to its proper working order. Tasks associated with non-routine maintenance include, but are not limited to:

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

Since non-routine maintenance needs (e.g., berm failure) often require both structural repair and soil stabilization work, it is anticipated that most non-routine repairs will performed jointly by Division Maintenance and Roadside Environmental personnel. If non-routine 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 SCMs. 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 an SCM, 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 non-routine maintenance. Refer to Chapter 2 Section 4 for a list of common safety concerns.

3.3.1 Sediment Removal

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

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

Sediment that has accumulated and is inhibiting the function of an SCM must be removed. In general, remove sediment if it appears to have accumulated more than 3 inches or is impeding the function. 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 SCM where stormwater could come into contact with it and transport it back to the SCM or nearby receiving waters. If there is evidence of pollution (a sheen on the sediment or odor), contact the DEO and/or DSO 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 example conditions could lead to structural failure and may necessitate a non-routine 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 reduction benefits of an SCM. 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, or cause erosion on dams and embankments. 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 that is not removed can also impede access to SCM outlet control structures, preventing proper operation of devices such 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. When removing rooted plants from the filer media, depending on the size of the root mass and depth, the filter media may need to be replaced and provide sand-based sod grass to immediately provide vegetative surface cover; otherwise the filter media could washout or form a sinkhole.

3.3.5 Animal Burrow Repair

Voids created by animal burrows can weaken dams and embankments and create preferential flow paths of water through the embankment, resulting in structure failure. Animal burrows found in the dams, berms, and embankments of SCMs should be filled in as soon as possible. Burrows should be excavated and cleaned of all loose/excess soil and/or debris along the pathway. The excavated area should be leveled and then backfilled and properly compacted using an appropriate earthen material. If the burrows are greater than 3 feet in depth, flowable fill may be used to close the burrows in-place, as directed by an Engineer. Care should be taken to ensure that low pressure filling occurs to avoid blowing out embankment sections. After filling

the burrow, 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.

3.4 Maintenance Schedule

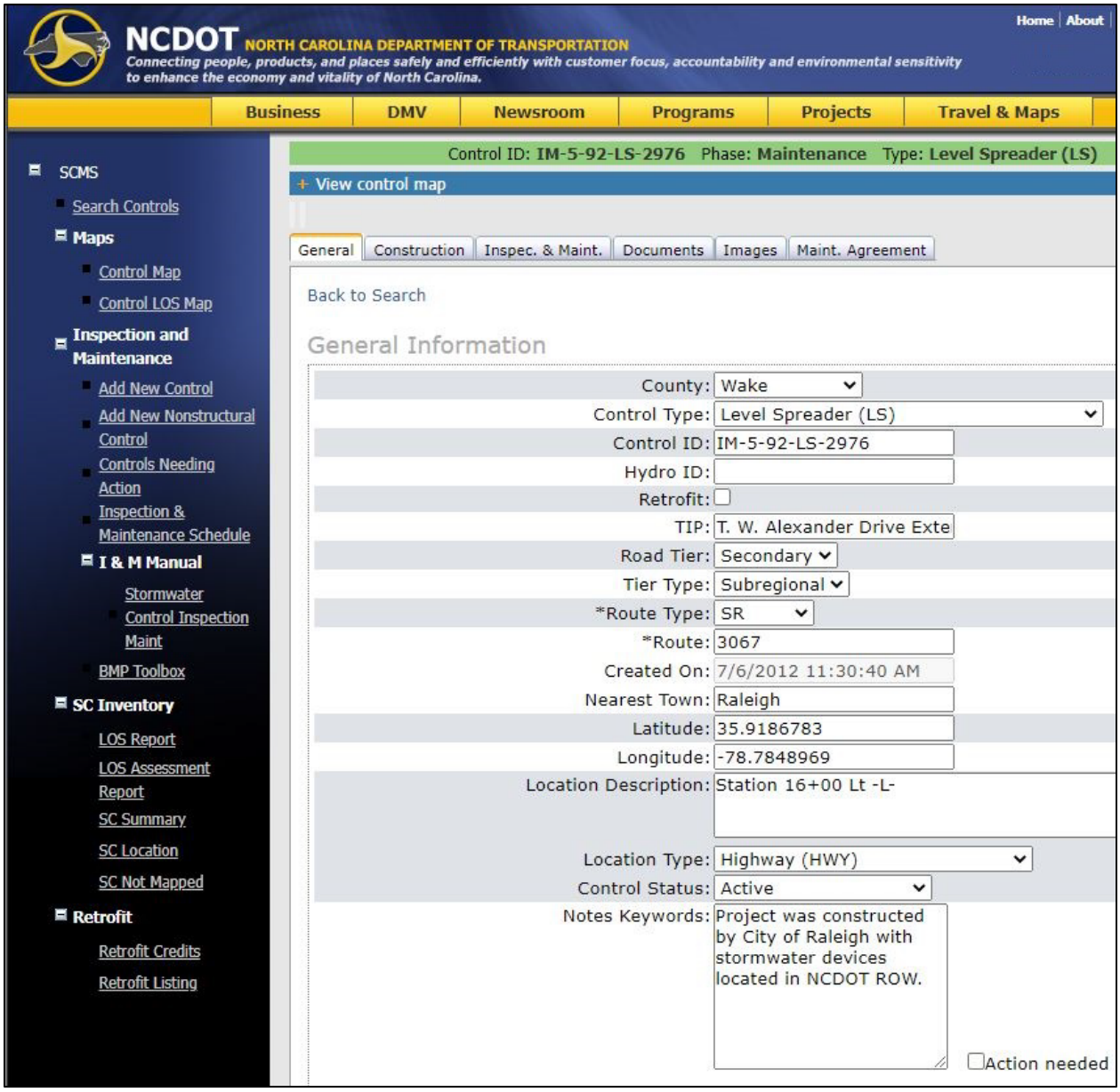
Routine maintenance includes procedures performed on a regular basis to maintain the proper working order of an SCM. Non-routine or immediate maintenance are performed to correct a problem and restore an SCM to its proper working order.

The proposed schedules for maintenance needs are determined by the Level of Service (LOS) rating determined during the inspection.

LOS Rating	Level of Service Description	Proposed Maintenance Timeframe
A	Some aging and wear has occurred, but no structural deterioration or maintenance needs were found. Device is functioning properly.	Routine maintenance activities should continue.
B	Minor structural deterioration and/or maintenance needs were found, but function of the device has not been affected.	Routine maintenance activities should continue.
C	Moderate structural deterioration and/or maintenance needs were found, but function of the device has not been significantly affected.	Routine maintenance activities. Anticipated to be completed within 180 days of inspection.
D	Serious deterioration in at least one structural component and/or major maintenance needs were found. Function of the device is inadequate.	Immediate maintenance required. Anticipated to be completed within 90 days of inspection.
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.	Immediate Maintenance required. Anticipated to be completed within 90 days of inspection.

Note: The proposed maintenance timeframes were developed during the 2022 update of this manual. Thus, these timeframes will be considered for inspections completed in 2024 and beyond depending on maintenance needs and assuming NCDOT has the resources available to implement these proposed maintenance timeframes.

CHAPTER 4 Reporting and Record Keeping



4.1 Reporting Overview

NCDOT's NPDES Permit requires that NCDOT maintain written procedures outlining the inspection and maintenance requirements for various types of SCMs and an inspection and maintenance tracking mechanism. This manual and the web-based database described in the following paragraph were developed to comply with this requirement.

4.2 Inspection Documentation

Each SCM inspection should be documented using the corresponding SCM inspection checklist included in Appendix A of this manual. Proper documentation helps NCDOT adequately perform its inspection and maintenance responsibilities as required by the NPDES Permit.

Each completed inspection report should contain the following information, if applicable:

- Date of inspection
- Type of inspection (routine, non-routine, or follow-up)
    - **If an LOS rating of a "D" or "F" is issued and maintenance is necessary, a follow-up inspection should be performed after the maintenance has been completed.**
- Name of the inspector
- Type and location of SCM
- Current condition of the SCM
- 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 should be maintained in SCMS for at least a period of five years and should be made available to NCDEQ if requested.

4.3 LOS Ratings

After each inspection, the SCM should be assigned an LOS rating. The following table describes the ratings; however, it is important to note that ratings are subjective, and the overall functionality of the SCM 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 Rating	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 any type of accidental spill or illegal dumping is observed while conducting an inspection of a SCM, assess the situation and contact the 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. This is an online management tool used to track SCM inspection and maintenance activities. The general process for documenting inspection and maintenance of SCMs is as follows:

1. Perform the inspection using a tablet computer that provides wireless access to SCMS while in the field and complete the appropriate SCM Inspection report. SCMS can be searched to find each SCM by using the Control Map or the Search Controls page. The Control Map can be filtered by Division or Control Type, and the SCM can be selected by navigating to the location. The Search Controls page returns a list of SCMs based on the search features used (e.g., full or partial Control ID, Control Type, Division, County, or Control Status). Then, select the desired SCM from the automated list. In the Inspection report, document any notable findings or observations. Assign an LOS rating in the space provided on the inspection checklist.
    a. If unable to access SCMS via tablet computer during the inspection, then complete SCM inspection using blank hardcopy SCM inspection checklist(s) in the field, and upon returning to the office, transfer the hardcopy inspection information into SCMS by completing the appropriate Inspection reports for each SCM inspected.
2. Complete a separate Maintenance Needed or Maintenance Completed report in SCMS if needed. A Maintenance Needed report (Appendix A) needs to be filled out when non-routine maintenance needs are identified, and the party or parties responsible for repair need to be notified immediately. A Maintenance Completed report (Appendix A) should be filled out when the maintenance has been completed to ensure that the SCM has returned to a satisfactory standard.
3. Complete a follow-up inspection report after maintenance has been completed.
    a. If maintenance is performed NOT in association with an inspection, this information can later be entered and the LOS rating can be changed if the respective maintenance improved the LOS rating of the SCM.

A follow-up inspection must be conducted and entered into SCMS after all significant maintenance is performed on a SCM to verify that each need has been properly addressed and to make sure that the LOS rating is properly updated. This is especially important for SCMs with an existing LOS rating of a D or F.

It is recommended that during inspections, digital photographs be taken and entered into SCMS to track the status of each SCM and document the maintenance needed and maintenance completed activities. Preferably, photographs should be taken before and after maintenance is performed to document the improvements made to the SCM. In addition, photographs can be taken at each inspection to document the general condition of the SCM. Upload the appropriate photographs to the Images tab on the SCMS website when you are viewing the relevant SCM.

CHAPTER 5 Bioretention Basin

Overview

A BIORETENTION BASIN (BB) is a type of filtration basin (see Chapter 6) with landscaped shrubs and other various plants, filter media, and a mulch cover to enhance pollutant reduction.

PURPOSE AND DESCRIPTION

- Bioretention Basins are structural SCMs 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 reduction capabilities of the basin.

INSPECTION

- Ponded water should infiltrate into the filter media within 48 to 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 for 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.
- Sediment should be removed if there is greater than 3 inches of sediment accumulation in the forebay.

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

5.1 Bioretention Basin Overview

A Bioretention Basin (BB) is a soil and plant-based filtering system designed to reduce pollutants from stormwater runoff. It works by capturing stormwater runoff and allowing it to slowly infiltrate into the soil over a period of 48 to 72 hours. As stormwater slowly passes through the soil, pollutants are filtered out and adsorbed. The filtered water then enters the basin's underdrain system, where it exits the Bioretention Basin and flows to the nearest storm drainage system or surface water body.

Figure 5-1 illustrates the flow path and treatment processes in a typical Bioretention Basin.

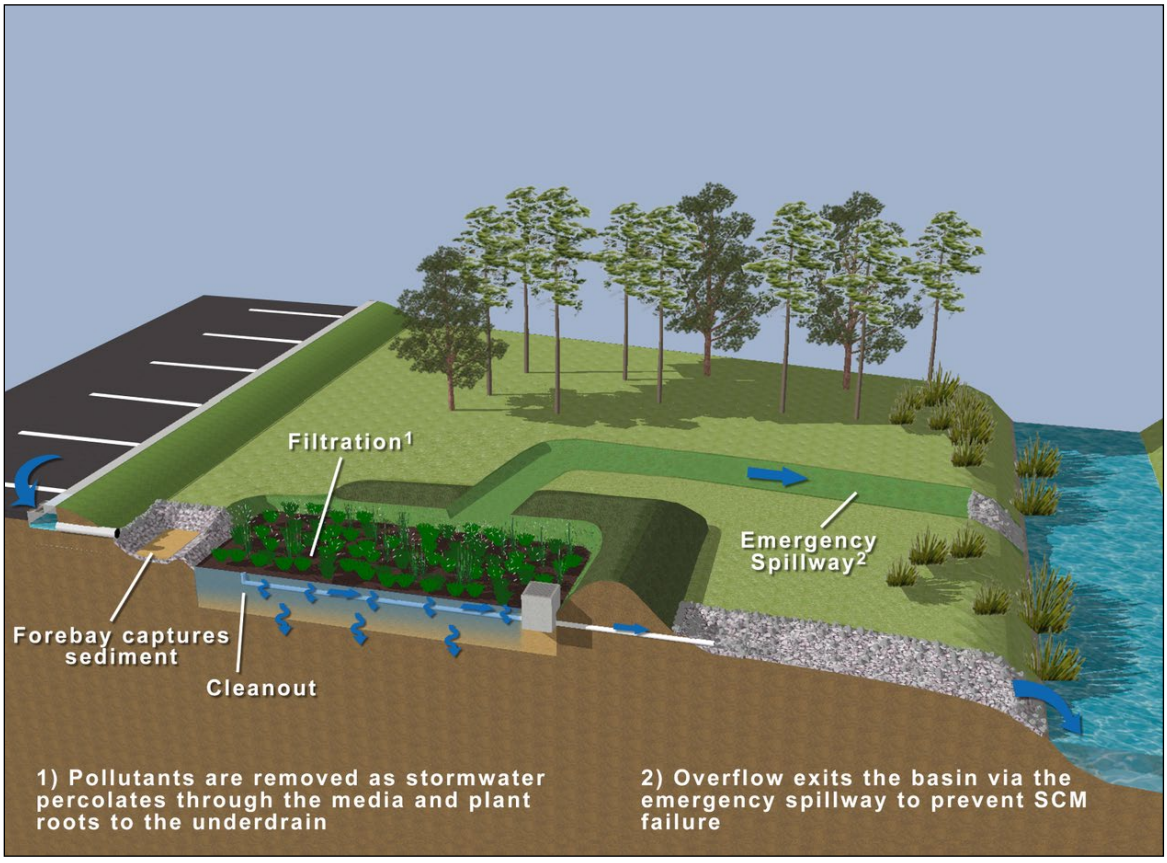


Figure 5-1. Cutaway of a Bioretention Basin layout and treatment processes

5.2 Bioretention Basin 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, excess runoff that does not enter through the inlet drainage system 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 7 for inspection and maintenance information and figures for flow bypass systems. The typical Bioretention Basin configuration includes the following components:

- Inlet Drainage System
- Forebay
  - Transition Berm
- Basin
  - Embankment, Filter Media
- Landscaping
- Underdrain System
  - Cleanout
- Outlet Control Structure
  - Trask Rack and/or Trash Screen
- Outlet Drainage System
  - Outlet Pipe, Outlet Protection, and Emergency Spillway, if present

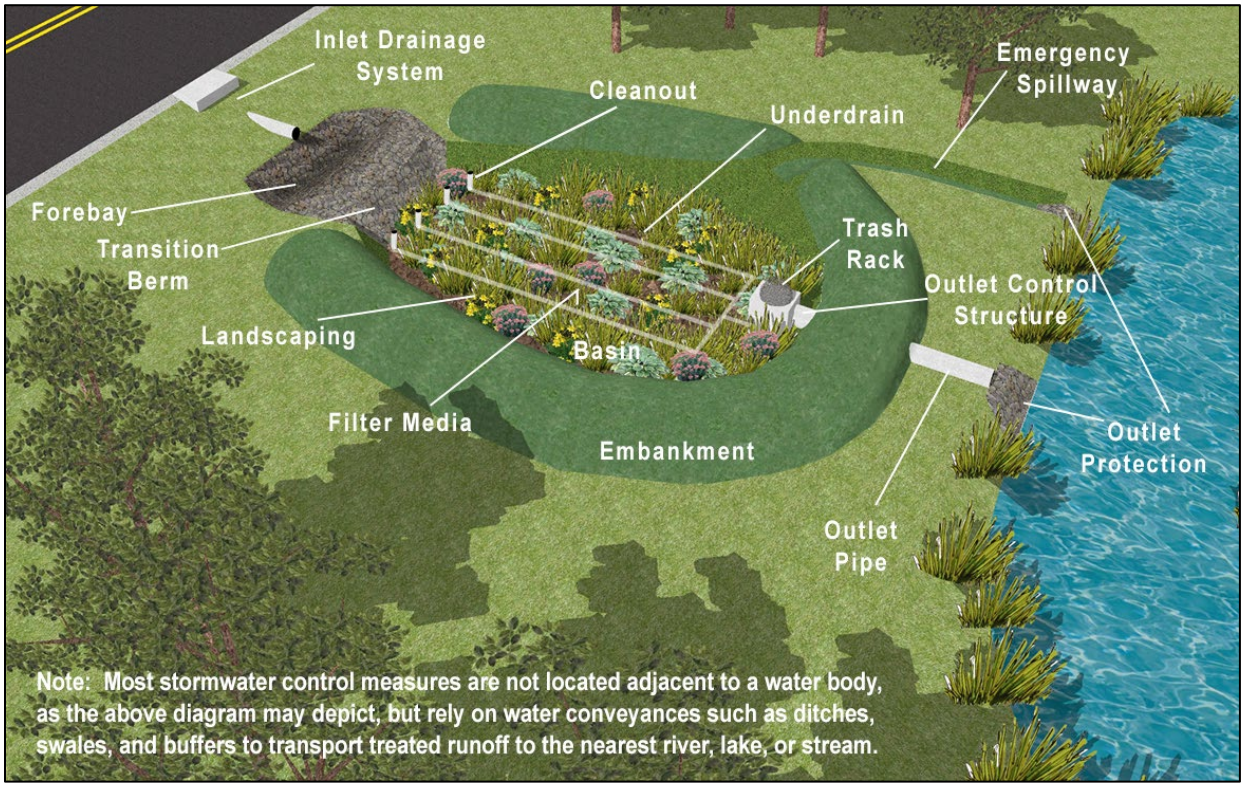


Figure 5-2. Bioretention Basin layout and components

5.3 Inspection and Maintenance

Bioretention Basins should be inspected periodically to determine whether they are functioning as intended. Refer to Chapter 2 for recommended inspection frequency. If any part of the Bioretention Basin is not functioning properly, determine the cause and restore the SCM 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.

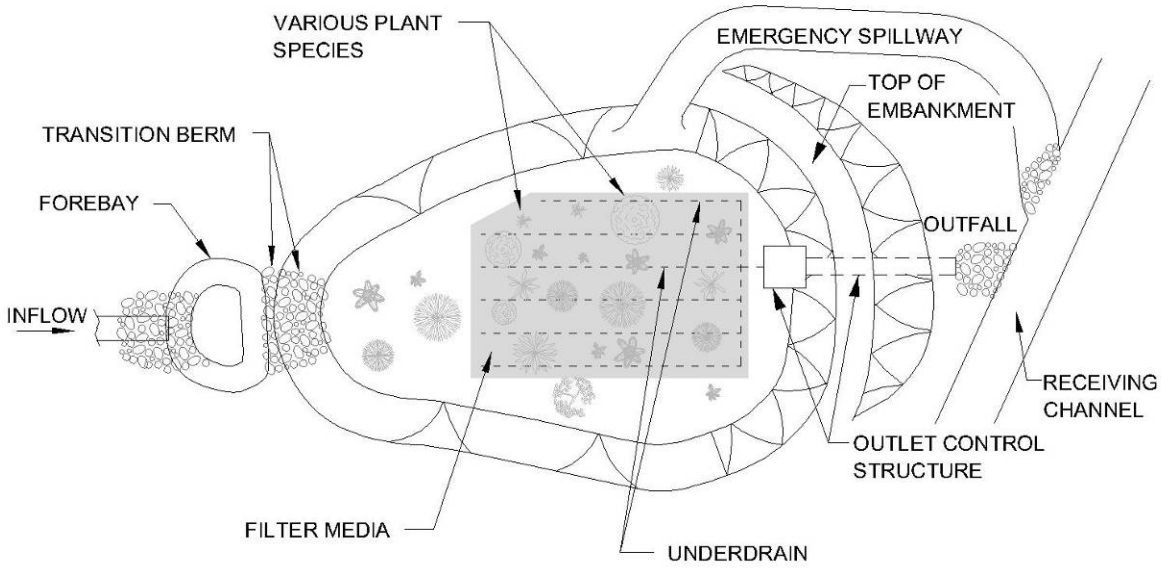


Figure 5-3. Plan view of a Bioretention Basin and its components

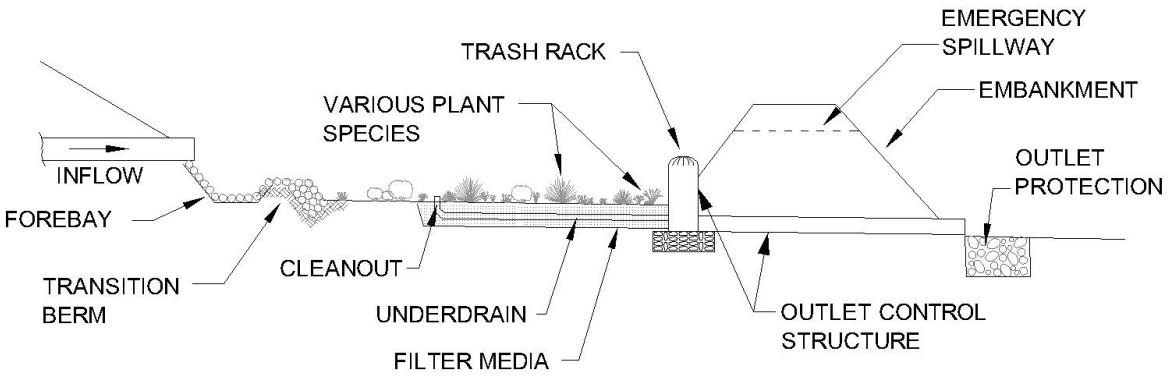


Figure 5-4. Profile view of a Bioretention Basin and its components

All inspection findings and maintenance activities should be entered into SCMS via mobile devices in the field. In cases of technical difficulties, these should be noted on the inspection checklist (see Appendix A) and entered into SCMS upon return to the office. Take photographs and upload them to SCMS to track the status of the SCM. Document the maintenance activities and inspections. Refer to Chapter 4 for further guidance on I&M reporting.

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, curbs and gutters, and catch basins. Some Bioretention Basin designs use flow bypass structures to divert a predetermined amount of runoff to the SCM while bypassing excess flow so that the basin, outlet control structure, and embankment do not fail. If this is the case, refer to Chapter 7 for inspection and maintenance guidance on flow bypass systems.

Inspection

Stormwater runoff should be allowed to flow freely into the basin. Inspect 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 sinkholes, depressions, or 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 (NCDEQ, 2020). 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 trash, debris, and undesirable vegetation, then properly dispose of it off-site. Remove sediment and dispose of it off-site if sediment appears to have accumulated more than 3 inches or is impeding the function. Repair 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 SCM that pretreats stormwater (see Figure 5-5). A forebay reduces the runoff velocity of stormwater, which in turn allows larger sediment to settle out before entering the 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 SCM. The presence of a forebay reduces the risk of SCM failure.

Some forebays within Bioretention Basins have been designed with special transition weirs. 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 in the basin. Figure 5-6 illustrates two examples of transition weirs.

Inspection

Inspect forebays for trash, debris, accumulated sediment, and undesirable vegetation. Inspect to determine whether forebays are structurally sound and functional. Inspect the embankment and transition berm for structural integrity and signs of erosion. Forebays are generally lined with riprap and sometimes underlined with geotextile fabric. Check for complete riprap coverage and/or rock displacement. Inspect for undesirable vegetation. Forebays are not designed to support other vegetation. Minimal plant growth is tolerable, but if it becomes excessive, the storage volume for sediment is reduced and dredging becomes more difficult. In some cases, Forebays are designed to be earthen and covered in turf-type grass. These Forebays are still not designed to support excessive vegetation. If any invasive species are present, it is preferable to remove them before they become well-established.

Maintenance

Remove trash, debris, sediment, and undesirable vegetation and properly dispose of it off-site. Remove sediment if it appears to have accumulated more than 3 inches or is impeding the function. Replace erosion protection materials (e.g., 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, 2014) 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 floor 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 to 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 floor of the basin, interior and exterior side slopes, the area surrounding the basin, and 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, furrowing, and for the presence of invasive shrubs and trees. Also, inspect the downstream toe of the embankment for seepage (NCDEQ, 2020). 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 or is impeding the function (NCDEQ, 2020). 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.

Some Bioretention Basins have been planted with certain grasses, trees, shrubs, and herbaceous vegetation to enhance their aesthetic appeal and increase their pollutant reduction ability (see Figure 8-5). Check the design plans, when available, if there is any question about what is meant to be planted. If applicable, verify that this vegetation remains healthy and uniformly established.

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 floor (NCDEQ, 2020). Use best professional judgment when selecting landscaping equipment for use in the basin and minimize foot traffic on the basin floor.

Flush the underdrain system if the basin is not draining properly including the upturned elbow if an internal water storage (IWS) zone is provided. 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, then replace the original filter media with new media (NCDEQ, 2020). These components should be repaired or replaced to meet the original design specifications unless they are deemed insufficient. For additional guidance, consult the NCDEQ *Stormwater Design Manual*.

Repair areas of erosion, channelization, or animal burrows by regrading and reestablishing the proper cover. 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 make sure 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 reduction of stormwater pollutants. Triple-shredded hardwood mulch should be used (NCDOT, 2014 and NCDEQ, 2020). Mulch conserves soil moisture during dry periods, adds organic matter, 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). Plants provide uptake of nutrients and water. Plant roots improve soil structure and enhance the soil's ability to filter out stormwater pollutants (NCDEQ, 2020). Photographs of some appropriate plants to 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 outcompeting the others. 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 (e.g., riprap).

The basin floor should be covered with a layer of triple-shredded hardwood 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 make sure 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 floor (NCDEQ, 2020). Use best professional judgment when selecting landscaping equipment for use in the basin and minimize foot traffic on the basin floor.

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.

Although the plants selected should be tolerant to site-specific conditions, watering may be needed during prolonged dry periods after plants are established (NCDEQ, 2020).

Add triple-shredded hardwood mulch and reestablish grass or herbaceous groundcover where cover is insufficient. Use triple-shredded mulch where needed. Remove undesirable vegetation, taking care not to damage desirable vegetation. Replace dead or unhealthy plants using the original design drawings or landscaping plan when available. Fertilize turfgrass and/or plants upon reestablishment if necessary. When removing rooted plants from the basin, depending on the size of the root mass and depth, the filter media may need to be replaced and provide sod grass to immediately provide vegetative surface cover, otherwise the filter media could washout or form a sinkhole. 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 plastic 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. In some Bioretention Basins, an IWS or anaerobic zone is created to enhance nitrogen reduction. This is achieved by providing an upturned elbow to tie the underdrains to the outlet riser structure.

Inspection

Verify that cleanout 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. The basin should be inspected for sinkholes or 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, including the upturned elbow if present, by spraying water into cleanouts. Replace all cleanout caps that are missing, cracked, or otherwise damaged. NCDEQ recommends flushing underdrain systems, including cleanouts, annually if they appear to have a tendency to clog (NCDEQ, 2020). If roots or soil are present in the underdrain system, it is likely that the filter fabric protecting the perforated pipe is damaged. If this is the case, the underdrain system should be excavated then repaired or replaced. To avoid crushing the underdrain system, heavy equipment should not be driven in the basin. Repair or replace underdrain systems in accordance with the original design specifications. If additional guidance is needed, consult the NCDEQ *Stormwater Design Manual*.

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 (NCDEQ, 2020), above the basin floor. 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 signs of damage such as cracks, holes, or leaks. The leakage can be verified by inspecting around the area of outlet pipe penetration at the embankment or if it is causing piping in the embankment. 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 SCM 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 sinkholes, depressions, or other signs that might indicate pipe breakage

or separation. Inspect ditches for signs of erosion and undesirable vegetation. If outlet protection materials (e.g., 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 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

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 and no scour is occurring below the slab 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 maintained at a height of 6 to 15 inches. If present, repair concrete or replace riprap as necessary. Repair areas of erosion.

5.4 Inspection and Maintenance Summary

Observations made while inspecting SCMs must be documented on the appropriate SCM inspection form (Appendix A) electronically in SCMS or entered into SCMS as soon the inspector is able. Observations recorded should include a general description of the SCM, if it is functioning well, and the maintenance needs identified such as the removal of accessible trash, sediment, and undesirable vegetation. Additionally, the inspector assigns a Level of Service (LOS) rating to the SCM during each inspection. Refer to Chapter 3 of this manual for approximate timeframes to complete maintenance activities based on the LOS ratings. Photographs should be taken during the inspection and uploaded to SCMS as soon as the inspector is able.

Maintenance needs documented in the inspection report can be routine or non-routine. Mowing and removal of accessible trash and debris, which the inspector may be able to perform during the inspection, are examples of routine maintenance activities. Non-routine maintenance items may include removing excess sediment or repairing structural parts of the SCM. Non-routine maintenance needs often require specialized equipment and/or trained personnel. Typically, any

tree greater than 6 inches should be left in place so an engineered approach can be taken to avoid dam failure. If non-routine maintenance needs are identified during an inspection (e.g., failure of the SCM), the inspector should fill out a Maintenance Needed report in SCMS, then either correct the problem at that time or contact the party or parties responsible to schedule non-routine maintenance repairs.

If non-routine maintenance needs are not corrected at the time of inspection, the inspector should conduct a follow-up inspection to verify that the responsible party or parties have taken action and the maintenance needs have been addressed. Observations made during the follow-up inspection should also be documented on the Maintenance Completed report in SCMS. A follow-up inspection report should also be entered to change the LOS rating of the SCM.

CHAPTER 6 Filtration Basin

Overview

A FILTRATION BASIN (FB) is a stormwater control measure (SCM) 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 SCMs designed to temporarily capture stormwater runoff, filter out pollutants, and minimize peak flows.
- Inflow to the SCM is detained and filtered through a natural or engineered media, which reduces pollutants.
- Filtration Basins are designed with an underdrain system that typically conveys filtered runoff to an outlet control structure.

INSPECTION

- All ponded water visible above the surface of the Filtration Basin should drain within 24 hours; prolonged ponding indicates that the filter media or underdrain system requires maintenance.
- Refer to Chapter 2 for recommended inspection frequency.

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 Filtration Basin Overview

A Filtration Basin (FB) is an SCM that uses a filter media (typically sand) to reduce pollutants from stormwater runoff. It works by temporarily detaining stormwater runoff and allowing it to slowly soak into the filter media. As stormwater slowly passes through the filter media, pollutants are filtered and adsorbed as the stormwater contacts soil particles. The filtered water then enters the basin's underdrain system where it exits and flows to the nearest storm drainage system or surface water body.

Filtration Basins are effective in removing many of the common pollutants found in stormwater runoff, especially finer sediments and sediment-bound pollutants. All ponded water visible above the surface of the Filtration Basin should be drawn down within 24 hours and the media filter should be drained of stormwater within 48 hours (NCDOT, 2014). Previous designs may have used a 2-to-5-day drawdown period. The stormwater flow path and treatment process described here are illustrated in Figure 6-1.

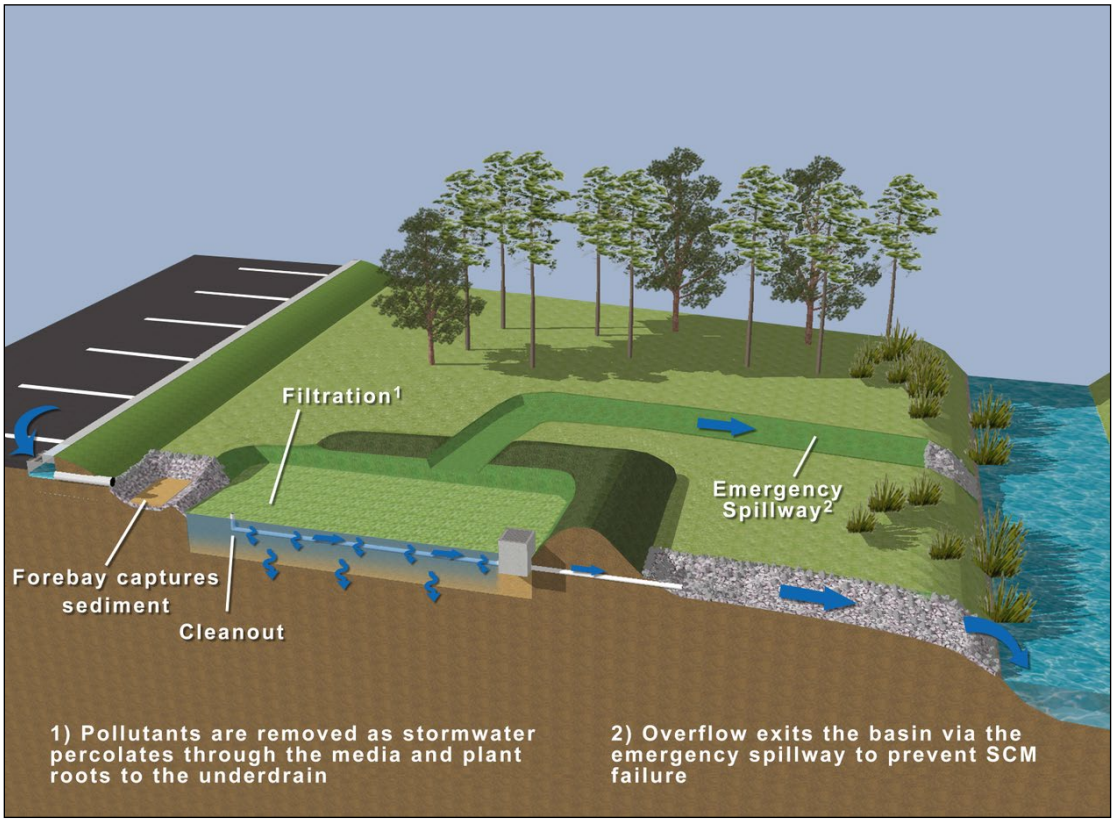


Figure 6-1. Cutaway of a Filtration Basin flow diagram and treatment processes

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 omit certain components. Filtration Basins may include the following:

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

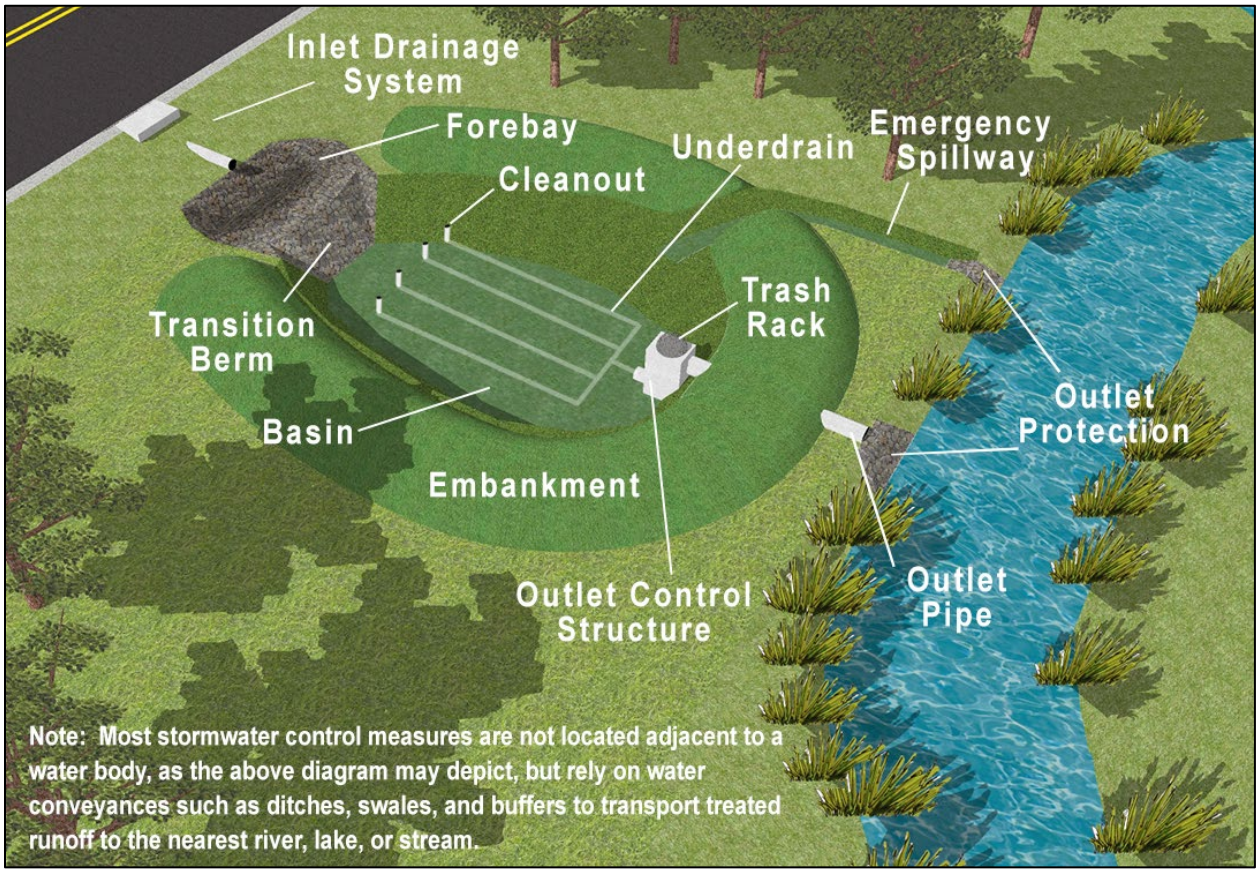


Figure 6-2. Filtration Basin layout and components

The underdrain system is the component that sets a Filtration Basin apart from an Infiltration Basin. If an underdrain system is present, cleanouts should be visible in the basin. Sand Filters and Bioretention Basins are also types of Filtration Basins.

6.3 Inspection and Maintenance

Filtration Basins should be inspected to evaluate whether they are functioning as intended. Refer to Chapter 2 for recommended inspection frequency. If a Filtration Basin is found to be functioning improperly, determine the cause and restore the SCM 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 entered into SCMS via mobile devices in the field. In cases of technical difficulties, these should be noted on the inspection checklist (see Appendix A) and entered into SCMS upon return to the office. Take photographs and upload them to SCMS to track the status of the SCM. Document the maintenance activities and inspections. Refer to Chapter 4 for further guidance on I&M reporting.

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

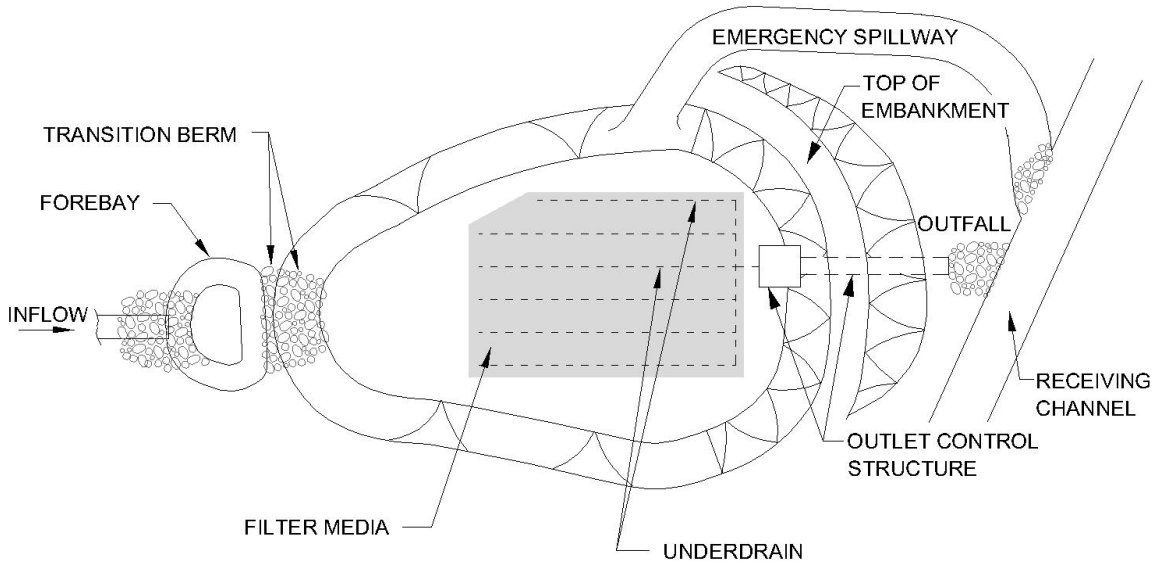


Figure 6-3. Plan view of a Filtration Basin and its components

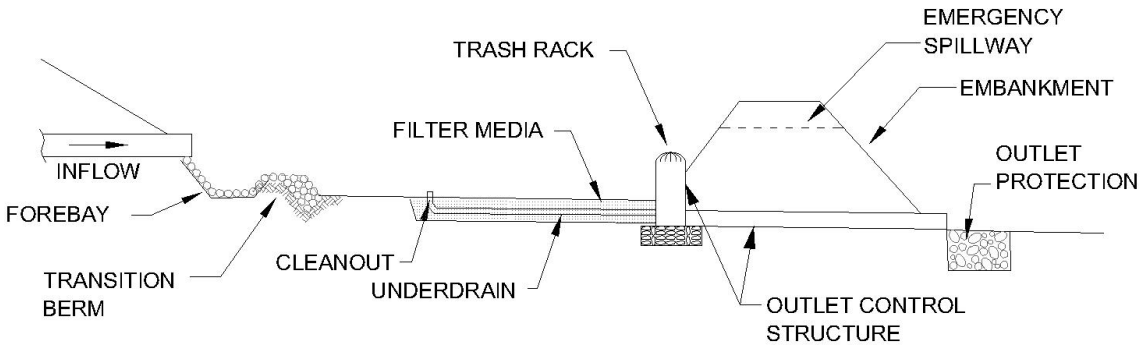


Figure 6-4. Profile view of a Filtration Basin and its components

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, curbs and gutters, and catch basins. Some Filtration Basin designs use flow bypass structures to divert a predetermined amount of runoff to the SCM while bypassing excess flow so that the basin, outlet control structure, and embankment do not fail. If this is the case, refer to Chapter 13 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 sinkholes, depressions, or 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 (NCDEQ, 2020).

Maintenance

Remove trash, debris, and undesirable vegetation, then properly dispose of it off-site. 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 an SCM that pretreats stormwater. A forebay reduces the runoff velocity of stormwater, which in turn allows sediment to settle out before entering the 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 SCM. The presence of a forebay reduces the risk of SCM failure.

Inspection

Inspect forebays for trash, debris, accumulated sediment, and undesirable vegetation. Inspect to determine whether forebays are structurally sound and functional. Inspect the embankment and transition berm for structural integrity and signs of erosion. Forebays are generally lined with riprap and sometimes underlined with geotextile fabric. Check for complete riprap coverage and/or rock displacement. Inspect for undesirable vegetation. Forebays are not designed to support other vegetation. Minimal plant growth is tolerable, but if it becomes excessive, the storage volume for sediment is reduced and dredging becomes more difficult. In some cases, Forebays are designed to be earthen and covered in turf-type grass. These Forebays are still not designed to support excessive vegetation. If any invasive species are present, it is preferable to remove them before they become well-established.

Maintenance

Remove trash, debris, sediment, and undesirable vegetation and properly dispose of it off-site. Remove sediment and dispose of it off-site if it appears to have accumulated more than 3 inches or is impeding the function. Replace erosion protection materials (e.g., 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 weir. Refer to Chapter 3 for additional guidance on sediment disposal. Consult the NCDOT *Stormwater Best Management Practices Toolbox* (NCDOT, 2014) or the Hydraulics Unit 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 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. 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 the basin for structural integrity. Note any signs of erosion, burrowing animals, or undesirable vegetation. Inspect the embankment or berms for settling, scouring, cracking, sloughing, furrowing, and for the presence of invasive shrubs and trees. Also, inspect the downstream toe of the embankment for seepage (NCDEQ, 2020). Note trash, debris, and/or sediment found in the basin or surrounding areas. Sediment should be removed if it has reached a

depth of 3 inches or is impeding the function (NCDEQ, 2020). Refer to Chapter 3 for guidance on sediment removal. Currently, Filtration Basins are designed to drain within 24 hours; however, a 2-to-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 (NCDEQ, 2020). 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. 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, then replace the original filter media with new media (NCDEQ, 2020). These components should be repaired or replaced to meet the original design specifications unless deemed insufficient. For additional guidance, consult the NCDEQ *Stormwater Design Manual*.

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 plastic pipe. The perforated pipe is wrapped in filter fabric to prevent clogging and installed in a layer of washed coarse aggregate, typically 12 inches of No. 57 stone or alternate. Cleanouts provide access to the underdrain system for inspection and maintenance activities and are typically visible from the surface. To avoid crushing the underdrain system, heavy equipment should not be driven in the basin. In some Filtration Basins, an internal water storage (IWS) or anaerobic zone is created to enhance nitrogen reduction. This is achieved by providing an upturned elbow to tie the underdrains to the outlet riser structure.

Inspection

Verify that cleanout 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. The basin should be inspected for sinkholes or 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, including the upturned elbow if present, by spraying water into cleanouts. Replace cleanout caps that are missing, cracked, or otherwise damaged. NCDEQ recommends flushing underdrain systems, including cleanouts, annually if they appear to have a tendency to clog (NCDEQ, 2020). If roots or soil are present in the underdrain system, it is likely that the filter fabric protecting the perforated pipe is damaged. If this is the case, the underdrain system should be excavated then repaired or replaced. To avoid crushing the underdrain system, heavy equipment should not be driven in the basin. Repair or replace underdrain systems in accordance with the original design specifications. If additional guidance is needed, consult the NCDEQ *Stormwater Design Manual*.

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 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 DSO 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.

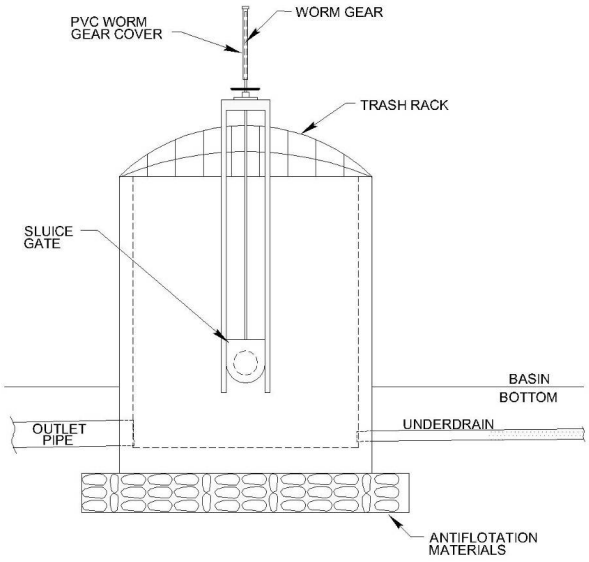


Figure 6-5. Components of an outlet control structure

Inspection

Inspect the outlet control structure thoroughly for any sign of damage such as cracks, holes, or leaks. The leakage can be verified by inspecting around the area of outlet pipe penetration at the embankment or if it is causing piping in the embankment. Inspect to make sure that the outlet box remains covered with a trash rack(s) 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 make sure 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 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, 2018b). Perform additional maintenance and repairs as described in the design drawings. 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. Make sure 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 SCM 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 sinkholes, depressions, or other signs that might indicate pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation. If outlet protection materials (e.g., 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 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 and no scour is occurring below the slab or verify that adequate riprap is present. Note all erosion and undesirable vegetation.

Maintenance

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

6.4 Inspection and Maintenance Summary

Observations made while inspecting SCMs must be documented on the appropriate SCM inspection form (Appendix A) electronically in SCMS or entered into SCMS as soon the inspector is able. Observations recorded should include a general description of the SCM, if it is functioning well, and the maintenance needs identified such as the removal of accessible trash, sediment, and undesirable vegetation. Additionally, the inspector assigns a Level of Service (LOS) rating to the SCM during each inspection. Refer to Chapter 3 of this manual for approximate timeframes to complete maintenance activities based on the LOS ratings. Photographs should be taken during the inspection and uploaded to SCMS as soon as the inspector is able.

Maintenance needs documented in the inspection report can be routine or non-routine. Mowing and removal of accessible trash and debris, which the inspector may be able to perform during the inspection, are examples of routine maintenance activities. Non-routine maintenance items may include removing excess sediment or repairing structural parts of the SCM. Non-routine maintenance needs often require specialized equipment and/or trained personnel. Typically, any tree greater than 6 inches should be left in place so an engineered approach can be taken to avoid dam failure. If non-routine maintenance needs are identified during an inspection (e.g., failure of the SCM), the inspector should fill out a Maintenance Needed report in SCMS, then either correct the problem at that time or contact the party or parties responsible to schedule non-routine maintenance repairs.

If non-routine maintenance needs are not corrected at the time of inspection, the inspector should conduct a follow-up inspection to verify that the responsible party or parties have taken action and the maintenance needs have been addressed. Observations made during the follow-up

inspection should also be documented on the Maintenance Completed report in SCMS. A follow-up inspection report should also be entered to change the LOS rating of the SCM.

CHAPTER 7 Infiltration Basin

Overview

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

PURPOSE AND DESCRIPTION

- Infiltration Basins are structural SCMs 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 adsorbed and reduced from the runoff.

INSPECTION

- Infiltration Basins should drain completely during dry periods; standing water in the basin may indicate the need for maintenance.
- Pretreatment SCMs, such as forebays, are of particular importance to the function of the Infiltration Basin. If pretreatment SCMs are neglected, excessive sedimentation in can occur in the basin, which may require intensive maintenance to correct.
- Refer to Chapter 2 for recommended inspection frequency.

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 Infiltration Basin Overview

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

In North Carolina, Infiltration Basins are more common in the coastal region where sandy soils promote faster 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 Infiltration Basin.

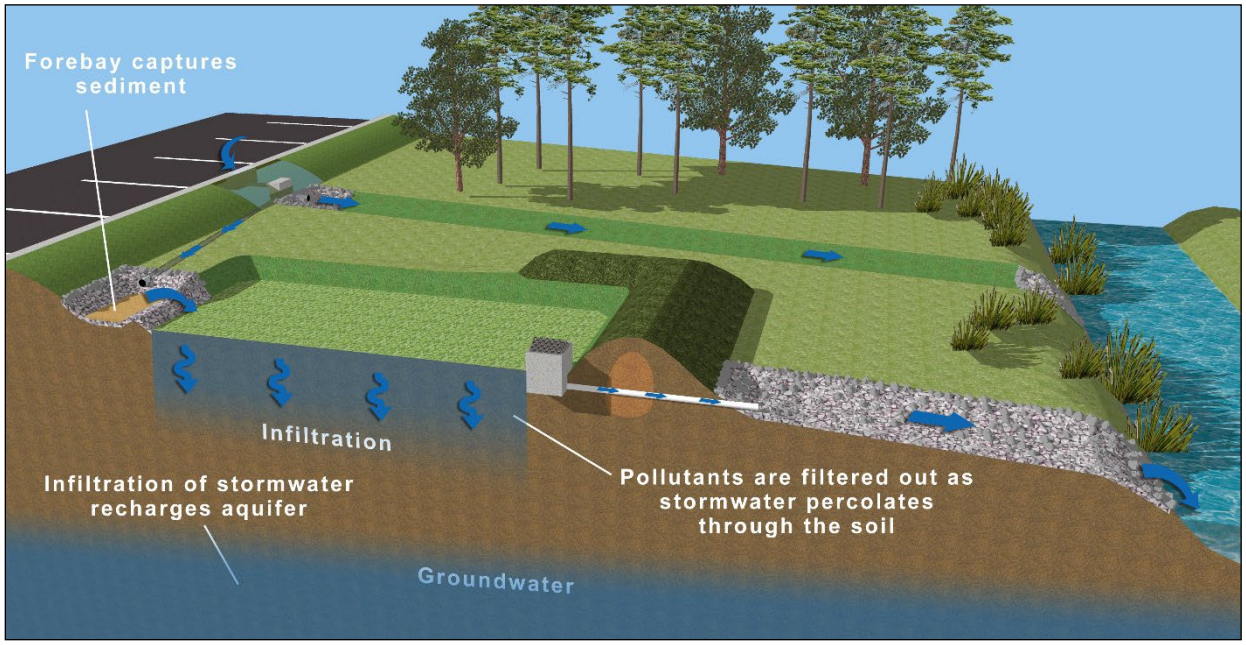


Figure 7-1. Cutaway of an Infiltration Basin flow diagram and treatment processes

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

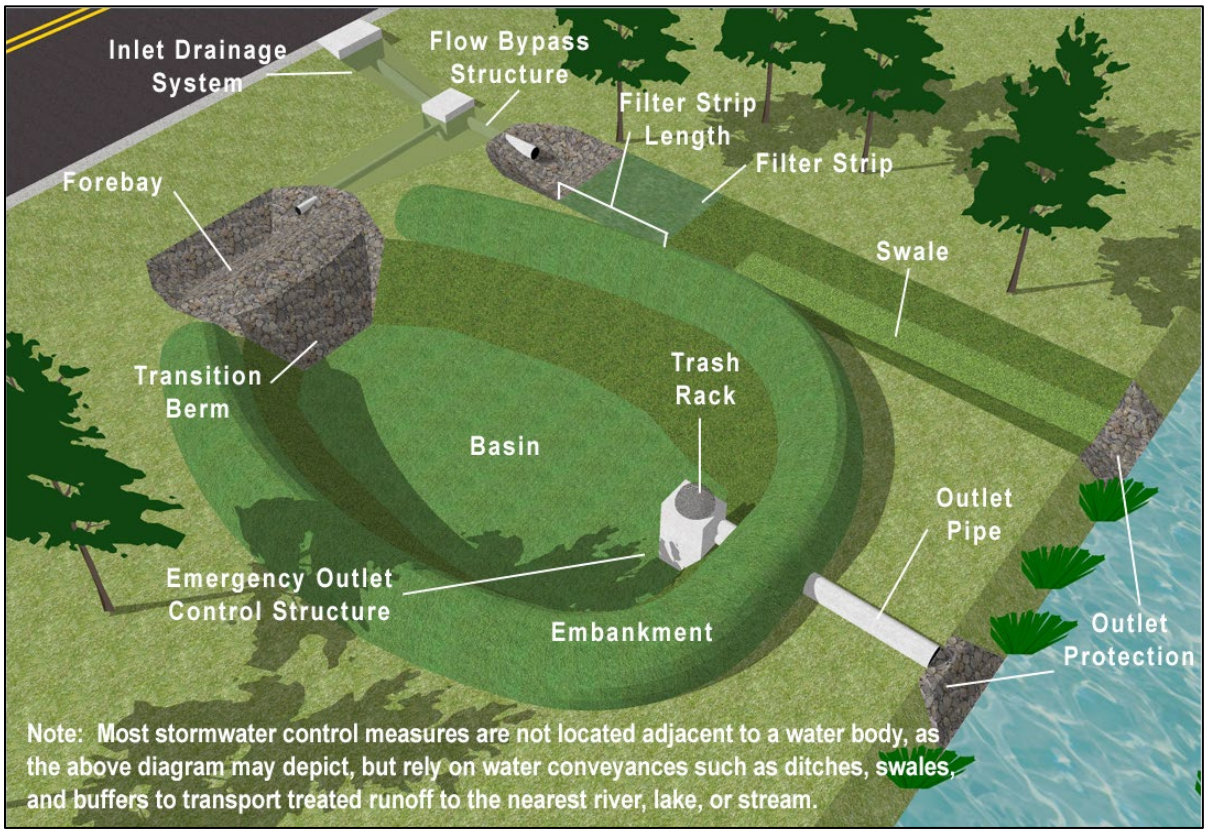


Figure 7-2. Components of a typical Infiltration Basin

7.3 Inspection and Maintenance

Infiltration Basins should be inspected to determine whether they are functioning as intended. Refer to Chapter 2 for recommended inspection frequency. If an Infiltration Basin is found to be functioning improperly, determine the cause and restore the SCM 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 entered into SCMS via mobile devices in the field. In cases of technical difficulties, these should be noted on the inspection checklist (see Appendix A) and entered into SCMS upon return to the office. Take photographs and upload them to SCMS to track the status of the SCM. Document the maintenance activities and inspections. Refer to Chapter 4 for further guidance on I&M reporting.

Note that the ability of the soil in the Infiltration Basin to percolate water is critical to the SCM's function. To minimize compaction, heavy machinery should not be used in the basin (NCDOT, 2014).

The following sections describe the function of an Infiltration Basin and provide inspection and maintenance guidance for its major components.

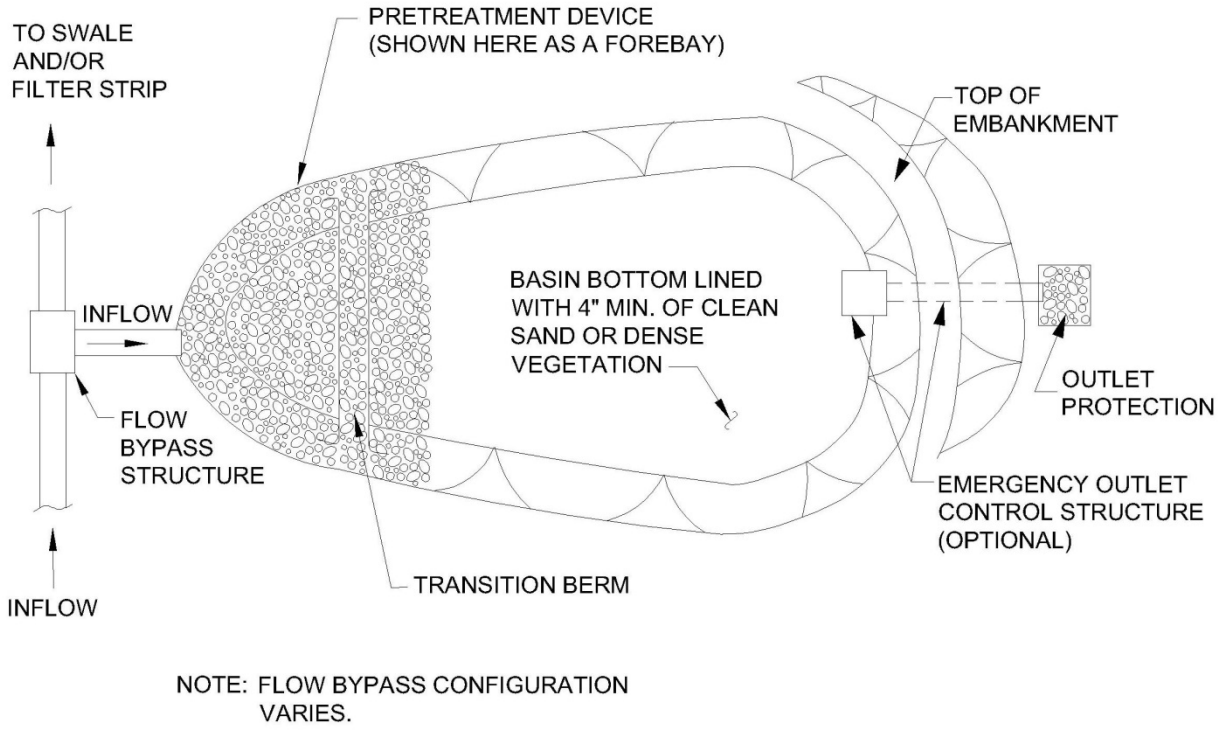


Figure 7-3. Plan view of an Infiltration Basin and its components

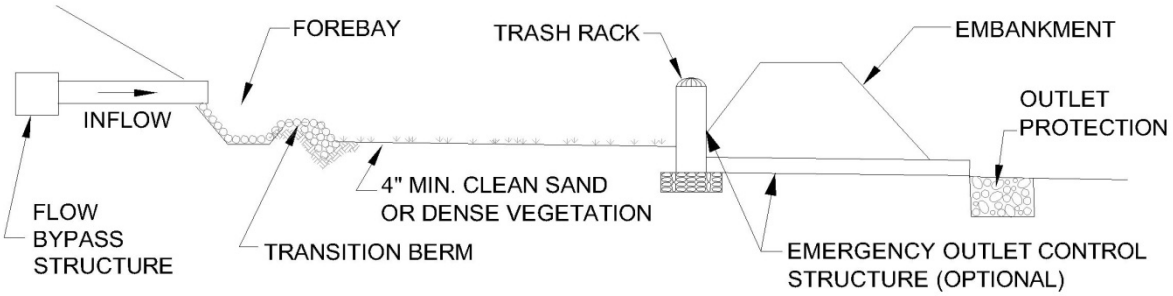


Figure 7-4. Profile view of an Infiltration Basin and its components

7.3.1 Inlet Drainage System

Function

The inlet drainage system collects and conveys water to the SCM. Inlet drainage systems can consist of open channels, pipes, curbs and gutters, 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 sinkholes, depressions, or 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 trash, debris, and undesirable vegetation, then properly dispose of it off-site. Remove sediment and dispose of it off-site if sediment appears to have accumulated more than 3 inches or is impeding the function. Repair eroded areas and damaged pipes. Refer to Chapter 3 for additional guidance on maintenance techniques.

7.3.2 Flow Bypass System

Water that enters the Infiltration Basin primarily infiltrates through the soil, which can be a relatively slow process. Therefore, a flow bypass system diverts a predetermined amount of runoff to the SCM 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.

Function

The flow bypass structure diverts runoff to the Infiltration Basin under normal conditions 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, cracks, and any erosion that would allow runoff to flow around the structure. If present, 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 trash, debris, and undesirable vegetation then properly dispose of it off-site. If the flow bypass structure is clogged, remove sediment and properly dispose of it off-site. Repair any cracks, holes, and eroded areas associated with the flow bypass structure. Replace components as necessary. Replace or repair any materials (e.g., riprap) used to protect the outlet of the bypass structure to the filter strip or swale.

7.3.3 FILTER STRIP

Function

Some flow bypass systems use filter strips to treat runoff that has bypassed the Infiltration Basin. Filter strips promote infiltration, biological uptake of pollutants, and filter out sediment. The filter strip should have a minimum length of 50 feet if draining to a class SA water body (e.g., tidal saltwater used for commercial shellfishing) or 30 feet for all other areas (NCDOT, 2014).

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.

Maintenance

Remove trash, undesirable vegetation, and debris that could cause channelization. Repair areas affected by erosion or channelization. Mow grass and repair or replace Permanent Soil Reinforcement Matting (PSRM) as necessary. Make sure that grass remains dense for optimum

reduction of pollutants. If excessive sediment has accumulated, remove the sediment and regrade the filter strip. Reestablish vegetation and replace PSRM where necessary (NCDEQ, 2020).

7.3.4 FOREBAY

Function

A forebay is a basin located at the inlet of an SCM that pretreats stormwater. Forebays reduce the runoff velocity of stormwater, which in turn allows sediment in the stormwater to settle before entering the 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 SCM. The presence of a forebay reduces the risk of SCM failure.

If the forebay is full of sediment, the sediment can then enter the main basin, reducing the infiltration rate. The basin may begin to retain water, potentially causing a failure to treat the runoff. Invasive species would have greater opportunity to take over. Erosion of the emergency spillway from overuse can also occur.

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.

Inspection

Inspect forebays for trash, debris, accumulated sediment, and undesirable vegetation. Inspect to determine whether forebays are structurally sound and functional. Inspect the embankment and transition berm for structural integrity and signs of erosion. Forebays are generally lined with riprap and sometimes underlined with geotextile fabric. Check for complete riprap coverage and/or rock displacement. Inspect for undesirable vegetation. Forebays are not designed to support other vegetation. Minimal plant growth is tolerable, but if it becomes excessive, the storage volume for sediment is reduced and dredging becomes more difficult. In some cases, Forebays are designed to be earthen and covered in turf-type grass. These Forebays are still not designed to support excessive vegetation. If any invasive species are present, it is preferable to remove them before they become well-established.

Maintenance

Remove trash, debris, sediment, and undesirable vegetation and properly dispose of it off-site. Remove sediment if it appears to have accumulated more than 3 inches or is impeding the function. Replace erosion protection materials (e.g., 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 weir. Refer to Chapter 3 for further guidance on sediment disposal. Consult the NCDOT *Stormwater Best Management Practices Toolbox* (NCDOT, 2014) or the Hydraulics Units if major repairs are required.

7.3.5 Basin and Surrounding Area

Function

The main pollutant reduction processes occur in the basin. Runoff is detained and allowed to infiltrate into the soil, in order to eventually infiltrate into the water table. Infiltration of stormwater into the basin soil is the primary mechanism for water leaving the SCM. **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 (NCDEQ, 2020). 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.

Inspection

The floor 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 the basin for structural integrity. Note any signs of erosion, burrowing animals, or undesirable vegetation. Inspect the embankment for settling, scouring, cracking, sloughing, furrowing, and the presence of shrubs or trees. Also, inspect the downstream toe of the embankment for seepage (NCDEQ, 2020). Note trash, debris, and/or sediment found in the basin or surrounding areas. Sediment should be removed if it has reached a depth of 3 inches or is impeding the function (NCDEQ, 2020). Refer to Chapter 3 for guidance on sediment removal.

The basin floor 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 5 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. Contact NCDOT REU if you have additional concerns.

If the basin appears to be retaining water longer than 5 days, it may need to be pumped out or drained via an outlet structure such as a maintenance sluice or drain (if present) 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 DSO or REU for guidance.

Maintenance

Remove all undesirable vegetation (using 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. Reestablish turf grass 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 infiltration

media 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, 2014). Infiltration media clogged with sediment should be removed and the basin bottom tilled. To minimize compaction, heavy equipment should not be used in the basin.

7.3.6 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 below 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, 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 DSO or the REU for guidance. If there are no obvious signs of pollutants, 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 make sure 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 make sure 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 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, 2018b). 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. Make sure 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

7.3.7 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 and no scour is occurring below the slab or verify that adequate riprap is present. Note all erosion and undesirable vegetation.

Maintenance

Emergency spillways must be free of trash, debris, sediment, and undesirable vegetation at all times to function properly. 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.

7.3.8 Outlet Drainage System

Function

The outlet drainage system conveys water from the SCM 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 sinkholes, depressions, or other

signs of pipe breakage or separation, which will result in leakage. The leakage can be verified by inspecting around the area of outlet pipe penetration at the embankment or if it is causing piping in the embankment. If the outlet drainage system consists of an earthen ditch, inspect for signs of erosion and undesirable vegetation. If outlet protection materials (e.g., 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 eroded areas and damaged pipes. Replace outlet protection materials as necessary. Refer to Chapter 3 for additional guidance on maintenance techniques.

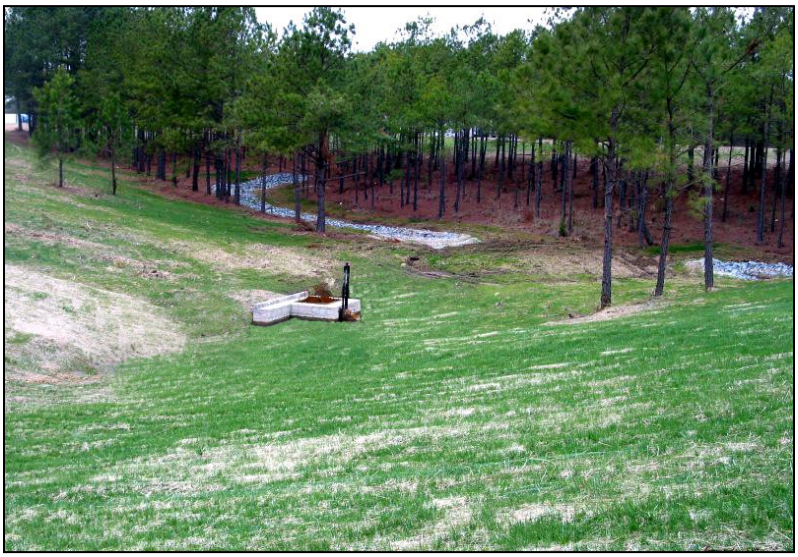
7.4 Inspection and Maintenance Summary

Observations made while inspecting SCMs must be documented on the appropriate SCM inspection form (Appendix A) electronically in SCMS or entered into SCMS as soon the inspector is able. Observations recorded should include a general description of the SCM, if it is functioning well, and the maintenance needs identified—such as the removal of accessible trash, sediment, and undesirable vegetation. Additionally, the inspector assigns an LOS rating to the SCM during each inspection. Refer to Chapter 3 of this manual for approximate timeframes to complete maintenance activities based on the LOS ratings. Photographs should be taken during the inspection and uploaded to SCMS as soon as the inspector is able.

Maintenance needs documented in the inspection report can be routine or non-routine. Mowing and removal of accessible trash and debris, which the inspector may be able to perform during the inspection, are examples of routine maintenance activities. Non-routine maintenance items may include removing excess sediment or repairing structural parts of the SCM. Non-routine maintenance needs often require specialized equipment and/or trained personnel. Typically, any tree greater than 6 inches should be left in place so an engineered approach can be taken to avoid dam failure. If non-routine maintenance needs are identified during an inspection (e.g., failure of the SCM), the inspector should fill out a Maintenance Needed report in SCMS, then either correct the problem at that time or contact the party or parties responsible to schedule non-routine maintenance repairs.

If non-routine maintenance needs are not corrected at the time of inspection, the inspector should conduct a follow-up inspection to verify that the responsible party or parties have taken action and the maintenance needs have been addressed. Observations made during the follow-up inspection should also be documented on the Maintenance Completed report in SCMS. A follow-up inspection report should also be entered to change the LOS rating of the SCM.

CHAPTER 8 Dry Detention Basin



Overview

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

PURPOSE AND DESCRIPTION

- Dry Detention Basins are structural SCMs designed to temporarily capture stormwater runoff and reduce flow velocity.
- Inflow to the SCM 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.
- Refer to Chapter 2 for recommended inspection frequency.

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 Dry Detention Basin Overview

A Dry Detention Basin (DDB) is an SCM whose outlet has been designed to temporarily detain contaminated runoff and release it slowly over a period of 48-72 hours. Previous designs may have used a 2- to 3-day drawdown period. It is during this time that runoff velocity is lowered and physical processes work to reduce pollutants. As stormwater is detained and runoff velocity is lowered, suspended solids and other associated pollutants settle out and are reduced from the runoff before it exits the basin and enters the nearest storm drainage system or surface water body.

The primary pollutant reduction process is sedimentation. Vegetation in the Dry Detention Basin can also filter out and take up pollutants. Additionally, some water may infiltrate through the floor of the basin, which recharges groundwater and aquifers.

The basin's main outlet is small and located near the floor 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.

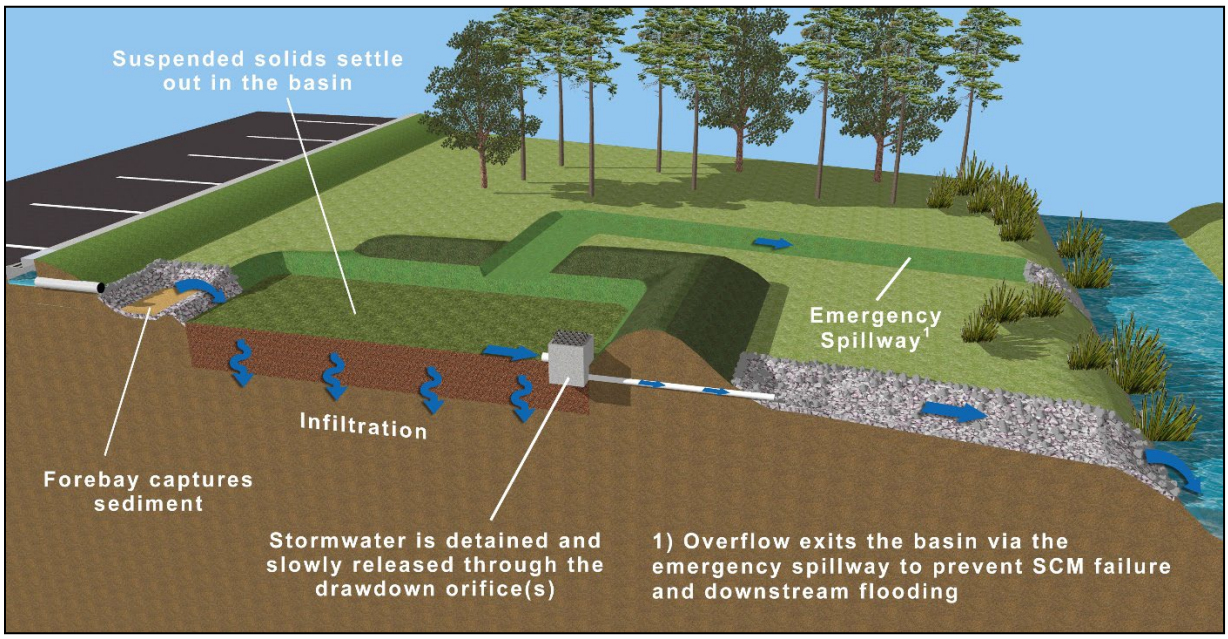


Figure 8-1. Cutaway of a Dry Detention Basin flow diagram and treatment processes

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 omit certain components. For example, an underdrain system may not be present in all Dry Detention Basins. Dry Detention Basins may include the following:

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

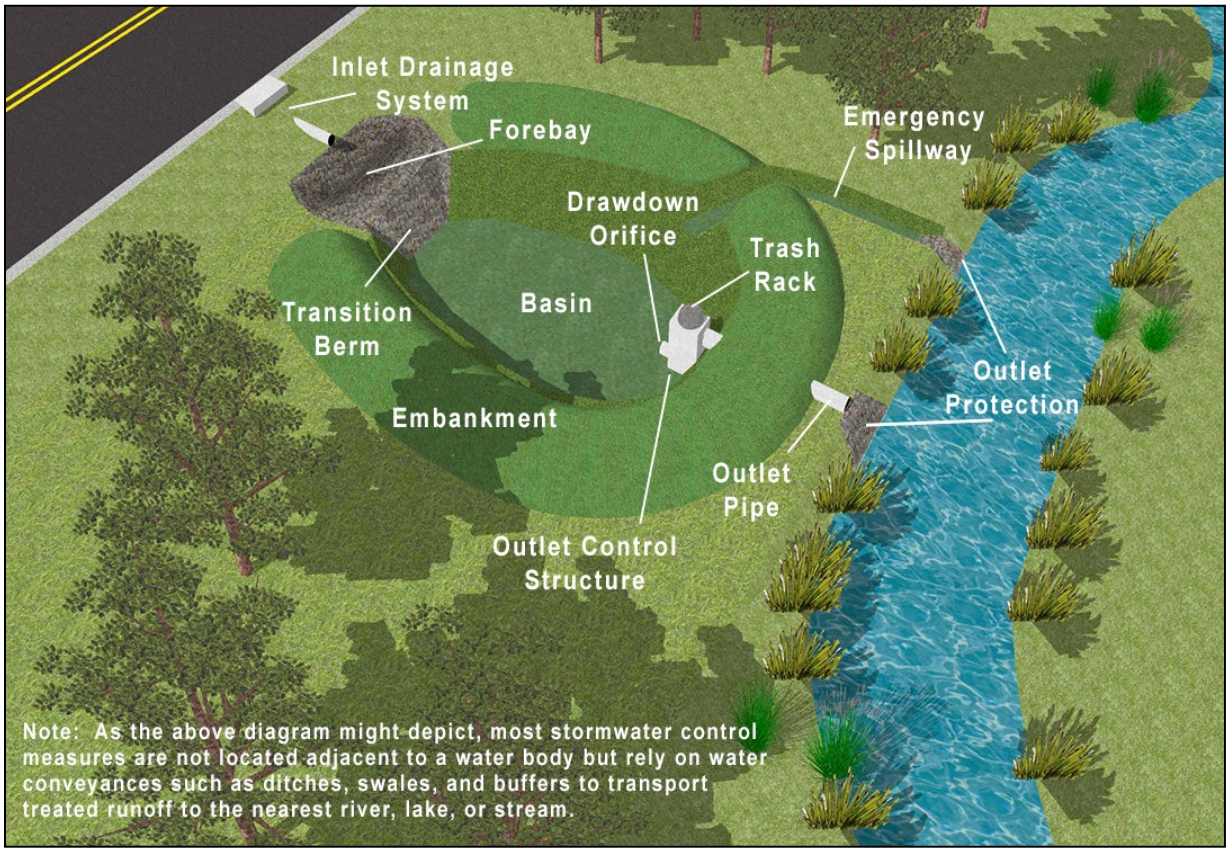


Figure 8-2. Components of a typical Dry Detention Basin

8.3 Inspection and Maintenance

Dry Detention Basins should be inspected to determine whether they are functioning as intended. Refer to Chapter 2 for recommended inspection frequency. If a Dry Detention Basin is found to be functioning improperly, determine the cause and restore the SCM 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 entered into SCMS via mobile devices in the field. In cases of technical difficulties, these should be noted on the inspection checklist (see Appendix A) and entered into SCMS upon return to the office. Take photographs and upload them to SCMS to track the status of the SCM. Document the maintenance activities and inspections. Refer to Chapter 4 for further guidance on I&M reporting.

The following sections describe the function of a Dry Detention Basin and provide inspection and maintenance guidance for its major components.

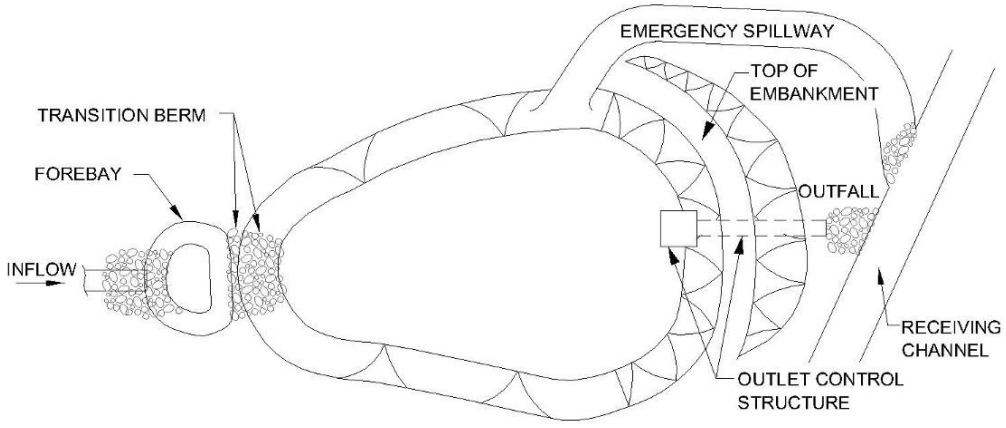


Figure 8-3. Plan view of a Dry Detention Basin and its components

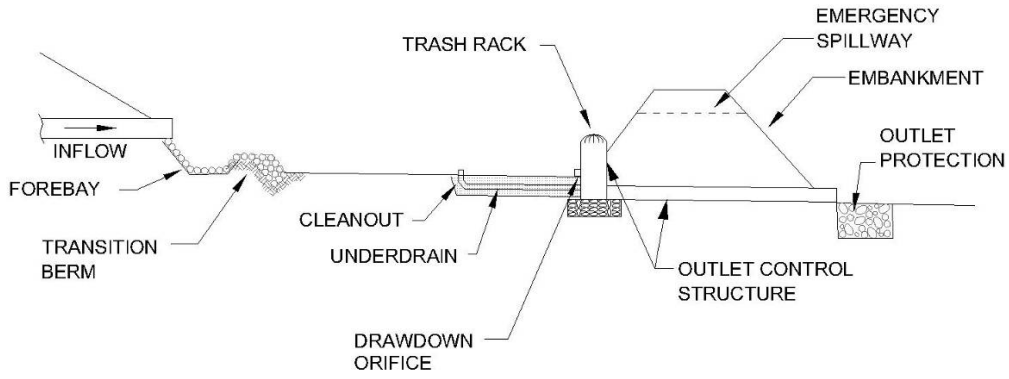


Figure 8-4. Profile view of a Dry Detention Basin and its components

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, curbs and gutters, 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 sinkholes, depressions, or 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 trash, debris, undesirable vegetation, and major sediment accumulations, then dispose of it off-site. 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 SCM that pretreats stormwater. Forebays reduce the runoff velocity of stormwater, which in turn allows sediment in the stormwater to settle before entering the 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 SCM. The presence of a forebay reduces the risk of SCM failure.

Inspection

Inspect forebays for trash, debris, accumulated sediment, and undesirable vegetation. Inspect to determine whether forebays are structurally sound and functional. Inspect the embankment and transition berm for structural integrity and signs of erosion. Forebays are generally lined with riprap and sometimes underlined with geotextile fabric. Check for complete riprap coverage and/or rock displacement. Inspect for undesirable vegetation. Forebays are not designed to support other vegetation. Minimal plant growth is tolerable, but if it becomes excessive, the storage volume for sediment is reduced and dredging becomes more difficult. In some cases, Forebays are designed to be earthen and covered in turf-type grass. These Forebays are still not designed to support excessive vegetation. If any invasive species are present, it is preferable to remove them before they become well-established.

Maintenance

Remove trash, debris, sediment, and undesirable vegetation and properly dispose of it off-site. Remove sediment if it appears to have accumulated more than 3 inches or is impeding the

function. Replace erosion protection materials (e.g., 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, 2014) or the Hydraulics Unit 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. Inspect the basin for structural integrity. Note any signs of erosion, burrowing animals, or undesirable vegetation. Inspect the embankment or berms for settling, scouring, cracking, sloughing, furrowing, and for the presence of invasive shrubs and trees. Also, inspect the downstream toe of the embankment for seepage (NCDEQ, 2020). Note trash, debris, and/or sediment found in the basin or surrounding areas. Sediment should be removed if it has reached a depth of 3 inches or is impeding the function (NCDEQ, 2020). Refer to Chapter 3 for guidance on sediment removal. 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 underdrain (if present), clogged drawdown orifice(s), and localized low areas.

Some Dry Detention Basins have been planted with certain grasses, trees, shrubs, and herbaceous vegetation to enhance their aesthetic appeal and increase their pollutant reduction ability (see Figure 8-5). Check the design plans, when available, if there is any question about what is meant to be planted. If applicable, verify that this vegetation 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 to 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 vegetation 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 floor 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 triple-shredded hardwood bark. Replace dead or unhealthy vegetation and fertilize turfgrass and/or vegetation 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 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 appears to have accumulated more than 3 inches or is impeding the function.

8.3.4 UNDERDRAIN SYSTEM (IF PRESENT)

Function

Some large Dry Detention Basins are equipped with underdrain systems to make sure 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 high-density polyethylene (HDPE) pipe. The perforated pipe is wrapped in filter fabric to prevent clogging and installed in a layer, typically 12 inches, of washed coarse aggregate of No. 57 stone or alternate. To avoid crushing the underdrain system, heavy equipment should not be driven on the basin floor. 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 may be 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 sinkholes or depressions, which is another indication that soil is entering the underdrain system.

If the basin is holding water longer than 5 days, (NCDEQ, 2020) the underdrain system, if present, can be used to drain the basin via its cleanouts so that any plant or soil material 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 DSO or REU for guidance.

Maintenance

A high-pressure hose can be used to flush out underdrain system, including the upturned elbow if present, by spraying water into cleanouts. Replace cleanout caps that are missing, cracked, or otherwise damaged. NCDEQ recommends flushing underdrain systems, including cleanouts, annually if they appear to have a tendency to clog (NCDEQ, 2020). If roots or soil are present in the underdrain system, it is likely that the filter fabric protecting the perforated pipe is damaged. If this is the case, the underdrain system should be excavated then repaired or replaced. To avoid crushing the underdrain system, heavy equipment should not be driven in the basin. Repair or replace underdrain systems in accordance with the original design specifications. If additional guidance is needed, consult the NCDEQ *Stormwater Design Manual*.

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 DSO or 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. The leakage can be verified by inspecting around the area of outlet pipe penetration at the embankment or if it is causing piping in the embankment. 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. Make sure that the proper NCDOT safety procedures are followed when working in or around standing water.

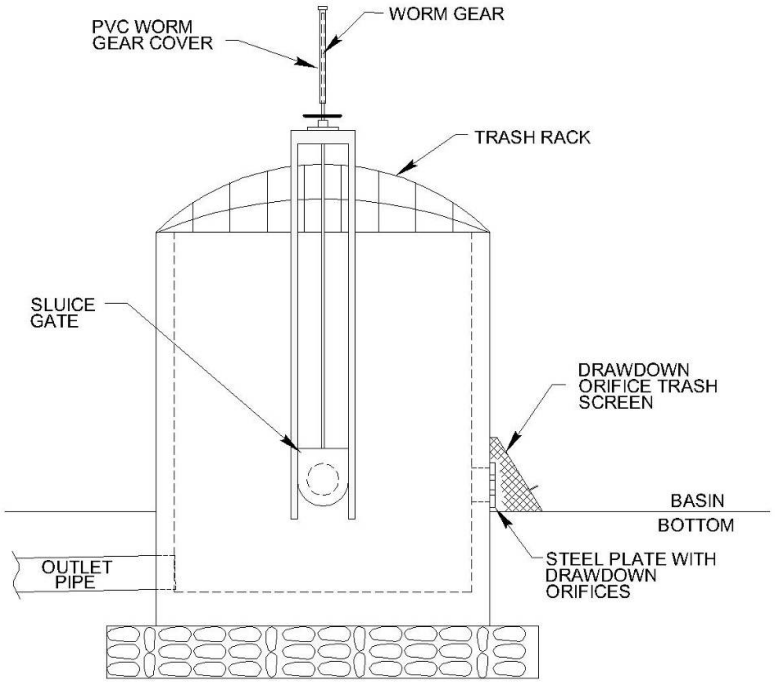


Figure 8-6. Components of an outlet control structure

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. Exercise the hinges, if present, and make sure it opens and closes to allow for any non-routine maintenance that may need to occur. If the trash rack has a lock on it, contact the Hydraulics Unit to obtain the keys before going to the field.

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 SCM. If drawings or specifications are not available, use the 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. If the device has a down-turned tee fitting in the orifice to allow self-flushing, inspect the fitting for clogging.

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 holes 2 to 3 inches in diameter drilled directly into the side of the box or a manufactured outlet opening covered by a predrilled steel plate attached to the side of the outlet control structure.

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. Verify that the plate is sealed properly, preventing any leakage and providing the dewatering as intended. 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 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, 2018b). 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 SCM 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 the outlet box and pipe(s) for sediment and debris. Inspect the ground surface above buried pipes and structures for sinkholes, depressions, or other signs that might indicate pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation. If outlet protection materials (e.g., 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 eroded areas and damaged pipes. Replace outlet protection materials 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 SCM 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 and no scour is occurring below the slab, 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 SCMs must be documented on the appropriate SCM inspection form (Appendix A) electronically in SCMS or entered into SCMS as soon the inspector is able. Observations recorded should include a general description of the SCM, if it is functioning well, and the maintenance needs identified, such as the removal of accessible trash, sediment, and undesirable vegetation. Additionally, the inspector assigns an LOS rating to the SCM during each inspection. Refer to Chapter 3 of this manual for approximate timeframes to complete maintenance activities based on the LOS ratings. Photographs should be taken during the inspection and uploaded to SCMS as soon as the inspector is able.

Maintenance needs documented in the inspection report can be routine or non-routine. Mowing and removal of accessible trash and debris, which the inspector may be able to perform during the inspection, are examples of routine maintenance activities. Non-routine maintenance items may include removing excess sediment or repairing structural parts of the SCM. Non-routine maintenance needs often require specialized equipment and/or trained personnel. Typically, any tree greater than 6 inches should be left in place so an engineered approach can be taken to avoid dam failure. If non-routine maintenance needs are identified during an inspection (e.g., failure of the SCM), the inspector should fill out a Maintenance Needed report in SCMS, then either correct the problem at that time or contact the party or parties responsible to schedule non-routine maintenance repairs.

If non-routine maintenance needs are not corrected at the time of inspection, the inspector should conduct a follow-up inspection to verify that the responsible party or parties have taken action and the maintenance needs have been addressed. Observations made during the follow-up inspection should also be documented on the Maintenance Completed report in SCMS. A follow-up inspection report should also be entered to change the LOS rating of the SCM.

CHAPTER 9 Wet Detention Basin

OVERVIEW

A WET DETENTION BASIN (WDB) is a stormwater control measure (SCM) 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 runoff velocity 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, referred to as the drawdown time. The typical drawdown time for a Wet Detention Basin is 2 to 5 days.

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.
- Refer to Chapter 2 for recommended inspection frequency.

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 Wet Detention Basin 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.

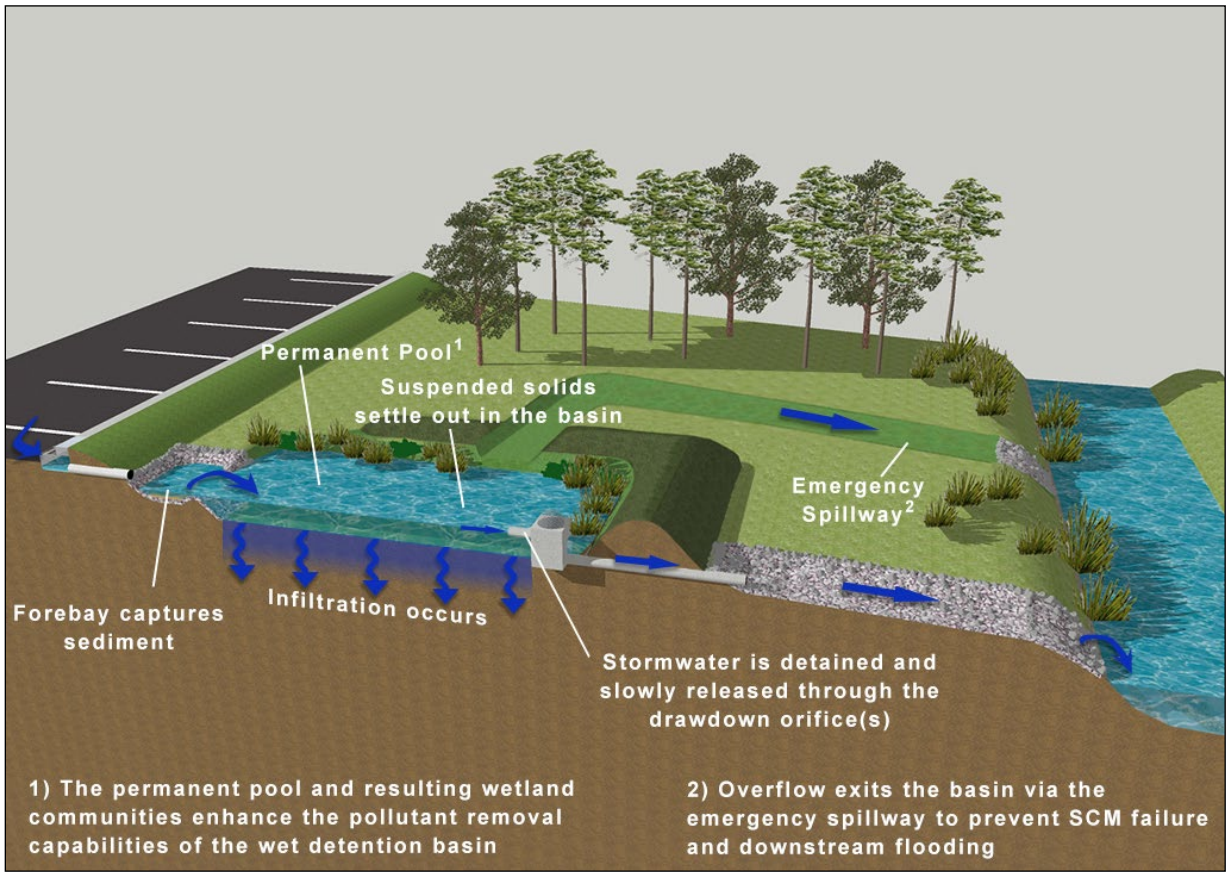


Figure 9-1. Cutaway of a Wet Detention Basin flow diagram and treatment processes

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 omit certain components. Wet Detention Basins may include the following:

- Inlet Drainage System
- Forebay
  - Transition Berm
- Basin
- Vegetated Shelf
- Outlet Control Structure
  - Drawdown Orifice
- Outlet Drainage System
  - Trash Rack and/or Trash Screen, Erosion Protection, and Outlet Pipe
- Emergency Spillway

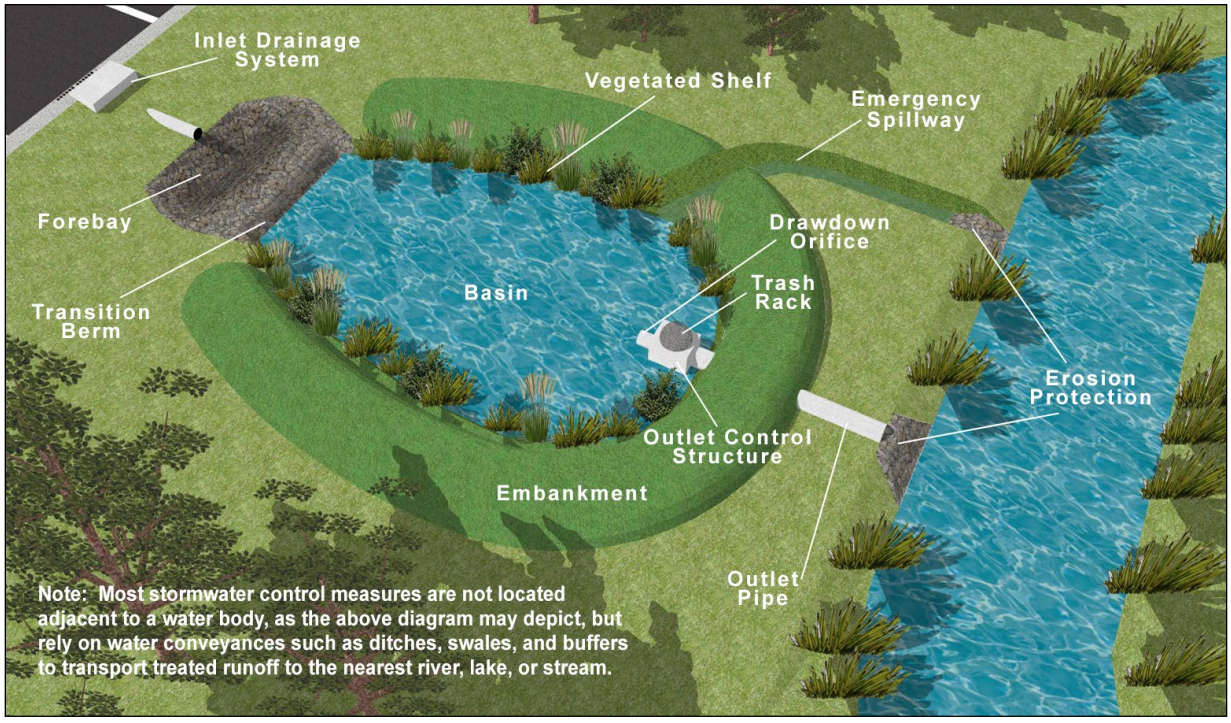


Figure 9-2. Components of a typical Wet Detention Basin

9.3 Inspection and Maintenance

Wet Detention Basins should be inspected to evaluate whether they are functioning as intended. Refer to Chapter 2 for recommended inspection frequency. If a Wet Detention Basin is found to be functioning improperly, determine the cause and restore the SCM 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 entered into SCMS via mobile devices in the field. In cases of technical difficulties, these should be noted on the inspection checklist (see Appendix A) and entered into SCMS upon return to the office. Take photographs and upload them to SCMS to track the status of the SCM. Document the maintenance activities and inspections. Refer to Chapter 4 for further guidance on I&M reporting.

The following sections describe the function of a Wet Detention Basin and provide inspection and maintenance guidance for its major components.

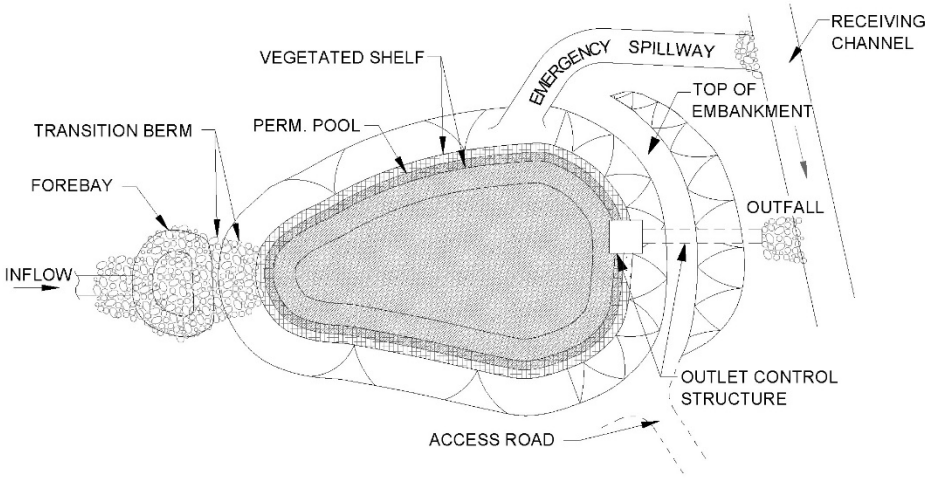


Figure 9-3. Plan view of a Wet Detention Basin and its components

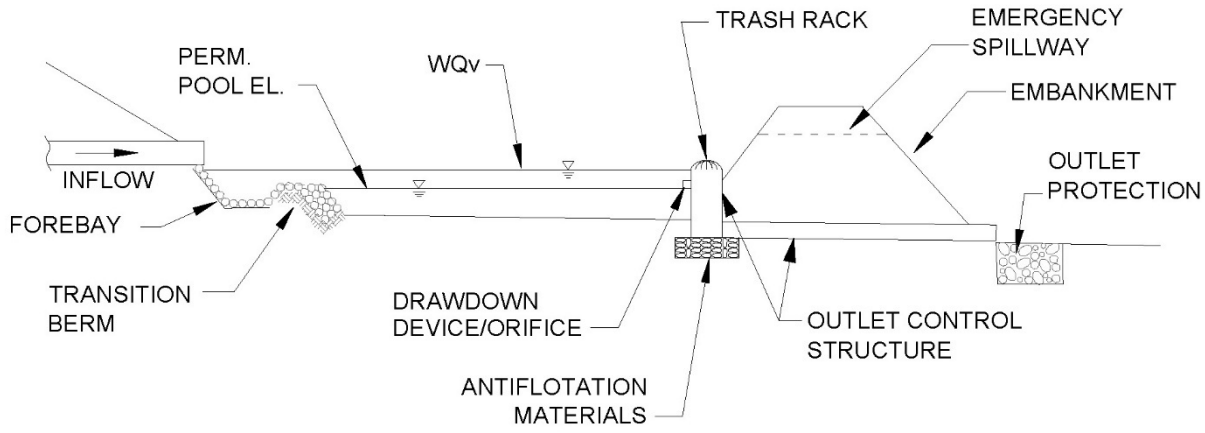


Figure 9-4. Profile view of a Wet Detention Basin and its components

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, curbs and gutters, 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 sinkholes, depressions, or other signs of pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation.

Maintenance

Remove trash, debris, undesirable vegetation, and major sediment accumulations, then properly dispose of it off-site. Remove sediment and dispose of it off-site if sediment appears to have accumulated more than 3 inches or is impeding the function. 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 an SCM that pretreats stormwater. A forebay reduces the runoff velocity of stormwater, which in turn allows sediment in the stormwater to settle before entering the 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 SCM. The presence of a forebay reduces the risk of SCM failure.

Inspection

Inspect forebays for trash, debris, accumulated sediment, and undesirable vegetation. Inspect to determine whether forebays are structurally sound and functional. Inspect the embankment and transition berm for structural integrity and signs of erosion. Forebays are generally lined with riprap and sometimes underlined with geotextile fabric. Check for complete riprap coverage and/or rock displacement. Inspect for undesirable vegetation. Forebays are not designed to support other vegetation. Minimal plant growth is tolerable, but if it becomes excessive, the storage volume for sediment is reduced and dredging becomes more difficult. In some cases, Forebays are designed to be earthen and covered in turf-type grass. These Forebays are still not designed to support excessive vegetation. If any invasive species are present, it is preferable to remove them before they become well-established.

Maintenance

Remove trash, debris, sediment, and undesirable vegetation and properly dispose of it off-site. Remove sediment if it appears to have accumulated more than 3 inches or is impeding the function. Replace erosion protection materials (e.g., 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, 2014) 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.

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. Inspect the embankment for settling, scouring, cracking, sloughing, and furrowing, and for the presence of invasive shrubs and trees. Also, inspect the downstream toe of the embankment for seepage (NCDEQ, 2020). Note trash, debris, and/or sediment found in the basin or 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 or could indicate a potential issue with the outlet structure or embankment integrity. If this is an aesthetic problem or is causing adverse effects on the vegetation, a liner can be installed. 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. Refer to Chapter 3 for guidance on sediment removal.

Algal growth in Wet Detention Basins occurs as a result of 1) nutrient enriched water, 2) shallow water, and 3) direct sunlight. When the algal population is controlled, algae provide nutrient reduction. Generally, if the algae mats are not thick enough to provide mosquito refuge, they should not require removal. However, excessive 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 (NCDEQ, 2020). Algal growth can be removed physically or chemically. Available chemical control options are discussed in the North Carolina Agricultural Chemicals Manual (NCSU, 2022). Applicators require a commercial pesticide applicators license with an aquatic endorsement. Contact the REU for guidance.

Some Wet Detention Basins have a vegetated shelf at the perimeter that is planted with wetland vegetation to increase pollutant reduction. Consult the design drawings or landscaping plan to determine whether the appropriate vegetation is present. Note any undesirable vegetation and verify that appropriate vegetation remains healthy and uniformly established. Cattails and other invasive plants should be removed if they cover more than 50% of the basin area (NCDEQ, 2020).

Maintenance

Make sure that the proper NCDOT safety procedures are followed when working in or around standing water. Remove undesirable vegetation by hand if possible; otherwise, wipe 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 REU if further guidance is necessary to maintain vegetation in Wet Detention Basins.

Repair all animal burrows. 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.

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 DSO or REU for guidance.

9.3.4 Outlet Control Structure (Box)

Function

The outlet control structure regulates the water level and slowly releases stormwater. Outlet control structures may include the following components: 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. Make sure that the proper NCDOT safety procedures are followed when working in or around standing water.

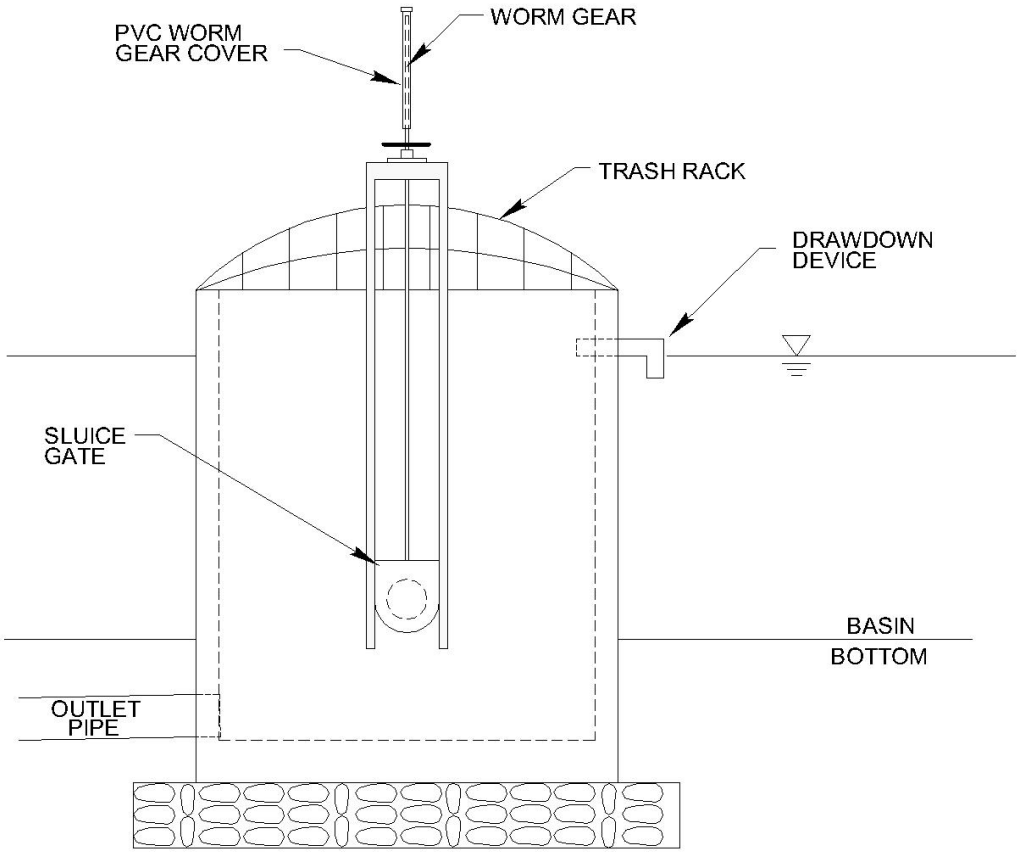


Figure 9-5. Components of an outlet control structure

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. Exercise the hinges and make sure it opens and closes to allow for any non-routine maintenance that may need to occur. If the trash rack has a lock on it, contact the Hydraulics Unit to obtain keys before going to the field.

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 SCM. If drawings or specifications are not available, contact the Hydraulics Unit to obtain standard trash rack specifications or details.

9.3.6 DRAWDOWN DEVICE

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. Another type of drawdown device has a PVC downturned elbow or tee that maintains the orifice opening below the permanent pool water level so it does not become clogged with floating debris. Figure 9-5 illustrates this configuration.

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

Inspection

If it is accessible, inspect the drawdown device to make sure 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-to-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. Two types of sluice gates are currently in use: (1) a screw-type gate, and (2) a lift-type gate. Figure 9-8 is a photograph of a screw-type sluice gate. Figure 9-9 shows a lift-type sluice gate.

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

Figure 9-9. A lift-type sluice gate

Inspection

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 opened or closed.

Maintenance

If lubrication is necessary, lubricate with marine-type grease. It is recommended that a cover be fabricated to protect the screw-type 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 9-10). 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, 2018b). 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 SCM 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 sinkholes, depressions, or other signs that might indicate pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation. If outlet protection materials (e.g., riprap) are present, verify that these materials are adequate to protect against erosion.

Maintenance

Remove any sediment or debris that is accessible. Repair eroded areas and damaged pipes. Replace outlet protection materials 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 SCM 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 and no scour is occurring below the slab or 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. If present, repair concrete or replace riprap as necessary. Repair areas of erosion.

9.3.10 VEGETATED SHELF (IF PRESENT)

Function

The vegetated shelf is a shallow area around the perimeter of the basin designed to promote safety, wetland vegetation growth, and enhance pollutant reduction through biological uptake. The vegetated shelf is typically about 10 feet wide with the inside edge 6 inches below and outside edge 6 inches above the permanent pool elevation. Figure 9-11 illustrates the cross section of a typical vegetated shelf. The landscaping plan includes multiple shallow water and wetland species located on the vegetated shelf.

Inspection

The vegetated shelf should be examined for signs of erosion or bare areas as well as optimal vegetation health. Note all erosion and undesirable vegetation. Plants should not appear to be diseased or dying.

Maintenance

Remove any invasive species identified during the inspections. Pruning is a best practice to maintain optimal plant health and should be conducted as a routine maintenance item if deemed necessary during inspection. If plants appear to be diseased or dying, identify and remedy the problem or replace the vegetation. **If pesticide is used, it should be wiped on the plants and not sprayed. If a soil-test suggests using fertilizer, provide a one-time application to establish ground cover.** Repair areas of erosion.

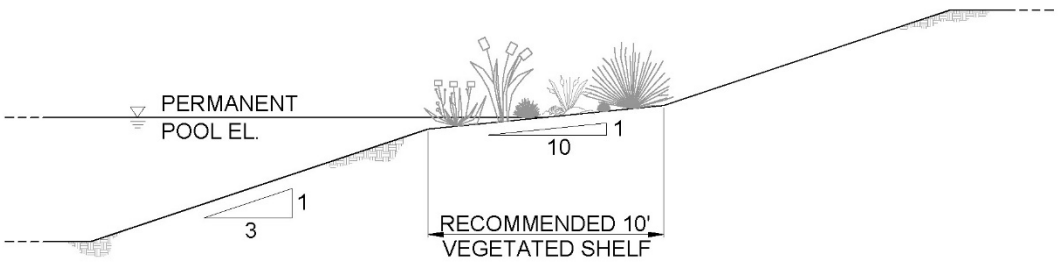


Figure 9-11. Vegetated shelf cross section

9.4 Inspection and Maintenance Summary

Observations made while inspecting SCMs must be documented on the appropriate SCM inspection form (Appendix A) electronically in SCMS or entered into SCMS as soon the inspector is able. Observations recorded should include a general description of the SCM, if it is functioning well, and the maintenance needs identified such as the removal of accessible trash, sediment, and undesirable vegetation. Additionally, the inspector assigns an LOS rating to the SCM during each inspection. Refer to Chapter 3 of this manual for approximate timeframes to complete maintenance activities based on the LOS ratings. Photographs should be taken during the inspection and uploaded to SCMS as soon as the inspector is able.

Maintenance needs documented in the inspection report can be routine or non-routine. Mowing and removal of accessible trash and debris, which the inspector may be able to perform during the inspection, are examples of routine maintenance activities. Non-routine maintenance items may include removing excess sediment or repairing structural parts of the SCM. Non-routine maintenance needs often require specialized equipment and/or trained personnel. Typically, any tree greater than 6 inches should be left in place so an engineered approach can be taken to avoid dam failure. If non-routine maintenance needs are identified during an inspection (e.g., failure of the SCM), the inspector should fill out a Maintenance Needed report in SCMS, then either correct the problem at that time or contact the party or parties responsible to schedule non-routine maintenance repairs.

If non-routine maintenance needs are not corrected at the time of inspection, the inspector should conduct a follow-up inspection to verify that the responsible party or parties have taken action and the maintenance needs have been addressed. Observations made during the follow-up inspection should also be documented on the Maintenance Completed report in SCMS. A follow-up inspection report should also be entered to change the LOS rating of the SCM.

CHAPTER 10 Hazardous Spill Basin

OVERVIEW

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

PURPOSE AND DESCRIPTION

- Hazardous Spill Basins protect water quality by detaining hazardous materials that have been spilled on roadways near designated sensitive water, other environmentally sensitive areas, and areas with concentrated truck parking.
- Under typical 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.
- Refer to Chapter 2 for recommended inspection frequency.

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 make sure 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 Hazardous Spill Basin 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 cleanup of accidental spills. Under typical conditions, runoff is allowed to 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 storm drainage system or surface water body.

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 "cleanup" 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 properly trained.**

Refer to Chapter 2 for recommended inspection frequency. Figure 10-1 illustrates the function of a Hazardous Spill Basin.

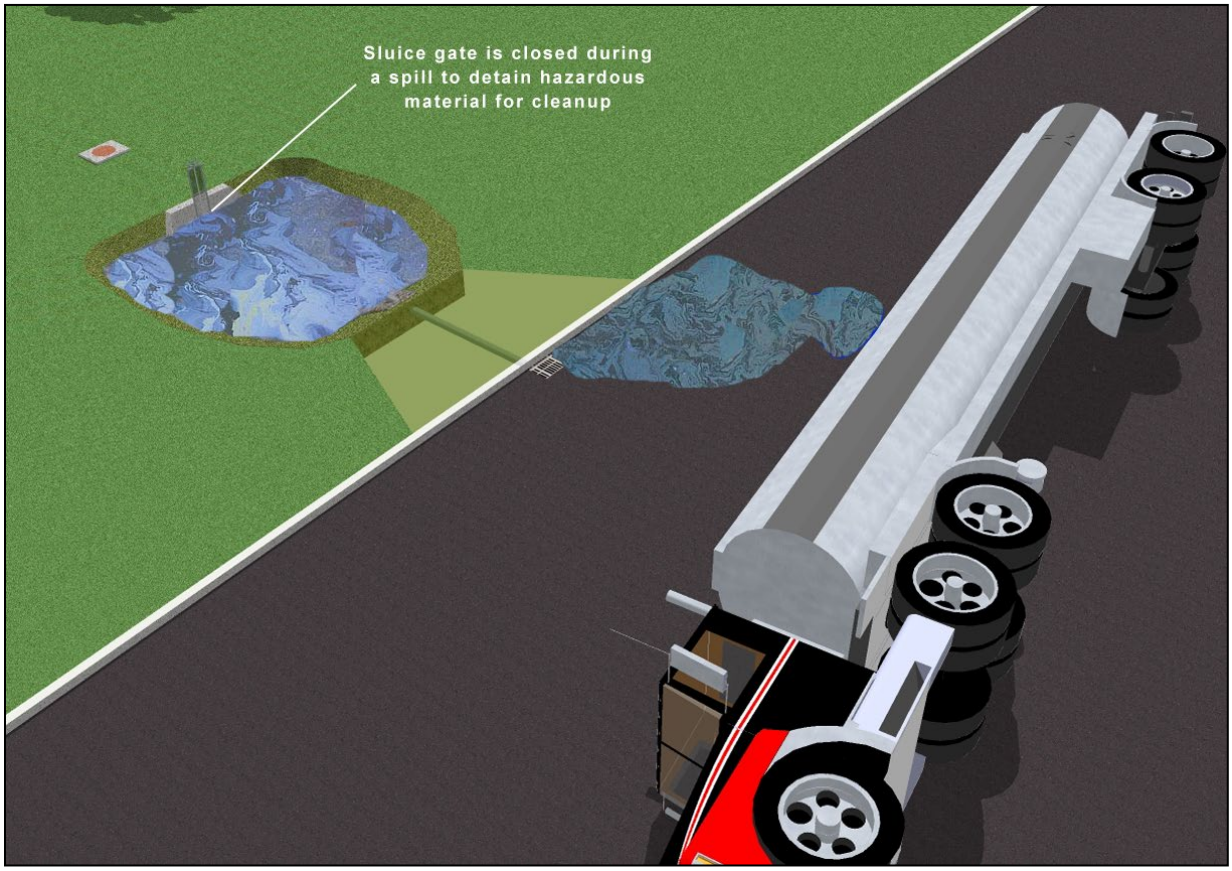


Figure 10-1. Function of a Hazardous Spill Basin

10.2 Hazardous Spill Basin Components

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

- Inlet Drainage System
- Riprap for Erosion Control
- Basin
- Outlet Structure
- Sluice Gate
- Outlet Drainage System

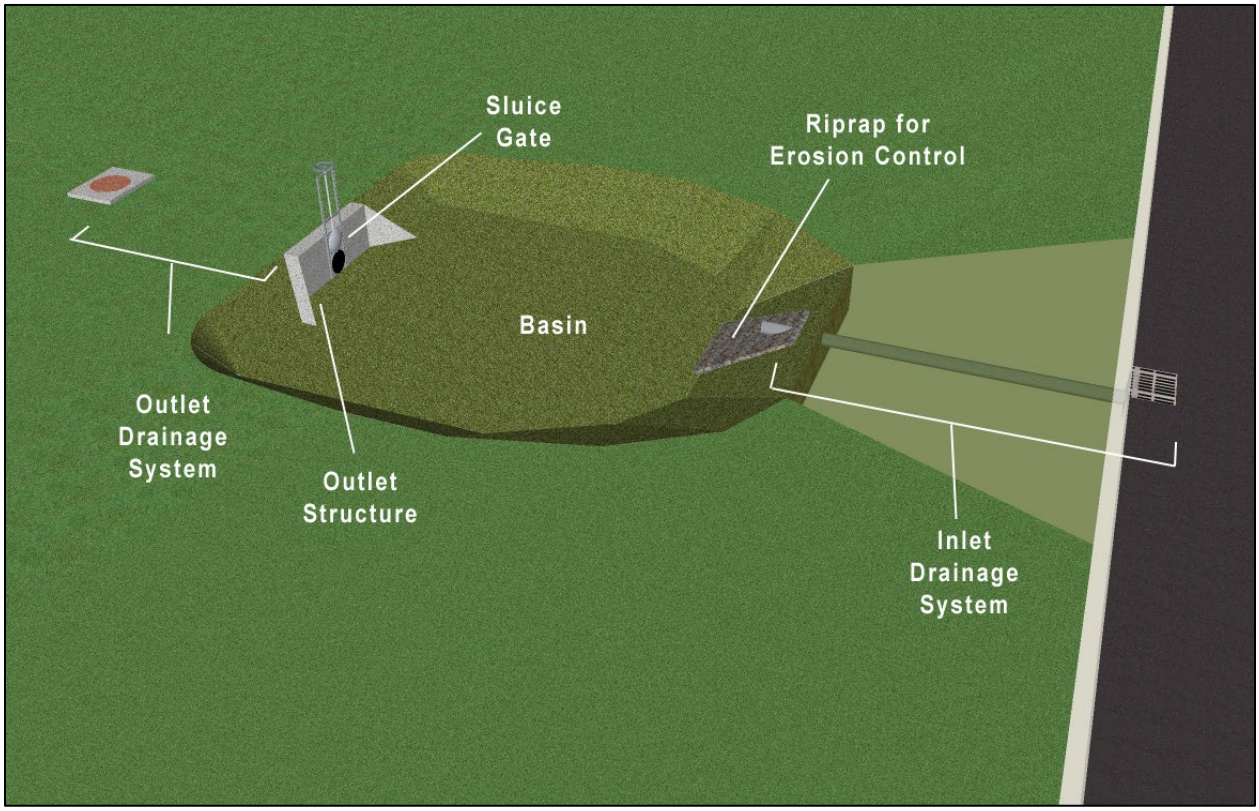


Figure 10-2. Components of a typical Hazardous Spill Basin

10.3 Inspection and Maintenance

Hazardous Spill Basins can sometimes be 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. See below for additional information.

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, 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.

Hazardous Spill Basins should be inspected to determine whether they are functioning as intended. Refer to Chapter 2 for recommended inspection frequency. 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. Figures 10-3 and 10-4 illustrate a plan and profile view of the areas that should be inspected and maintained for a typical Hazardous Spill Basin. Figure 10-3 also illustrates the flow path under normal conditions.

All inspection findings and maintenance activities should be entered into SCMS via mobile devices in the field. In cases of technical difficulties, these should be noted on the inspection checklist (see Appendix A) and entered into SCMS upon return to the office. Take photographs and upload them to SCMS to track the status of the SCM. Document the maintenance activities and inspections. Refer to Chapter 4 for further guidance on I&M reporting.

The following sections describe the function of a Hazardous Spill Basin and provide inspection and maintenance guidance for its major components.

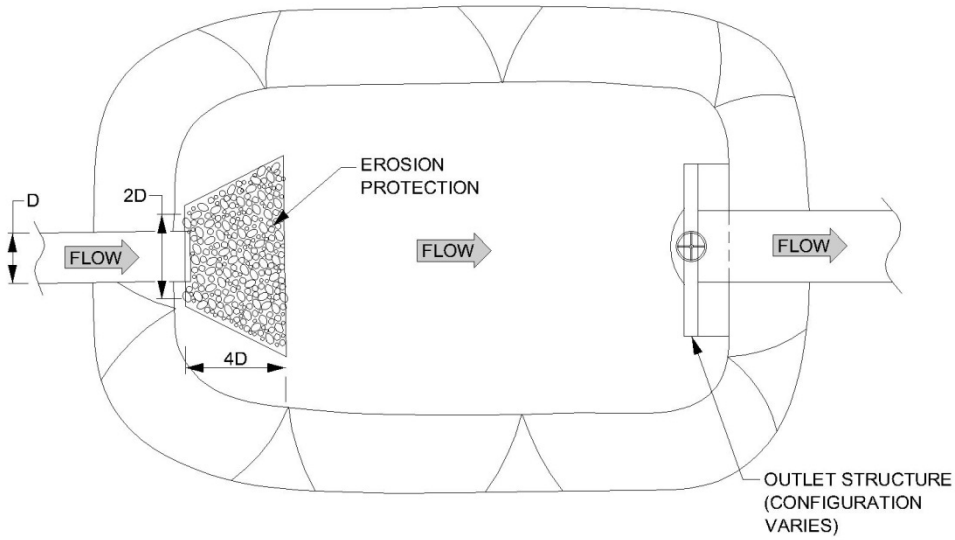


Figure 10-3. Plan view of a Hazardous Spill Basin and its components

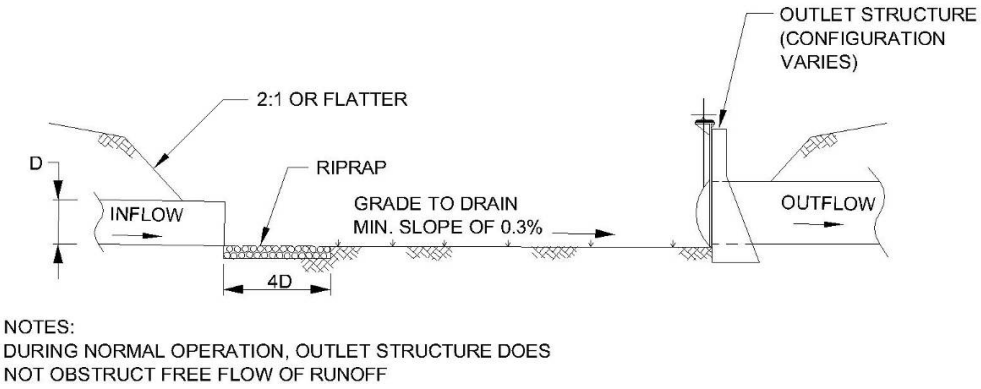


Figure 10-4. Profile view of a Hazardous Spill Basin and its components

10.3.1 Inlet Drainage System

Function

The inlet drainage system collects and conveys water to the SCM. Inlet drainage systems can consist of open channels, pipes, curbs and gutters, 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 sinkholes, depressions, or other signs of pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation.

Maintenance

Remove trash, debris, and undesirable vegetation, then properly dispose of off-site. Remove sediment if it appears to have accumulated more than 3 inches or is impeding the function, especially if it is blocking the sluice gate. 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 (e.g., riprap) may have been placed at the inlet to the Hazardous Spill Basin to protect this area from erosion. For some Hazardous Spill Basins, the entire basin is lined with riprap.

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 relative dimensions for erosion protection at the basin inlet. Refer to NCDOT Standard Drawing No. 876.02 for additional guidance (NCDOT, 2018b). 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 Hazardous Spill Basin that stores contaminants in the event of a spill. Based on a typical design, 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 the basin for structural integrity. Note any signs of erosion, burrowing animals, or undesirable vegetation. Inspect the embankment for settling, scouring, cracking, sloughing, furrowing, and for the presence of shrubs and trees. Also, inspect the downstream toe of the embankment for seepage (NCDEQ, 2020). Note trash, debris, and/or sediment found in the basin or surrounding areas. Sediment should be removed it if has reached a depth of 3 inches or is impeding the function (NCDEQ, 2020). Refer to Chapter 3 for guidance on sediment removal.

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, where possible. If there is a constant flow of water, other measures should be taken to ensure the basin remains stabilized. 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.

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 shows 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 Hazardous Spill Basins, 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.** 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 make sure 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 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, 2018b). Perform additional maintenance and repairs as described in the manufacturer's instructions.

10.3.6 OUTLET DRAINAGE SYSTEM

Function

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

Inspection

Inspect the headwall, pipes, and other drainage structures for cracks or leaks. Inspect the ground surface above buried pipes and structures for sinkholes, depressions, or other signs that might indicate pipe breakage or separation. Inspect ditches for signs of erosion and undesirable

vegetation. If outlet protection materials (e.g., 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 eroded areas and damaged pipes. Replace outlet protection materials as necessary. Refer to Chapter 3 for additional guidance on maintenance techniques.

10.3.7 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 (e.g., overgrown vegetation). Make repairs and remove obstructions to the sign as necessary. Figure 10-11 shows some examples of signage associated with Hazardous Spill Basins. Note that not all Hazardous Spill Basins have signage present.

Figure 10-11. Signage associated with HSBs

10.4 Inspection and Maintenance Summary

Observations made while inspecting SCMs must be documented on the appropriate SCM inspection form (Appendix A) electronically in SCMS or entered into SCMS as soon the

inspector is able. Observations recorded should include a general description of the SCM, if it is functioning well, and the maintenance needs identified, such as the removal of accessible trash, sediment, and undesirable vegetation. Additionally, the inspector assigns an LOS rating to the SCM during each inspection. Refer to Chapter 3 of this manual for approximate timeframes to complete maintenance activities based on the LOS ratings. Photographs should be taken during the inspection and uploaded to SCMS as soon as the inspector is able.

Maintenance needs documented in the inspection report can be routine or non-routine. Mowing and removal of accessible trash and debris, which the inspector may be able to perform during the inspection, are examples of routine maintenance activities. Non-routine maintenance items may include removing excess sediment or repairing structural parts of the SCM. Non-routine maintenance needs often require specialized equipment and/or trained personnel. Typically, any tree greater than 6 inches should be left in place so an engineered approach can be taken to avoid dam failure. If non-routine maintenance needs are identified during an inspection (e.g., failure of the SCM), the inspector should fill out a Maintenance Needed report in SCMS, then either correct the problem at that time or contact the party or parties responsible to schedule non-routine maintenance repairs.

If non-routine maintenance needs are not corrected at the time of inspection, the inspector should conduct a follow-up inspection to verify that the responsible party or parties have taken action and the maintenance needs have been addressed. Observations made during the follow-up inspection should also be documented on the Maintenance Completed report in SCMS. A follow-up inspection report should also be entered to change the LOS rating of the SCM.

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 reduce 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.
- Refer to Chapter 2 for recommended inspection frequency.

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 algal 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 Wetland Overview

Stormwater Wetlands (SW) are constructed SCMs 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 to 36 inches deep) dissipate flow energy, trap sediment, reduce nitrogen, and promote infiltration. Deep pools are also important for mosquito control by providing habitat for fish. The shallow water zone (2 to 4 inches) provides habitat for diverse wetland plants that provide additional nitrogen and phosphorus reduction. 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 to 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.

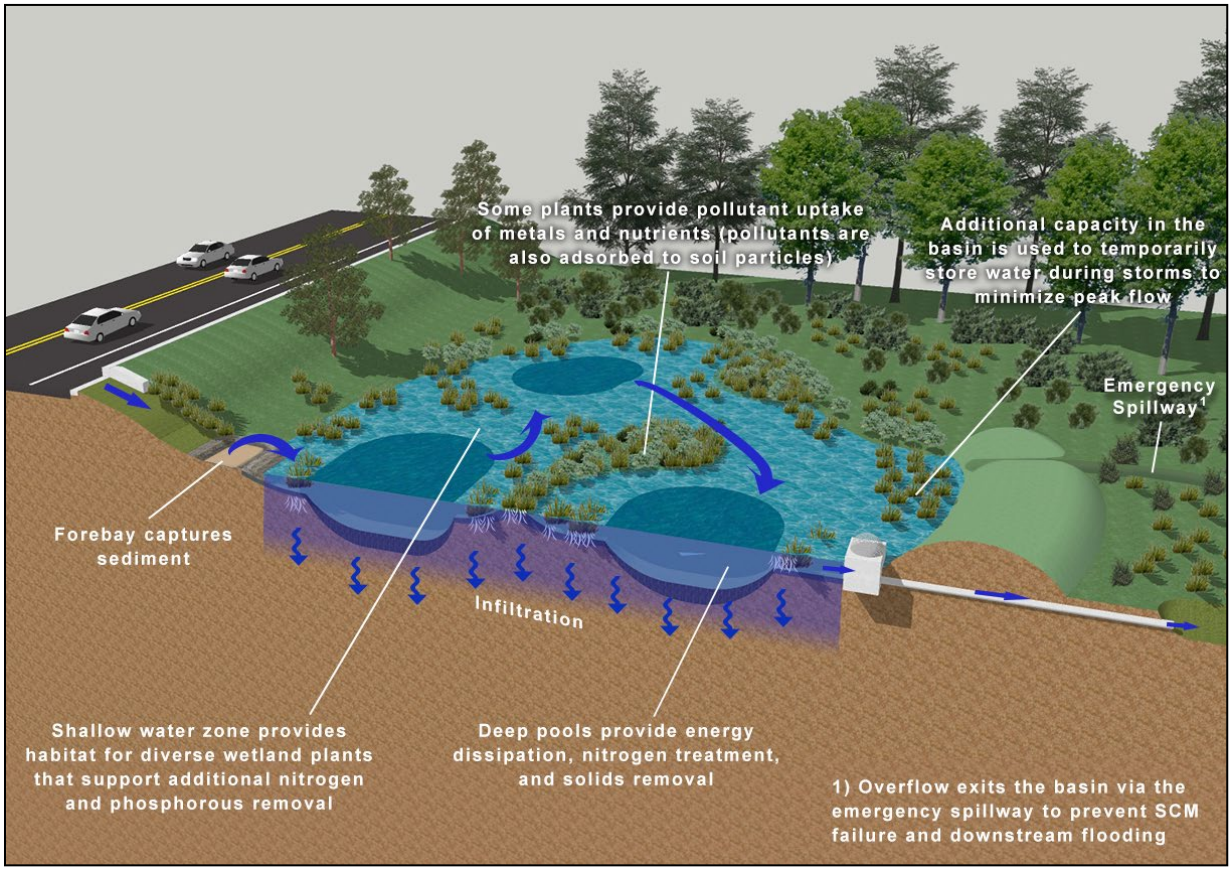


Figure 11-1. Cutaway of a Stormwater Wetland flow diagram and treatment processes

11.2 Stormwater Wetland Components

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

- Inlet Drainage System
- Forebay(s)
- Basin, containing Shallow Zones and Deep Pools
- Outlet Control Structure
- Outlet Drainage System
- Emergency Spillway

A typical Stormwater Wetland layout and its components are shown in Figure 11-2.

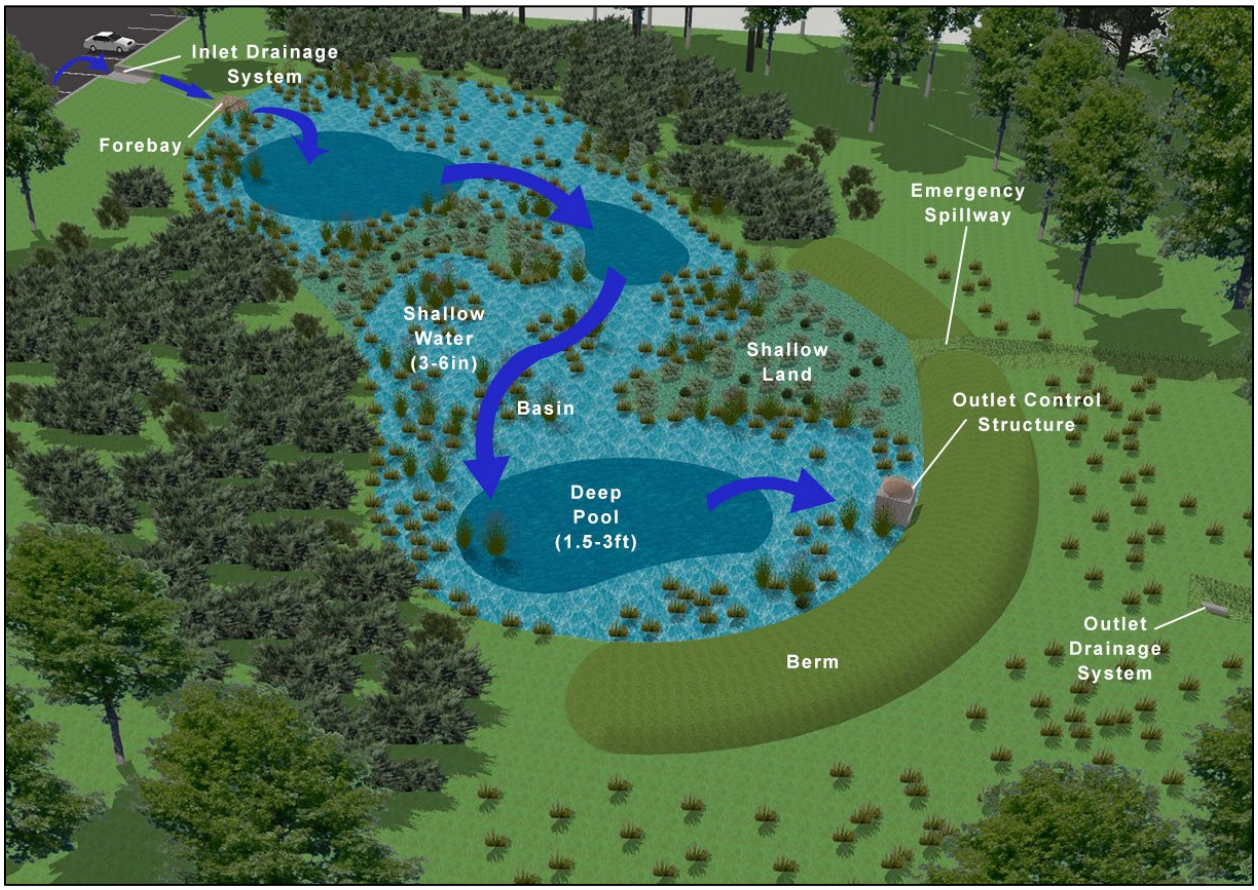


Figure 11-2. Components of a typical Stormwater Wetland

As runoff enters the Stormwater Wetland forebay, the runoff velocity is quickly reduced, allowing large trash, debris, and solids to be reduced. After leaving 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 reduction by anaerobic microbes (Hunt et al., 2007).

In contrast 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 to 5 days. This reduces the runoff velocity of the discharge and allows additional physical and chemical processes to reduce pollutants while the water is detained in the Stormwater Wetland.

11.3 Inspection and Maintenance

Stormwater Wetlands should be inspected to evaluate whether they are functioning as intended. Refer to Chapter 2 for recommended inspection frequency. Most importantly, 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 to be functioning improperly, determine the cause and restore the SCM 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 should be entered into SCMS via mobile devices in the field. In cases of technical difficulties, these should be noted on the inspection checklist (see Appendix A) and entered into SCMS upon return to the office. Take photographs and upload them to SCMS to track the status of the SCM. Document the maintenance activities and inspections. Refer to Chapter 4 for further guidance on I&M reporting.

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

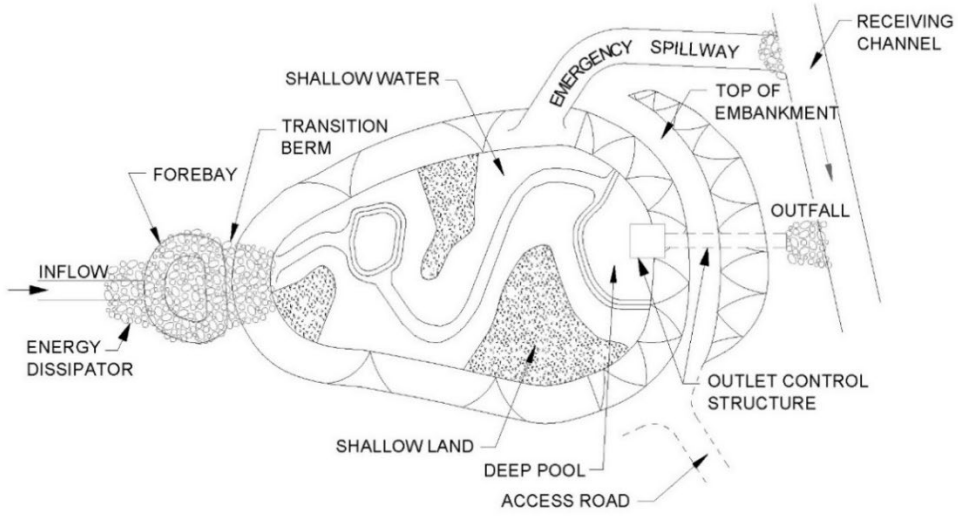


Figure 11-3. Plan view of a Stormwater Wetland and its components

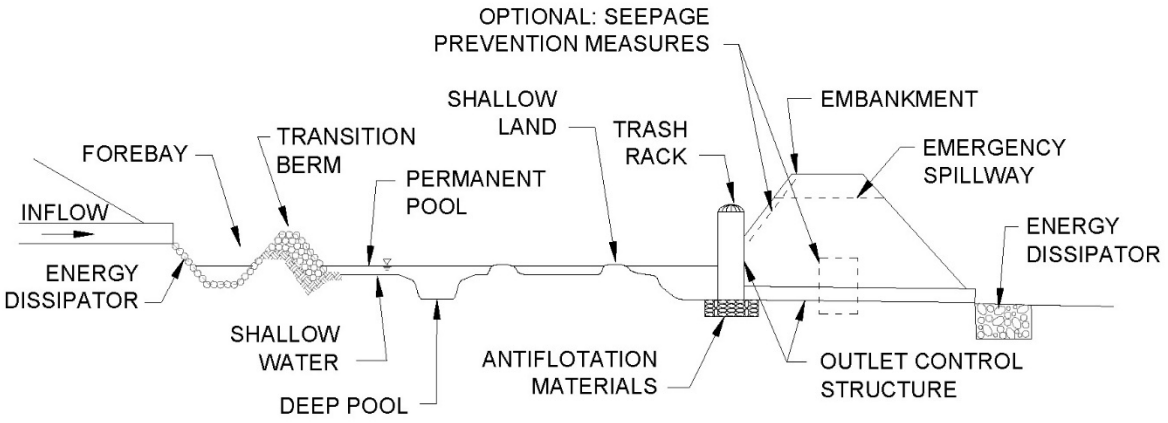


Figure 11-4. Profile view of a Stormwater Wetland and its components

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, curbs and gutters, 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 sinkholes, depressions, or 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 an SCM that pretreats stormwater. A forebay reduces the velocity of stormwater, which in turn allows sediment in the stormwater to settle before entering 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 SCM. The presence of a forebay reduces the risk of SCM failure.

Inspection

Inspect forebays for trash, debris, accumulated sediment, and undesirable vegetation. Inspect to determine whether forebays are structurally sound and functional. Inspect the embankment and transition berm for structural integrity and signs of erosion. Forebays are generally lined with riprap and sometimes underlined with geotextile fabric. Check for complete riprap coverage and/or rock displacement. Inspect for undesirable vegetation. Forebays are not designed to support other vegetation. Minimal plant growth is tolerable, but if it becomes excessive, the storage volume for sediment is reduced and dredging becomes more difficult. In some cases, Forebays are designed to be earthen and covered in turf-type grass. These Forebays are still not designed to support excessive vegetation. If any invasive species are present, it is preferable to remove them before they become well-established.

Maintenance

Remove trash, debris, sediment, and undesirable vegetation and properly dispose of it off-site. Remove sediment if it appears to have accumulated more than 3 inches or is impeding the function. Replace erosion protection materials (e.g., 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, 2014) 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 specific vegetation that varies depending on the water level around the SCM.

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 listed 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 (e.g., inadequate water supply, disease) and record it on the inspection report (Appendix A). Ideal vegetation density should be greater than 90% in planted areas. 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 or undesirable species can be detrimental to a Stormwater Wetland because they will very quickly displace the desirable wetland plants. Once established, it can be nearly 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 they will be much more difficult to kill by the following year. Examples of invasive species that can be problematic for Stormwater Wetlands include hydrilla, phragmites, and purple loosestrife. Although they are native and provide some pollutant reduction, cattails are also a problem species. They multiply quickly; therefore, they can reduce the device's storage capacity, crowd out desirable species, and create a breeding habitat for mosquitoes (Hunt et al., 2007).

Many Stormwater Wetlands contain algae. Algae occur in Stormwater Wetlands as a result of 1) nutrient-enriched water, 2) shallow water, and 3) intense sunlight. When the algal population is controlled, algae can provide nutrient reduction. Generally, if the algae mats are not thick enough to provide mosquito refuge, they do 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 30% of the Stormwater Wetland, develop a management plan to remove and prevent reoccurrence of such growth (NCDEQ, 2020). Physical removal is one option. Approved chemical control options are discussed in the North Carolina Agricultural Chemicals Manual (NCSU, 2022). Applicators are required to have a commercial pesticide applicators license with an aquatic endorsement. Contact the REU 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, furrowing, and for the presence of invasive shrubs and trees. Also, inspect the downstream toe of the embankment for seepage (NCDEQ, 2020). Note trash, debris, and/or sediment found in the Stormwater Wetland or 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 checklist. 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. Repair animal burrows.

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 SCM or if the wetland is dry during non-drought periods, contact the DEO or the REU for guidance. In this event, it may be necessary to perform soil amendments or to regrade the basin.

If excessive algae are noted during the inspection, follow any appropriate actions in the algae management plan for the SCM.

Unlike most other stormwater controls, solids that have settled in the Stormwater Wetland cannot be removed by dredging. Any dredging of the wetland could negatively impact the vegetative cover. Solids should be removed from the Stormwater Wetland only if it is deemed critical to the function of the Stormwater Wetland. The top layer of dredged material should be replaced over the wetland to reestablish vegetation (NCDEQ, 2020). Proper maintenance of the forebay should prevent more costly dredging of the Stormwater Wetland basin.

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, unusual odors, or an excessive amount of suspended solids. If any of these are present, do not drain the wetland basin. Call the DSO or the REU for guidance.

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, drawdown device or orifice, 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 wetland 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 accessible. If the outlet is clogged or blocked, hip waders or a small boat may be needed to make the necessary repairs. Make sure that the proper NCDOT safety procedures are followed when working in or around standing water.

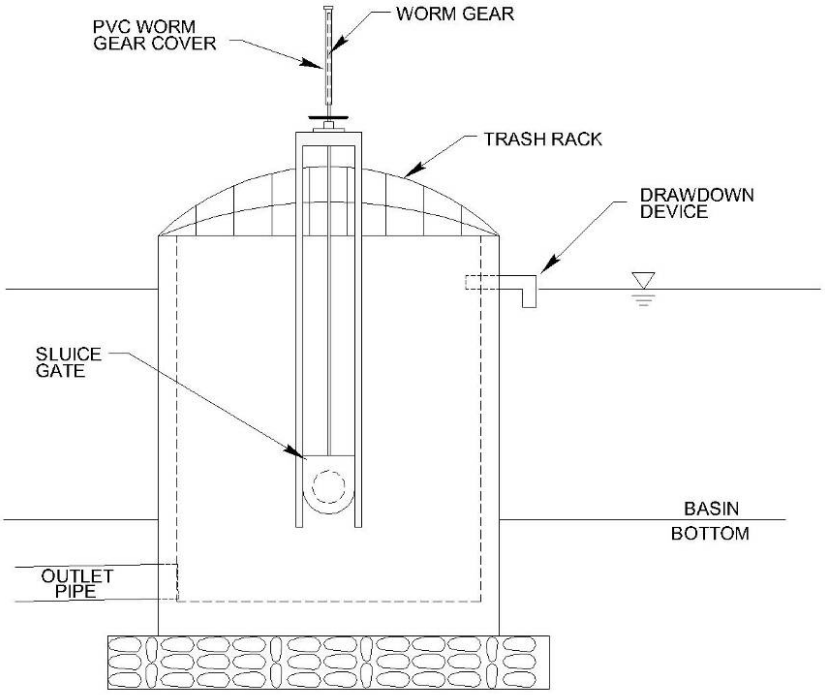


Figure 11-5. Components of a typical outlet control structure for a Stormwater Wetland

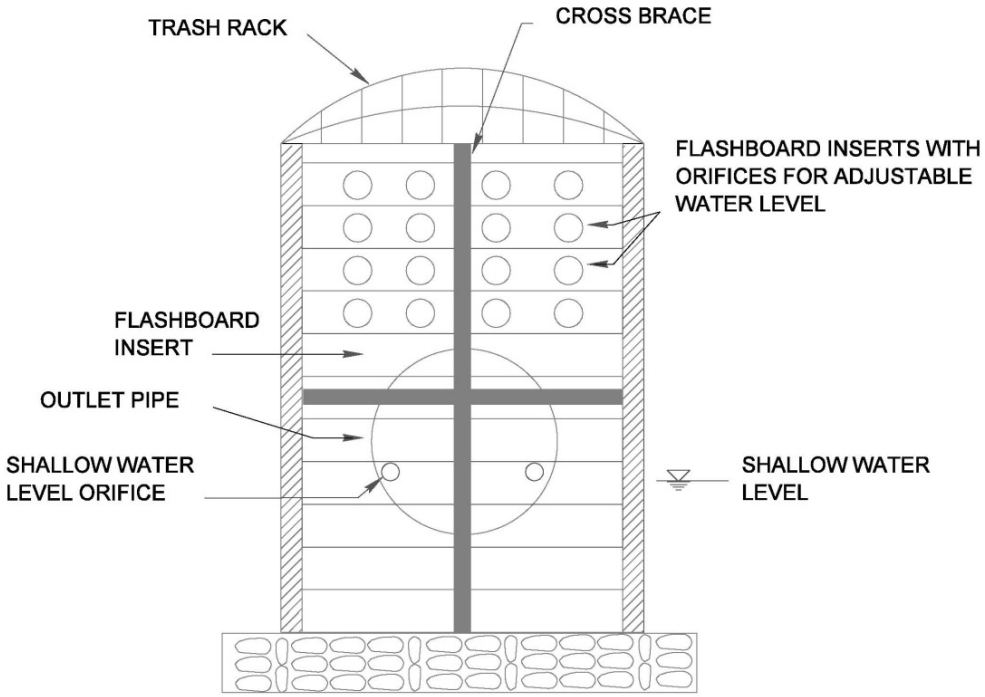


Figure 11-6. Components of a flashboard riser outlet control structure for a Stormwater Wetland

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

11.3.5 TRASH RACK, IF PRESENT

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. Check hinges for free movement and if needed, provide lubrication. If needed, the replacement trash rack should be consistent with the design specifications for the SCM. If drawings or specifications are not available, contact the 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 are used. 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 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 a clog.

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 the orifice 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: a screw-type gate or 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 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, 2018b). 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 SCM 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 pipes and drainage structures for cracks or leaks and to make sure they are free of sediment and debris. Inspect the ground surface above buried pipes and structures for sinkholes, depressions, or other signs that might indicate pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation. If outlet protection materials (e.g., riprap) are present, verify that these materials are adequate to protect against erosion.

Maintenance

Remove any sediment or debris that is accessible. Repair eroded areas and damaged pipes. Replace outlet protection materials (e.g., 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 SCM 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 and no scour is occurring below the slab or verify that adequate riprap is present. Note all erosion and undesirable vegetation. Note any debris in spillway or flow paths in grass as it may indicate frequent overflow due to outlet structure not functioning properly.

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.

11.4 Inspection and Maintenance Summary

Observations made while inspecting SCMs must be documented on the appropriate SCM inspection form (Appendix A) electronically in SCMS or entered into SCMS as soon the inspector is able. Observations recorded should include a general description of the SCM, if it is functioning well, and the maintenance needs identified such as the removal of accessible trash, sediment, and undesirable vegetation. Additionally, the inspector assigns an LOS rating to the SCM during each inspection. Refer to Chapter 3 of this manual for approximate timeframes to complete maintenance activities based on the LOS ratings. Photographs should be taken during the inspection and uploaded to SCMS as soon as the inspector is able.

Maintenance needs documented in the inspection report can be routine or non-routine. Mowing and removal of accessible trash and debris, which the inspector may be able to perform during the inspection, are examples of routine maintenance activities. Non-routine maintenance items may include removing excess sediment or repairing structural parts of the SCM. Non-routine maintenance needs often require specialized equipment and/or trained personnel. Typically, any tree greater than 6 inches should be left in place so an engineered approach can be taken to avoid dam failure. If non-routine maintenance needs are identified during an inspection (e.g., failure of the SCM), the inspector should fill out a Maintenance Needed report in SCMS, then either correct the problem at that time or contact the party or parties responsible to schedule non-routine maintenance repairs.

If non-routine maintenance needs are not corrected at the time of inspection, the inspector should conduct a follow-up inspection to verify that the responsible party or parties have taken action

and the maintenance needs have been addressed. Observations made during the follow-up inspection should also be documented on the Maintenance Completed report in SCMS. A follow-up inspection report should also be entered to change the LOS rating of the SCM.

CHAPTER 12 Swale

OVERVIEW

A SWALE is a channel that treats and conveys runoff from small drainage areas. NCDOT installs different types of Swales. They are classified as Grass Swales (S), Infiltration Swales (IS), Bioswales (BS), and Wet Swales (WS). Each type of Swale is explained further in the chapter.

PURPOSE AND DESCRIPTION

- Swales are broad and shallow, causing water to flow slowly through them.
- Swales reduce suspended solids, metals, and nutrients through sedimentation, vegetative filtration, infiltration, and biological uptake.

INSPECTION

- Swales should be monitored for erosion so they do not contribute sediment to receiving waters.
- Swales should be inspected at the specified frequencies to verify that the ideal vegetation type is maintained at the proper density and height. Refer to Chapter 2 for recommended inspection frequency.
- Each type of Swale (S, IS, BS, WS) is unique and the inspection requirements may vary. Specific guidance is provided further in this Chapter.

TYPICAL MAINTENANCE

- Sediment and debris should be removed before it negatively impacts vegetation growth or inhibits infiltration.
- Vegetation management should be performed 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.
- Each type of Swale (S, IS, BS, WS) is unique, and the maintenance requirements may vary. Specific guidance is provided further in this Chapter.

12.1 Stormwater Control Measure Overview

Swales (Grass-S, Infiltration Swale-IS, Bioswale-BS,Wet Swale-WS) both convey and treat 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.

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

There are 4 sub-classifications of Swales now present in SCMS. They are: Grass Swale, Infiltration Swale, Bioswale, and Wet Swale.

12.1.1 Grass Swales

Grass Swales (S) 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 Grass Swale and a roadside ditch is that Grass Swales are especially broad and shallow. The broad and shallow design and the vegetation in the Swale help to slow the speed of runoff, providing an opportunity for stormwater runoff treatment via the processes of filtration, settling, and infiltration.

12.1.2 Infiltration Swales

Infiltration Swales (IS) differ from Grass Swales due to the presence of false sumps or earthen dam-like structures. These structures are intended to temporarily pond and slow down the flow of runoff, which promotes infiltration. This type of Swale is particularly useful where soils have a high infiltration rate. Infiltration Swales greatly reduce the amount of water that goes through the storm drainage system and allows instead for runoff to infiltrate back into the groundwater.

12.1.3 Bioswales

Bioswales (BS) are similar to Infiltration Swales but have an engineered filter media to reduce pollutants from stormwater runoff. Like Infiltration Swales, these SCMs work by temporarily detaining stormwater runoff via false sumps and allowing the water to infiltrate into the filter media. As stormwater slowly passes through the filter media, pollutants are filtered and adsorbed as they make contact with soil particles. The filtered water then enters the underdrain system of the Bioswale, where it exits and flows to the nearest storm drainage system or surface water body.

Bioswales are effective in removing many of the common pollutants found in stormwater runoff, especially finer sediments and sediment-bound pollutants. All ponded water visible above the surface of the Bioswale should be infiltrated within 12 hours of completion of runoff into the Swale.

12.1.4 Wet Swale

Wet Swales (WS) treat water differently than other Swales in that they are more like a linear Stormwater Wetland. Wetland vegetation is encouraged to grow as the Swale remains wet or very close to the water table year-round. The wetland soils and vegetation treat pollutants from the runoff rather than through infiltration.

Figure 12-1 illustrates flow entering two different Grass Swale configurations, being conveyed, and exiting the Swales. The figure also shows the treatment processes that occur in a typical Grass Swale. Much of this flow path and many of these treatment processes are applicable for all four types of Swales.

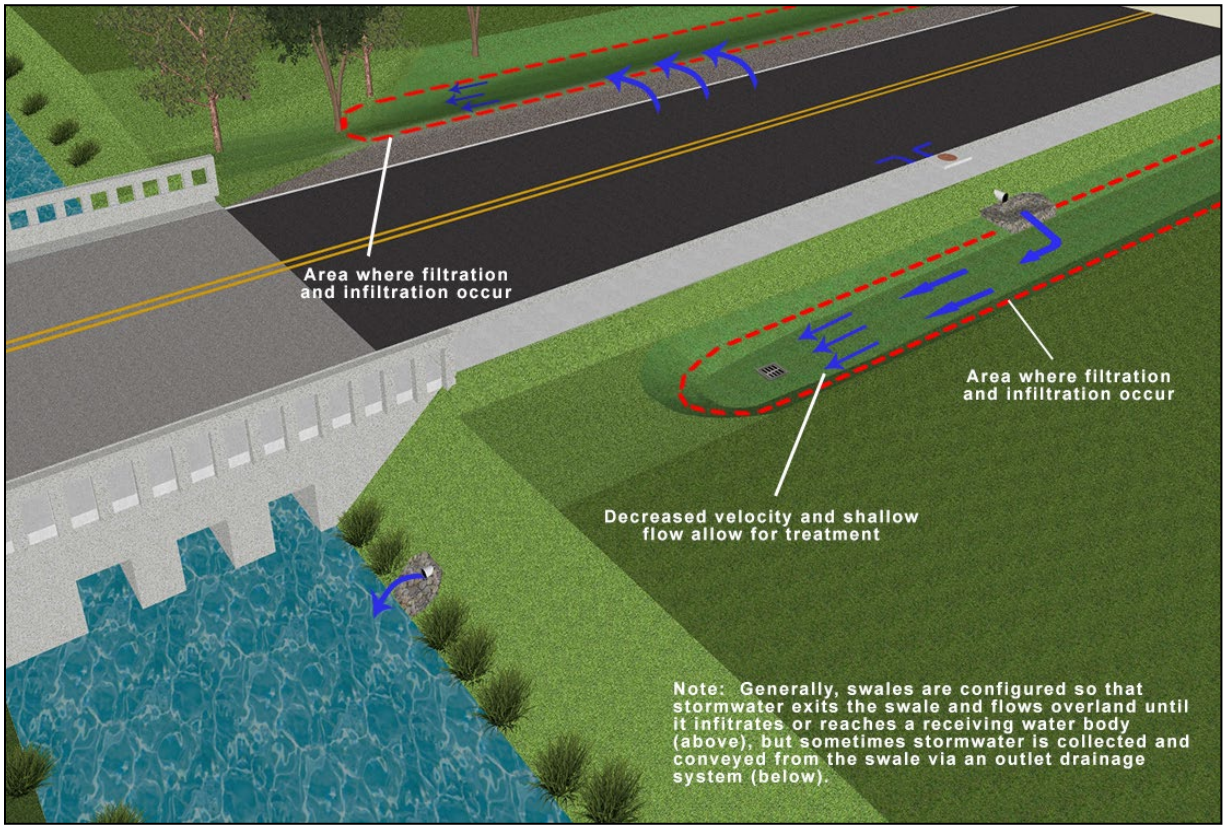


Figure 12-1. Grass Swale flow diagram and treatment processes

12.2 Swale Components

Note that Swale layouts vary by the type of Swale. Listed below are the typical components found in each of the Swale sub-classifications. Some Swale types will have additional components, while others may omit certain components.

12.2.1 Grass Swale Components

Figure 12-2 illustrates the various components of a typical Grass Swale. Grass Swale systems may include the following:

- Inlet Drainage System
- Pretreatment System (Forebay, Splash Pad, or Energy Dissipator)
- Channel
- Outlet Drainage System

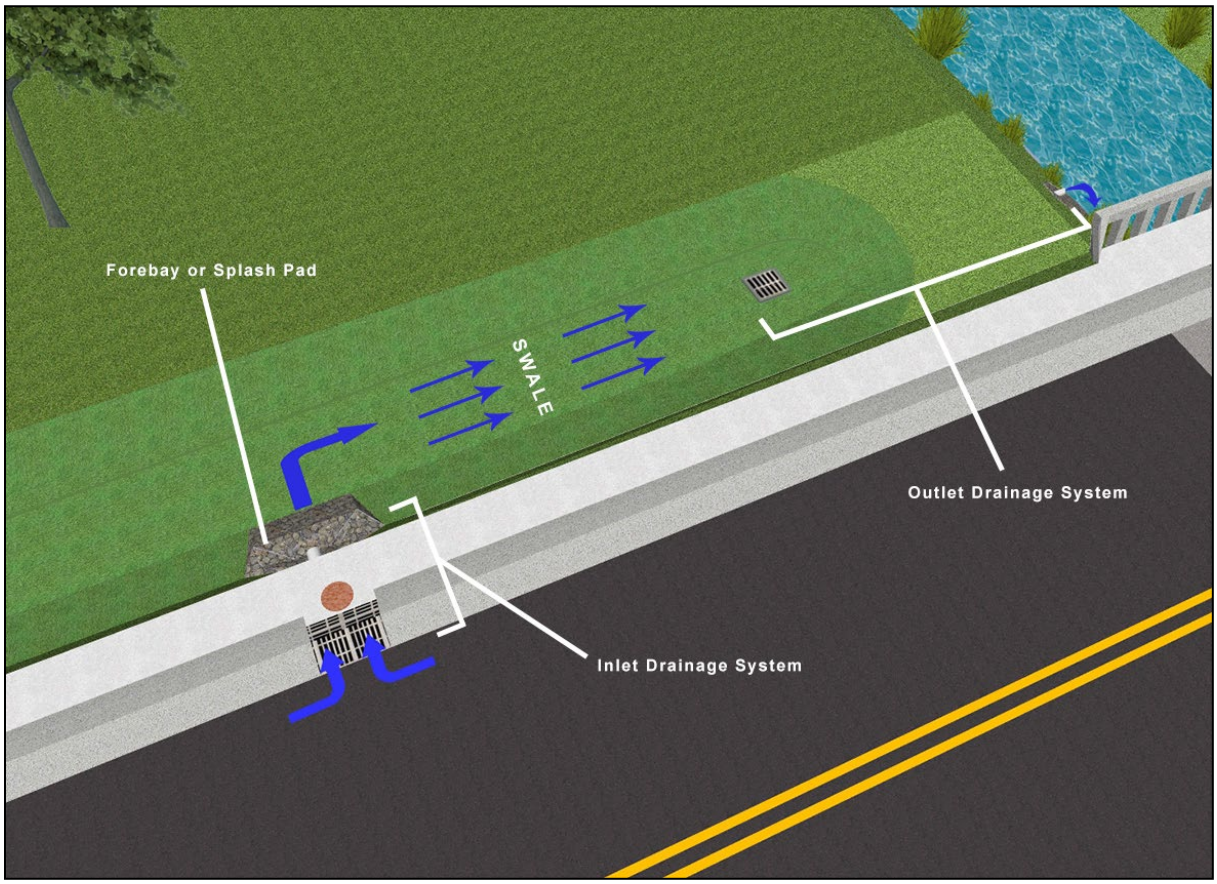


Figure 12-2. Components of a typical Grass Swale system

12.2.2 Infiltration Swale Components

Figure 12-3 shows the typical configurations of an Infiltration Swale. Infiltration Swales have the same components as Grass Swales, but the check dams will typically be present and are a key component of this Swale sub-classification. Some shorter and flatter Infiltration Swales may not have check dams since sufficient temporary ponding can be achieved by a raised outlet structure. The typical components present in an Infiltration Swale are:

- Inlet Drainage System
- Pretreatment System (Forebay, Splash Pad, or Energy Dissipator)
- Channel

- Check Dams (typically present)
- Outlet Drainage System (Outlet structure is typically raised 0.5’ – 1.0’)

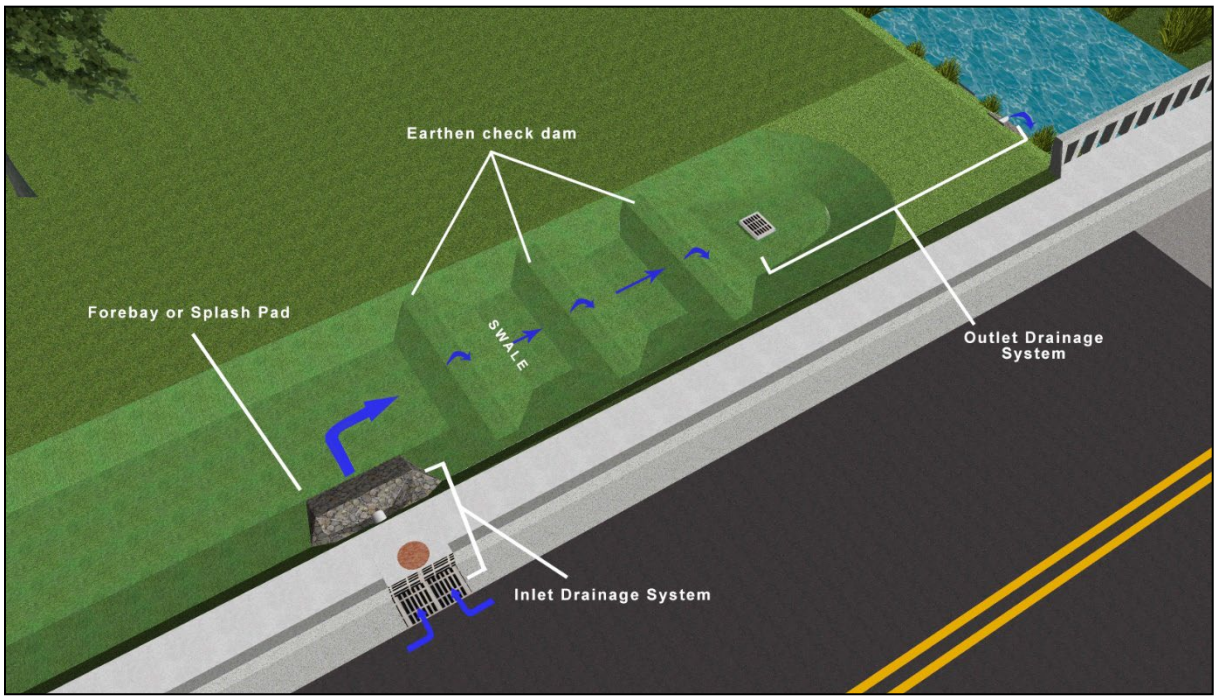


Figure 12-3. Components of a typical Infiltration Swale system

12.2.3 BIOSWALE COMPONENTS

Figure 12-4 shows the typical configurations of a Bioswale. Bioswale components may include the following:

- Inlet Drainage System
- Pretreatment System (Forebay, Splash Pad, or Energy Dissipator)
- Channel
- False Sump(s)
- Engineered Filter Media
- Underdrain System and Cleanouts
- Outlet Control Structure
- Outlet Drainage System

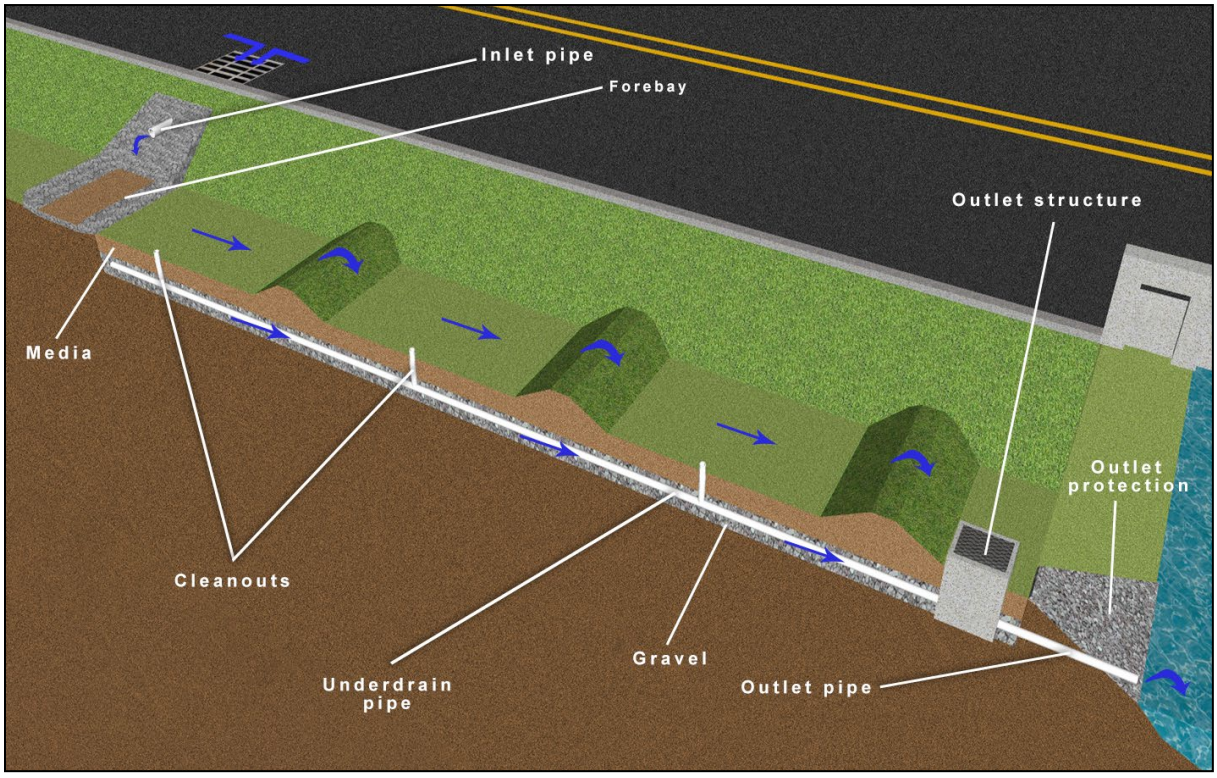


Figure 12-4. Components of a typical Bioswale system

12.2.4 WET SWALE COMPONENTS

Figure 12-5 shows the typical configurations of a Wet Swale. The typical components present in a Wet Swale are:

- Inlet Drainage System
- Pretreatment System (Forebay, Splash Pad, or Energy Dissipator)
- Channel
- False Sump(s)
- Outlet Control Structure
- Outlet Drainage System

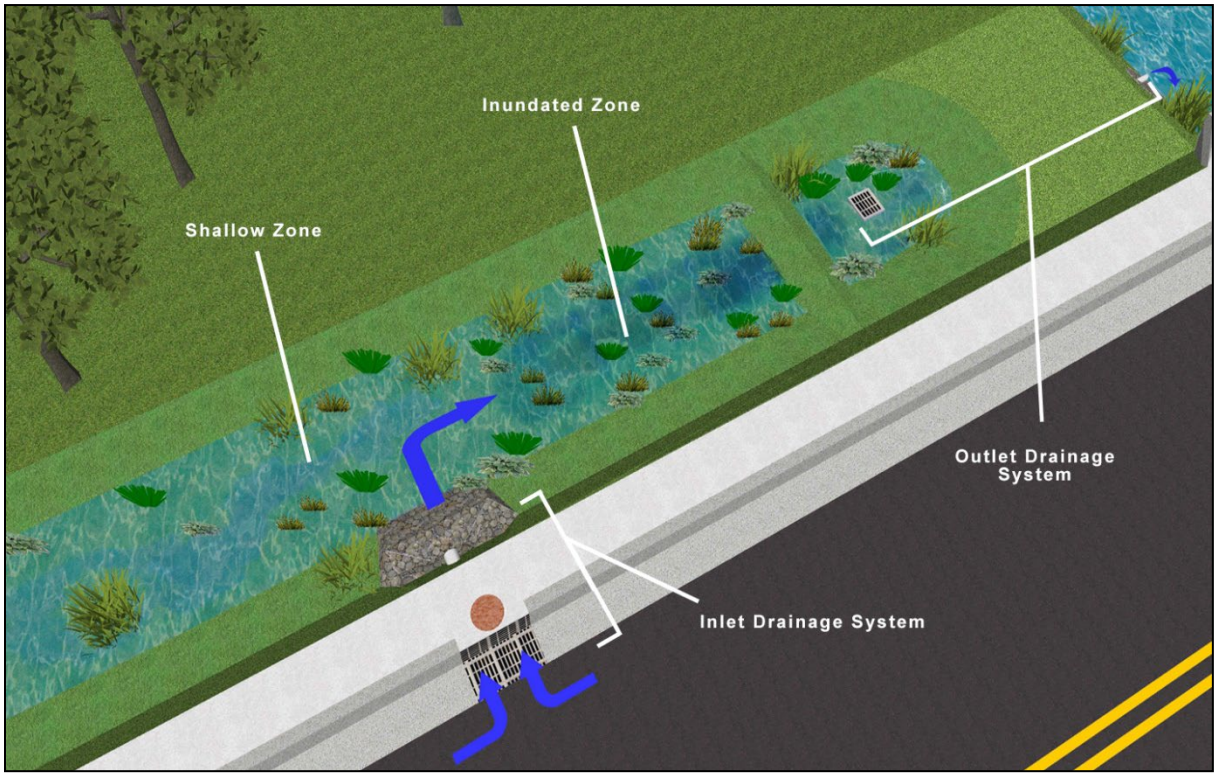


Figure 12-5. Components of a typical Wet Swale system

12.3 Inspection and Maintenance

Swales and the drainage structures associated with them should be inspected to evaluate whether they are functioning as intended. Refer to Chapter 2 for recommended inspection frequency. If the system is found to be functioning improperly, determine the cause and restore the SCM to working order as soon as possible.

All inspection findings and maintenance activities should be entered into SCMS via mobile devices in the field. In cases of technical difficulties, these should be noted on the inspection checklist (see Appendix A) and entered into SCMS upon return to the office. Photographs should be taken and uploaded to SCMS to track the status of the SCM, and the maintenance activities conducted should be documented. Refer to Chapter 4 for further I&M 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 SCM. Inlet drainage systems can consist of open channels, pipes, curbs and gutters, and catch basins. An inlet drainage system may not be present if the Swale receives runoff directly from the source via overland flow.

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 sinkholes, depressions, and other signs of pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation. Undesirable vegetation includes any woody plants or invasive species that may impede the inlet drainage system or inlet pipe.

Maintenance

Remove and properly dispose of trash, debris, and undesirable vegetation. Remove and properly dispose of sediment that has accumulated more than 3 inches or is impeding the function. 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 PRETREATMENT SYSTEM (IF PRESENT)

Function

The pretreatment system is an energy dissipator that may be used at the inlet(s) of a Swale to pretreat stormwater of sediment and debris and to protect against erosion. Pretreatment systems can include forebays, splash pads, and/or plunge pools. A forebay reduces the flow velocity of stormwater runoff, which in turn allows suspended solids in the stormwater to settle before entering the Swale. Forebays facilitate maintenance by collecting sediment in one area where it can be removed easily, increasing the life of the SCM. Splash pads protect against erosion where runoff exits a pipe, in this case, at the inlet to the Swale. A plunge pool is a riprap-lined pool similar to a forebay albeit typically smaller, located at the inlet of an SCM to dissipate the energy of high velocity flows and prevent erosion of the inlet. Additionally, due to the reduced velocities, the plunge pool allows sediment in the stormwater to settle before the water is released into the SCM. Plunge pools and forebays have a transition berm to act as a weir by releasing runoff into the SCM. Figure 12-6 shows a forebay.

Inspection

Inspect forebays, splash pads, plunge pools, and PSHs for trash, debris, and undesirable vegetation. Inspect to determine whether the pretreatment system is structurally sound and that it does not contain more than 3 inches of accumulated sediment. Splash pads, however, are not typically designed to store sediment at all. In addition, any sediment accumulation that has the potential to wash downstream or cause problems in the SCM should be removed. Inspect the pretreatment system for signs of erosion, and check for complete riprap coverage and/or rock displacement if applicable.

Figure 12-6. A well-maintained forebay

Maintenance

Remove sediment, trash, debris, and undesirable vegetation, then properly dispose of it off-site. Remove and properly dispose of sediment if it appears to have accumulated more than 3 inches or is impeding the function. Correct any structural deficiencies and replace erosion protection materials (e.g., riprap) as needed. If necessary, reestablish vegetation for earthen forebays. Refer to Chapter 3 for additional guidance on sediment disposal. Consult the NCDOT *Stormwater Best Management Practices Toolbox* (NCDOT, 2014) or the Hydraulics Unit if major repairs are required.

12.3.3 CHANNEL

Function

The channel decreases runoff velocity of stormwater runoff. By slowing runoff, suspended solids and associated pollutants settle out of stormwater before being conveyed downstream, and water is more likely to infiltrate into the ground. Typically, Swale channels work best on relatively flat grades. However, check dams or false sumps (see section 12.3.4) may be installed in areas with steeper slopes to help slow the flow. Swale channels often drain directly into receiving waters or other SCMs. For this reason, it is important that channels are carefully inspected and maintained to prevent excessive pollutants from being conveyed downstream. Figure 12-7 shows two photos of typical channels in a highway setting. Channel design and inspection needs vary based on Swale sub-classification; for example, most Swale channels should not be filled with water year-round unless the SCM is considered a Wet Swale. Wet Swales combine microtopographic pools and shallow water areas typically intercepting the seasonal high water table (SHWT) to develop wetland conditions, including wetland soils, hydrology, and vegetation.

Inspection

The base of the channel, its interior and exterior side slopes, and areas surrounding the Swale should be stabilized. 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. Steeper side slopes increase the risk of excessive channelization and an increase in flow velocity, which decreases the effectiveness of the Swale.

Figure 12-7. Linear highway applications of Swales

Verify that turf grasses are being mowed at a frequency to maintain the desired height. While the ideal grass height for achieving stormwater runoff treatment in a swale is typically between 4 to 6 inches, the grass height can be up to 15 inches for swales located in the areas where mowing is infrequent. Refer to Chapter 3 for guidance on vegetation maintenance. If the planting plan is available, typically for Bioswales and Wet Swales, it should be referred to for plant species and composition to be maintained. For more guidance on maintaining the plants for Bioswales and Wet Swales, contact the Hydraulics Unit.

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 channel. Excessive accumulation of sediment should be removed when typical flow is altered or grass can no longer be seen, where applicable. In addition, sediment accumulation in Wet Swales should be removed to maintain the microtopographic pools. Stabilize any eroding surfaces in or around the SCM, and repair undercut slopes by restoring the proper grade and reseeding. Refer to Chapter 3 for further guidance on maintenance techniques.

12.3.4 Check Dams & False Sumps (if present)

Function

Check dams and false sumps are small, grassed earthen or riprap dams constructed to enhance the water quality benefits of Swales. These devices are installed in Swales to create storage volume or to slow flow in areas with steep slopes. Figure 12-8 shows examples of rock check dams and grassed false sumps implemented in Swales. Check dams and false sumps are permanent structures constructed to enhance water quality and should not be confused with an erosion & sediment control temporary device used during roadway construction.

Figure 12-8. Swale with check dams (left) and Swale with false sumps (right)

Inspection

Inspect check dams and false sumps for trash, debris, undesirable vegetation, excessive sediment, and erosion around the sides of the structure. Verify that check dams retain the proper dimensions per construction drawings.

If the check dam or false sump is a grassed earthen type, verify that it has adequate grass cover and look for signs of erosion, especially on the downgrade slopes. If the grassed earthen check dams or false sumps have PSRM or another type of matting, it should be inspected for damage and verified that it is properly toed in and anchored.

The main structure of the rock check dam should be composed of riprap with smaller stone located on the upstream side of the check dam to capture sediment. Displacement of rocks may indicate flow velocities that are higher than designed and/or problems upstream of the SCM. Figure 12-9 shows the basic configurations of a rock check dam and earthen check dam.

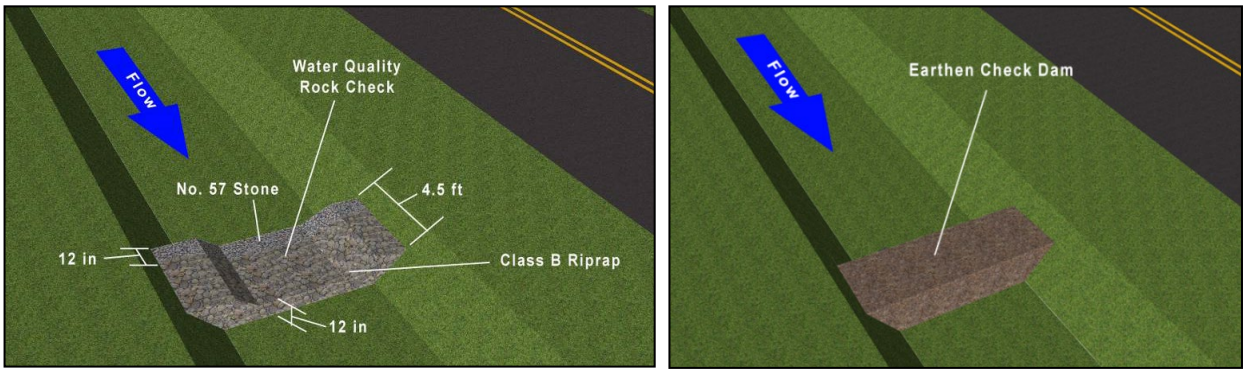


Figure 12-9. Rock check dam and earthen check dam

Maintenance

If possible, maintenance on the permanent check dam or false sump should be performed when the SCM is dry so as to prevent accumulated sediment from washing downstream. Remove and

properly dispose of trash, debris, undesirable vegetation, and sediment. Sediment should be removed if it begins to cover the turf grass (as applicable) or if it has accumulated more than 3 inches. If erosion or lack of adequate vegetation is observed in grassed earthen check dams or false sumps, it may require revegetation and reinstallation of matting. Replace riprap and stone as needed, repair erosion, and rebuild or reshape check dams and false sumps as necessary. Handheld equipment should be used when mowing around check dams and false sumps as they are highly susceptible to damage from typical roadside mowers. It is recommended that SCMs with rock check dams and false sumps be marked with white-tipped stakes or other similar markers so the maintenance staff knows where the boundaries of the SCM are. This way, maintenance-related damages can be avoided.

12.3.5 Bioswale Media

Function

This component is specific to Bioswales. The Bioswale media is the component that reduces the stormwater velocity so infiltration can occur, allowing the filter media to reduce contaminants from infiltrated runoff. Filter media can consist of engineered material, amended soil, or sand. A minimum of 18" of media is required, but the total depth of media can vary based on the design. The filter media is typically covered with a thin layer of topsoil and grass.

Inspection

The interior and exterior side slopes of the Bioswale and all areas surrounding the Bioswale should be stabilized with at least a cover of turf-type grass. Grass height should be maintained between 6 and 15 inches. Inspect the Bioswale for structural integrity. Note any signs of erosion, burrowing animals, or undesirable vegetation. Inspect the Bioswale for settling, scouring, cracking, sloughing, furrowing, and for the presence of invasive shrubs and trees. Note trash, debris, and/or sediment found in the Bioswale or in surrounding areas. Currently, the Bioswales are designed to drain within 12 hours. Use design drawings to determine the drawdown period and inspect the Bioswales for evidence that water remains in the Bioswale longer than intended. Cattails and other wetland vegetation are good indicators that water is remaining in the Bioswale 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 Bioswale will fail. Vehicles and construction equipment should not be driven on the Bioswale bottom (NCDEQ, 2007) since this could compact the media or damage the underdrain. Use best professional judgement when selecting mowing and other landscaping equipment for use in the Swale. Avoid the use of riding lawnmowers and minimize foot traffic on the Bioswale bottom. Mow grass to the ideal height of 4 to 6 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 Swale is not draining properly. 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, then replace the original filter media with the new media (NCDEQ, 2020). These components should be repaired or replaced to meet the original design specifications unless deemed insufficient. For additional guidance, consult the NCDOT *Stormwater Best Management Practices Toolbox* (NCDOT, 2014).

12.3.6 Underdrain System and Cleanouts

Function

Bioswales 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 high-density polyethylene (HDPE) pipe. The perforated pipe is wrapped in filter fabric to prevent clogging and installed in a layer of washed coarse aggregate. Typically, cleanouts provide access to the underdrain system for inspection and maintenance activities. If there are no cleanouts present, it may be possible to access the underdrain system through the outlet control structure. To avoid crushing the underdrain system, heavy equipment should not be driven in the Bioswale.

Inspection

Inspect the cleanouts to ensure the caps and standpipes are in place and undamaged. Damage to the cleanouts will allow stormwater to exit the Bioswale untreated. Alternatively, the cleanouts can be used to drain the Bioswale 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. Standing water may indicate that the underdrain system is cogged. However, it is not a concern if the Bioswale has an Internal Water Storage (IWS) zone. Inspectors should consult the design drawings to determine if an IWS zone is present. If water is available, the system can be tested by pouring water into the cleanouts using a hose and observing the flow in the outlet control structure or outlet pipe. If the water does not exit freely, the underdrain system may be clogged and can be accessed through the outlet control structure. If the Bioswale has depressions or sediment is flushed from the underdrain system, the underdrain system may have been damaged and may need to be excavated and repaired.

Maintenance

A high-pressure hose can be used to flush out underdrain systems by spraying water into cleanouts. Replace cleanouts that are missing, cracked, or otherwise damaged. NCDEQ recommends flushing underdrain systems annually if they appear to have a tendency to clog (NCDEQ, 2020). If roots or soil are present in the underdrain system, it is likely that the filter fabric protecting the perforated pipe is damaged. If this is the case, the underdrain system should

be excavated, then 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 Bioswale.

12.3.7 Outlet Control Structure

Function

Bioswales and Wet Swales contain an outlet control structure which is designed to release excess stormwater during large storm events. The outlet control structure retains water in the shallow zones for Wet Swales and allows smaller storm events to infiltrate for Bioswales. In addition, the Bioswale underdrain system connects to the outlet control structure. Outlet control structures can have several components including a riser, trash rack, and outlet pipe. If standing water needs to be drained or pumped out for inspection or maintenance, 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 are present, do not drain the Swale. Call the DSO or REU for guidance.

Inspection

Inspect the outlet control structure thoroughly for any sign of damage such as cracks, holes, or leaks. Sinkholes around the riser structure may indicate a poor pipe-to-structure connection. The leakage can be verified by inspecting around the area of outlet pipe penetration at the embankment or if it is causing piping in the embankment. Inspect to make sure that the outlet box remains covered with a trash rack(s) and that the trash rack is not excessively corroded. Note the amount of trash and debris buildup on the trash rack in the inspection report.

Maintenance

Repair any damaged areas of the outlet control structure, and remove sediment and debris. Replace trash rack or grate if necessary. Perform additional maintenance and repairs as described in the manufacturer's instructions. Remove trash and debris from trash rack if it has become significantly obstructed. If a sinkhole is noted around the outlet structure, provide backfill and compact. Investigate the cause of the sinkhole to prevent further soil loss or damage.

12.3.8 Outlet Drainage System (if present)

Function

The outlet drainage system conveys water from the SCM 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 sinkholes, 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 to protect against erosion.

Maintenance

Remove and properly dispose of debris, undesirable vegetation, and major sediment accumulations. Repair eroded areas and damaged pipes. If a sinkhole is noted around the underground structures or pipes, provide backfill and compact. Replace outlet protection materials (e.g., riprap) as necessary. Refer to Chapter 3 for additional guidance on maintenance techniques.

12.4 Inspection and Maintenance Summary

Observations made while inspecting SCMs must be documented on the appropriate SCM inspection form (Appendix A) electronically in SCMS or entered into SCMS as soon the inspector is able. Observations recorded should include a general description of the SCM, if it is functioning well, and the maintenance needs identified such as the removal of accessible trash, sediment, and undesirable vegetation. Additionally, the inspector assigns an LOS rating to the SCM during each inspection. Refer to Chapter 3 of this manual for approximate timeframes to complete maintenance activities based on the LOS ratings. Photographs should be taken during the inspection and uploaded to SCMS as soon as the inspector is able if a separate camera was used.

Maintenance needs documented in the inspection report can be routine or non-routine. Mowing and removal of accessible trash and debris from the channel or around earthen dams, which the inspector may be able to perform during the inspection, are examples of routine maintenance activities. Non-routine maintenance items may include removing excess sediment, replacement of media (Bioswale) or unhealthy plantings (Wet Swale), or repairing structural parts of the SCM. Non-routine maintenance needs often require specialized equipment and/or trained personnel. If non-routine maintenance needs are identified during an inspection (e.g., failure of the SCM), the inspector should fill out a Maintenance Needed report in SCMS, then either correct the problem at that time or contact the party or parties responsible to schedule non-routine maintenance repairs.

If non-routine maintenance needs are not corrected at the time of inspection, the inspector should conduct a follow-up inspection to verify that the responsible party or parties have taken action and the maintenance needs have been addressed. Observations made during the follow-up inspection should also be documented on the Maintenance Completed report in SCMS. A follow-up inspection report should also be entered to change the LOS rating of the SCM.

CHAPTER 13 Level Spreader

OVERVIEW

A LEVEL SPREADER (LS) is a structural stormwater control measure (SCM) 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.
- Refer to Chapter 2 for recommended inspection frequency.

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 Level Spreader Overview

A Level Spreader (LS) is an SCM used to slow runoff velocity, 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 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.

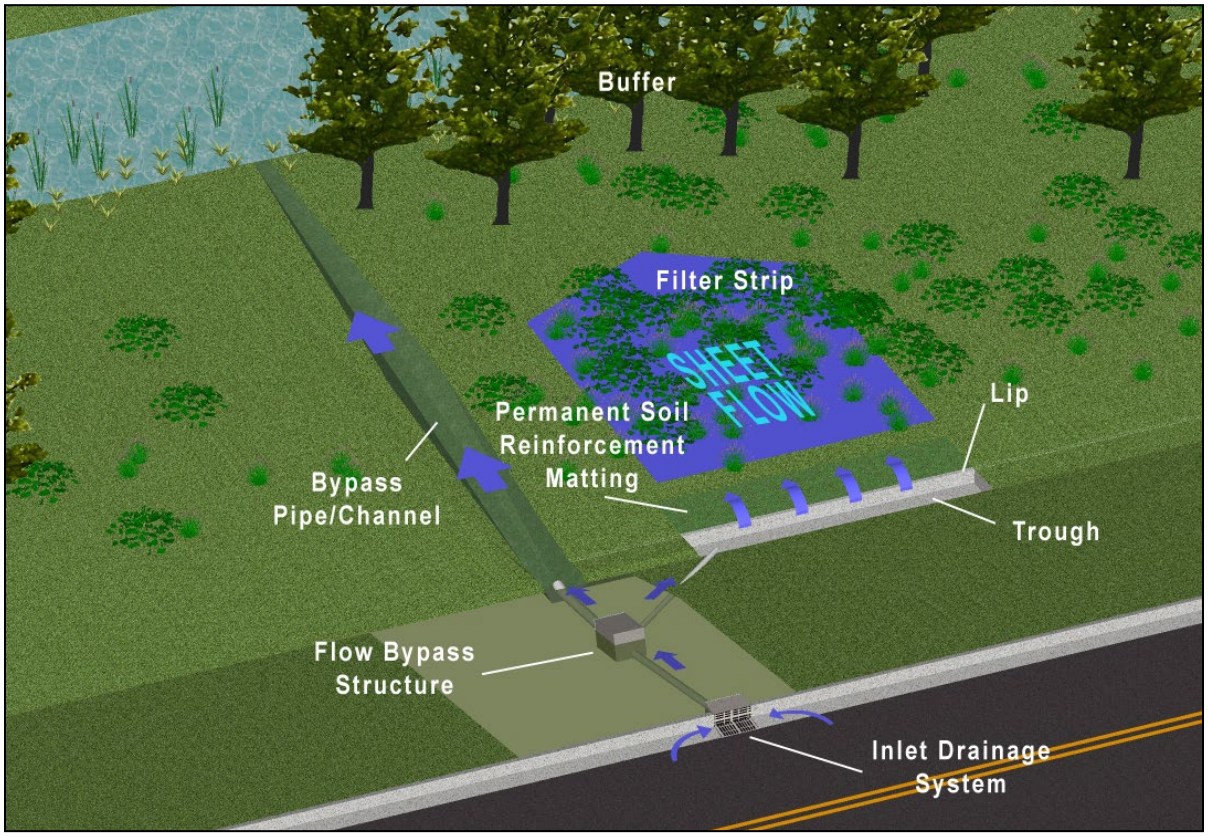


Figure 13-1. Water flow through a Level Spreader

Figure 13-2 illustrates the treatment processes that occur in a typical Level Spreader system.

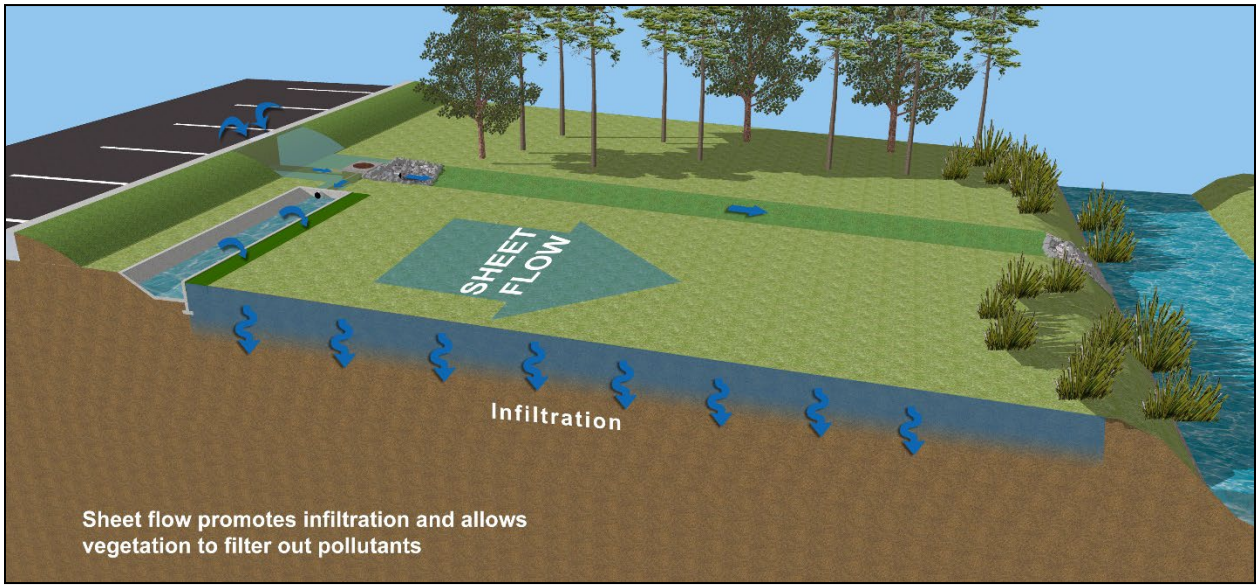


Figure 13-2. Level Spreader treatment processes

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, 2014). 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
- Forebay, if present
- Flow Bypass Structure/System
- Level Spreader Trough and Lip
- Filter Strip and/or Buffer
- Bypass Swale/Pipe or Outlet Ditch

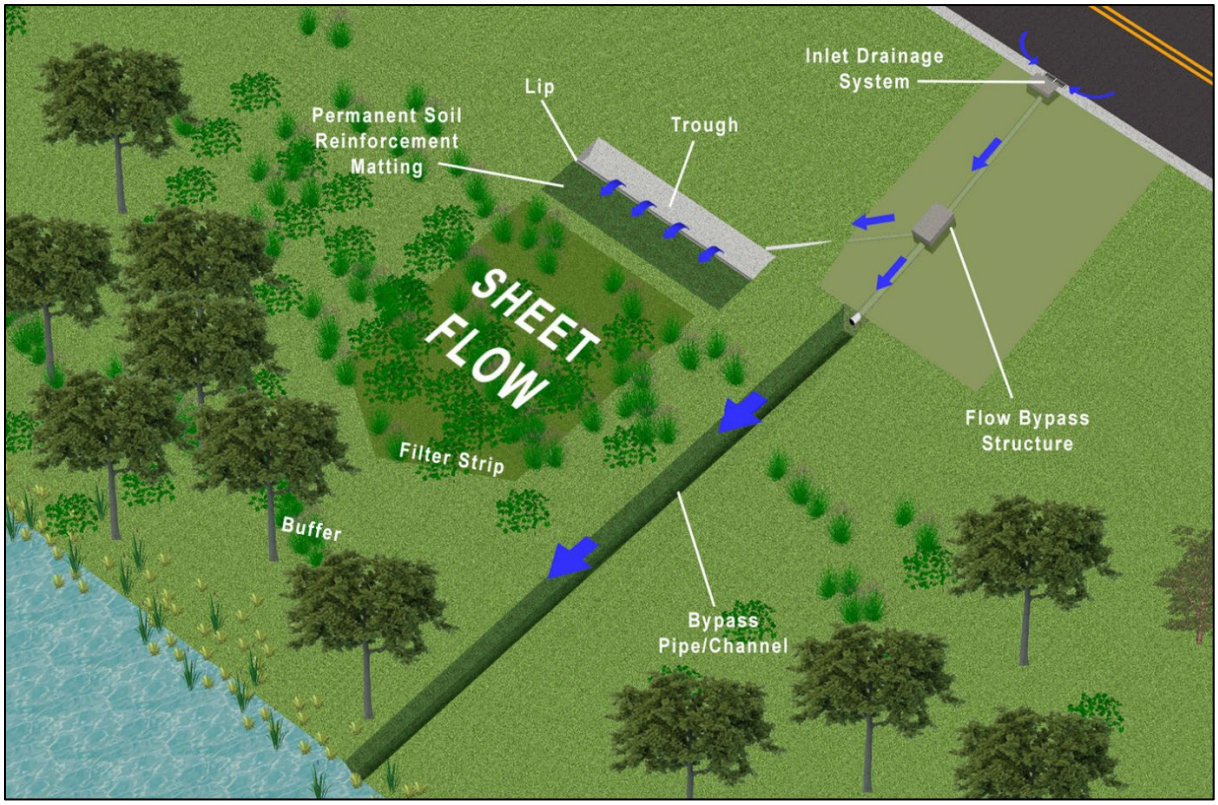


Figure 13-3. Components of a typical Level Spreader

13.3 Inspection and Maintenance

Level Spreaders should be inspected to determine whether they are functioning as intended. Refer to Chapter 2 for recommended inspection frequency. Most importantly, it should be verified that the Level Spreader is distributing flow evenly. If a Level Spreader is found to be functioning improperly, determine the cause and restore the SCM to working order as soon as possible. Figures 13-4 and 13-5 illustrate a plan and profile view of the areas that should be inspected and maintained in a typical Level Spreader configuration.

All inspection findings and maintenance activities should be entered into SCMS via mobile devices in the field. In cases of technical difficulties, these should be noted on the inspection checklist (see Appendix A) and entered into SCMS upon return to the office. Photographs should be taken and uploaded to SCMS to track the status of the SCM, and the maintenance activities conducted should be documented. 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.

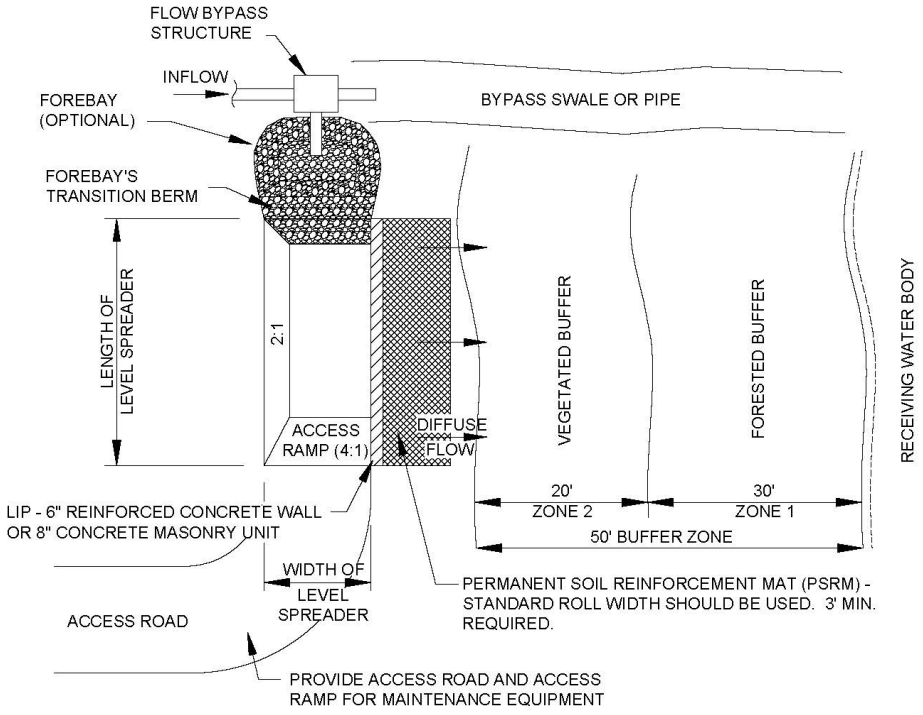


Figure 13-4. Plan View of a typical Level Spreader system and its components

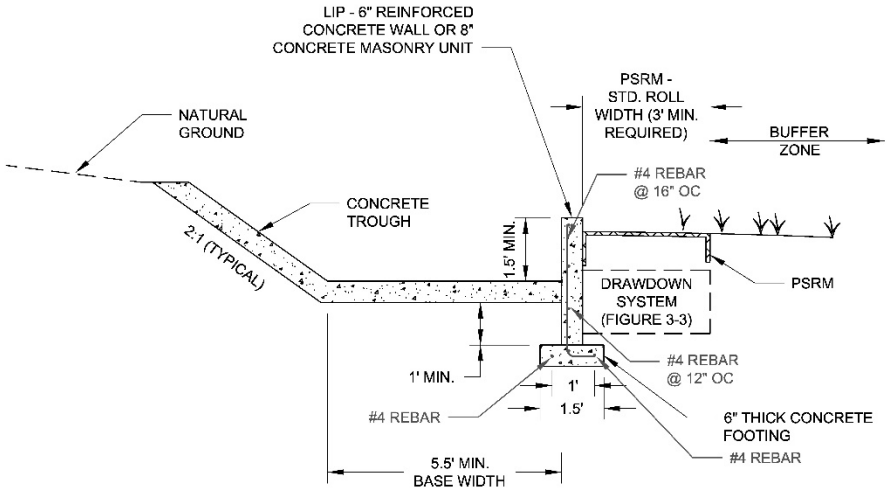


Figure 13-5. Profile View of a typical Level Spreader system and its components

13.3.1 Inlet Drainage System

Function

The inlet drainage system collects and conveys water to the SCM. Inlet drainage systems can consist of open channels, pipes, curbs and gutters, 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 sinkholes, depressions, and other signs of pipe breakage or separation. Inspect ditches for signs of erosion and undesirable vegetation. Undesirable vegetation includes any woody plants or invasive species that may impede the inlet drainage system.

Maintenance

Remove trash, debris, undesirable vegetation, and major sediment accumulations, then dispose of it off-site. 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 an SCM that pretreats stormwater. A forebay reduces the runoff velocity of stormwater, which in turn allows sediment in the stormwater to settle before entering the Level Spreader. The presence of a forebay reduces the risk of SCM failure due to clogging of the filter strip and sediment accumulation in the trough.

Inspection

Inspect forebays for trash, debris, accumulated sediment, and undesirable vegetation. Inspect to determine whether forebays are structurally sound and functional. Inspect the embankment and transition berm for structural integrity and signs of erosion. Forebays are generally lined with riprap and sometimes underlined with geotextile fabric. Check for complete riprap coverage and/or rock displacement. Inspect for undesirable vegetation. Forebays are not designed to support other vegetation. Minimal plant growth is tolerable, but if it becomes excessive, the storage volume for sediment is reduced and dredging becomes more difficult. In some cases, Forebays are designed to be earthen and covered in turf-type grass. These Forebays are still not designed to support excessive vegetation. If any invasive species are present, it is preferable to remove them before they become well-established.

Maintenance

Remove trash, debris, sediment, and undesirable vegetation and properly dispose of it off-site. Remove sediment if it appears to have accumulated more than 3 inches or is impeding the function. Replace erosion protection materials (e.g., riprap) as needed. If the surrounding soil is

disturbed during cleanout of the forebay, or at any time, reseed any areas of bare soil with grass to prevent erosion. Refer to Chapter 3 for further guidance on sediment disposal.

If a Level Spreader is being cleaned out, and it is discovered that it has only an earthen bottom, replacing the LS with a concrete trough is suggested if the Division is able to do so. If not, please alert REU or the Hydraulics Unit, as it may be a good candidate for a retrofit. Consult the NCDOT *Stormwater Best Management Practices Toolbox* (NCDOT, 2014) or the Hydraulics Unit if major repairs are required.

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 passes 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, cracks, and any erosion that would allow runoff to flow around the structure. Note any undesirable vegetation that might prevent the flow bypass structure from functioning. 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, 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 rock 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 permanent soil reinforcement matting (PSRM) and vegetation (NCDEQ, 2020). Sediment should be removed before it interferes with the Level Spreader's ability to distribute flow evenly. Repair the lip if it 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 13-6 for examples of Level Spreaders with typical maintenance needs.

Figure 13-6. Typical maintenance concerns: erosion at the Level Spreader lip and channelization in the filter strip (top), and woody debris in need of removal (bottom)

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 also filter out sediment. 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 13-7. 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.

Figure 13-7. Example of a Level Spreader and filter strip with a drawdown device consisting of weep holes with rock bags

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 (NCDEQ, 2020). If PSRM has been installed, inspect it for damage and verify that it is properly toed in and anchored.

Note: If the Level Spreader appears to be functioning properly but channelization or erosion is still occurring, contact the Hydraulics Unit as it may be a suitable candidate for retrofit.

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 enough to protect against erosion. Ensure that grass

remains dense and thick for optimum reduction of pollutants. If excessive sediment has accumulated, remove the sediment, reestablish vegetation, and regrade if necessary (NCDEQ, 2020).

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. 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 sinkholes, depressions, or other 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, undesirable vegetation, and major sediment accumulations. Repair eroded areas and damaged pipes. Replace or repair any material (e.g., riprap) or structure used to prevent discharge to the stream from causing erosion. Refer to Chapter 3 for additional guidance on maintenance techniques and mowing frequency.

13.4 Inspection and Maintenance Summary

Observations made while inspecting SCMs must be documented on the appropriate SCM inspection form (Appendix A) electronically in SCMS or entered into SCMS as soon the inspector is able. Observations recorded should include a general description of the SCM, if it is functioning well, and the maintenance needs identified such as the removal of accessible trash, sediment, and undesirable vegetation. Additionally, the inspector assigns an LOS rating to the SCM during each inspection. Refer to Chapter 3 of this manual for approximate timeframes to complete maintenance activities based on the LOS ratings. Photographs should be taken during the inspection and uploaded to SCMS as soon as the inspector is able.

Maintenance needs documented in the inspection report can be routine or non-routine. Mowing and removal of accessible trash and debris, which the inspector may be able to perform during the inspection, are examples of routine maintenance activities. Non-routine maintenance items may include removing excess sediment or repairing structural parts of the SCM. Non-routine maintenance needs often require specialized equipment and/or trained personnel. If non-routine maintenance needs are identified during an inspection (e.g., failure of the SCM), the inspector

should fill out a Maintenance Needed report in SCMS, then either correct the problem at that time or contact the party or parties responsible to schedule non-routine maintenance repairs.

If non-routine maintenance needs are not corrected at the time of inspection, the inspector should conduct a follow-up inspection to verify that the responsible party or parties have taken action and the maintenance needs have been addressed. Observations made during the follow-up inspection should also be documented on the Maintenance Completed report in SCMS. A follow-up inspection report should also be entered to change the LOS rating of the SCM.

CHAPTER 14 Permeable Pavement

OVERVIEW

PERMEABLE PAVEMENT (PP) 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 (NCDEQ, 2020).

PURPOSE AND DESCRIPTION

- Permeable Pavement is a stormwater control measure (SCM) that promotes the infiltration of stormwater into void spaces that filters pollutants, decreases runoff rate, and reduces pollutant loads (NCDEQ, 2020 and ICPI, 2011).

INSPECTION

- Refer to Chapter 2 for recommended inspection frequency. 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.
- 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 areas 1 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 Permeable Pavement Overview

Permeable Pavement includes permeable asphalt, permeable concrete, and permeable interlocking concrete pavement (PICP) systems. As of this time, NCDOT largely uses PICP, which is the focus of this chapter. 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 during intense rain events, also reduces pollution (ICPI, 2015). PICPs are highly aesthetic, durable, easily repaired, require little 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.

14.2 PICP Components

Figure 14-2 illustrates the various components of a typical PICP system. Note that layouts vary. Some systems will have additional components, whereas others may omit certain components. PICP systems may include the following:

- 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

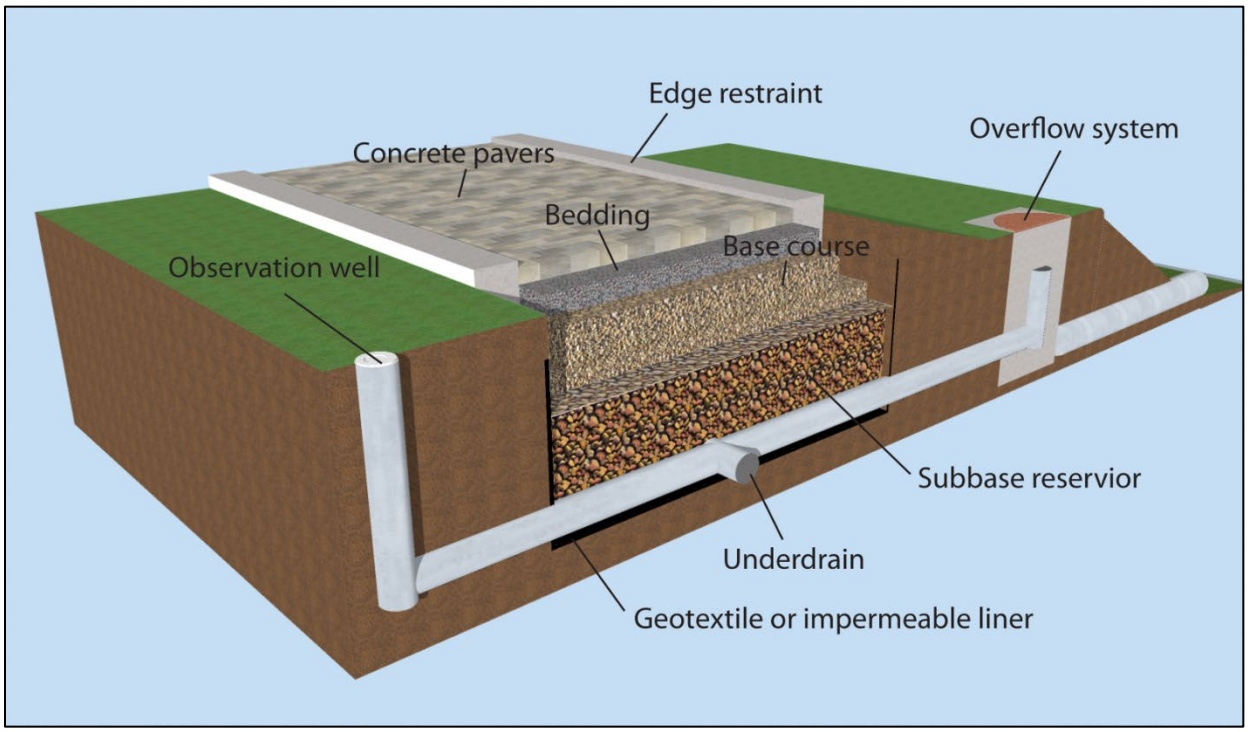


Figure 14-2. A cross-section of a Permeable Interlocking Concrete Paver installation.

14.3 Inspection and Maintenance

PICP should be inspected periodically to determine whether it is functioning as intended. Refer to Chapter 2 for recommended inspection frequency. Parking lot and driveway surfaces should be vacuumed 1 to 2 times annually (typically spring/fall). The vacuuming schedule should be adjusted as needed to prevent clogging. If PICP is found to be functioning improperly, determine the cause and restore the SCM to working order as soon as possible.

All inspection findings and maintenance activities should be entered into SCMS via mobile devices in the field. In cases of technical difficulties, these should be noted on the inspection checklist (see Appendix A) and entered into SCMS upon return to the office. Take photographs and upload them to SCMS to track the status of the SCM. Document the maintenance activities and inspections. Refer to Chapter 4 for further guidance on I&M reporting.

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

which decreases the effectiveness of the Swale.

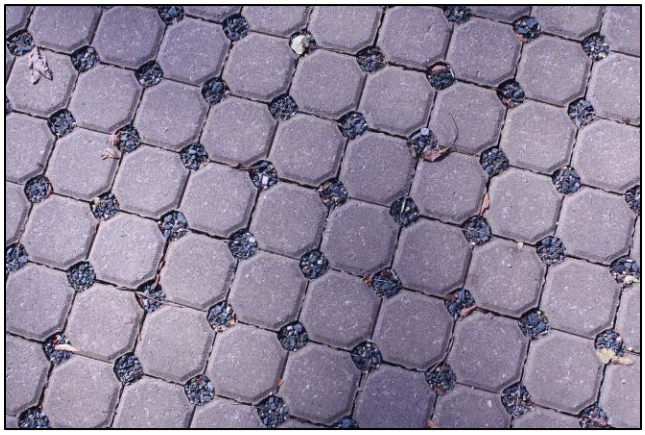



Figure 14-3. Examples of PICP

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, 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. PICP reduces runoff volume, decreases runoff rate, filters stormwater, 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 the 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, 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 pollutant loads and greater compaction of pavers.

Vacuum surface 1 to 2 times annually (typically spring/fall) using a regenerative air vacuum sweeper to remove trash, sediment, and debris, then properly dispose of it off-site. Use a true vacuum sweeper for restoring highly clogged surfaces. Do not pressure wash or use compressed air to unclog surface joints. Replenish aggregate in joints when more than ½ in. from chamfer bottoms on paver surfaces exists. The landscaped areas around these systems also need to be well-maintained to prevent soil washout onto the pavers. Do not pull up undesirable vegetation! Use an approved systemic herbicide, such as glyphosate, 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 a 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 sinkholes, depressions, or other 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 the underdrain system in accordance with the original design specifications. Consider flushing the underdrain system annually if it appears it has a tendency to clog.

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

The impermeable liner 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 make sure 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 make sure 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 (e.g., riprap) or structure used to prevent erosion at the outfall.

14.3.7 Overflow System

Function

The overflow system 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 clogging in the outlet pipe. Inspect the outlet area for signs of erosion. Check for damaged or corroded pipes and other damaged 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 (e.g., riprap) or structure used to prevent the erosion at the outfall.

14.4 Inspection and Maintenance Summary

Observations made while inspecting SCMs must be documented on the appropriate SCM inspection form (Appendix A) electronically in SCMS or entered into SCMS as soon the

inspector is able. Observations recorded should include a general description of the SCM, if it is functioning well, and the maintenance needs identified such as the removal of accessible trash, sediment, and undesirable vegetation. Additionally, the inspector assigns an LOS rating to the SCM during each inspection. Refer to Chapter 3 of this manual for approximate timeframes to complete maintenance activities based on the LOS ratings. Photographs should be taken during the inspection and uploaded to SCMS as soon as the inspector is able.

Maintenance needs documented in the inspection report can be routine or non-routine. Mowing and removal of accessible trash and debris, which the inspector may be able to perform during the inspection, are examples of routine maintenance activities. Non-routine maintenance items may include removing excess sediment or repairing structural parts of the SCM. Non-routine maintenance needs often require specialized equipment and/or trained personnel. If non-routine maintenance needs are identified during an inspection (e.g., failure of the SCM), the inspector should fill out a Maintenance Needed report in SCMS, then either correct the problem at that time or contact the party or parties responsible to schedule non-routine maintenance repairs.

If non-routine maintenance needs are not corrected at the time of inspection, the inspector should conduct a follow-up inspection to verify that the responsible party or parties have taken action and the maintenance needs have been addressed. Observations made during the follow-up inspection should also be documented on the Maintenance Completed report in SCMS. A follow-up inspection report should also be entered to change the LOS rating of the SCM.

CHAPTER 15 Preformed Scour Hole

OVERVIEW

A PREFORMED SCOUR HOLE (PSH) is a structural stormwater control measure (SCM) 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 or improper construction. Studies have been done on the longevity of PSHs and NCDOT has adopted a policy that if a Preformed Scour Hole receives a LOS Rating of "C" or better one year after project acceptance, the device is considered to be functional, and no further inspection or maintenance will be required for the device.

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 an 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 (PSRM) to minimize downstream erosion.

15.1 Preformed Scour Hole Overview

Preformed Scour Holes are pre-shaped, riprap-lined 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 was 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 PSRM is required around and downgrade of the SCM. Preformed Scour Holes absorb the impact of high runoff velocities and reduce the potential for downgrade erosion from point discharges When Preformed Scour Holes are implemented under low peak flow conditions and installed on level ground, they redistribute concentrated inflow as diffuse outflow to the adjacent land. The outside perimeter of the scour hole is required to be level such that an 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.

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 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 should be used on top of the filter fabric to line the Preformed Scour Hole.

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 one foot underneath the filter fabric and natural ground around the perimeter of the scour hole. Make sure 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:

- Inlet Drainage System
  - Inlet Pipe
- Scour hole
- Filter fabric
- Riprap
- PSRM

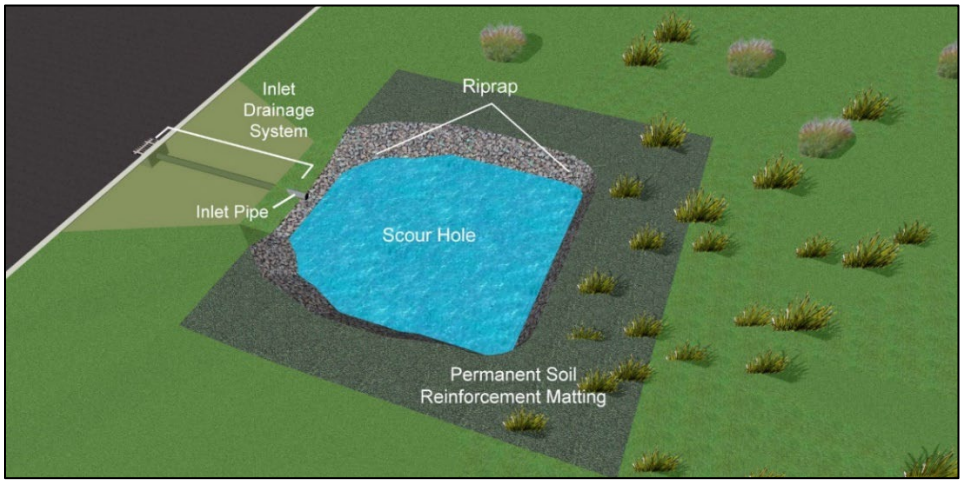


Figure 15-2. Typical Preformed Scour Hole layout and components

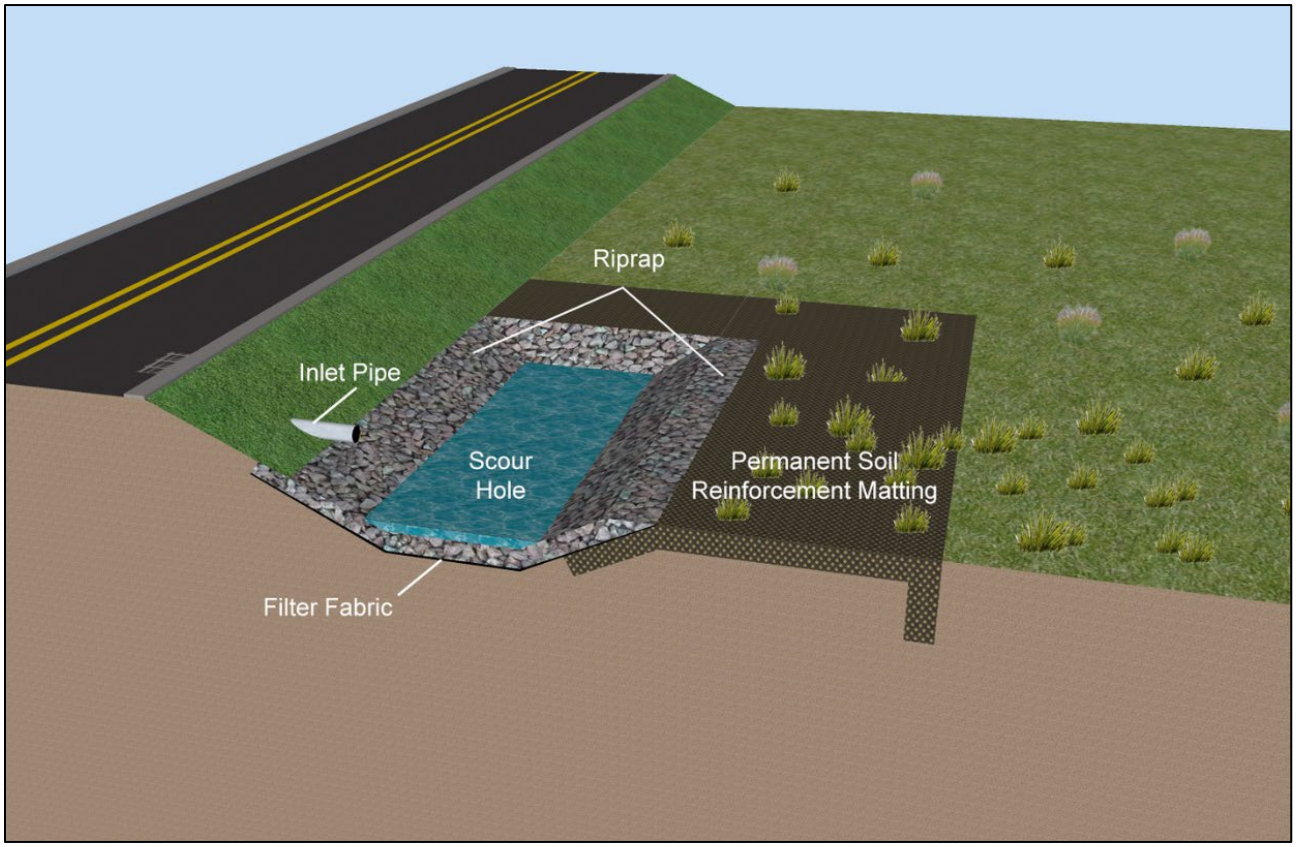


Figure 15-3. Cross-section of a Preformed Scour Hole

15.3 Inspection and Maintenance

Preformed Scour Holes are inspected one year after project acceptance to determine their functionality and overall condition. If a PSH receives an 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 one-year inspection, a PSH receives an LOS rating of D or F, the device is considered nonfunctional and corrective maintenance and/or repair is required. A follow-up inspection is conducted once the maintenance and/or repair is completed; this inspection is only to verify that the identified maintenance items have been completed satisfactorily. If the device (rating C or better), no further inspection or maintenance is required.

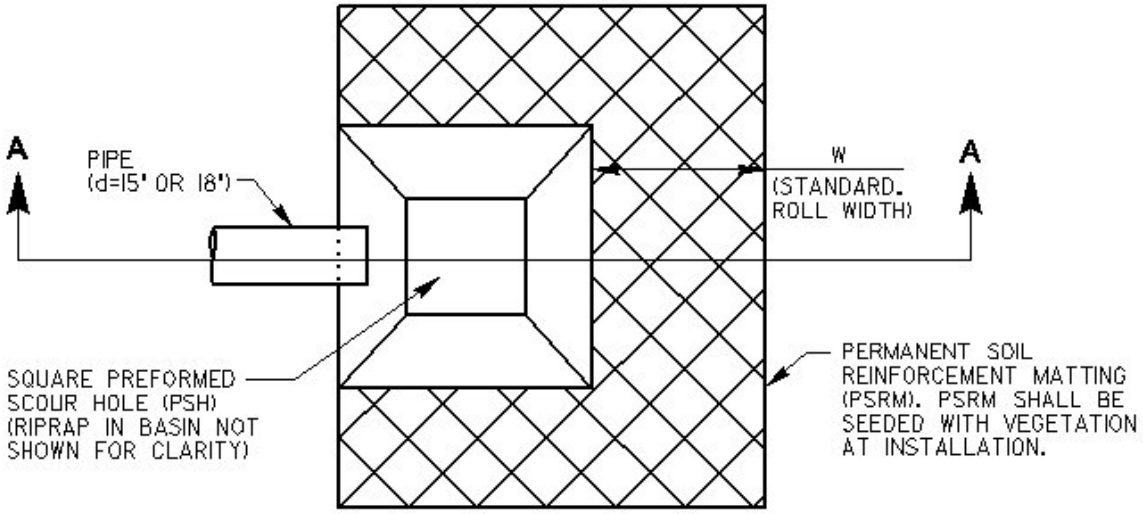


Figure 15-4. Plan view of Preformed Scour Holes

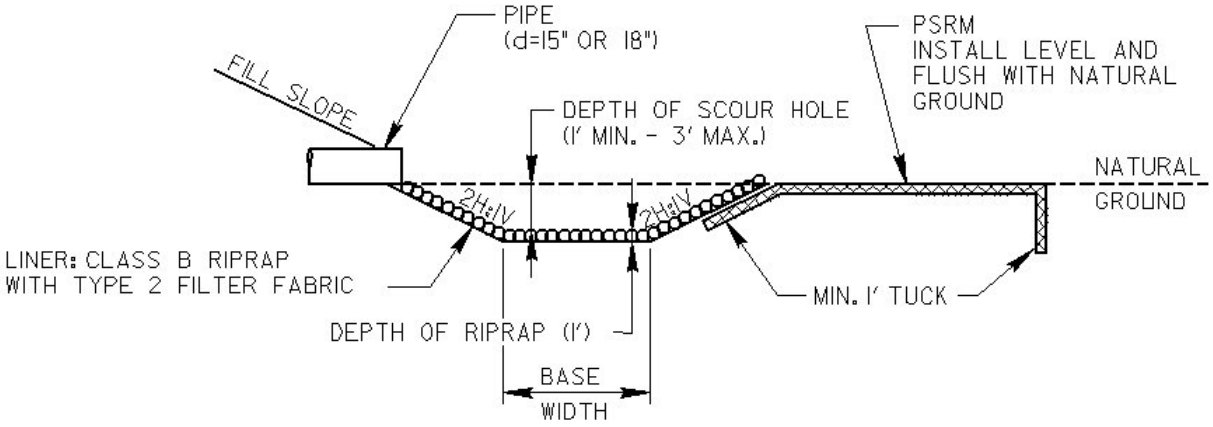


Figure 15-5. Profile view of Preformed Scour Holes

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, and it 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 that it is not filled with trash or unwanted debris. Inspect the riprap for a well-graded mixture. Verify that the outside perimeter of the Scour Hole is level to prevent any downgrade erosion.

Maintenance

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

15.3.2 FILTER FABRIC

Function

The Type 2 filter fabric is an erosion protection and stabilization material, which lines the riprap basin. It prevents soil movement into or through the riprap and protects the riprap from being undercut or displaced.

Inspection

Verify that the filter fabric is undamaged, remains in place as installed, and appears adequate to protect the area from erosion. Check to make sure that the filter fabric is anchored or keyed-in 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-lined 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 fabric over the damaged area and securing it using wire staples or anchor pins. The new filter fabric should provide adequate overlap onto the existing undamaged fabric. 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 highly erosion-resistant stone which is effective in many locations to dissipate energy, reduce flow velocity of the runoff water, and to protect and stabilize areas that are subject to erosion. The riprap should be Class B 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 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 smaller-sized stones to fill voids. If the riprap appears moved or erosion is visible, schedule maintenance to make repairs to prevent further damage.

15.3.4 Permanent Soil Reinforcement Matting

Function

The PSRM is installed to prevent soil erosion from high flows and promote vegetation growth 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 keyed in firmly below ground, overlain by the filter fabric, and the edges are not exposed.

Maintenance

Reseed areas of 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 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 SCM 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 SCMs must be documented on the appropriate SCM inspection form (Appendix A) electronically in SCMS or entered into SCMS as soon the inspector is able. Observations recorded should include a general description of the SCM, if it is functioning well, and the maintenance needs identified such as the removal of accessible trash, sediment, and undesirable vegetation. Additionally, the inspector assigns an LOS rating to the SCM during each inspection. Refer to Chapter 3 of this manual for approximate timeframes to

complete maintenance activities based on the LOS ratings. Photographs should be taken during the inspection and uploaded to SCMS as soon as the inspector is able.

Maintenance needs documented in the inspection report can be routine or non-routine. Mowing and removal of accessible trash and debris, which the inspector may be able to perform during the inspection, are examples of routine maintenance activities. Non-routine maintenance items may include removing excess sediment or repairing structural parts of the SCM. Non-routine maintenance needs often require specialized equipment and/or trained personnel. If non-routine maintenance needs are identified during an inspection (e.g., failure of the SCM), the inspector should fill out a Maintenance Needed report in SCMS, then either correct the problem at that time or contact the party or parties responsible to schedule non-routine maintenance repairs.

If non-routine maintenance needs are not corrected at the time of inspection, the inspector should conduct a follow-up inspection to verify that the responsible party or parties have taken action and the maintenance needs have been addressed. Observations made during the follow-up inspection should also be documented on the Maintenance Completed report in SCMS. A follow-up inspection report should also be entered to change the LOS rating of the SCM.

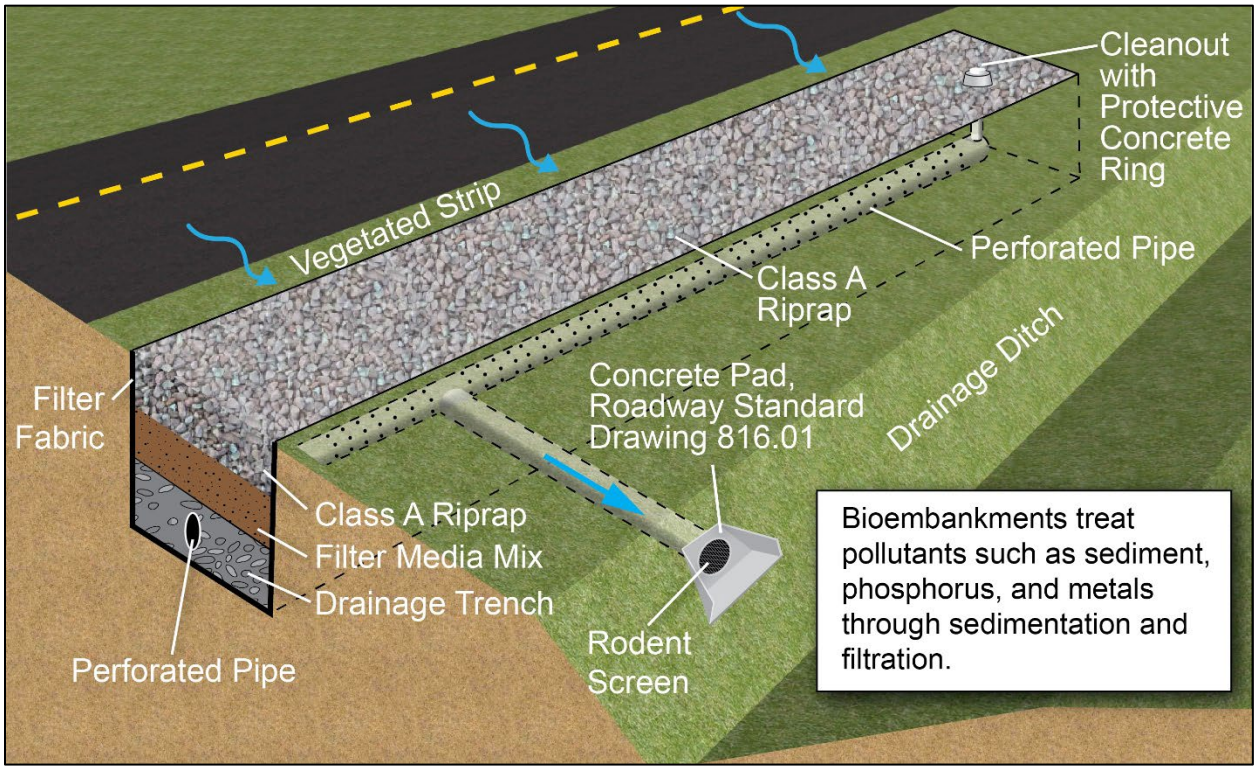
CHAPTER 16 Catch-Alls

16.1 Purpose

Chapter 16 was created to encompass several newer SCMs. These mini-chapters are intended to provide necessary information on function, inspection, and maintenance for each SCM. These devices are being further evaluated by the Hydraulics Unit to see if NCDOT will pursue installing these across the state, and to determine the best ways to design these SCMs.

16.2 Table of Contents

CHAPTER 16-A Bioembankment



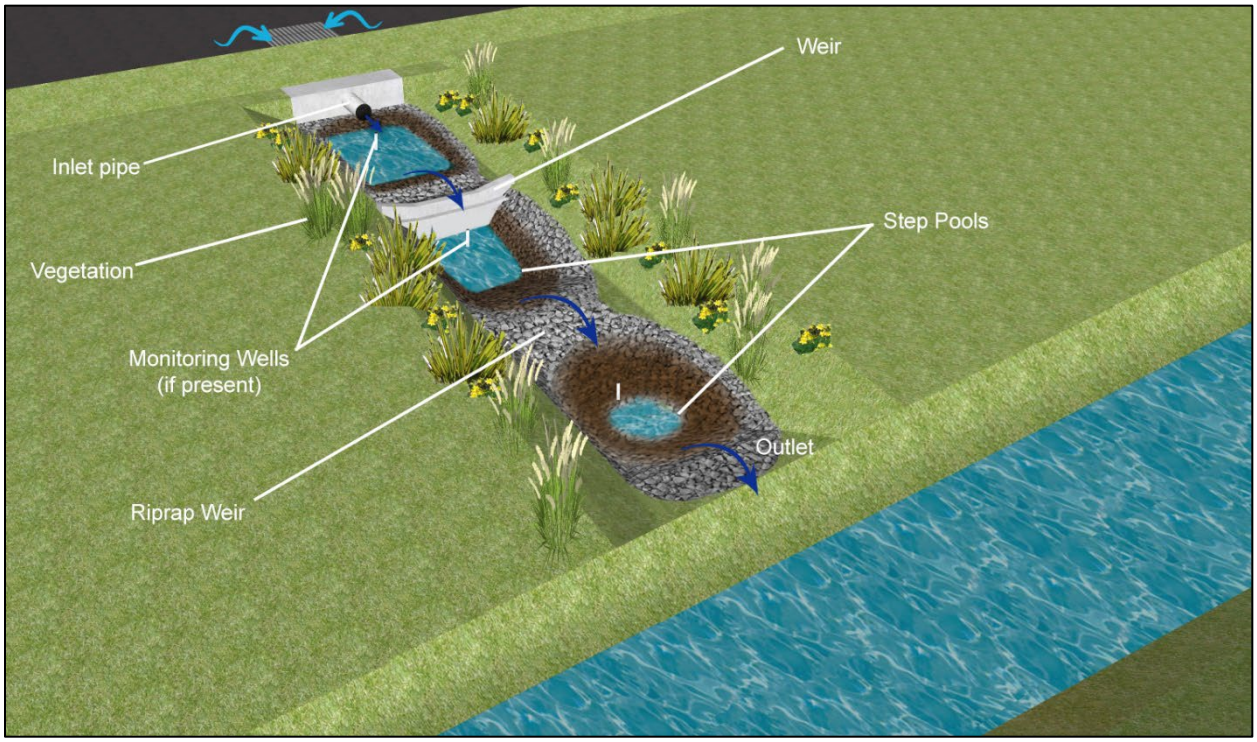
PURPOSE AND DESCRIPTION

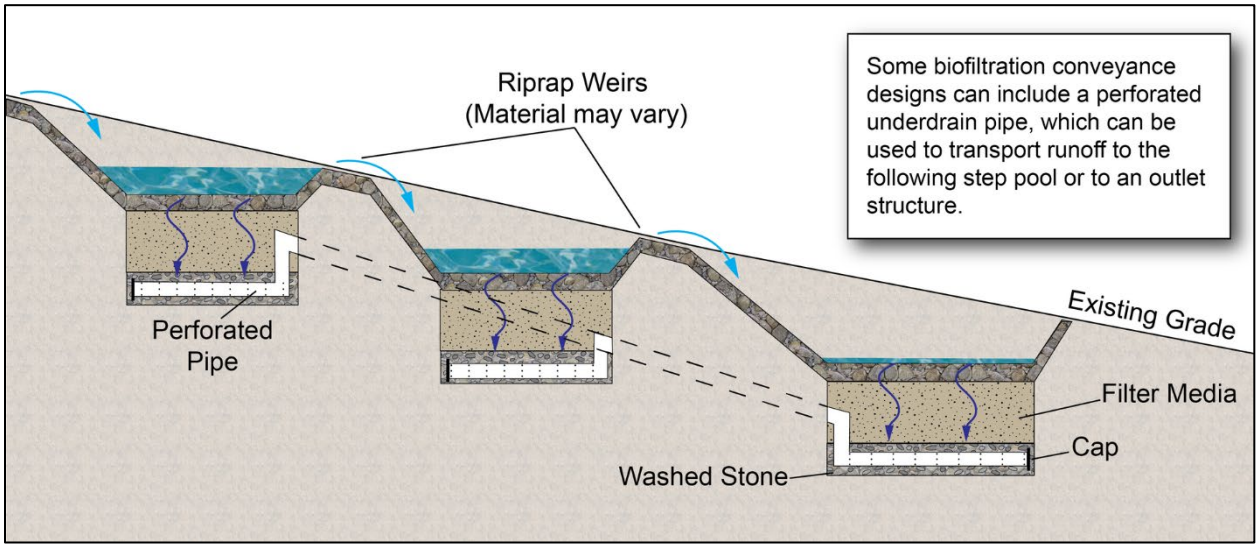
- A Bioembankment (BE) is designed to slow down, retain, and treat stormwater runoff using a filter media mix and a perforated pipe underdrain system. This type of SCM is ideal for projects with limited right-of-way space. When construction is completed, a Bioembankment will look like a normal shoulder embankment but act as a filtration device.

Inspection and Maintenance Overview

Components	Inspection	Maintenance
Vegetated Strip	• The grass should be healthy and mowed. Inspect for any erosion or scouring occurring on slope. • The vegetated strip should be graded to promote sheet flow of runoff from the roadway shoulder. Inspect to ensure sediment buildup has not occurred.	• Reseed grass if condition or coverage is poor. • Mow grass to appropriate height. • Stabilize slope if erosion or scouring is occurring. • If sediment buildup has occurred, regrade vegetated strip to promote sheet flow. Any graded areas should be sodded to establish vegetation coverage.
Treatment Layers (Class A riprap layer, Filter Media, Underdrain including Cleanout and Perforated Pipe, and Outlet Pipe)	• Check cleanout pipe (if present) or outlet pipe for standing water, which can indicate clogged filter media or sediment accumulation. Standing water should not be present 3 days after a rain event. • **The device should be marked using white-tipped stakes or similar markers to prevent damage. Make sure markers are visible and that there is no maintenance-related damage to the device.**	• Remove any standing water present using an industrial vacuum and investigate potential causes if accessible. • If the filter media is determined to be clogged or excess sediment is noted, the device needs to be cleaned out, which may involve digging up and replacing the affected layers. • **Make sure to use hand mowers when mowing the device. Do not drive heavy machinery over the device; they will damage the Bioembankment.**
Cleanout Pipe (if present)	• Cleanout pipe should be structurally intact. • Make sure the cap is secure. • Make sure the concrete ring/collar is present and not significantly damaged.	• Repair any structural damage that has occurred. • Replace cap if missing. • Replace concrete ring/collar
Perforated Pipe	• If standing water is present in the SCM, this may be an indicator that the underdrain system is clogged. Inspect perforated pipes through drop inlet access if present or through the drainage structure or cleanout.	• Flush out or vacuum any sediment or debris clogging perforated pipes through drop inlet access, if present, or through the drainage structure.
Outlet Pipe*	• No trash or debris should be present in outlet pipe. • Inspect concrete pad and outlet structure/pipe for any structural damage (e.g., cracks). • Ensure rodent screen is in place. • Outlet area should be free of erosion and scouring. ***Note:** Multiple outlet pipes may be present.	• Remove any trash or debris present. • Repair any structural damage that has occurred and is impeding the function of the outlet. • Replace rodent screen if missing. • Stabilize eroded areas by reseeding or placing riprap.

CHAPTER 16-B Biofiltration Conveyance





PURPOSE AND DESCRIPTION

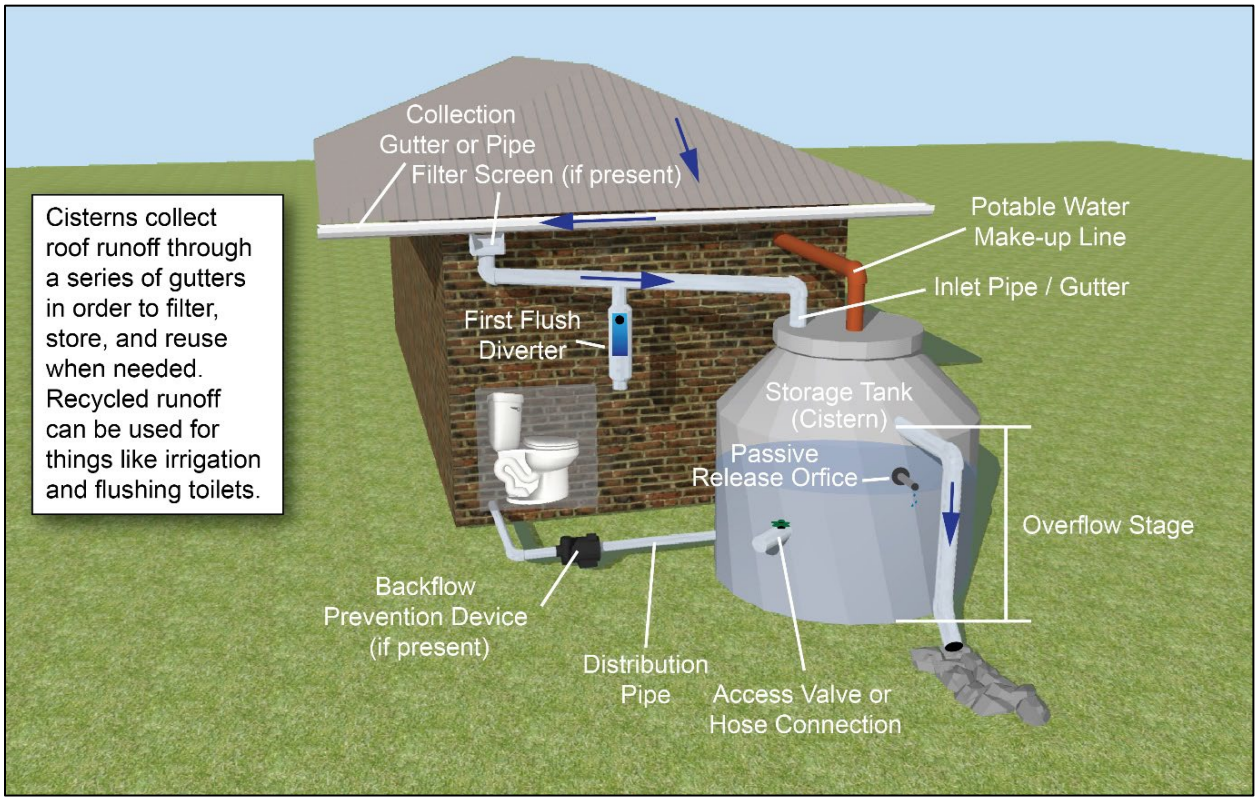
- The Biofiltration Conveyance (BFC) is designed to slow down and treat stormwater runoff through a series of weirs and step pools, allowing for settling of solids and infiltration or filtration of the stormwater runoff.

Inspection and Maintenance Overview

COMPONENTS	INSPECTION	MAINTENANCE
Inlet Drainage System	• Inspect inlet for trash and/or debris. • Inspect inlet area for erosion. Area should be stabilized and not show signs of erosion, which leads to soil loss and can compromise the structural integrity of side slopes. • Check for structural damage.	• Remove trash and debris from inlet. • Stabilize areas of erosion according to original design (riprap, seed, etc.). • Repair structural damage immediately if inhibiting inlet function.
Forebay (if present)	• Forebay is designed to slow runoff and collect sediment. Inspect the amount of sediment present in forebay.	• Remove sediment if it appears to have accumulated more than 3 inches or is impeding the function.
Vegetation	• This SCM is meant to look 'natural' but inspect for any invasive species, or species with root systems that are damaging the SCM. • Vegetation should be healthy and pruned to appropriate height.	• Remove any undesirable vegetation. • Prune or remove any vegetation that is inhibiting the function of the SCM.
Riprap/Concrete Weir*	• Weirs help control the flow of stormwater runoff by reducing the flow velocity. Inspect weir structures for damage and weir openings for blockage. ***Note**: Wooden weir designs are specifically related to research projects and may not be present.	• Repair any structural damage that has occurred. • Remove any blockages around the weir openings.
Step Pools	• Riprap tiers should be structurally sound. • Step pools should be free of woody vegetation. • Check step pools for large amount of sediment accumulation.	• Repair any structural damage that has occurred if it is impeding the function of the BFC. • Remove undesirable vegetation if present. • Remove accumulated sediment from step pools if it appears to have accumulated more than 3 inches or is impeding the function.
Treatment Layers	• Inspect top layer of filter media for signs of washout. Refer to design plans if needed to confirm layers initially installed. • Inspect for areas of standing water. The treatment layers should not be clogged so runoff can infiltrate properly.	• Replace any filter media that has been washed out. • Remove any sediment or debris that may be clogging the top layer. Replenish filter media as needed to match design plans.

COMPONENTS	INSPECTION	MAINTENANCE
Cleanouts and Underdrain Pipes (if present)	• Make sure the cap is secure. • Check cleanouts (if present) for standing water or sediment buildup, which may indicate clogging if the BFC is not designed to have an IWS. If IWS is part of the design, standing water in the underdrains is expected.	• Replace cap if missing. • If clogged, remove clog with an industrial vacuum or flush out perforated pipe system.
Outlet	• Outlet should be clear of trash and debris. • Look for erosion occurring around the outlet. • Inspect riprap around outlet (if present) that may have washed downstream. • Inspect outlet for structural damage.	• Remove trash and debris from outlet. • Repair erosion occurring at the outlet by stabilizing area. • Replace riprap at outlet if needed. • Repair major structural damage around outlet if it is impeding the function of the BFC.

CHAPTER 16-C Cistern

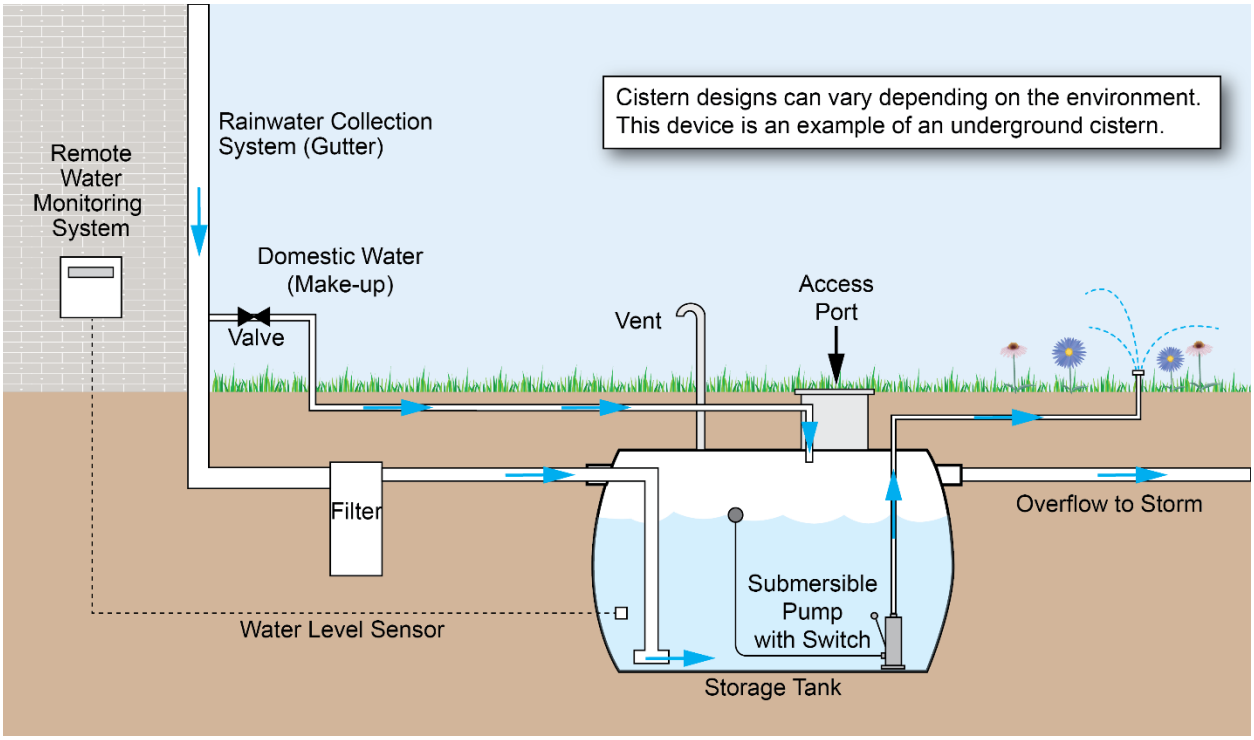


PURPOSE AND DESCRIPTION

- A Cistern (C) is a multi-function SCM that filters, collects, and stores rainwater that can be pumped or drained for reuse later. Aboveground Cistern systems typically store collected rainwater in an aboveground storage tank. These are typically easier to maintain as the components are largely or mostly above ground. Underground Cisterns are described later in this chapter.

Inspection and Maintenance Overview – Aboveground Cistern

COMPONENTS	INSPECTION	MAINTENANCE
Inlet Pipe/ Collection Gutter	• Inlet and collection gutter should be free of sediment, trash, and debris to prevent blockages and contamination of the stored water.	• Clean out collection gutter and inlet if sediment, trash, and debris are present.
Filter Screen (if present)	• This pretreatment component prevents larger debris from going into the storage tank.	• Remove any debris or trash from the screen. • Replace screen if damaged or broken.
First Flush Diverter (if present)	• This pretreatment component diverts and temporarily stores a portion of incoming runoff to reduce the amount of pollutants in the storage tank. Inspect diverter for accumulated runoff/debris.	• Remove the debris and water from the first flush diverter when needed to maintain storage volume in the device.
Aboveground Storage Tank	• There should be no debris or sediment present in stored water. Note: Inspector may need to check turbidity of water to verify.	• Remove any sediment and/or trash from tank using vacuums or flushing systems. The storage tank should be thoroughly cleaned annually. Brush and disinfect the tank when empty. • Visible cracks or leaks in the tank, joint seals, or appurtenances require repairs by product manufacturer or vendor.
Make-up Line (if present)	• Check the structural integrity of the pipe. No cracks or major deterioration should be present.	• Repair damages that may compromise function if left unresolved.
Backflow Prevention Device (if present)	• The backflow prevention device helps prevent contamination from occurring. The device should be tested annually to make sure it is functioning properly.	• Perform annual inspection test on backflow prevention device if present. • Repair/replace device if backflow occurs and the stored water becomes contaminated.
Distribution Pipe	• Check the structural integrity of the pipe. No cracks or major deterioration should be present.	• Repair any damage that has occurred.
Access Valve/Hose Connection	• There should be no trash, debris, or sediment blocking opening. • Check the structural integrity of the valve. No cracks or major deterioration should be present.	• Remove any trash, debris, or sediment if present. • Repair any damage that has occurred.
Overflow Pipe	• Overflow pipe should be free of sediment, trash, and debris to prevent blockages.	• Clean out pipe if sediment, trash, and debris are present.



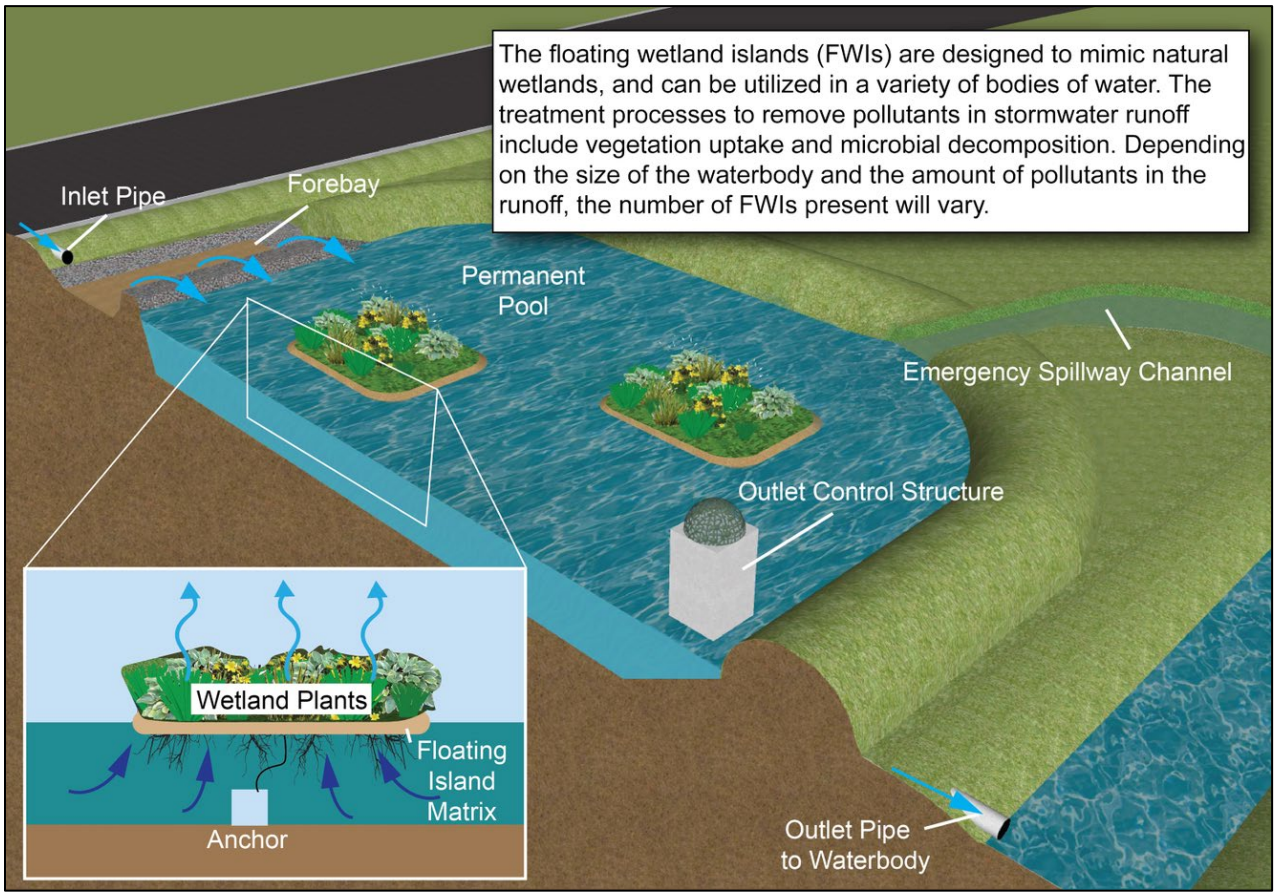
- A Cistern (C) is a multi-function SCM that filters, collects, and stores rainwater that can be pumped or drained for reuse later. Underground Cistern systems typically store collected rainwater in an underground storage tank. These are typically more complicated to maintain than aboveground Cisterns as the components are mostly underground.

Inspection and Maintenance Overview – Underground Cistern

COMPONENTS	INSPECTION	MAINTENANCE
Inlet Pipe/ Collection Gutter	• Inlet and collection gutter should be free of sediment, trash, and debris to prevent blockages and contamination of the stored water.	• Clean out collection gutter and inlet if sediment, trash, and debris are present.
Make-up Line (if present)	• Check the structural integrity of the pipe. No cracks or major deterioration should be present.	• Repair any damage that has occurred.
Valve	• Check the structural integrity of the valve. No cracks or major deterioration should be present.	• Repair any damage that has occurred.
Filter Screen (if present)	• This pretreatment component prevents larger debris from going into the storage tank.	• Remove any debris or trash from the filter. • Replace filter according to manufacturer's guidelines.

COMPONENTS	INSPECTION	MAINTENANCE
Remote Water Monitoring System	• This component monitors the water level in the storage tank and the filter status. • Check the monitoring system to ensure it is functioning properly.	• Address any issues identified by the monitoring system. • Repair the water monitoring system if it is experiencing any technical issues.
Vent	• Air inside of the storage tank is forced out through the vent in order to equalize air pressure. • There should be nothing blocking the vent opening. • Check the structural integrity of the vent. No cracks or major deterioration should be present.	• Remove any blockage from the vent opening. • Repair any damage that has occurred.
Access Port	• The access port can be used to inspect components within the underground storage tank. Note: Confined space training will be required to enter drop inlet. • Make sure the access port lid is secure and in good condition.	• Secure access port lid when needed and repair any damage that has occurred.
Underground Storage Tank	• There should be no debris or sediment present in stored water. Note: Inspector may need to check turbidity of water to verify. • Inspect pipes, apertures, other visible components, and surrounding ground for evidence of leaks.	• Remove any sediment and/or trash from tank using vacuums or flushing systems. The storage tank should be thoroughly cleaned annually. Brush and disinfect the tank when empty. • Visible cracks or leaks in the tank, joint seals, or appurtenances require repairs by product manufacturer or vendor.
Submersible Pump	• Pumps are used to transfer water from the tank to the reuse location. • Inspect pumps annually for proper operation according to manufacturer's instructions.	• If pump(s) fail(s), refer to manufacturer's instructions for repair guidance. Product manufacturer or licensed plumber/electrician may need to be engaged for repair.
Overflow Pipe	• Overflow pipe should be free of sediment, trash, and debris to prevent blockages.	• Clean out pipe if sediment, trash, or debris are present.

CHAPTER 16-D Floating Wetland Islands



PURPOSE AND DESCRIPTION

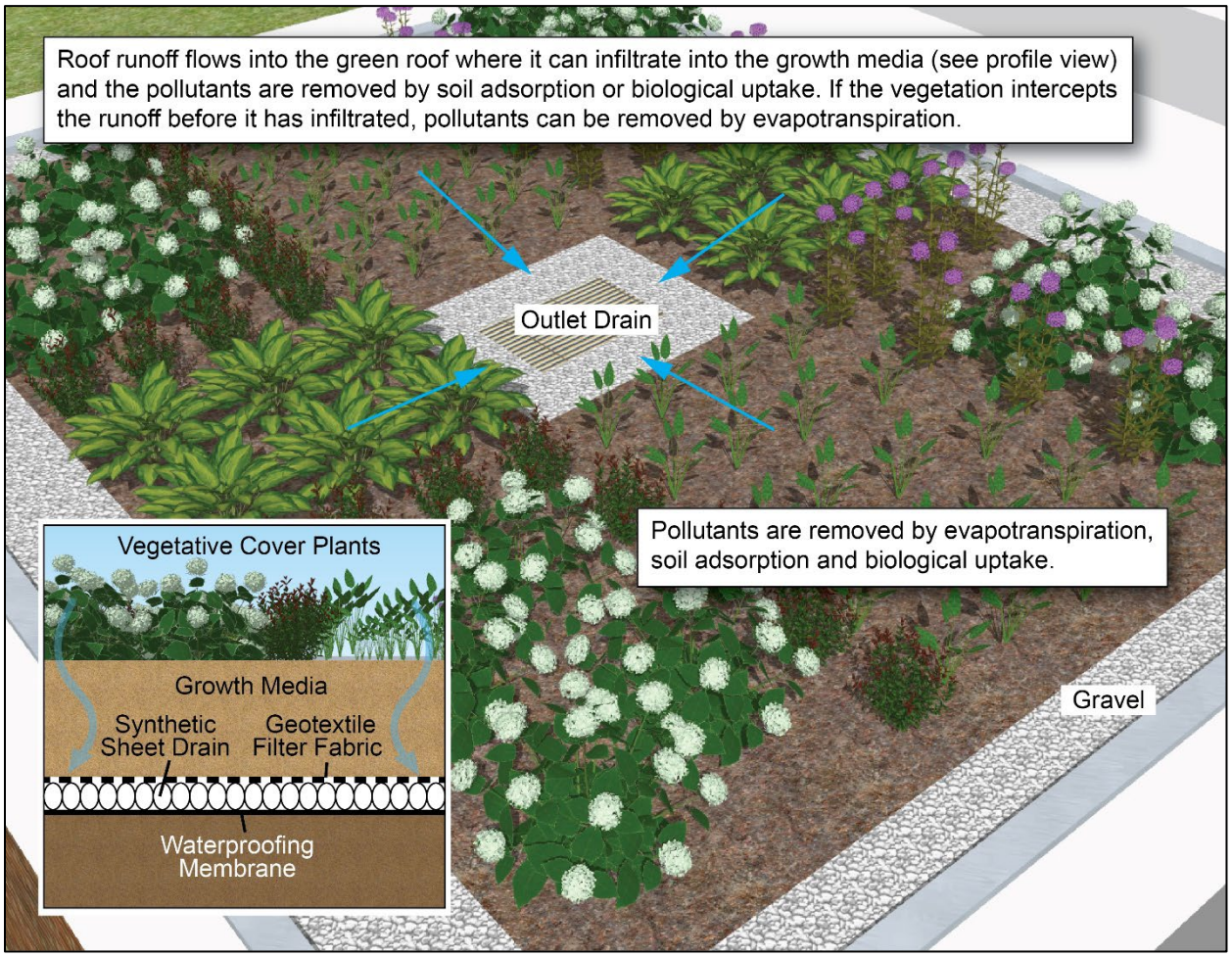
- Floating Wetland Islands (FWIs) are comprised of an engineered wetland island matrix that houses native wetland plants and are designed to float within a Wet Detention Basin (WDB) or pond. Installing FWIs within a WDB provides enhanced treatment for pollutants, such as nutrients and sediment (suspended solids), and improves water quality. While the WDB detains and treats runoff by allowing suspended solids to settle out in the basin, the FWIs reduce additional pollutants via biological uptake and degradation, and/or evapotranspiration.
- It is common when using FWIs for the design to require multiple FWIs be placed within a WDB. The number of FWIs is determined by the basin's size, FWI matrix design, anticipated pollutant loadings in runoff entering the WDB, etc.

Inspection and Maintenance Overview – Floating Wetland Island(s)

COMPONENTS	INSPECTION	MAINTENANCE
Floating Island Matrix	• Inspect island matrix for structural integrity. • Geese and beavers can use the matrices to nest or build dams, which will compromise the functionality of the FWI. • If multiple FWIs are present, they should be buoyant and anchored in such a way that the FWIs cannot reach the banks or outlet structure.	• If matrix appears to be compromised, refer to design plans to reference proper configuration and contact installation vendor for assistance with repairs if needed. • If geese and beavers are a consistent problem for the FWI, twine grids can be placed around the perimeter of the island matrix to prevent the animals from interfering. If they continue to be an issue, notify appropriate Division staff to consider their removal.
Wetland Plants	• Inspect condition of wetland plants. The wetland plants should be healthy and maintained per design guidance and as described in Chapter 3. • No undesirable vegetation (e.g., invasive wetland aquatic weeds) should be present.	• Coordinate with vendor or REU Central to replace wetland plants if needed. During prolonged dry periods, wetland plants may require additional watering if they appear distressed. • Remove undesirable vegetation if present. • Separate FWIs if they are stuck together.
Anchor	• The anchor keeps the island matrix in place and prevents it from getting tangled with other FWIs. • If a FWI has drifted to one end of basin, this may be an indicator that it has become unanchored.	• For anchor repair, confirm anchor has broken off by pulling island matrix out of basin, then replace anchor. Contact REU Central or vendor for assistance with FWI replacement items.

Inspectors should check SCMS to ensure that the wet detention basin (WDB) is listed as a separate SCM in the SCMS database. Inspect both the WDB and the FWI(s) at the same time.

CHAPTER 16-E Green Roof



PURPOSE AND DESCRIPTION

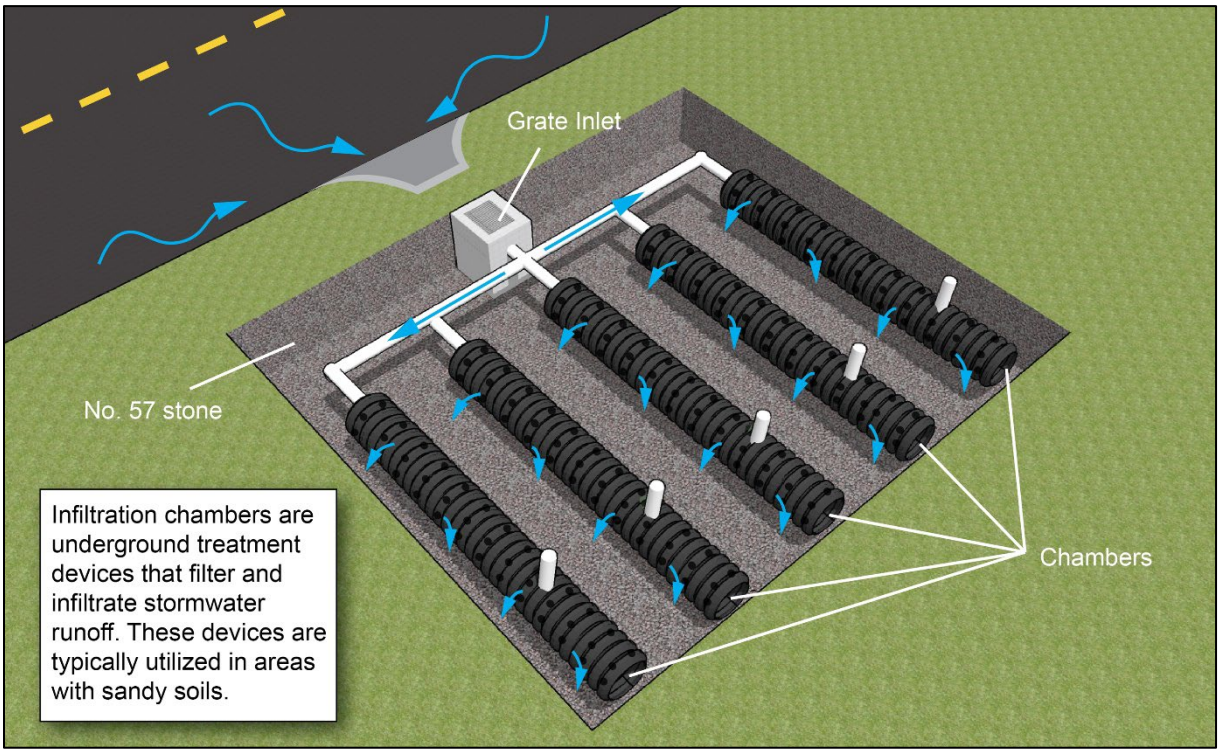
- A Green Roof (GR) is an SCM designed to temporarily detain, treat, and cool stormwater runoff, as well as reduce the stormwater runoff volume that is discharged. Additional benefits of this SCM include providing aesthetic benefits and insulation for the building, which can reduce energy costs. Vegetation maintenance is based on the design plan specifications, which may not be accessible to the maintenance crew. Signs posted on site will be available to provide guidance about appropriate plant species, plant height, and fertilizer use.

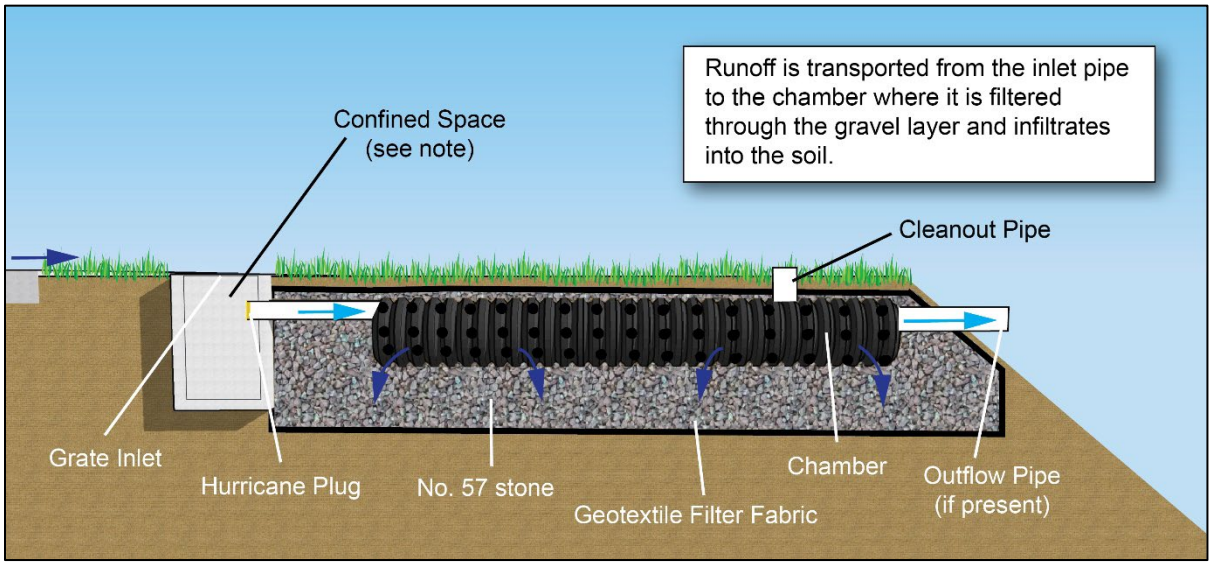
Inspection and Maintenance Overview

COMPONENTS	INSPECTION	MAINTENANCE
Vegetative Cover Plants	• Plants should be healthy and pruned. • Make a note of any undesirable vegetation present (woody vegetation, weeds, etc.). • Plants should thoroughly cover the surface area of the roof to maximize benefits.	• Prune plants. Reference plant guide in design plans, if available, to check appropriate plant height if unsure. • Remove all undesirable vegetation present (reference plant guide in design plans). • Replant or re-seed if plants or grass dies. Avoid using fertilizer to promote plant growth. • If there is a prolonged dry period and/or plants appear to be consistently dried out, consider an irrigation schedule to provide or increase watering.
Irrigation System (if present)	• Some Green Roof designs require an irrigation system, and some designs are irrigated naturally. If irrigation system is present, make sure system is functioning properly.	• Repair irrigation system if it is not functioning properly.
Growth Media	• Depending on the vegetation selected, growing media depth can range from 2-6 inches. Inspectors should refer to design plans, if available, to verify correct depth. • If there are pools of standing water present several days after a rain event, the growth media may be clogged.	• Replace growth media when it is washed out, less than required depth, or if water does not appear to be infiltrating. • If growth media is clogged it will need to be replaced with fresh media. Refer to design plans before replacing media.
Geotextile Filter Fabric	• Located beneath growing media layer, geotextile filter fabric is used to hold the media and keep it from entering the runoff and drains. • The liner should not have any holes or rips in the material. Inspect for any indication of geotextile filter fabric not functioning, such as sunken media or media clogging the drains.	• Replace geotextile liner if ripped or damaged. • If liner is not covering/extending the full area under the growing media, adjust or replace accordingly.

COMPONENTS	INSPECTION	MAINTENANCE
Synthetic Sheet Drain* (if present)	• The synthetic sheet drain is designed to collect runoff infiltrating the growth media and transport it toward a drain/gutter to prevent ponding in or on the growth media. ***Note:** This layer not needed for roofs with slopes >2% but is recommended	• Repair/replace synthetic sheet drain if it has been structurally damaged and is no longer functioning as intended.
Waterproofing Membrane	• This layer prevents water leaking from the roof and plant roots from penetrating.	• Check roof for possible leaks. If leaks are occurring, inspect the membrane and replace if necessary.
Outlet Drain	• Excess runoff will leave the Green Roof via the outlet drain so it should be free of debris, trash, and sediment. • Structural damage (cracks, worn bolts, etc.) can impede the function of the outlet. • The outlet drain will lead to gutters (if present), which should be free of trash and debris.	• Remove any trash and debris blocking outlet. • Repair any erosion or structural damage occurring around the outlet. • Clean out gutters (if present) so they are free of debris.
Fencing/Barrier (if present)	• The fencing acts as a safeguard around the roof perimeter for inspection and maintenance operators.	• Repair any damaged sections of the fence and test for stability.

CHAPTER 16-F Infiltration Chamber





PURPOSE AND DESCRIPTION

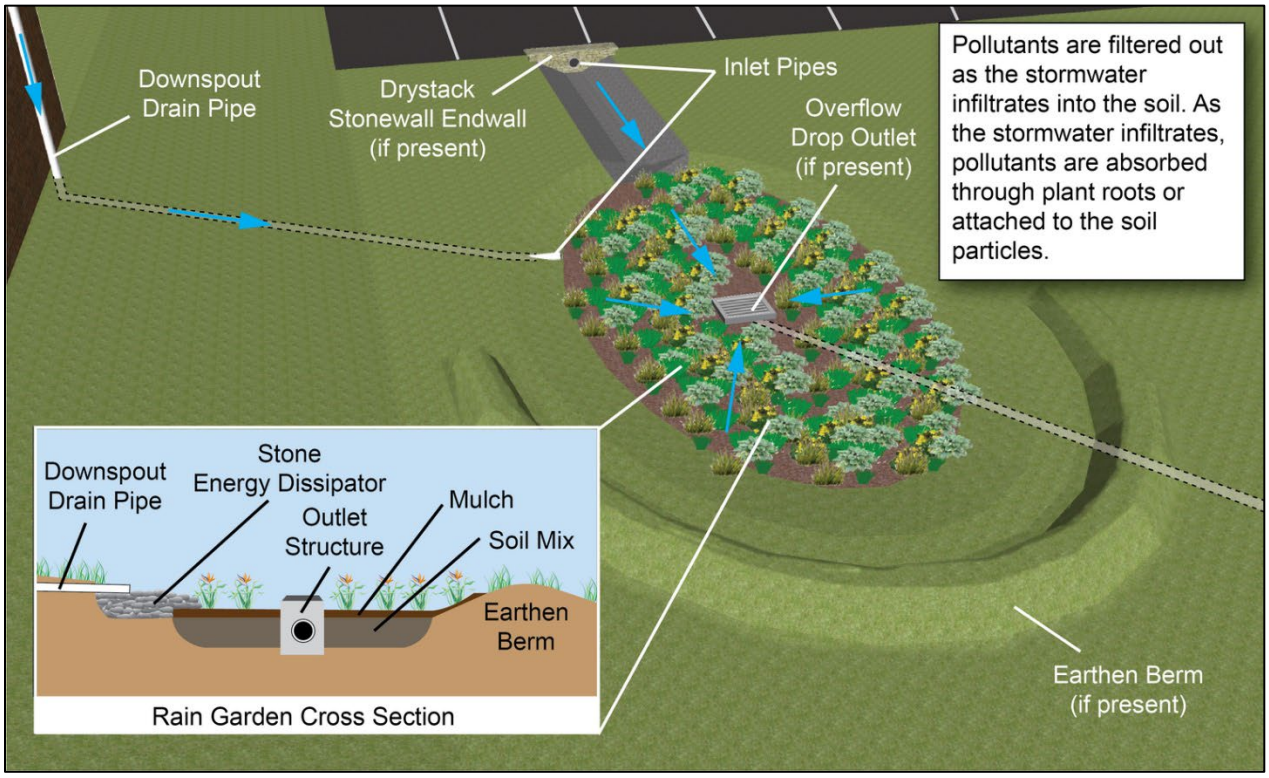
- An Infiltration Chamber (IC) is an SCM designed to detain, filter, and infiltrate stormwater runoff. It uses gravel and/or a sand layer to filter total suspended solids, including sediment, road salt, and debris. This SCM is beneficial for accepting runoff from large impervious areas (e.g., sidewalks, parking lots, roads). The subsurface system often occupies less aboveground space, making it ideal for areas with a limited footprint or a need for multi-uses.

Inspection and Maintenance Overview

Components	Inspection	Maintenance
Grate Inlet* (includes catch basin)	• Inlet should be cleared of any trash, debris, sediment, or standing water above invert of the pipe. • Immediate drainage area should be stabilized and not show signs of erosion. Erosion leads to soil loss, and if not addressed can accumulate and clog the Infiltration Chamber. • Inspect inlet for standing water or accumulated sediment. Ponding water or accumulated sediment can indicate that the chambers are clogged. Water should not be present above the invert of the pipe 5 days post rainfall. • Inlet structure should be functioning properly and free of any structural damage. ***Note:** Confined space training will be required to enter drop inlet.	• Remove trash, debris, and sediment from inlet. • Stabilize areas of erosion within immediate drainage area. • If standing water is present, a high-powered vacuum and pressure washer can be used to flush and vacuum out the system. Never attempt to enter a chamber if a manhole access is present as this requires confined space training. • Repair any structural damage that is impeding the SCM's functionality.
PVC cleanout pipe (if present)	• Inspect cleanout pipe to see if chamber may be clogged (check for standing water or a large amount of sediment). • Ensure that cleanout caps are in place and undamaged.	• A high-powered vacuum truck or pressure washer can be used at a cleanout pipe to remove standing water or sediment.
Chamber (perforated pipe)	• Use the cleanout pipe to inspect chamber for trash, debris, and sediment. If there is no cleanout pipe, a vacuum truck can access the chamber via the catch basin if clogging is suspected.	• A high-powered vacuum truck or pressure washer can be used at a cleanout pipe or via the catch basin to remove standing water, sand, debris, or other materials.
Hurricane Plug*	• In the event of a large storm event, the inlet pipe should be capped with a hurricane plug to prevent the chambers from being clogged with excess trash, sediment, or debris. ***Note:** This is not a permanent component.	• Once the storm event has ended, the hurricane plug can be removed.
Filter bed (may include gravel or sand layer, and geotextile fabric layer)	• Filter layer should be infiltrating. If cleanout pipe or catch basin has standing water or accumulated sediment, filter bed may be clogged.	• See entry above for removing water and sediment from cleanout. If water continues to fill cleanout pipe or catch basin, may need to replace filter layer. Contact REU Central if assistance is needed for testing filter layer.

COMPONENTS	INSPECTION	MAINTENANCE
Outflow pipe (if present - may be used exclusively for overflow depending on the design plan)	• Outflow discharge area should be well stabilized. • Clear area of any trash, debris, and sediment. • Overflow pipe should be functioning properly and free of any structural damage.	• Repair areas of erosion if present at discharge and along discharge conveyance. • Remove trash, debris, and sediment where outflow pipe discharges (e.g., daylights). • Repair any structural damage that is impeding the SCM's functionality.

CHAPTER 16-G Rain Garden



PURPOSE AND DESCRIPTION

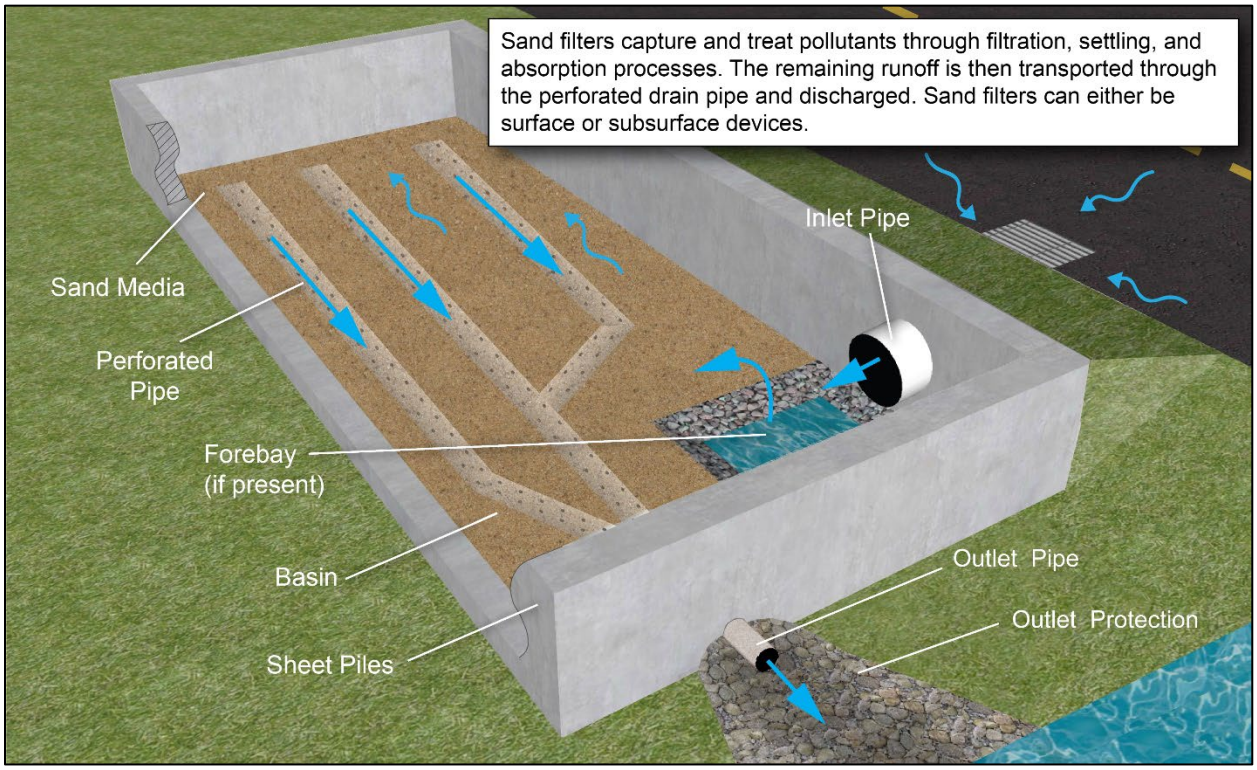
- A Rain Garden (RG) is an SCM consisting of a vegetated and depressed storage area. Designed to infiltrate stormwater, reduce peak flows, and partially treat runoff through filtration, biological uptake, and soil adsorption, Rain Gardens also help recharge groundwater and provide aesthetic benefits.

Inspection and Maintenance Overview

COMPONENTS	INSPECTION	MAINTENANCE
Inlet Drainage System (Downspout Drain Pipe / Inlet Pipes)	• Inspect inlet pipes for trash, debris, or sediment. • There should be no structural damage at inlet (no cracks, chips, etc.).	• Remove sediment, debris, and trash from inlet pipe if present. • Repair any structural damage to inlet pipe. • Repair any erosion or scour that has occurred around the inlet.
Stone Energy Dissipator (if present)	• Inspect energy dissipator near downspout drainpipe or other inlet (if present) for structural integrity (misplaced or damaged stone).	• Repair any structural damage that has occurred and is impeding its function. • Repair any erosion or scour that has occurred around the energy dissipator. Replace or add stone if needed.
Garden / Storage Area (This section contains information on multiple components located in the Garden area including the mulch layer and the soil mixture layer)	• Inspect mulch and soil layer depths (typically ranges from 2-4 inches for mulch and 18-24 inches for soil) to promote infiltration. • Inspect for standing water. Water should not be ponding 12 hours after a rain event. • Inspect Garden storage area for trash and debris. • Inspect Garden storage area for any erosion or scouring that has occurred. • The soil composition is important for a Rain Garden's success.	• Replace mulch/soil that has washed out. Refer to design plans for original storage area layer depths. • Remove standing water if present and investigate cause of ponding. (Sediment build-up and soil compaction can clog the soil and mulch layers, impeding the function of the Rain Garden.) • Remove any trash or debris present in Rain Garden. • Repair any erosion that has occurred. • Plant failure or drainage problems may be linked to improper soil mixtures. Contact REU Central for assistance if soil composition problems are suspected.
Vegetation	• Inspect health of vegetation. Vegetation should be healthy and pruned. • Make sure there are multiple different healthy species. • Inspect for invasive species—no invasive species/weeds should be present. • Ensure vegetation is providing appropriate coverage of the area.	• Remove any invasive vegetation. • Remove and replace any dead vegetation, and prune as necessary. Note: Vegetation height will vary depending on the species. Refer to design plans if plantings need to be replaced. If it appears plant species are not growing as intended, contact REU or Hydraulics Unit for additional guidance. • During extensive dry periods, additional irrigation may be necessary. Note: Fertilizer should not be used to aid plant growth.

COMPONENTS	INSPECTION	MAINTENANCE
Earthen Berm (if present)	• Inspect area for erosion. Area should be stabilized and not show signs of erosion, which leads to soil loss and can compromise the structural integrity of side slopes.	• Repair berm as needed and stabilize areas of erosion according to original design plan (mulch cover, riprap, etc.).
Overflow Outlet Structure (if present)	• Inspect overflow outlet/pipe for trash and/or debris. • Inspect overflow outlet/pipe for structural damage. • Check for scouring around outlet. If it is occurring consistently, may need to add riprap around drop outlet. • Check for sink holes around the outlet structure and over the outlet pipe. Sink holes would be indicative of bad pipe connections or pipe failures allowing soil loss.	• Remove trash and debris from drop outlet and/or pipe. • Repair any structural damage to outlet/pipe. • Stabilize areas of erosion occurring around the drop outlet/overflow pipe. • Repair drainage system connections and replace lost material per the design plans.

CHAPTER 16-H Sand Filter



PURPOSE AND DESCRIPTION

- A Sand Filter (SF) is an SCM that captures and treats pollutants such as total suspended solids, bacteria, organic material, hydrocarbons, and metals through filtration, settling, adsorption processes, and bioremediation. Sand Filters may be scaled differently depending on the size of the drainage area.

Inspection and Maintenance Overview

Components	Inspection	Maintenance
Inlet Drainage System	• Inspect inlet pipe and drop inlet box (if present) for trash, debris, or sediment. • Riprap with geotextile liner may be present around inlet to help prevent scouring. If present, inspect its condition. • Inspect inlet pipe for structural integrity.	• Remove sediment, debris, and trash from inlet pipe or drop inlet box (if present). • Stabilize area where erosion or scour has occurred around the inlet. Replace or add riprap if needed. • Repair any structural damage (cracks, fragmentation) that has occurred at inlet pipe and is impeding its function.
Forebay (if present)	• Inspect for sediment and debris present in forebay. • Inspect forebay for evidence of scouring or erosion occurring.	• Sediment should be removed if it appears to have accumulated more than 3 inches or is impeding the function. • Remove any trash from forebay. • Stabilize area where erosion or scour has occurred around forebay and is impeding its function.
Basin	• Inspect basin structural components for structural integrity. • Inspect basin for any trash or debris. • Inspect for pools of standing water. Water should not be present several days after a rain event. This could indicate clogging in the media.	• Repair any structural damage (cracks, fragmentation) that has occurred around the basin and is impeding its function. • Remove any trash or debris present. • Remove standing water if present, skim and replace sand layer, and investigate source of a possible clog. Use of a vacuum truck may be needed.
Sand Media	• The sand layer should have a minimum depth of 12 inches above the underdrain with a total depth of 18 inches. Inspect depth of sand filter if accessible.	• Replace sand as needed to maintain the design depth.
Perforated Pipe	• If cleanout pipes are present, inspect for standing water, which can indicate clogging in the underdrain, unless the sand filter is designed with IWS. If IWS is intended for the device, standing water in the underdrain is expected.	• If a clog is detected, clean out the underdrain (if accessible) using a pump or vacuum.
Outlet Pipe	• Inspect for any sediment, trash, or debris. • Inspect for erosion or scour around outlet pipe. • Inspect outlet pipe for structural integrity.	• Remove any sediment, trash, or debris present. • Stabilize areas where erosion or scouring has occurred. • Repair any structural damage (cracks, fragmentation) that has occurred and is impeding its function.

References

Code of Federal Regulations, Title 29, *Labor*, Part 1910, *Occupational Safety and Health Standards*, Subpart J, *General Environmental Controls*, 146, *Permit-Required Confined Spaces.*

EPA. 2014. *Permeable Interlocking Concrete Pavement.* United States Environmental Protection Agency. <https://www.epa.gov/green-infrastructure/what-green-infrastructure#permeablepavements> (accessed 19 May 2022).

FEMA. 2005. *Dam Owner's Guide to Plant Impact on Earthen Dams*. FEMA 534. Sept. 2005. <https://damsafety.org/sites/default/files/files/FEMA%20TM%20ImpactsPlants%20534_05.pdf > (accessed 19 May 2022).

Hunt, W.F., Burchell, M.R., Wright, J.D., and Bass, K.L. 2007. Stormwater Wetland Design Update: Zones, Vegetation, Soil and Outlet Guidance. NC Cooperative Extension, Raleigh, NC. <https://content.ces.ncsu.edu/stormwater-wetland-design-update-zones-vegetation-soil-and-outlet-guidance> (accessed 19 May 2022).

ICPI. 2011. *Sustainability Ecological solutions with concrete pavers.* <https://icpi.org/benefits-fact-sheets/sustainability> (accessed 19 May 2022).

ICPI. 2014. *ICPI Design: Permeable Interlocking Concrete Pavement*. <http://www.icpi.org/design> (accessed 27 August 2014).

ICPI. 2015. *Inspector's Guide for PICP Installation & Maintenance*. <https://static1.squarespace.com/static/5e70c7ccdc975f39a6d7b95f/t/5f2ae800243abc5b738b4cf8/1596647426280/PICP-Construction-Inspection-Checklist.pdf> (accessed 27 August 2014).

ICPI. 2019. *Tech Spec Number 18 Construction of Permeable Interlocking Concrete Pavement Systems.* <https://icpi.org/government-tech-specs> (accessed 19 May 2022).

NCAC. 2020. Title 15A, *Environment and Natural Resources*, Chapter 02, *Environmental Management*, Subchapter 02B, *Surface Waters and Wetlands Standards*. North Carolina Administrative Code, effective June 15, 2020. <https://deq.nc.gov/about/divisions/water-resources/water-resources-rules/nc-administrative-code-statutes> (accessed 19 May 2022).

NCCES. 2017. *Yellow Nutsedge (Figure 3)*. By Fred Yelverton. North Carolina State University, North Carolina Cooperative Extension Service. October 2017.

NCDENR. 2013. *Erosion and Sediment Control Planning and Design Manual.* Developed as cooperative effort between the North Carolina Sedimentation Control Commission, the North Carolina Department of Environment and Natural Resources, and the North Carolina Agricultural Extension Service. <https://deq.nc.gov/about/divisions/energy-mineral-and-land-resources/erosion-and-sediment-control/erosion-and-sediment-control-planning-and-design-manual> (accessed 19 May 2022).

NCDEQ. 2020. *Stormwater Design Manual.* North Carolina Department of Environment and Natural Resources. Division of Water Quality. Updated 20 Nov. 2020.

<https://deq.nc.gov/about/divisions/energy-mineral-and-land-resources/stormwater/stormwater-program/stormwater-design> (accessed 19 May 2022).

NCDOT. 2017. *Vegetation Management Manual.* North Carolina Department of Transportation, Roadside Environmental Unit, Raleigh, NC. <https://www.ncdot.gov/initiatives-policies/environmental/vegetation/Documents/vegetation-management-section-manual.pdf> (accessed 19 May 2022).

NCDOT. 2004. *Workplace Safety Manual*. North Carolina Department of Transportation, Transportation Mobility and Safety Division, Raleigh, NC. Revised November 2020. <https://connect.ncdot.gov/business/safety/Pages/SOP.aspx> (accessed 19 May 2022).

NCDOT. 2011. *Inspection and Maintenance Guidelines for Preformed Scour Holes (PSHs).* North Carolina Department of Transportation, Raleigh, NC.

NCDOT. 2012. *Invasive Exotic Plants of North Carolina.* By Cherri Smith. North Carolina Department of Transportation, Raleigh, NC. <https://connect.ncdot.gov/resources/Environmental/Compliance%20Guides%20and%20Procedures/Invasive_Exotic_Plants_Manual_May_2012.pdf>

NCDOT. 2013. *Preformed Scour Holes Follow-Up Investigation.* North Carolina Department of Transportation, Highway Stormwater Program, Roadside Environmental Unit, Raleigh, NC.

NCDOT. 2014. *Stormwater Best Management Practices Toolbox, Version 2.* North Carolina Department of Transportation, Hydraulics Unit, Raleigh, NC.

NCDOT. 2018a. *Standard Specifications for Roads and Structures.* North Carolina Department of Transportation, Raleigh, NC. <https://connect.ncdot.gov/resources/Specifications/StandSpecLibrary/2018%20Standard%20Specifications%20for%20Roads%20and%20Structures.pdf>

NCDOT. 2018b. *Roadway Standard Drawings*. North Carolina Department of Transportation, Raleigh, NC. <https://connect.ncdot.gov/resources/Specifications/Pages/2018-Roadway-Standard-Drawings.aspx>.

NCHRP. 2006. *Evaluation of Best Management Practices and Low Impact Development for Highway Runoff Control. User's Guide for BMP/LID Selection.* National Cooperative Highway Research Program, Transportation Research Board, Washington, DC.

NCSU. 2022. *2022 North Carolina Agricultural Chemicals Manual.* North Carolina State University. College of Agriculture and Life Sciences. February 2022. <https://content.ces.ncsu.edu/north-carolina-agricultural-chemicals-manual> (accessed 19 May 2022).

USDA, NRCS. 2022. The PLANTS Database <http://plants.usda.gov> (accessed 19 May 2022). National Plant Data Team, Greensboro, NC USA.

U.S. Fish and Wildlife Service. 2007. *(Yaupon Holly photograph).* <http://en.wikipedia.org/wiki/File:Ilex_vomitoria_fws.jpg> (accessed 30 June 2009).

Virginia Cooperative Extension. 2020. *Virginia Tech Weed Identification Guide*. *(Centipede grass photograph)* <https://weedid.cals.vt.edu/profile/414> (accessed 19 May 2022).

APPENDIX A Inspection Checklists

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: BIORETENTION BASIN
SCMS ID#: _____
DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____
Latitude: _____ (Decimal Degrees)
Longitude: _____ (Decimal Degrees)
Inspection Date: _____
Detailed Location: _____

Inlet/Outlet Drainage Systems

Y	N	N/A	
☐	☐	☐	Inlet drainage systems are structurally sound and functional.
☐	☐	☐	Inlet drainage systems are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Outlet control structure and components are structurally sound and functional.
☐	☐	☐	Outlet control structure and components are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Trash rack and/or screen is unobstructed and free of sediment, leaves, trash, and other debris.

Forebay

Y	N	N/A	
☐	☐	☐	Forebay and/or transition berm are structurally sound and functional.
☐	☐	☐	Forebay and/or transition berm are clean and free of sediment, leaves, trash, and other debris. (Sediment must be removed if there is greater than 3 inches of sediment accumulation in the forebay or sediment is impeding the function.)

Basin, Embankment, and Emergency Spillway

Y	N	N/A	
☐	☐	☐	Basin, embankment, and emergency spillway are structurally sound and functional.
☐	☐	☐	Basin, embankment, and emergency spillway are free of sediment, leaves, trash, and other debris. (Sediment must be removed from the basin if clogging the filer media or when it accumulates to 3 inches or more.)
☐	☐	☐	Filter media and underdrain, including cleanouts, appear to be structurally sound and functional.
☐	☐	☐	Plants are healthy and mulch layer is adequate (3-4 inches).
☐	☐	☐	Typical grass height is 6-15 inches.
☐	☐	☐	No undesirable vegetation is present.
☐	☐	☐	Basin is free of standing water (48-72 hours after the design storm event).
☐	☐	☐	Basin and surrounding areas are free of erosion.

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 Rating	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.

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: FILTRATION BASIN
SCMS ID#: _____
DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____
Latitude: _____ (Decimal Degrees)
Longitude: _____ (Decimal Degrees)
Inspection Date: _____
Detailed Location: _____

Inlet/Outlet Drainage Systems

Y	N	N/A	
☐	☐	☐	Inlet drainage systems are structurally sound and functional.
☐	☐	☐	Inlet drainage systems are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Outlet control structure and components are structurally sound and functional.
☐	☐	☐	Outlet control structure and components are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Trash rack and/or screen is unobstructed and free of sediment, leaves, trash, and other debris.

Forebay

Y	N	N/A	
☐	☐	☐	Forebay and/or transition berm are structurally sound and functional.
☐	☐	☐	Forebay and/or transition berm are clean and free of sediment, leaves, trash, and other debris. (Sediment must be removed when there is greater than 3 inches of sediment accumulation or sediment is impeding the function.)

Basin, Embankment, and Emergency Spillway

Y	N	N/A	
☐	☐	☐	Basin, embankment, and emergency spillway (if present) are structurally sound and functional.
☐	☐	☐	Basin, embankment, and emergency spillway (if present) are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Filter media and underdrain, including cleanouts, appear to be structurally sound and functional.
☐	☐	☐	Basin is free of standing water.
☐	☐	☐	Basin bottom has adequate cover (dense turfgrass 6-15 inches in height).
☐	☐	☐	Basin and surrounding areas are free of erosion.

Sluice Gate

Y	N	N/A	
☐	☐	☐	Sluice gate is in place, structurally sound, and functional.
☐	☐	☐	Sluice gate opening is unobstructed and free of sediment, leaves, trash, and other debris.

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 Rating	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.**

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: INFILTRATION BASIN
SCMS ID#: _____
DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____
Latitude: _____ (Decimal Degrees)
Longitude: _____ (Decimal Degrees)
Inspection Date: _____
Detailed Location: _____

Inlet/Outlet Drainage Systems Including Flow Bypass Structure

Y	N	N/A	
☐	☐	☐	Inlet drainage systems are structurally sound and functional.
☐	☐	☐	Inlet drainage systems are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Outlet control structure and components are structurally sound and functional.
☐	☐	☐	Outlet control structure and components are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Trash rack and/or screen is unobstructed and free of sediment, leaves, trash, and other debris.

Pretreatment System: Forebay/Swales

Y	N	N/A	
☐	☐	☐	Swales or Forebay and/or transition berm are structurally sound and functional.
☐	☐	☐	Swales or Forebay and/or transition berm are clean and free of sediment, leaves, trash, and other debris. (Sediment must be removed when there is greater than 3 inches of sediment accumulation or sediment is impeding the function.)

Basin, Embankment, and Emergency Spillway

Y	N	N/A	
☐	☐	☐	Basin, embankment, and emergency spillway (if present) are structurally sound and functional.
☐	☐	☐	Basin, embankment, and emergency spillway (if present) are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Basin side slopes and surrounding areas are stabilized with a dense cover of turfgrass maintained at a height of 6-15 inches.
☐	☐	☐	Basin bottom has adequate cover (4 inches of uniform sand layer or dense turfgrass 6-15 inches in height).
☐	☐	☐	Cattails or other wetland vegetation are present in the basin.
☐	☐	☐	Sediment was removed from basin if soil media appeared to be clogged.
☐	☐	☐	Basin and surrounding areas are free of erosion.

Sluice Gate

Y	N	N/A	
☐	☐	☐	Sluice gate is in place, structurally sound, and functional.
☐	☐	☐	Sluice gate opening is unobstructed and free of sediment, leaves, trash, and other debris.

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 Rating	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.**

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: DRY DETENTION BASIN
SCMS ID#: _____
DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____
Latitude: _____ (Decimal Degrees)
Longitude: _____ (Decimal Degrees)
Inspection Date: _____
Detailed Location: _____

Inlet/Outlet Drainage Systems

Y	N	N/A	
☐	☐	☐	Inlet drainage systems are structurally sound and functional.
☐	☐	☐	Inlet drainage systems are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Outlet control structure and components are structurally sound and functional.
☐	☐	☐	Outlet control structure and components are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Trash rack and/or screen is unobstructed and free of sediment, leaves, trash, and other debris.

Forebay

Y	N	N/A	
☐	☐	☐	Forebay and/or transition berm are structurally sound and functional.
☐	☐	☐	Forebay and/or transition berm are clean and free of sediment, leaves, trash, and other debris. (Sediment must be removed if there is greater than 3 inches of sediment accumulation in the forebay or sediment is impeding the function.)

Basin, Embankment, and Emergency Spillway

Y	N	N/A	
☐	☐	☐	Basin, embankment, and emergency spillway (if present) are structurally sound and functional.
☐	☐	☐	Basin, embankment, and emergency spillway (if present) are free of sediment, leaves, trash, and other debris. (Sediment must be removed when it takes up more than 25% of the basin's original storage capacity.)
☐	☐	☐	Typical grass height is 6-15 inches.
☐	☐	☐	No undesirable vegetation is present.
☐	☐	☐	Basin and surrounding areas are free of erosion.

Sluice Gate

Y	N	N/A	
☐	☐	☐	Sluice gate is in place, structurally sound, and functional.
☐	☐	☐	Sluice gate opening is unobstructed and free of sediment, leaves, trash, and other debris.

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 Rating	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.**

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: WET DETENTION BASIN
SCMS ID#: _____
DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____

Latitude: _____ (Decimal Degrees)

Longitude: _____ (Decimal Degrees)

Inspection Date: _____

Detailed Location: _____

Inlet/Outlet Drainage Systems

Y	N	N/A	
☐	☐	☐	Inlet drainage system is structurally sound and functional.
☐	☐	☐	Inlet drainage system is free of sediment, leaves, trash, and other debris.
☐	☐	☐	Outlet control structure and components are structurally sound and functional.
☐	☐	☐	Outlet control structure and components are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Trash rack and/or screen is unobstructed and free of sediment, leaves, trash, and other debris.

Forebay

Y	N	N/A	
☐	☐	☐	Forebay and/or transition berm are structurally sound and functional.
☐	☐	☐	Forebay and/or transition berm are clean and free of sediment, leaves, trash, and other debris. (Sediment must be removed if there is greater than 3 inches of sediment accumulation in the forebay or sediment is impeding the function.)

Basin, Embankment, and Emergency Spillway

Y	N	N/A	
☐	☐	☐	Basin, embankment, and emergency spillway are structurally sound and functional.
☐	☐	☐	Basin, embankment, and emergency spillway are free of sediment, leaves, trash, and other debris. (Sediment must be removed from the basin if sediment accumulation is impeding the function of the basin.)
☐	☐	☐	Permanent pool does not contain excessive (covers more than 50% of permanent pool surface area) algae or invasive plants (i.e., cattails).
☐	☐	☐	Water level is at or near the invert of the orifice.
☐	☐	☐	Typical grass height is 6-15 inches.
☐	☐	☐	No undesirable vegetation is present.
☐	☐	☐	Basin and surrounding areas are free of erosion.

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 Rating	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.

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: HAZARDOUS SPILL BASIN
SCMS ID#: _____
DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____
Latitude: _____ (Decimal Degrees)
Longitude: _____ (Decimal Degrees)
Inspection Date: _____
Detailed Location: _____

Inlet/Outlet Drainage Systems

Y	N	N/A	
☐	☐	☐	Inlet drainage systems and erosion protection at the inlet are structurally sound and functional.
☐	☐	☐	Inlet drainage systems and erosion protection at the inlet are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Outlet control structure and components are structurally sound and functional.
☐	☐	☐	Outlet control structure and components are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Trash and debris removal structure is unobstructed and free of sediment, leaves, trash, and other debris.
☐	☐	☐	Concrete headwall/outlet structure is in place, structurally sound, and functional.

Basin

Y	N	N/A	
☐	☐	☐	Basin and side slopes are structurally sound and functional.
☐	☐	☐	Basin is free of sediment, leaves, trash, and other debris.
☐	☐	☐	Typical grass height is 6-15 inches.
☐	☐	☐	No undesirable vegetation is present.
☐	☐	☐	Basin does not pond water for excessive periods of time.
☐	☐	☐	Basin does not emit odors.

Sluice Gate

Y	N	N/A	
☐	☐	☐	Sluice gate is in place, structurally sound, and functional.
☐	☐	☐	Sluice gate opening is unobstructed and free of sediment, leaves, trash, and other debris.

Signage

Y	N	N/A	
☐	☐	☐	Signage is undamaged, clear, and visible.

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 Rating	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.**

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: STORMWATER WETLAND

SCMS ID#: _____

DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____

Latitude: _____ (Decimal Degrees)

Longitude: _____ (Decimal Degrees)

Inspection Date: _____

Detailed Location: _____

Inlet/Outlet Drainage Systems

Y	N	N/A	
☐	☐	☐	Inlet drainage system is structurally sound and functional.
☐	☐	☐	Inlet drainage system is free of sediment, leaves, trash, and other debris.
☐	☐	☐	Outlet control structure and components are structurally sound and functional.
☐	☐	☐	Outlet control structure and components are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Trash rack and/or screen is unobstructed and free of sediment, leaves, trash, and other debris.

Forebay

Y	N	N/A	
☐	☐	☐	Forebay and/or transition berm are structurally sound and functional.
☐	☐	☐	Forebay and/or transition berm are clean and free of sediment, leaves, trash, and other debris. (Sediment must be removed if there is greater than 3 inches of sediment accumulation in the forebay or sediment is impeding the function.)

Basin, Embankment, and Emergency Spillway

Y	N	N/A	
☐	☐	☐	Basin, embankment, and emergency spillway are structurally sound and functional.
☐	☐	☐	Basin, embankment, and emergency spillway are free of sediment, leaves, trash, and other debris.
☐	☐	☐	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 (i.e., cattails).
☐	☐	☐	Water level is at or near the invert of the orifice.
☐	☐	☐	Wetland and surrounding areas are free of erosion.

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 Rating	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.

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: BIOSWALE
SCMS ID#: _____
DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____
Latitude: _____ (Decimal Degrees)
Longitude: _____ (Decimal Degrees)
Inspection Date: _____
Detailed Location: _____

Inlet/Outlet Drainage Systems

Y	N	N/A	
☐	☐	☐	Inlet drainage systems are structurally sound and functional.
☐	☐	☐	Inlet drainage systems are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Outlet control structure and components are structurally sound and functional.
☐	☐	☐	Outlet control structure and components are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Trash rack and/or screen is unobstructed and free of sediment, leaves, trash, and other debris.

Pretreatment System (Forebay/Splash Pad/Energy Dissipator)

Y	N	N/A	
☐	☐	☐	Pretreatment System is structurally sound and functional.
☐	☐	☐	Pretreatment System is clean and free of sediment, leaves, trash, and other debris.

Swale Channel

Y	N	N/A	
☐	☐	☐	Swale is clean, free of sediment, leaves, trash, and other debris.
☐	☐	☐	Swale has an established stand of turf grass.
☐	☐	☐	Typical grass height is 6-15 inches.
☐	☐	☐	No undesirable vegetation is present.
☐	☐	☐	Swale is free of standing water (12 hours after a storm event).
☐	☐	☐	Engineered filter media and underdrain appear to be structurally sound and functional.
☐	☐	☐	Cleanouts appear to be undamaged and functional.
☐	☐	☐	False sumps have adequate vegetation cover and the PSRM or other matting is not damaged.
☐	☐	☐	Swale and surrounding areas are free of erosion.

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 Rating	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.

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: GRASS SWALE
SCMS ID#: _____
DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____
Latitude: _____ (Decimal Degrees)
Longitude: _____ (Decimal Degrees)
Inspection Date: _____
Detailed Location: _____

Inlet/Outlet Drainage Systems

Y	N	N/A	
☐	☐	☐	Inlet drainage systems are structurally sound and functional.
☐	☐	☐	Inlet drainage systems are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Outlet control structure and components are structurally sound and functional.
☐	☐	☐	Outlet control structure and components are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Trash rack and/or screen is unobstructed and free of sediment, leaves, trash, and other debris.

Pretreatment System (Forebay/Splash Pad/Energy Dissipator)

Y	N	N/A	
☐	☐	☐	Pretreatment system is structurally sound and functional.
☐	☐	☐	Pretreatment system is clean and free of sediment, leaves, trash, and other debris.

Swale Channel

Y	N	N/A	
☐	☐	☐	Swale is clean, free of sediment, leaves, trash, and other debris.
☐	☐	☐	Swale has an established stand of turf grass.
☐	☐	☐	Typical grass height is 6-15 inches.
☐	☐	☐	No undesirable vegetation is present.
☐	☐	☐	Swale and surrounding areas are free of erosion.

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 Rating	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.

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: INFILTRATION SWALE
SCMS ID#: _____
DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____
Latitude: _____ (Decimal Degrees)
Longitude: _____ (Decimal Degrees)
Inspection Date: _____
Detailed Location: _____

Inlet/Outlet Drainage Systems

Y	N	N/A	
☐	☐	☐	Inlet drainage systems are structurally sound and functional.
☐	☐	☐	Inlet drainage systems are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Outlet control structure and components are structurally sound and functional.
☐	☐	☐	Outlet control structure and components are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Trash rack and/or screen is unobstructed and free of sediment, leaves, trash, and other debris.

Pretreatment System (Forebay/Splash Pad/Energy Dissipator)

Y	N	N/A	
☐	☐	☐	Pretreatment System is structurally sound and functional.
☐	☐	☐	Pretreatment System is clean and free of sediment, leaves, trash, and other debris.

Swale Channel

Y	N	N/A	
☐	☐	☐	Swale is clean, free of sediment, leaves, trash, and other debris.
☐	☐	☐	Swale has an established stand of turf grass.
☐	☐	☐	Typical grass height is 6-15 inches.
☐	☐	☐	No undesirable vegetation is present.
☐	☐	☐	Swale and surrounding areas are free of erosion.

Check Dams

Y	N	N/A	
☐	☐	☐	If present, rock check dams retain dimensions and have adequate riprap and No. 57 stone.
☐	☐	☐	If present, grassed earth check dams have adequate vegetation cover and the PSRM or other matting is not damaged.

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 Rating	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.

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: WET SWALE
SCMS ID#: _____
DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____
Latitude: _____ (Decimal Degrees)
Longitude: _____ (Decimal Degrees)
Inspection Date: _____
Detailed Location: _____

Inlet/Outlet Drainage Systems

Y	N	N/A	
☐	☐	☐	Inlet drainage systems are structurally sound and functional.
☐	☐	☐	Inlet drainage systems are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Outlet control structure and components are structurally sound and functional.
☐	☐	☐	Outlet control structure and components are free of sediment, leaves, trash, and other debris.
☐	☐	☐	Trash rack and/or screen is unobstructed and free of sediment, leaves, trash, and other debris.

Pretreatment System (Forebay/Splash Pad/Energy Dissipator)

Y	N	N/A	
☐	☐	☐	Pretreatment system is structurally sound and functional.
☐	☐	☐	Pretreatment system is clean and free of sediment, leaves, trash, and other debris.

Swale Channel

Y	N	N/A	
☐	☐	☐	Swale is clean, free of sediment, leaves, trash, and other debris.
☐	☐	☐	Swale is well-vegetated with the intended species.
☐	☐	☐	Wet Swale vegetation is maintained, and undesirable vegetation has been removed.
☐	☐	☐	If present, false sumps have adequate vegetation cover and the PSRM or other matting is not damaged.
☐	☐	☐	Water level is at or near the invert of the outlet structure.
☐	☐	☐	Swale and surrounding areas are free of erosion.

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 Rating	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.

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: LEVEL SPREADER
SCMS ID#: _____
DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____
Latitude: _____ (Decimal Degrees)
Longitude: _____ (Decimal Degrees)
Inspection Date: _____
Detailed Location: _____

Inlet/Outlet Drainage Systems

Y	N	N/A	
☐	☐	☐	Inlet pipe grate and flow bypass structure are in place, structurally sound, and functional.
☐	☐	☐	Inlet and outlet ditches are structurally sound and functional.
☐	☐	☐	Trash rack and/or screen is unobstructed and free of sediment, leaves, trash, and other debris.

Forebay

Y	N	N/A	
☐	☐	☐	Forebay and/or transition berm are structurally sound and functional.
☐	☐	☐	Forebay and/or transition berm are clean and free of sediment, leaves, trash, and other debris.

Level Spreader Trough and Lip

Y	N	N/A	
☐	☐	☐	Level spreader lip is in place, structurally sound, and functional.
☐	☐	☐	Level spreader trough is in place, structurally sound, and functional.
☐	☐	☐	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/Buffer

Y	N	N/A	
☐	☐	☐	Filter strip is structurally sound and functional.
☐	☐	☐	Filter strip has a good stand of grassed vegetation. No erosion noted.
☐	☐	☐	Typical grass height is 6-15 inches.
☐	☐	☐	No undesirable vegetation is present.
☐	☐	☐	Sediment has not accumulated in the filter strip/buffer to the degree that vegetation is dying.
☐	☐	☐	Trash and debris removal structure is unobstructed and free of sediment, leaves, trash, and other debris.

Bypass Swale/Outlet Ditch

Y	N	N/A	
☐	☐	☐	Bypass swale or pipe is structurally sound and functional.
☐	☐	☐	Bypass swale is vegetated and free of sediment, leaves, trash, and other debris.

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 Rating	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.**

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: PERMEABLE PAVEMENT
SCMS ID#: _____
DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____
Latitude: _____ (Decimal Degrees)
Longitude: _____ (Decimal Degrees)
Inspection Date: _____
Detailed Location: _____

Concrete Pavers

Y	N	N/A	
☐	☐	☐	Concrete pavers are structurally sound and functional.
☐	☐	☐	Concrete pavers are free of sediment, leaves, trash, and other debris.

Subbase, Base, Bedding, and Jointing Aggregate

Y	N	N/A	
☐	☐	☐	Subbase, base, bedding, and jointing aggregate are structurally sound and functional.
☐	☐	☐	Subbase, base, bedding, and jointing aggregate 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

Y	N	N/A	
☐	☐	☐	Underdrain/observation wells are structurally sound and functional.
☐	☐	☐	Underdrain/observation wells are free of sediment, leaves, trash, and other debris.

Geotextile/Impermeable Liner

Y	N	N/A	
☐	☐	☐	Geotextile/impermeable liner is structurally sound and functional.
☐	☐	☐	Geotextile/impermeable liner has been replaced.

Drainage and Overflow System

Y	N	N/A	
☐	☐	☐	Drainage swales or storm sewer inlets for emergency overflow are structurally sound and functional.
☐	☐	☐	Drainage swales or storm sewer inlets for emergency overflow are free of sediment, leaves, trash, unwanted vegetation, and other debris.

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 Rating	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.**

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

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

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐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.
☐	☐	☐	Side slopes are structurally sound and functional.
☐	☐	☐	Riprap has a gradation (varied sizes) of stone.

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 Systems

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 Rating	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.

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: BIOEMBANKMENT
SCMS ID#: _____
DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____

Latitude: _____ (Decimal Degrees)

Longitude: _____ (Decimal Degrees)

Inspection Date: _____

Detailed Location: _____

Questions

Y	N	N/A	
☐	☐	☐	Vegetated strip has been mowed to appropriate height.
☐	☐	☐	Perforated underdrain pipe and cleanout (cap, concrete ring, etc.) appears to be structurally sound and functional.
☐	☐	☐	Areas of erosion have been repaired.
☐	☐	☐	There is no significant standing water within the top layer 2 days after a rain event.
☐	☐	☐	Outlet pipes are structurally sound and functional.
☐	☐	☐	Outlet pipes are free of sediment, trash, and debris.
☐	☐	☐	If there is a rodent screen at the outlet pipe, is it in place and free of sediment, trash, and other debris?
☐	☐	☐	Are there maintenance needs for this site? (If yes, describe in Comments section.)
☐	☐	☐	Were maintenance activities conducted during the time of inspection? (If yes, describe in Comments section.)

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 Rating	LOS Descriptions
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.**

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: BIOFILTRATION CONVEYANCE

SCMS ID#: _____

DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____

Latitude: _____ (Decimal Degrees)

Longitude: _____ (Decimal Degrees)

Inspection Date: _____

Detailed Location: _____

Questions

Y	N	N/A	
☐	☐	☐	Inlet drainage system is structurally sound and functional.
☐	☐	☐	Inlet drainage system is free of trash, debris, and excess sediment.
☐	☐	☐	Vegetation is healthy and pruned (reference design plans).
☐	☐	☐	Undesirable/invasive vegetation has been removed.
☐	☐	☐	Step pools are free of significant standing water 3-4 days after a rain event (unless BFC is designed with IWS).
☐	☐	☐	Step pools are free of excess sediment, trash, and debris.
☐	☐	☐	Step pools contain an adequate layer of compost, riprap, or other service liner in good condition (i.e., not washed out).
☐	☐	☐	Riprap weirs are structurally sound and functional.
☐	☐	☐	Perforated underdrain pipes (if present) are structurally sound and functional.
☐	☐	☐	Monitoring wells (if present) are structurally sound and functional.
☐	☐	☐	Monitoring well caps are secure and undamaged.
☐	☐	☐	Areas of erosion have been repaired.
☐	☐	☐	Outlet is free of sediment, trash, and debris.
☐	☐	☐	Are structural repairs needed for this site? (If yes, describe in Comments section.)
☐	☐	☐	Are there maintenance needs for this site? (If yes, describe in Comments section.)
☐	☐	☐	Were maintenance activities conducted during the time of inspection? (If yes, describe in Comments section.)

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 Rating	LOS Descriptions
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.**

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: CISTERN (ABOVEGROUND)

SCMS ID#: _____

DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____

Latitude: _____ (Decimal Degrees)

Longitude: _____ (Decimal Degrees)

Inspection Date: _____

Detailed Location: _____

Questions

Y	N	N/A	
☐	☐	☐	Collection gutter is free of sediment, trash, and debris.
☐	☐	☐	First flush diverter (if present) has been emptied.
☐	☐	☐	Filter screen (if present) is free of sediment, trash, and debris and is undamaged.
☐	☐	☐	Storage tank is free of sediment, trash, and debris (Note: Inspector may need to check turbidity of water outflow to verify).
☐	☐	☐	Backflow prevention device is structurally sound and functional (Note: depending on the product, this device may require specific tests to ensure it is functioning properly. Refer to design plans, manufacturer's recommendations).
☐	☐	☐	Distribution pipe is structurally sound and functional (i.e., no cracks or major deterioration).
☐	☐	☐	Access valve/hose connection is free of sediment, trash, and debris.
☐	☐	☐	Access valve/hose connection is structurally sound and functional (i.e., no cracks or major deterioration).
☐	☐	☐	Passive release orifice is free of sediment, trash, and debris.
☐	☐	☐	Passive release orifice is structurally sound and functional (i.e., no cracks or major deterioration).
☐	☐	☐	Make-up line is structurally sound and functional (i.e., no cracks or major deterioration).
☐	☐	☐	Overflow pipe is free of sediment, trash, and debris.
☐	☐	☐	Areas of erosion have been repaired.
☐	☐	☐	Are structural repairs needed for this site? (If yes, describe in Comments section.)
☐	☐	☐	Are there maintenance needs for this site? (If yes, describe in Comments section.)
☐	☐	☐	Were maintenance activities conducted during the time of inspection? (If yes, describe in Comments section.)

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 Rating	LOS Descriptions
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.**

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: CISTERN (UNDERGROUND)

SCMS ID#: _____

DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____

Latitude: _____ (Decimal Degrees)

Longitude: _____ (Decimal Degrees)

Inspection Date: _____

Detailed Location: _____

Questions

Y	N	N/A	
☐	☐	☐	Collection gutter is free of sediment, trash, and debris.
☐	☐	☐	First flush diverter (if present) has been emptied.
☐	☐	☐	Filter screen (if present) is free of sediment, trash, and debris and is undamaged.
☐	☐	☐	Vent opening (if present) is unobstructed.
☐	☐	☐	Backflow prevention device is structurally sound and functional (Note: depending on the product, this device may require specific tests to ensure it is functioning properly. Refer to design plans, manufacturer's recommendations).
☐	☐	☐	Remote water monitoring system is functioning properly (if accessible).
☐	☐	☐	Storage tank is free of sediment, trash, and debris (Note: Inspector may need to check turbidity of water outflow to verify).
☐	☐	☐	Access port is structurally sound and functional.
☐	☐	☐	Valve is structurally sound and functional.
☐	☐	☐	Make-up line is structurally sound and functional (i.e., no cracks or major deterioration).
☐	☐	☐	Overflow pipe is free of sediment, trash, and debris (if accessible).
☐	☐	☐	Distribution system (including pumps, pipes, sprinkler systems, etc.) is structurally sound and functional.
☐	☐	☐	Areas of erosion have been repaired.
☐	☐	☐	Are structural repairs needed for this site? (If yes, describe in Comments section.)
☐	☐	☐	Are there maintenance needs for this site? (If yes, describe in Comments section.)
☐	☐	☐	Were maintenance activities conducted during the time of inspection? (If yes, describe in Comments section.)

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 Rating	LOS Descriptions
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.

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: FLOATING WETLAND ISLANDS

SCMS ID#: _____

DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____

Latitude: _____ (Decimal Degrees)

Longitude: _____ (Decimal Degrees)

Inspection Date: _____

Detailed Location: _____

Floating Wetland Islands Questions

Y	N	N/A	
☐	☐	☐	Island matrices are structurally sound and functional.
☐	☐	☐	Undesirable/invasive vegetation has been removed from the island matrices.
☐	☐	☐	Wetland plants on island matrices are healthy and pruned to appropriate height.
☐	☐	☐	All floating island wetlands are separated from the banks of the permanent pool and any structures that are present.
☐	☐	☐	Free of evidence that animal are nesting on island matrices.
☐	☐	☐	Anchor is structurally sound and functioning (Note: island matrices floating around the edges of the pond may indicate anchor failure).

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 Rating	LOS Descriptions
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.

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: GREEN ROOF
SCMS ID#: _____
DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____

Latitude: _____ (Decimal Degrees)

Longitude: _____ (Decimal Degrees)

Inspection Date: _____

Detailed Location: _____

Questions

Y	N	N/A	
☐	☐	☐	Has all undesirable/invasive vegetation been removed?
☐	☐	☐	The green roof is free of accumulated sediment, trash, and debris.
☐	☐	☐	Vegetation is healthy and pruned (refer to design plans).
☐	☐	☐	Green roof contains an adequate layer of growth media surrounded by gravel in good condition (i.e., not washed out).
☐	☐	☐	Areas of erosion have been repaired, and reason for erosion has been investigated and repaired.
☐	☐	☐	There is no significant standing water 12 hours after a rain event.
☐	☐	☐	Outlet drains and gutters structurally sound and functional.
☐	☐	☐	Outlet drains and gutters are free of sediment, trash, and debris.
☐	☐	☐	Safety railings (if present) around roof perimeter are structurally sound and functional.
☐	☐	☐	Are structural repairs needed for this site? Check on external and internal parts of the roof where possible. (If yes, describe in Comments section.)
☐	☐	☐	Are there maintenance needs for this site? (If yes, describe in Comments section.)
☐	☐	☐	Were maintenance activities conducted during the time of inspection? (If yes, describe in Comments section.)

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 Rating	LOS Descriptions
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.**

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: INFILTRATION CHAMBER

SCMS ID#: _____

DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____

Latitude: _____ (Decimal Degrees)

Longitude: _____ (Decimal Degrees)

Inspection Date: _____

Detailed Location: _____

Questions

Y	N	N/A	
☐	☐	☐	Is the inlet drainage system free of sediment, trash, and debris?
☐	☐	☐	Cleanout pipes (if present) and chambers appear to be structurally sound and functional.
☐	☐	☐	Cleanout pipe caps are secure and undamaged.
☐	☐	☐	There is no significant standing water 5 days after a rain event.
☐	☐	☐	Areas of erosion have been repaired.
☐	☐	☐	Hurricane plug was removed after large storm event.
☐	☐	☐	Outflow pipe is free of sediment, trash, and debris (if present).
☐	☐	☐	Infiltration chambers are free of sediment, trash, and debris (if present).
☐	☐	☐	Are structural repairs needed for this site? (If yes, describe in Comments section.)
☐	☐	☐	Are there maintenance needs for this site? (If yes, describe in Comments section.)
☐	☐	☐	Were maintenance activities conducted during the time of inspection? (If yes, describe in Comments section.)

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 Rating	LOS Descriptions
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.**

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: RAIN GARDEN
SCMS ID#: _____
DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____

Latitude: _____ (Decimal Degrees)

Longitude: _____ (Decimal Degrees)

Inspection Date: _____

Detailed Location: _____

Questions

Y	N	N/A	
☐	☐	☐	Is the inlet/downspout drainage system free of sediment, trash, and debris?
☐	☐	☐	Is the inlet/downspout drainage system structurally sound and functional?
☐	☐	☐	Stone energy dissipator is structurally sound and functional.
☐	☐	☐	Earthen berm (if present) is structurally sound and functional.
☐	☐	☐	Undesirable/invasive vegetation has been removed from the rain garden.
☐	☐	☐	Vegetation is healthy and pruned (refer to design plans).
☐	☐	☐	Rain garden contains adequate layers of mulch (2-4 inches) and soil in good condition (i.e., not washed out).
☐	☐	☐	There is no significant standing water in the rain garden 12 hours after a rain event.
☐	☐	☐	Rain garden is free of accumulated sediment, trash, and debris.
☐	☐	☐	Areas of erosion have been repaired.
☐	☐	☐	Are the outlet structure and pipe free of sediment, trash, and debris?
☐	☐	☐	Are the outlet structure and pipe structurally sound and functional?
☐	☐	☐	Are structural repairs needed for this site? (If yes, describe in Comments section.)
☐	☐	☐	Are there maintenance needs for this site? (If yes, describe in Comments section.)
☐	☐	☐	Were maintenance activities conducted during the time of inspection? (If yes, describe in Comments section.)

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 Rating	LOS Descriptions
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.**

NCDOT Highway Stormwater Program - Inspection and Maintenance Report

LOS Rating: ☐

STORMWATER SCM: SAND FILTER
SCMS ID#: _____
DIVISION: _____

CITY & COUNTY _____

LOCATION:
☐CMY ☐BMY ☐Rest Area
☐Ferry Terminal ☐DMV
☐Highway ☐DOH Offices
☐Municipal (City/Town)
☐Rail Facility
☐Remote Storage Yard
☐Other

Inspector(s): _____

Latitude: _____ (Decimal Degrees)

Longitude: _____ (Decimal Degrees)

Inspection Date: _____

Detailed Location: _____

Questions

Y	N	N/A	
☐	☐	☐	Is the inlet drainage system structurally sound and functional?
☐	☐	☐	Inlet drainage system is free of sediment, trash, and debris.
☐	☐	☐	Forebay (if present) is structurally sound and functional.
☐	☐	☐	Forebay is free of sediment, trash, and debris (Note: Sediment must be removed from the forebay when it exceeds 3 inches or impedes the function).
☐	☐	☐	Basin is free of sediment, trash, and debris.
☐	☐	☐	There is no significant standing water in the basin 2-5 days after a rain event.
☐	☐	☐	Basin contains an adequate amount of sand media in good condition (i.e., not washed out).
☐	☐	☐	Areas of erosion have been repaired.
☐	☐	☐	Perforated underdrain pipe appears to be structurally sound and functional.
☐	☐	☐	Outlet is structurally sound and functional.
☐	☐	☐	Outlet pipe is free of sediment, trash, and debris.
☐	☐	☐	Are structural repairs needed for this site? (If yes, describe in Comments section.)
☐	☐	☐	Are there maintenance needs for this site? (If yes, describe in Comments section.)
☐	☐	☐	Were maintenance activities conducted during the time of inspection? (If yes, describe in Comments section.)

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 Rating	LOS Descriptions
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.**

APPENDIX B Structural Stormwater Control Measure Field Guide

STRUCTURAL STORMWATER CONTROL MEASURE FIELD GUIDE

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

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.

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.

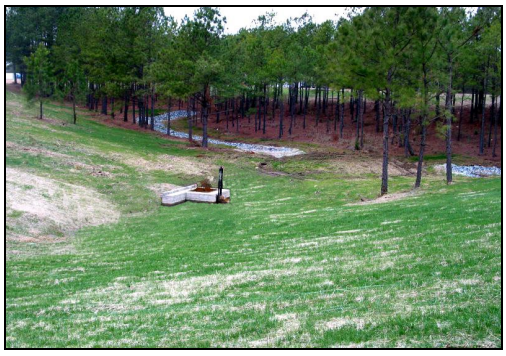
Infiltration Basin

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. Infiltration Basins also 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.



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 stormwater from large events.
- Vegetation growing around the perimeter of the basin provides for biological uptake of nutrients from the water.

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 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 reduce 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.

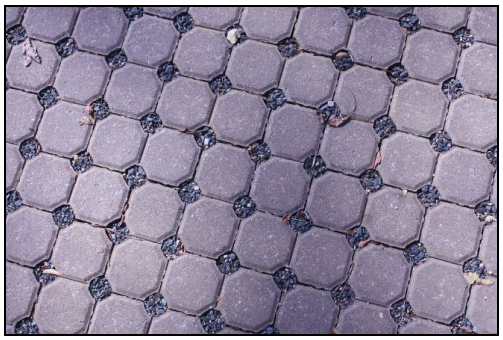
- Swales are shaped like channels and are designed based on target flow rates.
- Swales require nearly flat longitudinal slopes to function. Some applications use water quality rock checks to reduce the effective slope.
- There are four classifications: Grass Swales, Infiltration Swales, Bioswales, and Wet Swales.
    - Infiltration Swales slow water and promote infiltration.
    - Bioswales have specialized media and may include underdrains.
    - Wet Swales have wetland vegetation and soils as the swale is often wet.

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 SCMs 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.



Permeable Pavement

AN ALTERNATIVE PAVING MATERIAL WITH VOID SPACES FOR TEMPORARY DETENTION AND INFILTRATION OF STORMWATER

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.

- Permeable Pavement includes permeable asphalt, permeable concrete, and permeable interlocking concrete pavement (PICP) systems.
- The most prevalent maintenance concern is the potential clogging of the Permeable Pavement pores.
- Permeable Pavement may include a drainage swale, storm sewer inlet, or other overflow system for emergency overflow.

Preformed Scour Hole

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 (PSH) dissipates energy and diffuses flow. PSHs prevent downgrade erosion and promote infiltration.

- The basins are reinforced with riprap to prevent erosion and scour.
- PSH are used with pipe diameters of 18 inches or less.

An apron of permanent soil reinforcement matting (PSRM) is required downgrade of a PSH to prevent scour.

Bioembankment

A FILTER MEDIA MIX AND PERFORATED PIPE UNDERDRAIN SYSTEM

A Bioembankment is designed to slow down, retain, and treat stormwater runoff using a vegetated strip, a filter media mix, and a perforated pipe underdrain system. Bioembankments treat pollutants such as sediment, phosphorus, and metals through sedimentation and filtration.

- This type of SCM is ideal for projects with limited right-of-way space, such as road shoulders.
- When construction is completed, a Bioembankment will look like a normal shoulder embankment but act as a filtration device.

Biofiltration Conveyance

A SERIES OF RIPRAP WEIRS AND STEP POOLS FOR SETTLING OF SOLIDS, INFILTRATION, AND FILTRATION

The Biofiltration Conveyance is designed to slow down and treat stormwater runoff through a series of weirs and step pools, allowing for settling of solids and infiltration or filtration of the stormwater runoff. Weirs help control the flow of stormwater runoff by reducing the flow velocity.

- Some Biofiltration Conveyance designs can include a perforated underdrain pipe, which can be used to transport runoff to the following step pool or to an outlet structure.
- Biofiltration Conveyances may include a forebay, monitoring well, or perforated pipes.

Cistern

A MULTIFUNCTION SYSTEM CONTAINING A SERIES OF GUTTERS, PIPES, AND A STORAGE TANK

Cisterns collect roof runoff through a series of gutters for filtering, storage, and reuse when needed.

- Aboveground Cistern systems store collected rainwater in an aboveground storage tank.
- Underground Cistern systems store collected rainwater in an underground storage tank. These are typically more complicated to maintain than aboveground Cisterns as the components are mostly underground.

Floating Wetland Islands

A MAN-MADE ISLAND DESIGNED TO MIMIC NATURAL WETLANDS TO ENHANCE POLLUTANT TREATMENT

A Floating Wetland Island is an engineered wetland island matrix that houses native wetland plants and is designed to float within a Wet Detention Basin or pond. The FWIs reduce additional pollutants, such as nutrients and sediment (suspended solids), via biological uptake and degradation, and/or evapotranspiration.

- It is common to use multiple FWIs in a single pond or basin, depending on the size of the water body and the amount of pollutants in the runoff.
- The permanent pool containing the FWIs may or may not be listed as a separate SCM.

Green Roof

A VEGETATIVE COVER ON A ROOF THAT PROVIDES POLLUTANT REDUCTION, AESTHETIC BENEFITS, AND BUILDING INSULATION

A Green Roof is designed to temporarily detain, treat, and cool stormwater runoff, as well as reduce the stormwater runoff volume that is discharged. Pollutants are removed by evapotranspiration, soil adsorption, and biological uptake. Runoff will infiltrate the growth media, soak into the vegetation, or flow into the outlet drain.

- Vegetation maintenance varies based on plant species, plant height, and fertilizer use.
- A Green Roof may contain an irrigation system, a synthetic sheet drain, or a barrier around the perimeter.

Infiltration Chamber

AN UNDERGROUND TREATMENT DEVICE THAT FILTERS AND INFILTRATES STORMWATER RUNOFF

Infiltration Chambers are designed to detain, filter, and infiltrate stormwater runoff. An IC uses gravel and/or a sand layer to filter total suspended solids, including sediment, road salt, and debris. The subsurface system occupies less aboveground space, making it ideal for areas with a limited footprint or a need for multiple uses.

- Runoff is transported from the inlet pipe to the chamber where it is filtered through the gravel layer and infiltrates into the soil.
- ICs are beneficial for accepting runoff from large impervious areas, such as sidewalks, parking lots, or roads.
- The IC may contain a PVC cleanout pipe or outlet pipe.
- In the event of a large storm event, the inlet pipe should be temporarily capped with a hurricane plug to prevent the chambers from being clogged with excess trash, sediment, or debris.

Rain Garden

A VEGETATED AND DEPRESSED STORAGE AREA

A Rain Garden is a vegetated and depressed storage area designed to infiltrate stormwater, reduce peak flows, and partially treat runoff through filtration, biological uptake, and soil adsorption. Rain Gardens also help recharge groundwater and provide aesthetic benefits.

- Pollutants are filtered out as the stormwater infiltrates into the soil. As the stormwater infiltrates, pollutants are absorbed through plant roots or attached to the soil particles.

Sand Filter

A SAND MEDIA BASIN WITH INLET DRAINAGE SYSTEM, PERFORATED PIPES, AND OUTLET PIPE

Sand Filters capture and treat pollutants such as total suspended solids, bacteria, organic material, hydrocarbons, and metals through filtration, settling, adsorption processes, and bioremediation. The remaining runoff is then transported through the perforated drain pipe and discharged through the outlet pipe.

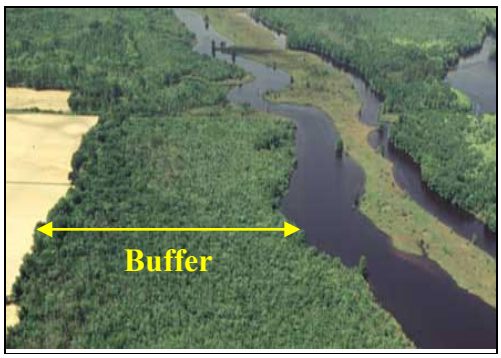
- Sand Filters can be surface or subsurface devices.
- Sand Filters may be scaled differently depending on the size of the drainage area.

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 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 reduce pollutants from runoff and shallow groundwater.

- Thin buffers provide bank stabilization, whereas wider buffers reduce 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.

Forebay (component)

A SMALL BASIN LOCATED UPSTREAM OF ANOTHER STORMWATER CONTROL MEASURE

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

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