Chapter 5

STORMWATER MANAGEMENT DESIGN

Table of Contents

5.1 INTRODUCTION

The traditional design of stormwater systems has been to collect and convey storm runoff as rapidly as possible to a suitable location where it can be discharged. As areas urbanize, this type of design can cause major drainage and flooding problems downstream. Current design practices treat stormwater at the source of runoff, distributed site by site throughout the watershed. Under these conditions, the temporary storage of some of the stormwater runoff can decrease downstream flows, capture and treat pollutants, prevent stream degradation and attenuate flood peaks. Stormwater Control Measures (SCMs) can range from small facilities contained in parking lots to large ponds located either on-site or in a suitable off-site location.

The City encourages the use of green stormwater infrastructure (GSI) as a best practice for stormwater management. GSI practices contribute to managing, treating, and reducing stormwater runoff as close as possible to the runoff's source, by preserving natural landscape features and/or by mimicking natural processes through installation and maintenance of structurally engineered devices. The majority of stormwater treated through GSI practices is designed to infiltrate or evapotranspire rather than leave the property as stormwater runoff. Thus, in comparison to conventional stormwater management practices, GSI practices can provide additional water quality benefits. More information and resources for implementing green stormwater infrastructure in the City of Raleigh, including special programs and incentives, can be found on the City of Raleigh's website here.

SCMs that maximize permeability and minimize off-site discharge are preferred, when possible, to mimic existing drainage patterns and provide water quality benefit. **Table 5.1** details the specific storm events required for calculations for sizing SCMs, based on the intended goal. Since SCMs often provide runoff control for larger events in addition to water quality treatment, the applicant shall perform an analysis downstream to the 10% point for the 1-, 10- and 100-year storm events as part of any SCM design calculations. The downstream analysis is further detailed in *Chapter 2 – Site Development Requirements*.

TABLE 5.1

DESIGN STORM REQUIREMENTS FOR INTENDED STORMWATER MANAGEMENT GOALS

Targeted Goal	*Design Storm*
Green Stormwater Infrastructure (GSI) Volume	90th Percentile Storm
Water Quality Volume	1-inch Rainfall (First Flush)
Erosion Protection Design Storm	1-year, 24-hour
Conveyance Design Storm	10-year, 24-hour
Flood Mitigation Design Storm	100-year, 24-hour

5.2 RATE OF RUNOFF CONTROL REQUIREMENTS

Large sites, subject to active stormwater control measures as specified in the City's Unified Development Ordinance (UDO), are required to meet runoff limitations and shall not have any increase in peak stormwater runoff leaving the site at each point of discharge between pre- and post-development conditions for the 1- and 10-year storm events. Guidance on acceptable hydrology calculations are found in *Chapter 3 – Hydrology*. The same method of calculating peak stormwater runoff leaving the site must be used for pre- and post-construction. SCMs, as detailed in this chapter, shall be implemented to comply with the rate of runoff control requirements. Additional runoff control measures may be required if stormwater runoff from a site could cause adverse effects on adjacent properties as stated in UDO Section 9.2.2.E.3.

5.3 WATER QUALITY REQUIREMENTS

5.3.1 Neuse Nutrient Requirements

The Neuse River Basin, identified as a Nutrient Sensitive Water (NSW) by the North Carolina Department of Environmental Quality (NCDEQ), has been negatively impacted by nutrient loads over many years from stormwater, wastewater and agricultural discharges. As a result, the basin has been given a nutrient reduction strategy, termed the Neuse Nutrient Strategy, requiring all development within the Neuse River Basin to comply with the following regulations:

- Achieve a 30% nitrogen reduction from the 1991 – 1995 baseline date at each controllable and quantifiable source;
- Protect riparian buffers to maintain their existing nitrogen removal capabilities; and
- Maintain no net increase in peak flows leaving a developed site from the pre-development conditions for the 1-year, 24-hour storm event

The Neuse Nutrient Strategy is applicable to all new development within the City. All existing development as of the effective date of the rule is grandfathered; contingent upon further subdivision, development, or redevelopment.

The following development activities are exempt from the Neuse Nutrient Strategy per UDO Section 9.2.2.A.3:

- Any land-disturbing activity that does not require a Land-Disturbing Permit provided that, upon application of any impervious surface exemptions, this exemption shall not apply
- Substitution of impervious surfaces must take place within one year or prior to expiration of a valid Building Permit or sunsetting of an approved subdivision or site plan

5.3.2 Water Supply Watershed Protection Program Requirements

Under this program, the state requires cities and counties statewide to implement watershed protection programs for areas where drinking water is supplied by surface impoundments or by direct withdrawal from streams. Nutrient load reduction requirements are specific to the watershed protection areas; requirements on loading rates can be found in UDO Article 9.5. Development in the Swift Creek and Falls Lake Watershed Overlay Districts is subject to additional restrictions for nitrogen and phosphorous loading rates, as stated in UDO Section 9.5.2.D for Falls Lake and UDO Section 9.5.3.D for Swift Creek.

Requirements specific to the watershed protection areas are detailed in UDO Article 9.5. These requirements include limitations to impervious area, required use of SCMs on lots exceeding certain specified impervious surface or built area limitations, and the incorporation of green stormwater infrastructure (GSI) for volume control. The UDO sections listed below are specific to each of the listed watershed protection areas and detail the requirements. For additional guidance on which Nutrient Management Strategy(ies) may apply, reference the City of Raleigh and Wake County iMaps.

- Urban Watershed – UDO Section 9.5.1
- Falls Watershed – UDO Section 9.5.2
- Swift Creek Watershed – UDO Section 9.5.3

5.3.3 Using GSI to Meet Nutrient Loading Requirements

GSI practices are intended to minimize stormwater impacts of development by matching the volume of water leaving each site before and after construction, thereby, preserving the existing hydrology of the area. The majority of stormwater treated through GSI practices is designed to infiltrate or evapotranspire rather than leave the property as stormwater runoff.

Practices suitable for GSI site development are identified in Section 5.4 below. To meet nutrient loading requirements for either the Neuse Basin or any watershed protection area applicants are required to adhere to NCDEQ guidance provided in the May 13, 2014 memorandum "*Procedure for Meeting the Requirements for Nutrient Sensitive Waters Stormwater Management Programs by Implementing Low Impact Development"* or any future updates to that procedure as issued by NCDEQ.

For new development, the pre-development land cover must be assumed to be forested for the entire development site. For redevelopment of sites with existing impervious area, a modified calculation may be performed. For the purposes of this calculation, any impervious area added as part of the redevelopment must be assumed to be forested in the predevelopment condition. In any case, calculations from an approved Nutrient Sensitive Waters methodology shall be provided to the City for purposes of recordkeeping and reporting, as per the memo referenced above.

Proper design of GSI practices in accordance with City Standards and the NCDEQ procedure above shall be accepted to satisfy nutrient loading requirements. However, the rate of runoff requirements and any other applicable stormwater regulations must still be addressed in the stormwater management plan.

5.3.4 Quantifying Nutrient Loads

NCDEQ has estimated nutrient removal rates, including but not limited to, total nitrogen (TN), total phosphorus (TP) and total suspended solids (TSS), for various SCMs by conducting research and investigating studies performed on SCMs to meet the nutrient load reduction requirements. The state (and industry) looks at both nutrient effluent concentrations leaving an

SCM and the historical rate of pollutant removal provided by an SCM. The total nutrient removal rates, based on current research, can be found in the NCDEQ *"Stormwater Control Measure Credit Document"*. To manage nutrient runoff, development must incorporate practices into their site that meet the nutrient reduction rates required by the specific watershed in which the project is located.

Nutrient loading rates must be calculated for a site to meet all Neuse Nutrient and Watershed Protection Area requirements, as applicable. Calculations for the loading rates must be determined for each site in pounds per acre per year (lbs/ac/yr) and included in the preliminary or permitting submittal, whichever occurs first. If the nutrient loading requirement(s) are not met, additional stormwater control measures (SCMs) shall be implemented onsite to reduce the nutrient export to a point at or below the acceptable threshold.

All impervious areas associated with a development or site shall be accounted for within nutrient loading calculations. This includes, but is not limited to, any right-of-way (ROW) improvements, sidewalks (proposed to be constructed or fee-in- lieu paid) or greenways. If a new greenway easement is being dedicated, applicants shall account for greenway impervious in their compliance calculations for the project.

To comply with the Watershed Protection Area nutrient requirements, current and future approved NCDEQ tools (i.e. the SNAP tool) may be used for calculating these loading rates. As methodologies and requirements change, the City will allow additional methodologies and discontinue use of outdated methodologies as appropriate. NCDEQ is in the process of adopting a loading tool to be implemented and required statewide for TN calculations. Until that adoption, Method 1 and Method 2 shall be used for TN calculations for projects located within Nutrient Sensitive Waters. Please visit the NCDEQ Nutrient Practicing and Crediting Website for the most current nutrient calculation tool information.

In addition, to comply with Neuse nitrogen reduction requirements three methodologies that may be used to make this calculation are presented below. Methods not explicitly listed may be used with prior approval by Stormwater Development Review staff.

5.3.4.1 Method 1

Method 1 is intended for residential developments, where lots are shown but the actual footprint of building, driveways and other impervious features are not yet known or shown on site plans. This method does not require calculation of the area of building footprints. The impervious surface resulting from building footprints is estimated based on typical impervious areas associated with a given lot size. Typical TN export rates are assumed based on the type of land use to determine the TN export from the site, with permanently protected undisturbed open space given a TN coefficient of 0.6 and managed open space given a TN coefficient of 1.2. Note that any areas identified as permanently protected undisturbed open space must be recorded as such on a plat and clearly delineated with a fence, per UDO Section 9.2.2.F.1.d. The TN export coefficient associated with the ROW and lots are found in **Figure 5.3.4.1.a** and **Figure 5.3.4.1.b**.

Steps in Method 1, utilizing **Table 5.3.4.1**, include:

1. Determine area for each type of land use and enter in Column (2).
2. Total the areas for each type of land use and enter at the bottom of Column (2).
3. Determine the TN export coefficient associated with the ROW using **Figure 5.3.4.1.a**.
4. Determine the TN export coefficient associated with the lots using **Figure 5.3.4.1.b**.
5. Multiply the areas in Column (2) by the TN export coefficients in Column (3) and enter answer in Column (4).
6. Total the TN exports for each type of land use and enter the value at the bottom of Column (4).
7. Determine the export coefficient for the site by dividing the total TN export from uses at the bottom of Column (4) by the total area at the bottom of Column (2) and enter it in at the bottom of Column (5).

TABLE 5.3.4.1
QUANTIFYING TN EXPORT USING METHOD 1

(1) *Type of Land Cover*	*(2)* *Site Area (ac)*	*(3)* *TN Export Coefficient (lbs/ac/yr)*	*(4)* *TN Export by Land Use (lbs/yr)*	*(5)* *TN Export from Site (lbs/ac/yr)*
Permanently Protected Undisturbed Open Space		0.6		
Managed Open Space		1.2		
ROW (Figure 5.3.4.1.a)				
Lots (Figure 5.3.4.1.b)				
Total				
Average for Site				

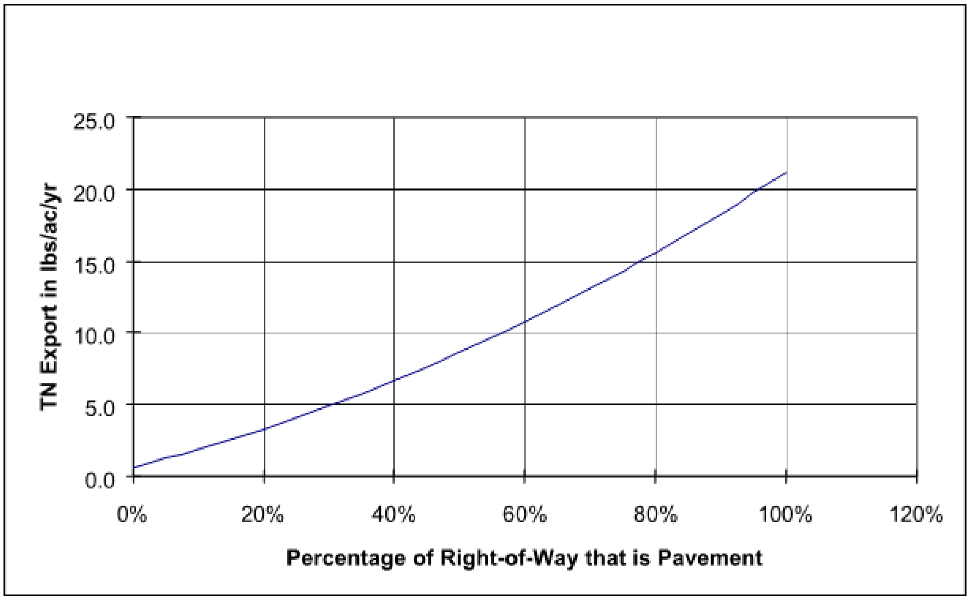


Figure 5.3.4.1.a Total Nitrogen Export from ROW

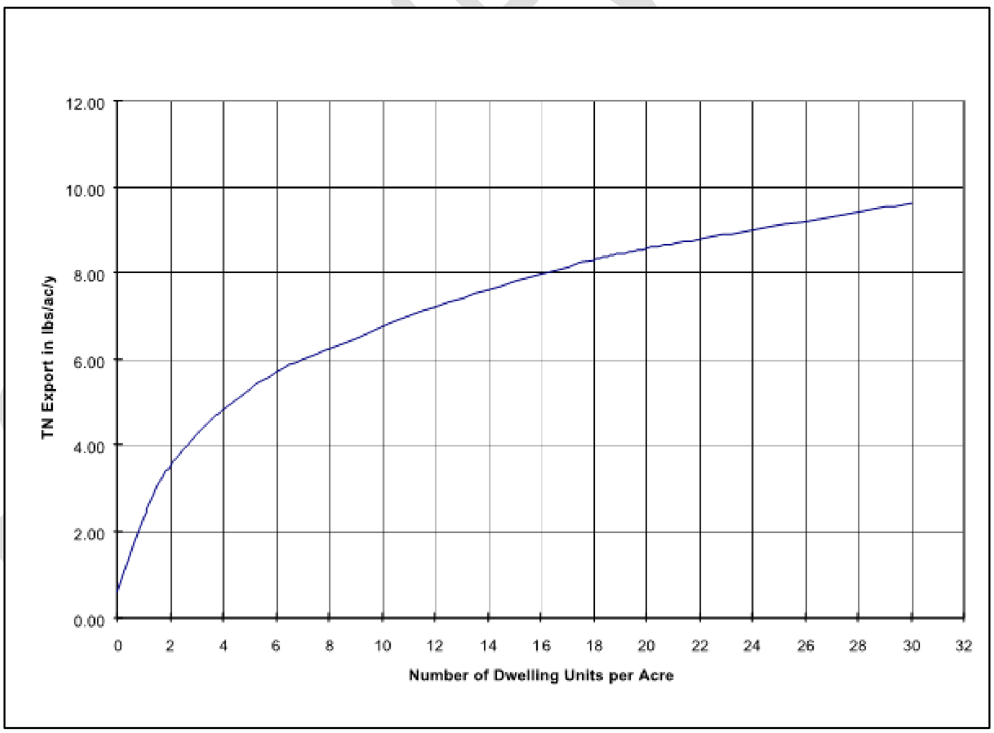


Figure 5.3.4.1.b Total Nitrogen Export from Lots

5.3.4.2 Method 2

Method 2 is intended for residential, commercial and industrial developments when the entire footprint of the roads, parking lots, buildings and any other built-upon area are shown on the site plans. Typical TN export rates are assumed based on the type of land use to determine the TN export from the site, with permanently protected undisturbed open space given a TN coefficient of 0.6, managed open space given a TN coefficient of 1.2, and impervious space given a TN coefficient of 21.2. Note that any areas identified as permanently protected undisturbed open space must be recorded as such on a plat and clearly delineated with a fence, per UDO Section 9.2.2.F.1.d. This method is more accurate because the impervious surface area is known.

Steps in Method 2, utilizing **Table 5.3.4.2**, include:

1. Determine the area for each type of land use and enter in Column (2).
2. Total the areas for each type of land use and enter at the bottom of Column (2).
3. Multiply the areas in Column (2) by the TN export coefficients in Column (3) and enter answer in Column (4).
4. Total the TN exports for each type of land use and enter answer at bottom of Column (4).
5. Determine the export coefficient for site by dividing the total TN export from uses at the bottom of Column (4) by the total area at the bottom of Column (2) and enter the result at the bottom of Column (5).

TABLE 5.3.4.2

QUANTIFYING TN EXPORT USING METHOD 2

(1) Type of Land Cover	*(2)* Site Area (ac)	*(3)* TN Export Coefficient (lbs/ac/yr)	*(4)* TN Export by Land Use (lbs/yr)	*(5)* TN Export from Site (lbs/ac/yr)
Permanently Protected Undisturbed Open Space		0.6		
Managed Open Space		1.2		
Impervious Surfaces		21.2		
Total				
Average for Site				

5.3.4.3 Apportioning Method

When an expansion is proposed for an existing site or when it is desired to determine the appropriate credit for an existing open space as part of a larger development, the apportioning method may be used to compute nitrogen loading. The apportioning method assigns appropriate portions of open space to new developments when the existing and future amounts of impervious and pervious surfaces are known. Note that any areas identified as permanently protected undisturbed open space must be recorded as such on a plat and clearly delineated with a fence, per UDO Section 9.2.2.F.1.d.

Steps in the Apportioning Method, utilizing **Table 5.3.4.3**, include:

1. Determine the apportioned area for each type of land use from **Eq. 5.3.4.3.a and Eq. 5.3.4.3.b** and enter in Column (2).

[EQ 5.3.4.3.a] $Apportioned\ Area = remaining\ undisturbed\ open\ space\ x\ \frac{IA_{new}}{IA_{existing} + IA_{new}}$

[EQ 5.3.4.3.b] $Apportioned\ Area = remaining\ managed\ open\ space\ x\ \frac{IA_{new}}{IA_{existing} + IA_{new}}$

$\boldsymbol{Where},$

$$IA = Impervious\ area\ (ac)$$

2. Total the apportioned areas for each type of land use and enter at the bottom of Column (2).
3. Multiply the areas in Column (2) by the TN export coefficients in Column (3) and enter answer in Column (4).
4. Total the TN exports for each type of land use and enter answer at bottom of Column (4).
5. Determine the export coefficient for site by dividing the total TN export from uses at the bottom of Column (4) by the total area at the bottom of Column (2) and enter the result at the bottom of Column (5).

TABLE 5.3.4.3 QUANTIFYING TN EXPORT USING APPORTIONING METHOD				
(1) *Type of Land Cover*	*(2)* *Site Area (ac)*	*(3)* *TN Export Coefficient (lbs/ac/yr)*	*(4)* *TN Export by Land Use (lbs/yr)*	*(5)* *TN Export from Site (lbs/ac/yr)*
Apportioned Permanently Protected Undisturbed Open Space		0.6		
Apportioned Managed Open Space		1.2		
New Impervious Surfaces		21.2		
Area Associated with New Development				
Average for Site				

5.4 STORMWATER CONTROL MEASURES DESIGN CRITERIA

5.4.1 General Design Criteria

Requirements for each SCM can be found in the NCDEQ Stormwater Design Manual. Compliance with the entirety of the NCDEQ manual is mandatory, including device specific maintenance requirements, and any requirements exceeding the NCDEQ Minimum Design Criteria (MDC) on specific measures are detailed in Section 5.5.

Additional SCMs, not covered in the NCDEQ manual, shall comply with the design requirements established in Section 5.6. Also, the following general requirements apply to the design of all measures within the City:

- All stormwater conveyances must flow by gravity. No pumping of stormwater shall be allowed as a necessary component of any SCM. Passive drawdown shall be allowed for rainwater harvesting devices as described in Section 5.5.7.
- All measures shall include an overflow or bypass device for inflow volumes in excess of the treatment or peak flow reduction volumes. Overflow from the 100-year storm event shall have a minimum of 6 inches of freeboard to an adjacent structure's lowest adjacent grade or to overtopping an earthen embankment. Stormwater control measures designed as green stormwater infrastructure shall provide the minimum of 6 inches of freeboard to an adjacent structure's lowest adjacent grade but shall not be required to provide 6 inches of freeboard to overtopping an earthen embankment.
- All measures shall be located a minimum of 10 feet from any structure or structural pier if located within a parking structure. The only exception to this requirement shall be above

ground rainwater harvesting devices located on a residential lot.

- Inlets and outlets of SCMs shall be designed/located to avoid short circuiting of the measure.
- No woody vegetation shall be planted on embankments or adjacent to structures. Any existing woody vegetation on embankments or adjacent to structures shall be removed.

5.4.2 Small Site Development Additional SCM Options

Additional SCMs have been selected by the City to provide small site developments more options for meeting site requirements. The additional SCMs are not located in the NCDEQ manual; thus, more information and guidance has been provided on the design, operations and maintenance of the devices listed in Section 5.6.

5.5 SCM DESIGN REQUIREMENTS

5.5.1 Infiltration System

DESCRIPTION:
Infiltration practices, which may also be classified as runoff-reducing, green stormwater infrastructure practices, are shallow excavations; typically filled with stone or an engineered soil mix, that are designed to intercept and temporarily store post-construction stormwater runoff until it infiltrates into the underlying and surrounding soils. If properly designed, infiltration systems can provide significant reductions in post-construction stormwater runoff rates, volumes and pollutant loads.
ADDITIONAL REQUIREMENTS BEYOND MDC:
• For infiltration trenches, medium or coarse sand, or crushed stone (with a uniformity coefficient of two or smaller) is required for the drainage media. The media shall be hard, durable, inert particles, free from slate, shale, clay, silt and organic matter. Trench media shall be washed, or preferably double washed. • Trench geotextiles shall enclose drainage media on all sides of the infiltration system. The top surface of the geotextile shall be 6 to12 inches below the upper surface of the drainage media. The other surfaces of the geotextile shall be in contact with the in-situ soil.
SUITABILITY:
GSI Consideration: Yes Small Site Appropriate: Yes Large Site Appropriate: Yes
IMPORTANT LINKS:
NCDEQ MDC C-1 Infiltration System

5.5.2 Bioretention Areas

DESCRIPTION:
A bioretention cell is generally an excavated area that is filled with a specialized, well-draining soil media and plants or sod. This device is designed to temporarily hold and filter stormwater. The device can be installed in a variety of soil types from clay to sand and fit within a wide variety of sites. Bioretention cells are effective at pollutant removal; using infiltration, absorption, adsorption, and other mechanisms for pollutant removal.
ADDITIONAL REQUIREMENTS BEYOND MDC:
• Flow should enter a bioretention cell via disperse flow with a velocity less than one foot per second (fps) for mulched cells or three fps for sodded cells to prevent erosion. If inflow is concentrated in a pipe or swale, then a rip-rap lined entrance, a forebay, or another energy-dissipation device should be used. If a forebay is used, it can both dissipate energy and provide pretreatment. • Clean-out pipes shall extend above the maximum ponding depth. • The outlet shall be maintained in a way so that it is visible and accessible at all times. • A bioretention cell should have a pretreatment area. The most commonly used pretreatment devices are: 1. A *grass and gravel combination:* This should consist of eight inches of gravel followed by three to five feet of sod perpendicular to flow. 2. *A forebay:* This should be 18 to 30 inches deep where the water enters and more shallow where water exits in order to dissipate hydraulic energy The forebay should be lined to ensure that water will not flow into the underdrain without first flowing through the treatment area of the bioretention cell. Lining material should allow for removal of sediment and debris with a shovel or vac-truck.
SUITABILITY:
GSI Consideration: Yes Small Site Appropriate: Yes Large Site Appropriate: Yes
IMPORTANT LINKS:
NCDEQ MDC C-2 Bioretention Areas

5.5.3 Wet Pond

DESCRIPTION:
A wet pond is a constructed stormwater retention basin that is designed to capture the design storm and release slowly over a period of two to five days through a properly designed outlet structure. The captured runoff shall have an adequate flow path to promote the removal of TSS through settling.
ADDITIONAL REQUIREMENTS BEYOND MDC:
• The riser shall be near the embankment to facilitate maintenance and reduce flotation forces. All flotation force for any outlet design subject to flotation forces shall be calculated by the designer. • Measures shall be provided along the principal spillway to prevent piping. • Durable materials, such as reinforced concrete, are required unless approved otherwise by Stormwater Development Review staff. • An emergency spillway is required to prevent failure of the embankment structure during large storm events. • The engineered design shall incorporate safety components (e.g. fencing, trash racks, shallow safety benches around the wet pond, etc.). • The outlet shall be maintained in a way so that it is visible and accessible at all times. • Maximum drainage area of 10 acres. • Embankments shall comply with State Dam Safety Regulations. • The rate of drawdown for maintenance shall be non-erosive and no more than one foot per week.
SUITABILITY:
GSI Consideration: No Small Site Appropriate: No Large Site Appropriate: Yes
IMPORTANT LINKS:
NCDEQ MDC C-3 Wet Pond

5.5.4 Stormwater Wetlands


DESCRIPTION:
Constructed wetland systems are used for stormwater management and mimic the function of natural wetlands through physical, chemical, and biological processes to treat stormwater. A stormwater wetland is designed to capture the design storm and release flow slowly over a period of two to five days through a properly designed outlet structure. The storage within the wetland in combination with the vegetative influence provides an ideal environment for pollutant removal.
ADDITIONAL REQUIREMENTS BEYOND MDC:
• The wetland shall have at least two acres of drainage area to provide year-round hydration for wetland plants to grow and thrive. • The outlet shall be maintained in a way so that it is visible and accessible at all times. • A minimum flow length to pond width ratio (L: W) shall be 3:1. • A minimum of four inches of topsoil shall be applied to the top layer of the stormwater wetland to promote plant growth. Topsoil is defined as the uppermost layer of soil capable of growing and supporting vegetation. Topsoil contains the essential microorganisms, nutrients, organic matter and physical characteristics necessary to grow and sustain permanent vegetation.
SUITABILITY:
GSI Consideration: Yes Small Site Appropriate: No Large Site Appropriate: Yes
IMPORTANT LINKS:
NCDEQ MDC C-4 Stormwater Wetland

5.5.5 Permeable Pavement Systems

DESCRIPTION:

A permeable pavement surface is comprised of structural units with void areas that are filled with pervious materials, such as gravel, sand or grass turf. Permeable paver systems are installed over a gravel base course that provides structural support and stores stormwater runoff that can infiltrate through the system into underlying permeable soils. In some design scenarios, an underdrain system may be necessary.

ADDITIONAL REQUIREMENTS BEYOND MDC:

- Geogrids shall be used at the top of the soil subgrade to provide additional structural support especially in very weak, saturated soils.
- Geotextiles (permeable) shall line the sides of the aggregate base to prevent migration of adjacent soils into it and subsequent permeability and storage capacity reduction. Geotextiles are not recommended under the aggregate base in an infiltration design because they can accumulate fines and inhibit infiltration.
- Geomembranes shall be used to provide a barrier on the sides and bottom of the aggregate base in a detention design to prevent infiltration into the subgrade. Geomembranes should also be used to line the sides of the aggregate base when structures or conventional pavement is within 20 feet or less.
- The designer shall ensure that the pavement meets its hydrologic and structural goals by involving a North Carolina licensed design professional with appropriate expertise in pavement design.
- The system shall be accessible for maintenance (i.e. vacuum truck).
- The required drawdown time shall be 24 hours.

SUITABILITY:

GSI Consideration: Yes
Small Site Appropriate: Yes
Large Site Appropriate: Yes

IMPORTANT LINKS:

NCDEQ MDC C-5 Permeable Pavement

5.5.6 Sand Filter

DESCRIPTION:
A sand filter is designed to treat stormwater runoff through filtration, using a sand bed as its primary filter media and an underdrain collection system. Sand filters function to remove pollutants through settling, filtering and adsorption processes.
ADDITIONAL REQUIREMENTS BEYOND MDC:
• Pervious areas shall be graded to drain away from sand filters. • The outlet shall be maintained in a way so that it is visible and accessible at all times. • Maximum drainage area of five acres. • Underground sand filters shall provide access in accordance with OSHA standards and requirements.
SUITABILITY:
GSI Consideration: Yes (when designed for infiltration) Small Site Appropriate: No Large Site Appropriate: Yes
IMPORTANT LINKS:
NCDEQ MDC C-6 Sand Filter

5.5.7 Rainwater Harvesting (RWH)

DESCRIPTION:
RWH involves many components that work together to collect, store and use rainwater. Usually RWH captures runoff from roofs; however, collecting runoff from other surfaces, such as parking lots, sidewalks and landscaped areas, is allowed. RWH can be very effective at controlling stormwater, mainly through runoff reduction. These systems can be used as stand-alone SCMs or can simply reduce the need for SCMs elsewhere on the site. An added benefit of RWH may be conservation of potable water.
ADDITIONAL REQUIREMENTS BEYOND MDC:
• A pretreatment screen filter must be provided prior to entering the barrel. It includes screens, basket screens and filters, and first flush diverters. Other options include settling tanks, oil-grit separators, hydrodynamic separators, sand filters, or proprietary devices. • A passive drawdown, designed to prevent clogging, is required. The passive drawdown should discharge over two to five days to a downstream vegetated receiving area meeting the requirement of this chapter or to another SCM. Because the orifice for passive drawdown is often very small, the passive release mechanism should be equipped with some type of filter, located on the inside of the tank, to prevent clogging. • The minimum easement for RWH measures (e.g. rain barrel) on single-family lots shall be five feet and 10 feet on all other developments.
SUITABILITY:
GSI Consideration: Yes Small Site Appropriate: Yes Large Site Appropriate: Yes
IMPORTANT LINKS:
NCDEQ MDC C-7 Rainwater Harvesting

5.5.8 Green Roof

DESCRIPTION:

A green roof is an alternative to traditional impervious roof surfaces. Green roofs typically consist of underlying waterproofing and drainage materials and overlying engineered growing media designed to support plant growth.

ADDITIONAL REQUIREMENTS BEYOND MDC:

- The designer shall ensure that the roof meets its hydrologic and structural goals by involving a North Carolina licensed design professional with appropriate expertise in roof design. The roof must be strong enough to support the loads associated with construction, maintenance and ongoing loads of media, plants and water.
- Measures shall be taken to minimize the potential for dangerous falls from the green roof (e.g. railing, fencing, suitable access, etc.).
- A geotextile layer and a drainage layer shall be placed beneath the growing media for roofs with slopes of less than 2%. Granular or aggregate materials may also be used for a drainage layer. The drainage layer should drain to the roof gutters and downspouts.
- The roof shall be equipped with a waterproof membrane to protect against leaks. Structural evaluation of the roof shall be sealed by a North Carolina licensed structural engineer. Sealed structural calculations shall be included in the calculation submittal package.

SUITABILITY:

GSI Consideration: Yes
Small Site Appropriate: Yes
Large Site Appropriate: Yes

IMPORTANT LINKS:

NCDEQ MDC C-8 Green Roof

5.5.9 Level Spreader – Filter Strip

DESCRIPTION:

A level spreader-filter strip (LS-FS) consists of a LS that is typically a poured concrete lip which flows onto a FS that is graded and grassed that filter and infiltrate stormwater. The LS does not remove pollutants by itself; however, it disperses concentrated flow needed to slow flow velocity to bring about pollutant removal in the FS. The vegetation and soils in the FS remove pollutants primarily via filtration and infiltration.

ADDITIONAL REQUIREMENTS BEYOND MDC:

- Pretreatment via the use of a forebay is required. The stormwater directly from the drainage area shall be directed to an excavated, bowl-shaped forebay that slows the stormwater and allows sediment and debris to settle out. The forebay shall have depth of three feet where the stormwater enters, sloping up to one foot where the stormwater leaves.
- Soil amendment is required to promote plant growth. The FS and side slopes shall be covered with at least six inches of stockpiled topsoil, imported topsoil or a combination of the two.
- Non-clumping, native, deep-rooted grasses shall be specified.
- Minimum depth to water table shall be 12 inches.
- The required setback is 10 feet from any property line or building.

SUITABILITY:

GSI Consideration: Yes
Small Site Appropriate: Yes
Large Site Appropriate: Yes

IMPORTANT LINKS:

[NCDEQ MDC C-9 Level Spreader-Filter Strip]

5.5.10 Disconnected Impervious Surface (DIS)

DESCRIPTION:
DIS involves the practice of directing stormwater runoff from built-upon areas to properly sized, sloped and vegetated pervious surfaces. Both roofs and paved areas can be disconnected with lightly differing designs. DIS is low-cost and has been proven to reduce the volume and flows associated with stormwater runoff. Much of the development across the state has been designed as connected impervious surface, which involves draining to pipes and ditches that rapidly convey stormwater without runoff reduction or treatment. Using DIS can help restore the hydrology of streams and reduce pollutant loadings. DIS can also reduce the size and/or number of other site-required SCMs.
ADDITIONAL REQUIREMENTS BEYOND MDC:
• The outfall distance must be a minimum of 10 feet from the property line.
• SUITABILITY:
GSI Consideration: Yes Small Site Appropriate: Yes Large Site Appropriate: Yes
IMPORTANT LINKS:
NCDEQ MDC C-10 Disconnected Roofs (DR) and Disconnected Pavement (DP)

5.5.11 Treatment Swales

DESCRIPTION:
Treatment swales are vegetated, open channels that are explicitly designed and constructed to capture and treat stormwater runoff within dry or wet cells formed by check dams or other means. Treatment swales can include bioswales.
ADDITIONAL REQUIREMENTS BEYOND MDC:
• The depth to the seasonal high-water table (SHWT) shall be a minimum of one foot. • The side slopes shall be 3H:1V maximum. • Inundation mapping for the 100-year storm event shall be provided on the plans.
SUITABILITY:
GSI Consideration: Yes Small Site Appropriate: Yes Large Site Appropriate: Yes
IMPORTANT LINKS:
NCDEQ MDC C-11 Treatment Swale

5.5.12 Dry Pond

DESCRIPTION:
A dry pond is a surface storage basin or facility designed to provide water-quality treatment and water-quantity control through detention of stormwater runoff. The primary purpose of a dry pond is to attenuate and delay stormwater runoff peaks. Dry ponds hold water immediately after a storm event and drain to be dry between storm events.
ADDITIONAL REQUIREMENTS BEYOND MDC:
• The outlet shall be maintained in a way so that it is visible and accessible at all times. • Depth to the SHWT shall be a minimum of two feet. • A flow length to pond width ratio (L: W) shall be 3:1. • If not designing for nutrient removal credit, maximum drawdown is two days. • No woody vegetation shall be planted on the pond embankments.
SUITABILITY:
GSI Consideration: No Small Site Appropriate: No Large Site Appropriate: Yes
IMPORTANT LINKS:
NCDEQ MDC C-12 Dry Pond

5.5.13 Proprietary Structural Controls

DESCRIPTION:
Proprietary structural controls are manufactured SCMs and treatment systems available from commercial vendors. These systems are designed to treat stormwater runoff and/or provide water quantity control. Only NCDEQ approved proprietary devices will be accepted by the City for compliance with nutrient treatment requirements.
ADDITIONAL REQUIREMENTS BEYOND MDC:
• The City may impose additional regulations on future or current approved proprietary measures.
SUITABILITY:
GSI Consideration: Varies Small Site Appropriate: Varies Large Site Appropriate: Varies
IMPORTANT LINKS:
Any proprietary measure NCDEQ approves may be allowed and must follow the MDCs and any other additional City requirements

5.6 ADDITIONAL SCM OPTIONS

5.6.1 Soakage Trench

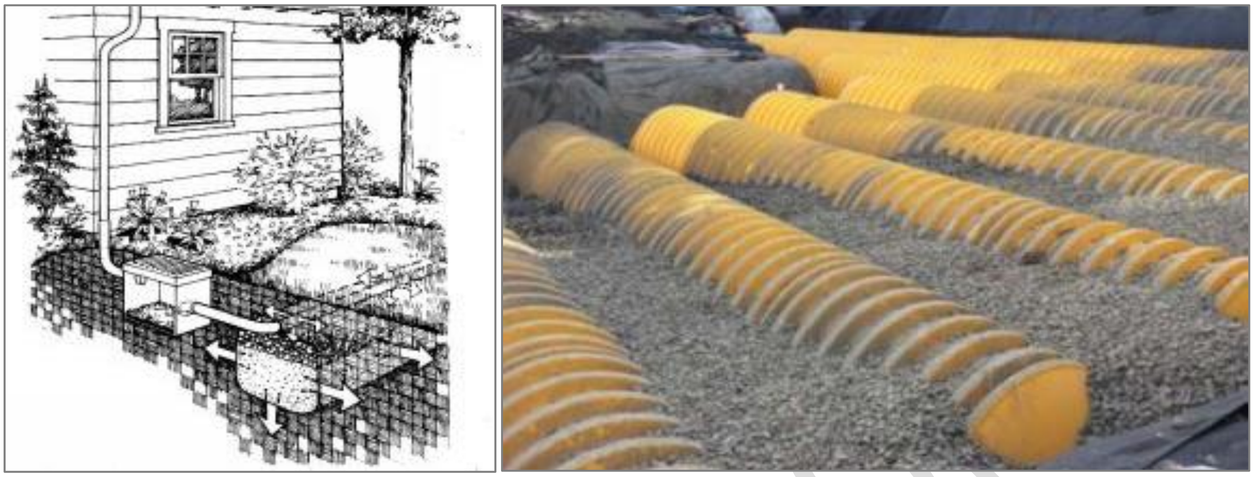


Photo Approval by City of Portland (Stormwater Management Manual, 2016)

DESCRIPTION:
A soakage trench is a shallow trench in permeable soil that is backfilled with washed gravel, free of fines. The surface of a soakage trench may be covered with grass, stone, sand or plantings. Soakage trenches discharge stormwater by collecting and recharging stormwater runoff into the ground. The use of soakage trenches is highly dependent on the soil type and depth to the SHWT. Soakage trenches are not allowed in the ROW.
SUITABILITY:
GSI Consideration: Yes Small Site Appropriate: Yes Large Site Appropriate: Yes (for detention only)

Design Criteria and Specifications

- A 2-inch/hour infiltration rate is required at the facility base. Infiltration test results shall be submitted for approval by the City.
- The soakage trench shall be located at least 10 feet from the nearest property line and 10 feet away from building foundations.
- The trench shall be constructed in native soil, uncompacted by heavy equipment.
- Sizing requirements vary by design approach. Pore space of the fill material shall be 30 percent, with vertical infiltration area only. The trench must infiltrate the entire depth design storm without overflow.
- Soakage trenches shall be designed with a minimum length of 20 feet, width of 2.5 feet, and depth of 1.5 feet.

- There shall be at least five feet between the bottom of the trench and any impervious layer or SHWT.
- A silt trap or similar device may be installed upstream of the perforated pipe, if pretreatment is needed prior to discharge.
- The bottom of the trench shall be filled with at least 18 inches of medium sand and covered with a layer of filter fabric.
- Appropriate filter fabric shall be installed between the filter medium and the native soils and covering the perforated pipe to prevent clogging.
- A minimum of 12 inches of ¾ to 2½ inches of washed round or crushed rock shall be separated from soil by one layer of geotextile fabric and will serve as the drainage layer.
- A minimum 12-inch cover is required from the top of all piping to the finished grade. Piping shall be 3-inch, schedule 40 PVC in diameter prior to the perforated drainage pipe or 4-inch, schedule 40 PVC if serving greater than 1,500 square feet of impervious area.
- The solid conveyance piping from a building or other source must be installed at a ¼-inch per linear foot slope prior to connection with the perforated pipe.
- The perforated pipe shall be an approved leach field pipe, either PVC D2729 or HDPE, with holes oriented downward. Perforated pipe must be laid on top of a gravel bed and covered with geotextile fabric.
- No more than 10,000 square feet of impervious area shall drain to the trench.
- A minimum of one foot of head is required to promote infiltration.

Inspection and Maintenance Requirements

The inspection and maintenance requirements for soakage trenches are intended to maintain an adequate drainage rate through the trench, avoiding flooding as shown in **Table 5.6.1**.

TABLE 5.6.1 **TYPICAL MAINTENANCE ACTIVITIES FOR SOAKAGE TRENCHES**	
Activity	*Schedule*
Ensure that inflow is unimpeded	Quarterly and within 48 hours of major storms
Clean silt trap if it is more than 25% full of sediment	As needed, based on minimum annual inspection
Inspect trench for waterlogged soils at surface	Between 24 – 48 hours after major storms

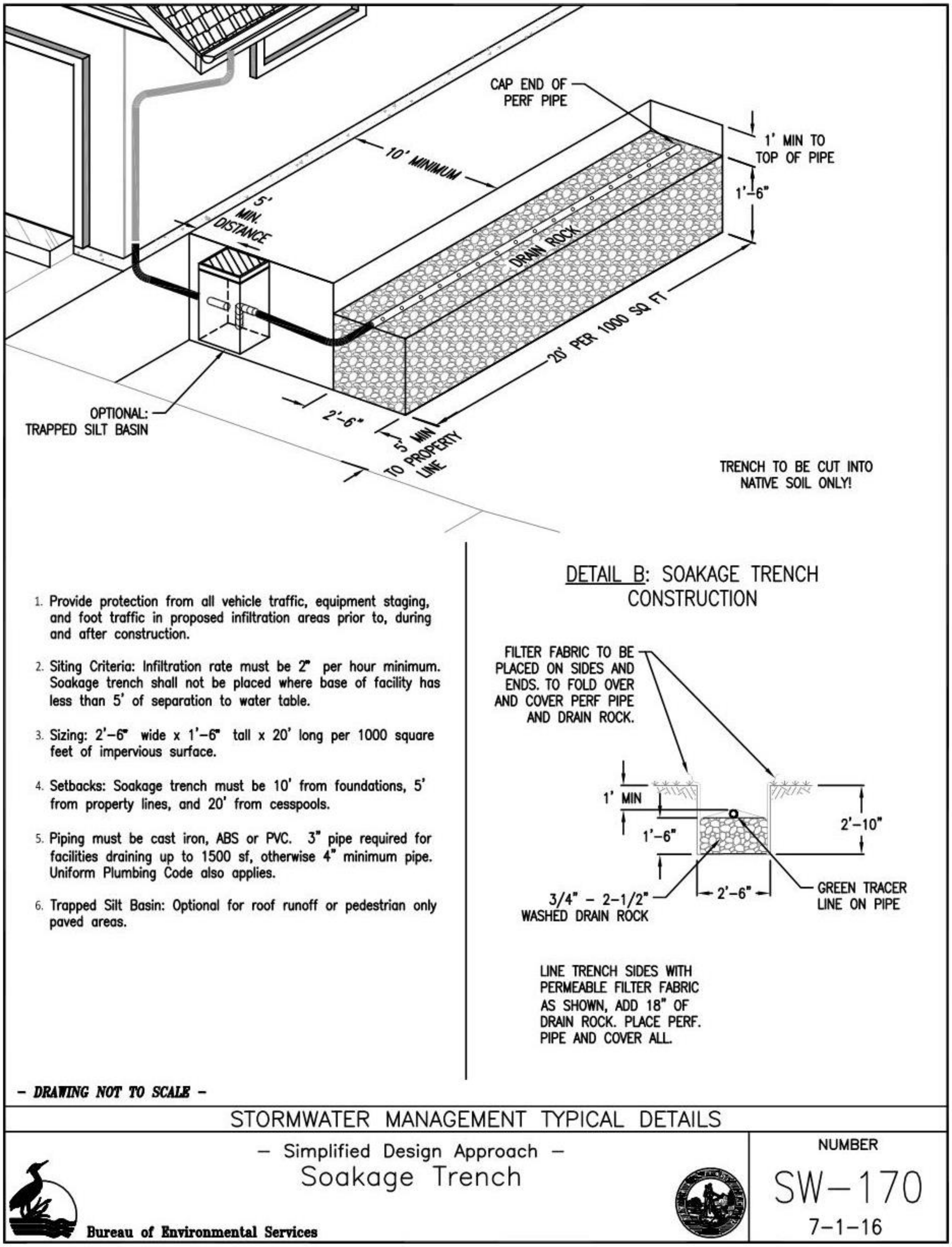


Figure 5.6.1 Example Construction Detail of a Soakage Trench (Source: City of Portland, Oregon)

5.6.2 Planter Box

DESCRIPTION:
Stormwater planters are landscape planter boxes that are designed to receive stormwater runoff. They consist of planter boxes equipped with waterproof liners, filled with an engineered soil mix and planted with trees, shrubs and other herbaceous vegetation. Stormwater planters are a modification of bioretention for sites with limited space, particularly highly urban/impervious sites. They are designed to capture and temporarily store stormwater runoff in the engineered soil mix, where runoff is subject to the hydrologic processes of evaporation and transpiration before being conveyed back into the stormwater conveyance system through an underdrain or drainage media with weep holes.
SUITABILITY:
GSI Consideration: Yes Small Site Appropriate: Yes Large Site Appropriate: Yes (for detention only)

Design Criteria and Specifications

- The infiltration and flow-through planter boxes can capture runoff from surrounding areas and provide limited storage in reservoirs. The ratio of planter area to impervious area shall be 7%, assuming a 90th percentile storm volume and a reservoir depth in the planter of 12 inches. The infiltration rate shall be greater than or equal to 2 inches per hour.
- The planter shall be constructed of stone, concrete or brick. Pressure-treated wood may be used if it does not leach out toxic chemicals that might contaminate stormwater.
- Filter media shall consist of sand, gravel and topsoil. As an alternative, compost/mulch can be used in place of the sand, gravel and topsoil, but will have different infiltration characteristics. Compost with organics will aid in pollutant removal through absorption,

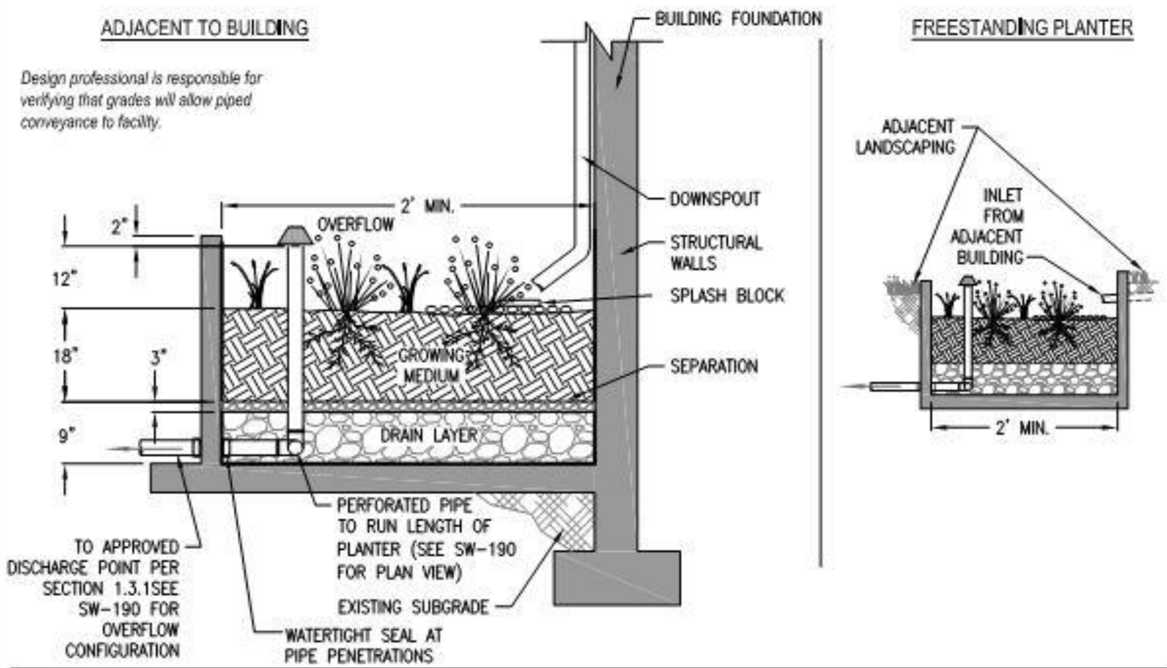
but it will remove nitrogen from the plant material as it breaks down/decomposes. A nitrogen fertilizer may need to be added shall this occur.

- Planter vegetation shall be relatively self-sustaining, with minimal fertilizer or pesticide requirements. Grasses, herbs, succulents, shrubs and trees may be used in planter boxes. Examples include rushes, reeds, sedges, iris, dogwood, currants and other approved species. Trees are encouraged as their foliage traps additional precipitation.
- All planters require at least 24 inches of growing media. A minimum width of 24 inches is recommended for the infiltration planter. The flow-through planter shall be at least 18 inches wide. The minimum widths help reduce water wicking down the insides of the planter wall.
- A minimum of 12 inches of ¾ to 1½ inches of washed round or crushed rock shall be separated from growing medium by one layer of 2- to 3-inches of pea gravel.
- The planter shall not slope more than 0.5 percent in any direction.
- Full or partial liners are required to protect adjacent utilities, streets, locations with hazardous materials or locations with topography considerations. Single-pour concrete box impervious bottoms are acceptable.
- Piping shall be 3-inch, schedule 40 PVC in diameter or 4-inch, schedule 40 PVC if serving greater than 1,500 square feet of impervious area. 6-inch or 8-inch ASTM 3034 SDR 35 PVC pipe is required in the ROW.
- Water shall drain through a planter within three to four hours after the storm event. Soils underneath an infiltration planter shall be soil type A or B.

Inspection and Maintenance Requirements

The inspection and maintenance requirements for planter boxes are focused on maintaining an adequate drainage rate through the planting media and maintaining attractive and healthy vegetation as shown in **Table 5.6.2**.

TABLE 5.6.2 **TYPICAL MAINTENANCE ACTIVITIES FOR PLANTER BOXES**	
Activity	*Schedule*
• Ensure that downspout or sheet flow from paving is unimpeded • Ensure planter reservoir drains within three to four hours • Replace or amend topsoil if drainage is unsatisfactory	Quarterly and within 48 hours of major storms
• Ensure that contributing area and planter boxes are clear of debris • Remove accumulated sediment if greater than four inches in depth • Ensure that planter vegetation is healthy, the planter is weeded, and shrubs and trees pruned • Planter vegetation may require water during long periods without precipitation	As needed, based on minimum annual inspection
• Remove fallen leaves and debris from deciduous plants	Three to four times per year
• Replenish mulch • Provide training/written materials to property owners and tenants	Annually
• Replace plant if cracked or rotted	Upon failure



1. Dimensions:
   Width of planter: 24" minimum.
   Depth of planter (from top of growing medium to overflow elevation): 12".
   Longitudinal slope of planter: 0.5% or less.
2. Setbacks:
   Planters must be less than 30" in height above finish grade if within 5-feet of property line.
3. Planter Walls:
   Material must be monolithically poured concrete. Walls must be included on foundation plans.
4. Waterproofing:
   Monolithically poured planter, without joints is required. Check state structural requirements for foundations.
5. Piping must be cast iron, ABS or PVC. 3" pipe required for facilities draining up to 1500 s.f., otherwise 4" minimum pipe. Uniform Plumbing Code also applies.
6. Drain Layer:
   3/4" - 1 ½" washed round rock. Depth: 9".
   Separation between drain rock and growing medium:
   Pea gravel lens, 2 to 3 inches deep.
7. Overflow:
   Planters must connect to approved discharge point according to section 1.3.1 and detail SW-190.
   Inlet elevation must allow for 2" of freeboard, minimum.
   Protect from debris and sediment with strainer or grate.
8. Growing Medium:
   18" minimum depth. Use sand/loam/compost 3-way mix, or approved mix that will support healthy plants.
   24" minimum depth is required if the lined facility is also meeting BDS landscape requirements.
9. Vegetation: Refer to plant list in SWMM section 2.4.1. Minimum container size is #1. # of plantings per 100sf of facility area:
   80 herbaceous plants OR;
   72 herbaceous plants and 4 small shrubs.
10. Splash Block: Install 4-6" washed river rock or splash pad for erosion control at inlets and downspout.
11. Inspections: Call BDS IVR Inspection Line, (503) 823-7000, request 487. 3 inspections required.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT TYPICAL DETAILS

- Simplified Design Approach -

Planter - lined

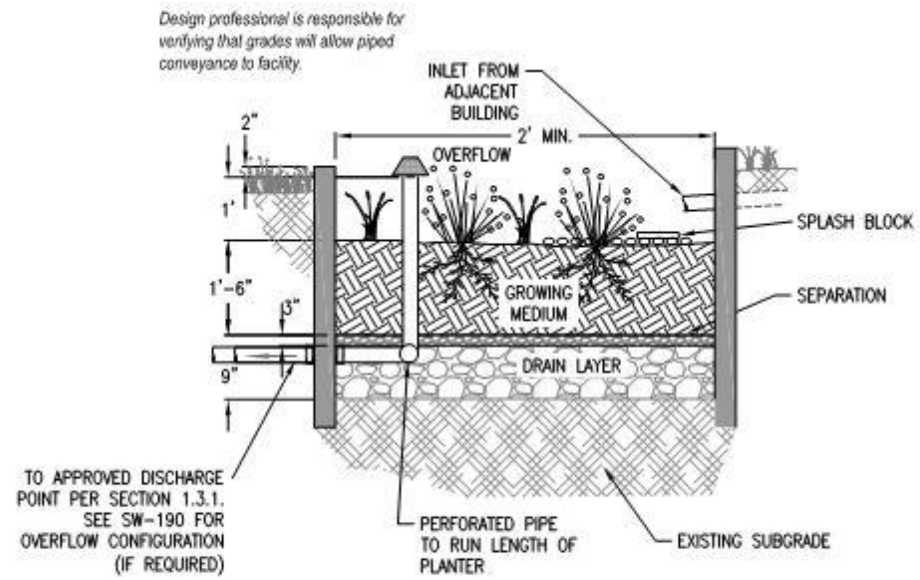
NUMBER

SW-140

7-1-16

Bureau of Environmental Services

Figure 5.6.2.a Example Construction Detail of a Planter (Lined)
(Source: City of Portland, Oregon)



1. Provide protection from all vehicle traffic, equipment staging, and foot traffic in proposed infiltration areas prior to, during, and after construction.

2. Dimensions:
   Width of planter: 24" minimum.
   Depth of planter (from top of growing medium to overflow elevation): 12".
   Longitudinal slope of planter: 0.5% or less.

3. Setbacks:
   Planters must be 5-feet from property line and 10-feet from building foundations.

4. Planter Walls:
   Material must be concrete, unless otherwise approved. Walls must be included on foundation plans.

5. Piping must be cast iron, ABS or PVC. 3" pipe required for facilities draining up to 1500 s.f., otherwise 4" minimum pipe. Uniform Plumbing Code also applies.

6. Drain Layer:
   3/4" - 1 ½" washed. Depth: 9".
   Separation between drain rock and growing medium:
   Pea gravel lens, 2 to 3 inches deep.

7. Overflow:
   Planters must connect to approved discharge point according to section 1.3.1 and detail SW-190.
   Inlet elevation must allow for 2" of freeboard, minimum.
   Protect from debris and sediment with strainer or grate.

8. Growing Medium:
   18" minimum depth. Use sand/loam/compost 3-way mix, or approved mix that will support healthy plants.
   24" minimum depth is required if the lined facility is also meeting BDS landscape requirements.

9. Vegetation: Refer to plant list in SWMM Section 2.4.1. Minimum container size is #1. # of plantings per 100sf of facility area:
   80 herbaceous plants OR;
   72 herbaceous plants and 4 small shrubs.

10. Splash Block: Install 4-6" washed river rock or splash pad for erosion control at inlets and downspout.

11. Inspections: Call BDS IVR Inspection Line, (503) 823-7000, request 487. 3 inspections required.

- DRAWING NOT TO SCALE -

STORMWATER MANAGEMENT TYPICAL DETAILS	
- Simplified Design Approach - Planter - unlined Bureau of Environmental Services	NUMBER SW-141 7-1-16

Figure 5.6.2.b Example Construction Detail of a Planter (Unlined)
(Source: City of Portland, Oregon)

5.6.3 Underground Detention

DESCRIPTION:
Underground detention storage is located in underground tanks, pipes or vaults designed to provide water quantity control through detention and/or extended detention of stormwater runoff.
SUITABILITY:
GSI Consideration: No Small Site Appropriate: Yes Large Site Appropriate: Yes (for detention only)

Design Criteria and Specifications

- Underground detention systems are to be located downstream of other structural stormwater controls providing treatment of the water quality volume.
- The maximum contributing drainage area to be served by a single underground detention vault or tank is 100 acres. For small site applications, the tank or vault shall be sized appropriately for the drainage area received.
- Underground detention systems are sized to provide temporary storage as needed for rate control from the required storm events.
- Routing calculations must be used to demonstrate that the storage volume is adequate. See *Chapter 3 – Hydrology* for procedures on the design of detention storage.
- A minimum 3,000 PSI structural reinforced concrete shall be used for underground detention vaults. All construction joints must be provided with water stops. Cast-in-place wall sections must be designed as retaining walls. The maximum depth from finished grade to the vault invert shall be 20 feet.
- The minimum pipe diameter for underground detention tanks is 36 inches.

- Underground detention vaults and pipe/tank systems must meet structural requirements for overburden support and traffic loading, as appropriate.
- Adequate maintenance access must be provided for all underground detention systems, and at a minimum, be provided over the inlet pipe and outflow structure. Access openings can consist of a standard frame, grate and solid cover or a removable panel and shall meet Occupational Safety and Health Administration (OSHA) requirements. Vaults with widths of 10 feet or less shall have removable lids.

Inlet and Outlet Structures

- A separate sediment sump or vault chamber sized to 0.1 inches per impervious acre of contributing drainage shall be provided at the inlet for underground detention systems that are in a treatment train with off-line water quality treatment structural controls.
- For erosion protection, a low-flow orifice capable of releasing the erosion protection volume over 24 hours must be provided. The orifice shall have a minimum diameter of three inches and shall be adequately protected from clogging by an acceptable external trash rack. The orifice diameter may be reduced to one inch, if internal orifice protection is used (e.g. an over perforated vertical standpipe with 0.5-inch orifices or slots that are protected by wire cloth and a stone filtering jacket, etc.). Adjustable gate valves can also be used to achieve this equivalent diameter.
- For on-site rate control, an additional outlet shall be sized for control of the chosen return period (based upon hydrologic routing calculations) and can consist of a weir, orifice, outlet pipe, combination outlet or other acceptable control structure.
- Riprap, plunge pools, pre-formed scour holes or other energy dissipators shall be placed at the end of the outlet to prevent scouring and erosion.
- A high-flow bypass shall be included in the underground detention system design to safely pass the Flood Mitigation Design Storm.

Inspection and Maintenance Requirements

The inspection and maintenance requirements for underground detention system are focused on maintaining an adequate storage volume in the system as shown in **Table 5.6.3**.

TABLE 5.6.3
TYPICAL MAINTENANCE ACTIVITIES FOR UNDERGROUND DETENTION SYSTEMS

Activity	*Schedule*
Remove any trash/debris and sediment buildup in the underground vaults or pipe/tank systems	Annually
Perform structural repairs to inlet and outlets	As needed, based on inspection
Maintain groundcover and stability of overall site to reduce incoming sediment loads	As needed, based on inspection

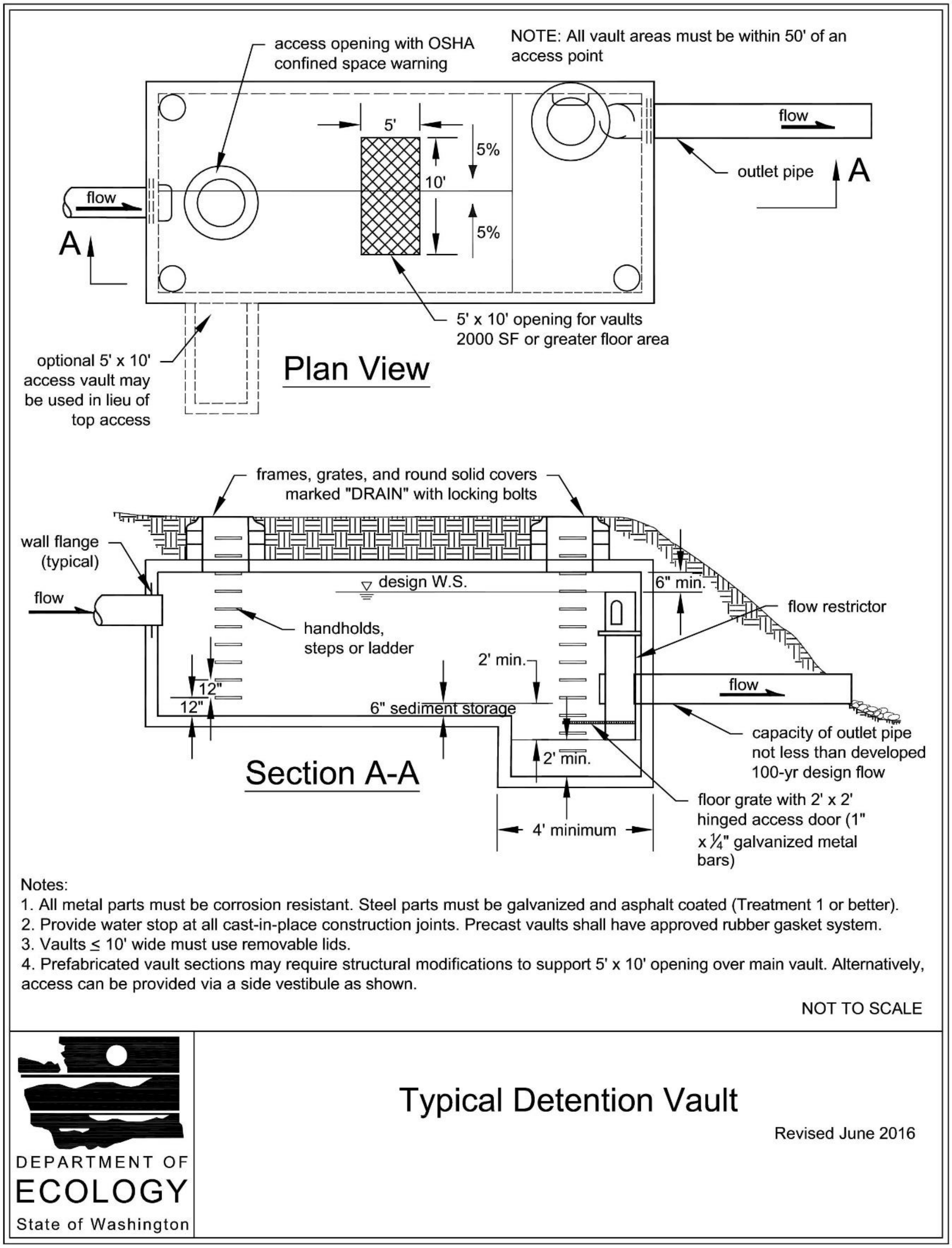


Figure 5.6.3 Example Schematic of an Underground Detention System (Source: Washington Department of Ecology, 2019)

5.6.4 Level Spreader – Diffuse Flow (No Filter Strip)

DESCRIPTION:
A level spreader may be used to diffuse flow without an associated filter strip. It shall have a constructed barrier (typically a concrete lip) that converts concentrated stormwater to diffuse flow. This level spreader does not remove pollutants (without the associated filter strip) but can be used in conjunction with other measures.
SUITABILITY:
GSI Consideration: No Small Site Appropriate: Yes Large Site Appropriate: Yes

Design Criteria and Specifications

- MDC criteria and guidance shall be utilized for design criteria for this measure, without the associated filter strip requirements.
- Shall be located 10 feet from any property line or building and 50 feet from streams.

5.7 CERTIFICATIONS AND AS-BUILT SURVEYS

Upon project completion, the City shall require submittal of certifications and as-built information to verify compliance with all applicable stormwater regulations. City acceptance of the as-built certifications and/or impervious or built area surveys are required on a project or a building prior to final approval of the following: the Stormwater Control Permit, the Certificate of Compliance, the Certificate of Occupancy or the Partial Certificate of Occupancy (commercial only).

5.7.1 Stormwater Control Measures

All SCMs require certification by an appropriate design professional, verifying that the actual construction of the measure conforms to the approved plans and provides the required level of stormwater treatment and/or peak flow control. The as-built plans and certification must be signed and sealed by an appropriate design professional, and all applicable checklist items must be included. Refer to *Stormwater Control Measure (SCM) As-Built Submittal Checklist*.

The as-built plans must show field location, size, depth and planted vegetation of all stormwater structures and measures as installed. The plans must identify, in tabular form, the acreage of impervious area, pervious or managed open space, and permanently protected open space.

5.7.2 Impervious Area or Built Area Surveys

Submittal of as-built impervious surveys is required if impervious restrictions are a permit condition of approval for a project and the submitted survey shall be sealed by a North Carolina licensed surveyor. An as-built impervious survey should include, but is not limited to, house footprint, driveway, sidewalk(s), retaining wall (s), deck, shed, gravel parking pads, and all other areas considered impervious per the UDO.

Projects in Water Supply Watersheds may also require a built area survey to show compliance with stormwater regulations applicable to their development. Submittal of as-built built area surveys is required if built area restrictions are a permit condition of approval for a project and the submitted survey shall be sealed by a North Carolina licensed surveyor. Refer to the definition of built area in UDO Section 12.2.

5.8 SCM OPERATIONS, MAINTENANCE & EASEMENT REQUIREMENTS

Operations and maintenance (O&M) refer to the performance and ongoing upkeep of an SCM after construction has finished. An O&M manual and an Inspection and Maintenance Agreement shall be completed at the time of permitting to ensure proper long-term maintenance. All SCMs must meet the requirements within Part A-7, "SCM Operation and Maintenance" as well as the maintenance needs specified in SCM specific chapters of the NCDEQ Stormwater Design Manual. To ensure any devices utilizing infiltration as a treatment mechanism are still infiltrating at an approved rate, an infiltration test shall be performed when the device reaches 75% of its life expectancy. Any maintenance issues that are identified during inspection of an SCM shall be addressed, as necessary, to meet the intent of design and to meet compliance requirements.

5.8.1 Operations and Maintenance Manual

To provide stormwater treatment as designed, SCMs must be properly operated and maintained. An O&M Manual shall be submitted with as-built documentation that specifies all upkeep necessary for the function of all SCM components. The O&M manual shall cover requirements for the stormwater conveyance system, perimeter of the device, inlet(s), pretreatment measures, main treatment area, outlet, vegetation and discharge point. Maintenance of vegetation for stormwater control measures is an essential practice which should not be overlooked, as healthy vegetation is necessary in order to achieve the intended performance of any measure which incorporates vegetation in its design. All SCMs permitted by the City shall have an O&M Manual approved in accordance with UDO Section 9.2.2.D.2 and the NCDEQ Stormwater Design Manual. One O&M manual shall be provided for each device, and each manual shall be sealed by a qualified registered North Carolina licensed professional engineer, land surveyor or landscape architect.

Major components of an O&M Manual include:

- A cover page with the project name, City case number, SCM name/identification, name and seal of the North Carolina licensed design professional, and name and notarized signature(s) of the property owner(s)
- A narrative describing each SCM and its design specifications (UDO Section 9.2.2.D.2.c), including a statement as to whether the SCM is shared amongst multiple lots or not
- An indication of which O&M actions are needed for the SCM, and the specific, quantitative criteria that shall be used to determine when these actions will be taken (UDO Section 9.2.2.D.2.e)
- An indication of the steps that shall be taken to restore a device to the design specifications in the event of a failure (UDO Section 9.2.2.D.2.f)
- A statement about the expected life of the device (UDO Section 9.2.2.D.2.g)
- A detailed, estimated cost of construction for the SCM and 24% replacement fund calculation (UDO Section 9.2.2.G.3)
- A replacement schedule, derived by dividing the initial construction cost of the SCM by the expected life of the device (UDO Section 9.2.2.D.2.g)
- A budget to include annual costs, such as routine maintenance, repair, periodic sediment removal, replenishment of riprap, insurance premiums associated with the device/SCM facilities, taxes levied against the device/SCM facilities, mowing and reseeding and required inspections (UDO Section 9.2.2.D.2.h)

SCMs that serve to meet compliance requirements for multiple lots are shared in their entirety among all lots within the property or homeowner's association, regardless of which lots drain to each device. However, in each O&M manual for a shared SCM, the design professional shall provide a description of which lots are served by the device (UDO Section 9.2.2.D.2.d).

5.8.2 Recorded Easement Requirements

All SCMs shall be placed within easements to provide the legal authority for inspections, maintenance, repair or reconstruction of the SCM, should the property owner fail to perform their responsibilities. The location and configuration of easements shall be established during the design phase and be clearly shown on the design drawings as discussed in *Chapter 2 – Site Development Requirements*.

The entire footprint of the SCM system shall be included in the easement, plus an additional 10 feet or more (unless otherwise specified in the design requirements) around the SCM to provide adequate room for the equipment and activities necessary to complete maintenance, repair or replacement tasks. If heavy equipment will be necessary to perform maintenance tasks, such as for devices with a forebay that will require sediment clean-out, appropriate access shall be available (recommended 25 feet rather than 10 feet). Direct maintenance access to the forebay shall be provided for SCMs which utilize a forebay. The SCM system includes components, such as the side slopes, forebay, riser structure, SCM device and basin outlet, as well as the dam embankment, outlet and emergency spillway. Easements for maintenance and access of SCMs shall extend to the nearest public right of way and shall not include lateral or incline slopes that exceed 3:1 (horizontal to vertical). In no case shall the recorded easement confer an obligation on the City to assume responsibility for the SCM.

Easements shall be held by the entity responsible for the operation and maintenance of the SCM facility, whether an individual, a corporation or a government unless determined otherwise. Easements for SCMs that are not publicly maintained require provisions that allow the permitting entity to access the device for inspections and potential assessments.

5.8.3 Inspection and Maintenance Agreements

To ensure proper long-term maintenance, an Inspection and Maintenance Agreement shall be a part of the design plans for any SCM. These agreements shall be signed and notarized and inspections shall be conducted by a qualified professional. An Inspection and Maintenance Agreement shall include:

- The frequency of inspections that are needed (based on the type of SCM proposed)
- The components of the SCM that need to be inspected
- The types of problems that may be observed with each SCM component
- The appropriate remedy for any problems that may occur

5.8.4 Small Site Considerations

SCMs proposed to show compliance with UDO Sections 9.2.2.A.4.b.i and ii have special considerations with respect to their O&M. These SCMs shall:

- Have an approved O&M manual in accordance with Section 5.8.1 of this manual;
- Contribute 24% of the replacement cost of the device to the City;
- Record an access and maintenance easement on a plat or via deed;
- Perform an annual inspections in accordance with UDO Section 9.2.2.A.4.c