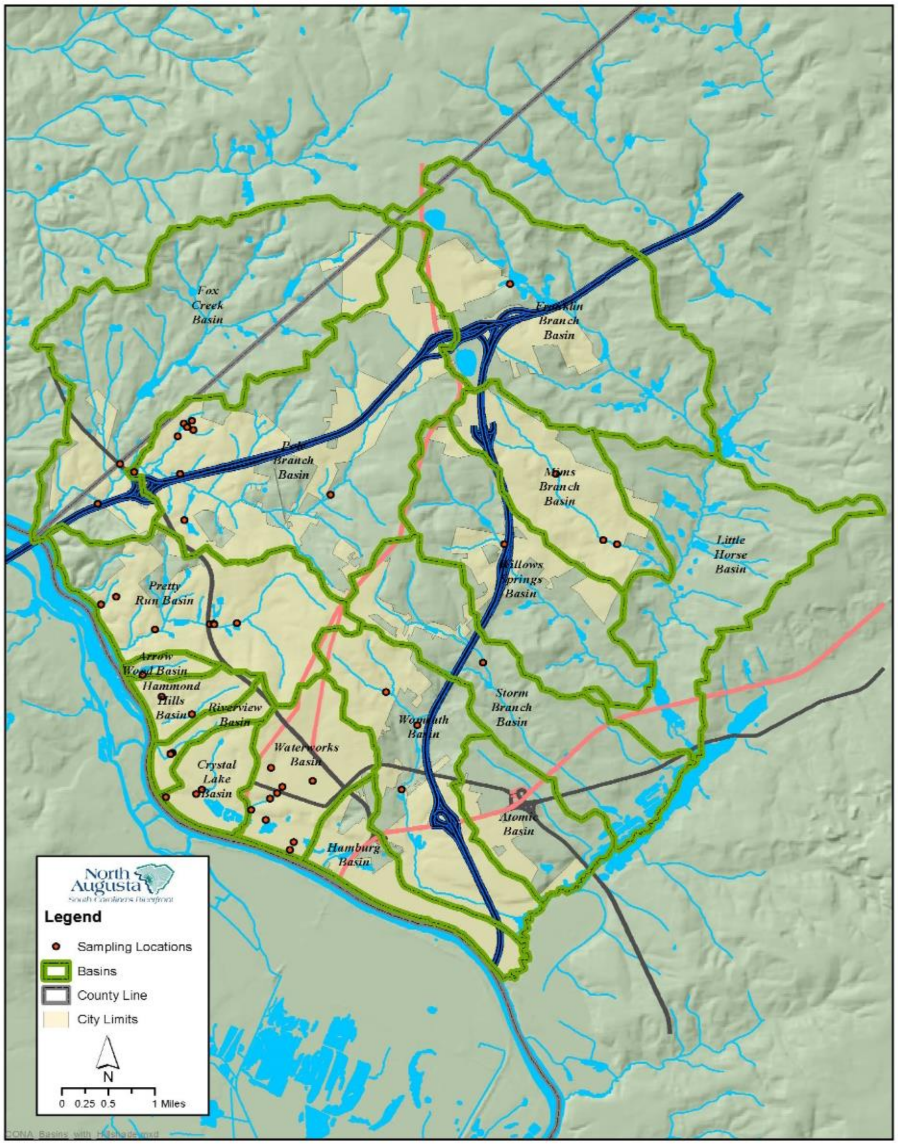
City of North Augusta
WATER QUALITY MANUAL
(A component of the NA Stormwater Management Manual - Part B)



North Augusta
South Carolina's Riverfront

Revised 2022 Edition

Table of Contents

List of Figures

CHAPTER 1 INTRODUCTION

Designing stormwater treatment practices (STPs) with water quality considerations is not a new practice, but over time the science of water quality treatment has advanced and local regulations have tightened. Water quality has typically been addressed through extended detention using a dry detention pond. Research has demonstrated that this method is not effective nor is it comparable to other types of treatments. This document is part of the North Augusta Stormwater Management Plan (also referred to as the North Augusta Stormwater Management Manual).

The North Augusta Stormwater Management Department (SWMD) requires treatment of the runoff from the first one-inch of rainfall from a project site. The following equation ("Simple Method" – Schueler, 1987) may be used to determine the Water Quality Volume (WQv):

$$\mathbf{WQ_v = (1in)(R_v)(A)/12\ \ (ac\text{-}ft)}$$
Where **A** = **Site Area (acres)**
Where $\mathbf{R_v}$ = $\mathbf{0.05 + 0.009I}$
Where **I** = **Site Impervious Cover (%)**

Explanation and Example:
A 5-acre site with a portion that has a 2-acre drainage area is being developed and the plans show 1.4 acres of impervious area proposed within that drainage area. To calculate the water quality volume for this drainage area to meet the required treatment for that portion of the site, per city ordinance, please follow these steps. *(Note: that this is a 5-acre site, so another drainage area exists where this calculation will be required a second time for that drainage area of the site).*

$\mathbf{R_v = 0.05 + 0.009(I)}$
where:

$\mathbf{R_v}$ **= volumetric runoff coefficient**
I = percent of impervious cover (%)

$$\mathbf{WQ_v = \frac{1.0\ RvA}{12}}$$
where:
$\mathbf{WQ_v}$ **= water quality volume (acre-feet)**
A = total drainage area (acres)

The percent of impervious cover is equal to the impervious area divided by the drainage area:
$$\mathbf{I = \frac{1.4}{2} = 0.70 = 70\%}$$
Then the volumetric runoff coefficient (R_v) is calculated using the percent of impervious cover:
$$\mathbf{R_v = 0.05 + 0.009(70) = 0.68}$$

Finally, the water quality volume is calculated for 1.0 inch rainfall
$$\mathbf{WQ_v = \frac{1.0*R_v*A}{12} = \frac{1.0(0.68)(2)}{12} = 0.1133\ acre\ feet}$$
So to meet water quality requirements for this part of the site, there must be a water quality treatment method that is sufficient to treat 0.1133 acre feet (4936.8 cubic feet) of water.

This equation uses the runoff coefficient (R_V), described in the *Simple Method*. Other simple regressions or methods could be used as a substitute to calculate the runoff volume. Regressions based on local data are preferred.

Tools of Analysis

For quantity-based water quality sizing criteria, several simple regressions can be used to calculate the runoff volume. A few methodologies for methods that calculate on-site loads include:

- The Simple Method is a way of calculating runoff and pollutant loads based on impervious cover, rainfall and event mean concentration (EMC) data for different water quality parameters. This model has been expanded to incorporate subsurface flows as well in the Simplified Urban Nutrient Output Model (SUNOM).
- SWIMM is a model developed by the EPA for analyzing stormwater quantity and quality associated with runoff from urban areas. Both single-event and continuous simulation can be performed on catchments having storm sewers, or combined sewers and natural drainage, for prediction of flows, stages and pollutant concentrations.
- SLAMM This model is based on small storm hydrology and pollutant runoff from urban land uses. Pollutant sources are identified and both structural and nonstructural stormwater practices can be accounted for in the model.

Pollutant removal effectiveness of the practices found in this manual will obviously vary widely based on site conditions and practice design. There are many programs available to determine pollutant removal rates for all practices covered here. In addition, vendors of proprietary treatment practices size their product based on specific site conditions. A general overview of pollutant removal rates for some of the more common STPs is presented in Table 1.

TABLE 1. STP SELECTION MATRIX

STP Selection Matrix Percent Pollutant Removal					
STP Group	**TSS**	**TP**	**TN**	**Metals[1]**	**Bacteria**
Ponds	80	51	33	62	70
Wetlands	76	49	30	42	78[2]
Filters[3]	86	59	38	69	37[2]
Infiltration	95[2]	70	51	99[2]	N/A
Open Channels [4]	81	34[2]	84[2,5]	61	-25[2]

1: Average of zinc and copper. Zinc only for infiltration practices.
2: Based on fewer than five data points.
3: Excludes vertical sand filters and filter strips.
4: Highest removal rates for dry swales
5: No data available for grass channels
N/A: Data not available

WETLANDS & OTHER SENSITIVE AREAS ON-SITE / BUFFERS

The SCDHEC NPDES General Permit for Construction (CGP) requires the following information be provided and followed for all projects over one acre. For more information and details (acronyms too), see the CGP or call for more information.

3.2.4 <u>Site Features and Sensitive Areas</u>

A. The C-SWPPP must identify and delineate all Waters of the State (WoS), including wetlands, located within the disturbed area and/or the total area associated with the construction site if the disturbed area is within 100-ft. The C-SWPPP must also identify all WoS, including wetlands, which are located immediately adjacent to or within the surrounding area of the construction site. The C-SWPPP must also identify receiving waters, including wetlands and South Carolina Navigable Waters. The following must be addressed when a WoS is required to be identified.

I. An additional, separate plan sheet, provided within the construction site plans when necessary that delineates all WoS within the construction site's Limits of Disturbance, and that identifies all WoS within the surrounding or adjacent areas. This plan sheet must identify all impacted areas with a description of the activities, whether permanent or temporary, and any other relevant information.

II. If impacts to WoS, the plan must show outlined areas of impacts and label that no work can begin in these areas until all necessary USACOE permits and SCDHEC 401 certifications have been obtained.

III. If Structural BMPs are proposed to be installed within a WoS, the C-SWPPP must specifically address the requirements listed in Section 3.2.6.A.V of this permit.

*C. **Buffer Zone Management.** In order to minimize sediment discharges, during construction, if surface waters are located on or immediately adjacent to the construction site, the C-SWPPP must address any stormwater discharges from the construction site to such waters so that these discharges are treated by an undisturbed buffer zone that is capable of achieving maximum pollutant removal.*

*I. **Requirements**. The C-SWPPP must identify an undisturbed buffer zone that meets the following criteria when surface waters are located on or immediately adjacent to the construction site:*

*(a) **30-Foot, Natural Buffer**. Provide and maintain, at a minimum, a 30-foot undisturbed buffer zone during construction. This Natural Buffer should be located between the surface waters and the outermost sediment and erosion controls at the construction site;*

*(b) **45-Foot, Extended Natural Buffer along both sides Sensitive Waters**. Provide and maintain, at a minimum, a 45-foot undisturbed buffer during construction where the surface waters are classified as Sensitive Waters as defined by this permit. This Extended Natural Buffer should be located between the surface waters and the outermost sediment and erosion controls at the construction site;*

(c) ***Velocity Dissipation Requirements****. All discharges into a buffer zone should be non-channelized and non-concentrated to prevent erosion, and must first be treated by the construction site's sediment and erosion controls. Velocity dissipation measures may be implemented within a buffer zone via Section 3.2.4.C.III.(d) of this permit; and*

(d) ***Additional Local Requirements****, where applicable. The provided buffer zone should meet any local requirements, if more restrictive. Local Requirements may allow for mechanisms that would affect the width or other parameters of a buffer zone given that, in the event that the buffer zone width is less than the required 30 ft or 45 ft widths, the requirements in Compliance Option B or C, Section 3.2.4.C.II.(b) or 3.2.4.C.II.(c) respectively, are met.*

Buffer REQUIREMENTS in the City of North Augusta as detailed in the following:

"North Augusta Development Code (NADC)"– (for development purposes, p*lease refer to the NADC located on the city website for the entire code and references therein. Links to the document can be found within the Planning Department webpages.)*

Excerpts only for reference at the time of this update (12/2022), please consult the code in case of changes that may have occurred since:
6.2.1 Wetlands as delineated and approved by the U.S. Army Corps of Engineers or the South Carolina Department of Health and Environmental Control or non-jurisdictional wetlands that meet the definition of a wetland as defined in Appendix A (*see riparian buffer)*

ARTICLE 6 – SITE ANALYSIS AND PROTECTION…. (Partial only)

6.2.1.3 Lands in the floodplain and floodway as delineated by the Federal Emergency Management Agency and U.S. Army Corps of Engineers.

6.2.2 Riparian Buffers
6.2.2.1 Applicability –
a. This section applies to any application for development approval that proposes any impervious surface or land-disturbing activity, except as provided below.
b. Nothing in this section shall prohibit or be construed to prohibit the building of a single-family dwelling on an existing lot of record, including the usual appurtenances thereto, within the buffer areas established herein, subject to the following conditions:

1. Such dwelling must be in compliance with all applicable zoning regulations in Article 3, Zoning Districts; and

2. No portion of any structure may be located closer than twenty-five (25) feet from the stream bank or any body of water.

6.2.2.2 Protection –
a. The corridors of all perennial streams and the areas around ponds, Carolina bays and other permanent or seasonal bodies of water are protected by the following

criteria:

1. An undeveloped open space riparian buffer shall be maintained for a distance of twenty-five (25) feet on both sides of the stream as measured from the stream banks and around all bodies of water as measured from the high water mark.
2. No impervious surface shall be constructed within a twenty-five (25) foot setback area on both sides of the stream as measured from the stream banks and around all bodies of water as measured from the high water mark.

b. Encroachments into the buffer area are permitted as needed for the construction of public roads, stormwater management facilities and public utility crossings. Such encroachments shall conform to all state and local erosion and sedimentation control requirements. Public utility crossings and stormwater management facilities may be permitted if:

1. The utility crossings and stormwater facilities are located as far from the stream or pond bank as reasonably possible;

2. The installation and maintenance of the utilities and facilities shall be such as to protect the integrity of the buffer and setback areas as well as is reasonably possible; and

3. Neither the utilities nor the stormwater management facilities shall impair the quality of the water.

CHAPTER 2   STORMWATER PONDS

Stormwater ponds are practices that have a combination of a permanent pool, extended detention or shallow marsh equivalent to the entire WQ_v. Design variants include:

- Micropool Extended Detention Pond (Figure 1)
- Wet Pond (Figure 2)
- Wet Extended Detention Pond (Figure 3)
- Multiple Pond System (Figure 4)
- Pocket" Pond (Figure 5)

Dry extended detention ponds that have no permanent pool are not considered an acceptable option for meeting WQ_v due to poor pollutant removal and chronic maintenance problems.

The term "pocket" refers to a pond or wetland that has such a small contributing drainage area that little or no base flow is available to sustain water elevations during dry weather. Instead, water elevations are heavily influenced and, in some cases, maintained by a locally high water table.

Stormwater ponds can also be used to provide Channel Protection volume as well as overbank and extreme flood attenuation.

SEDIMENT BASINS DURING CONSTRUCTION

SKIMMERS required for Sediment Basins

When discharging from Sediment Basins, the outlet structure must utilize a device that allows the withdrawal of water from near the water's surface within the basin. This requirement was implemented with the January 2012 issuance of the SCDHEC state construction general permit (design to convey flows for the 10-year storm at 24-hour release). Sediment basins must be designed to meet eighty percent (80%) trapping efficiency. Perforated riser structures are now obsolete in sediment basins. An example of a water surface outlet device is a skimmer. Skimmers utilize a floatation mechanism to withdraw from the water's surface. This device is connected to an orifice at the bottom of the riser structure.

(Photo credit: Harmon Engineering, Lafayette La. www.harmonengineering.net)

Porous Baffles

Another Sediment Basin requirement is the use of porous baffles within the basin. Baffles impede the flow of incoming runoff, allowing for enhanced sedimentation of suspended particulates.

Construct the porous baffle system inside sediment traps and sediment basins with appropriately sized zones to ensure they can adequately slow and dissipate sediment so it is not released out of the basin/trap. Ensure baffles are installed perpendicular to flow within the structure and are installed across the entire width of the basin/trap.

Do not install baffle systems until the sediment trap or basin is excavated and graded with a level bottom surface.

For **longer** sediment basins or traps (>25 feet in length), install three rows of baffles, dividing the sediment dam or basin into four equally sized separate chambers. Locate the 1st row about ¼ length of the basin, the 2nd row at ½ the length and the 3rd row ¾ the length.

For **smaller** sediment basins or traps (<25 feet in length), install two rows of baffles placing the 1st row across at 1/3 the length of the basin and the 2nd row at 2/3 the length.

Minimum Porous Baffle Material Height above bottom of Basin (ft.)	Steel Post Length (ft.)
3'	5'
4'	6'
5'	7'

Install steel posts no greater than 4 foot on centers across the structure bottom and up the embankment (posts should be driven 2 ft. into bottom). Attach porous baffle material to the upstream side of the steel posts using heavy-duty plastic ties or wire ties spaced evenly (no more than 6 inches apart) so as to prevent sagging or tearing of fabric. Use 12-inch anchors spaced no more than 1 foot apart to secure baffle material to bottom of trap and embankments or trench in at least 6 inches deep in a 6-inch-wide trench, backfill.

If material begins to sag or is sagging, stretch or weave a 9-gauge steel wire or rope across the top (between posts) to stretch the material so that sagging is corrected. If the entire length of the baffle is sagging, drive a steel post on each side of the sediment trap structure attaching wire and then pull the wire tight attaching to opposite side. Attach sagging baffle across the wire to hold it up.



Photos: SCDHEC Jill Stewart, P.E., IECA Conference presentation. (www.scdhec.gov)

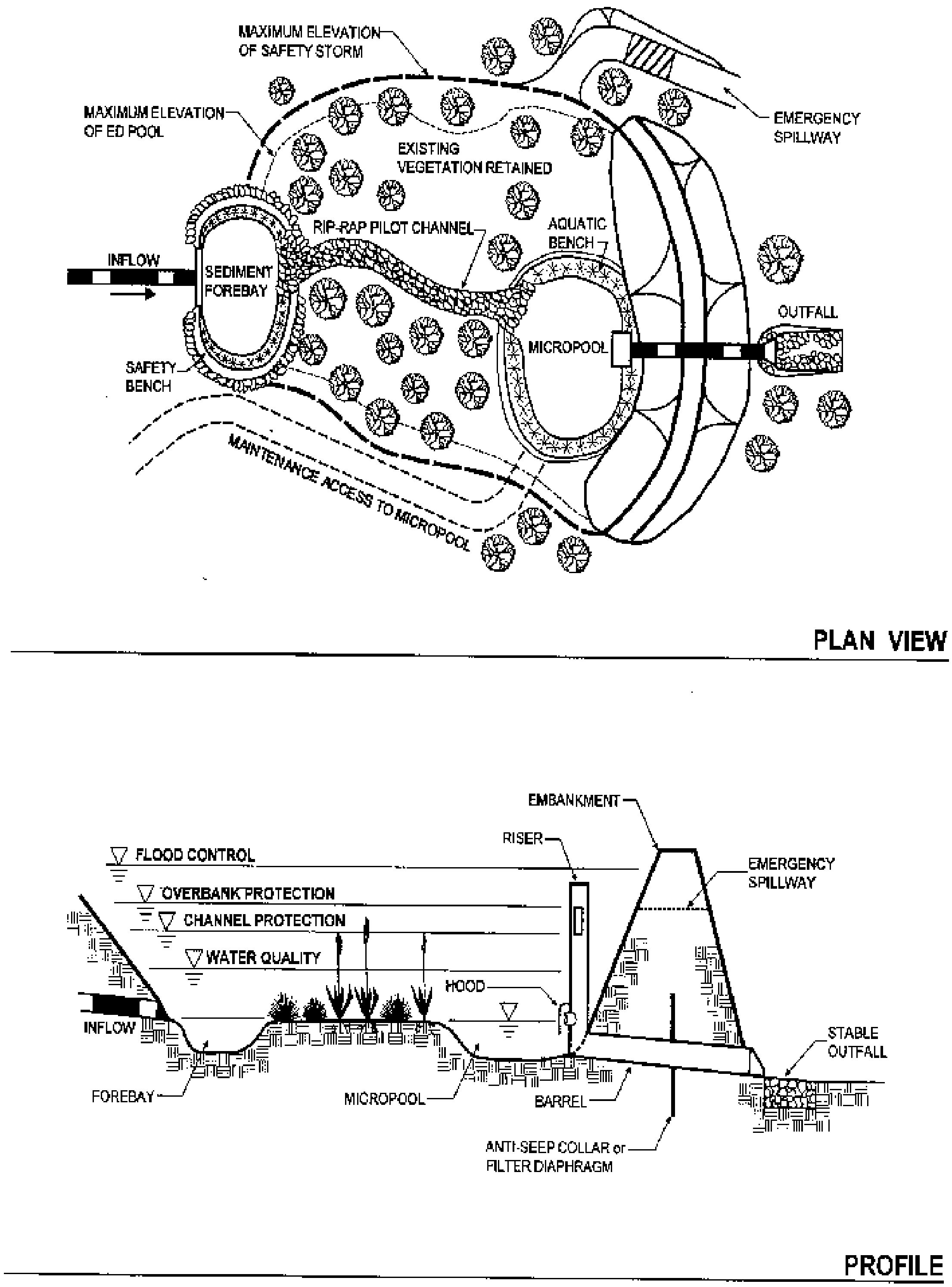
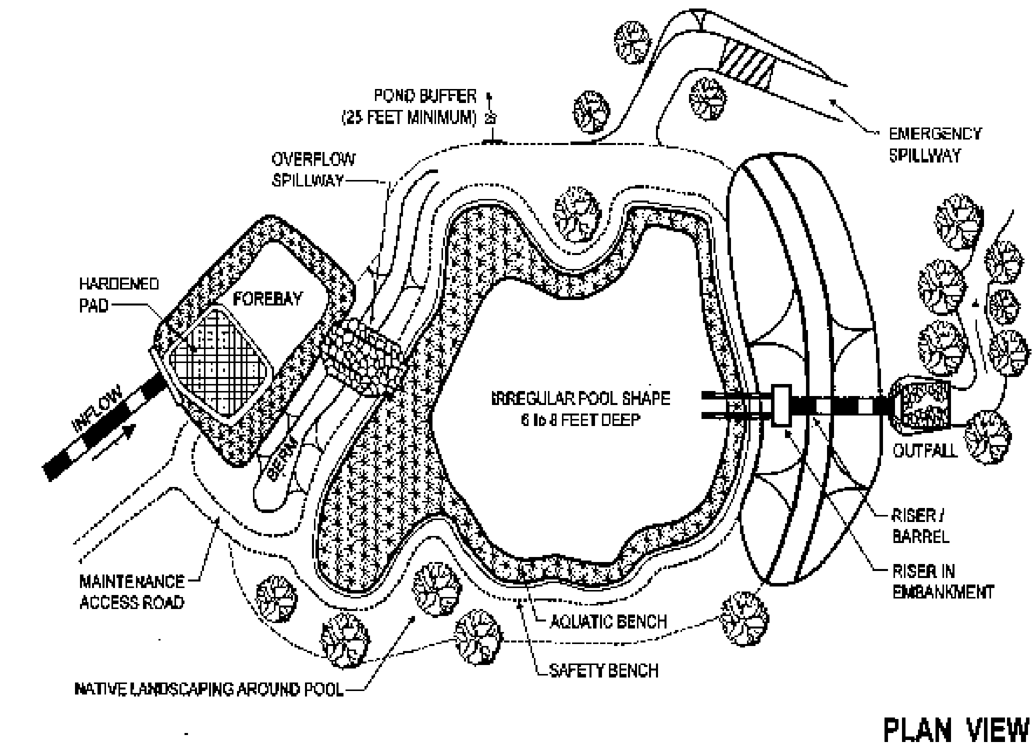


Figure 1. Micropool Extended Detention Pond



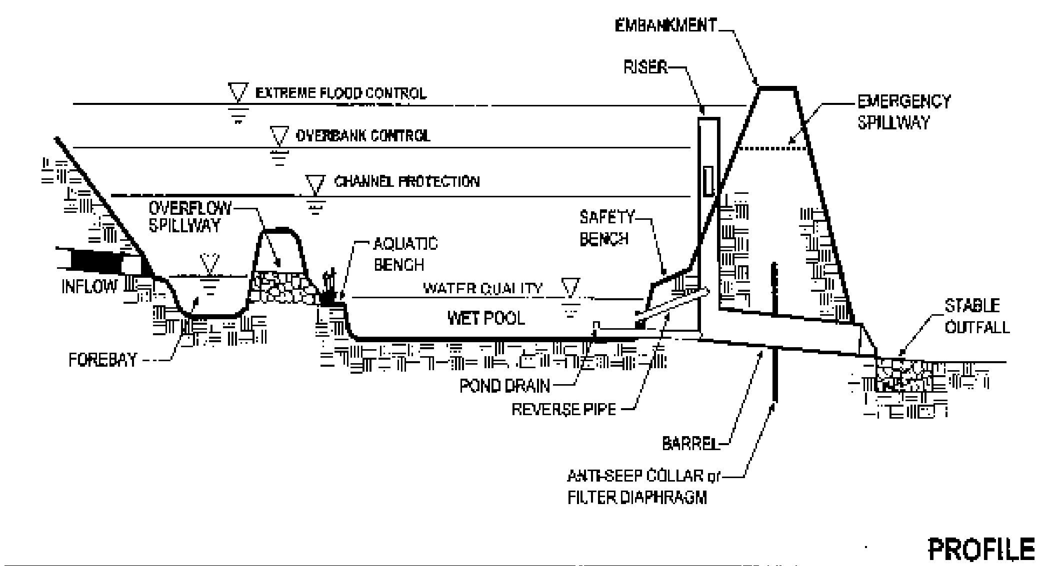
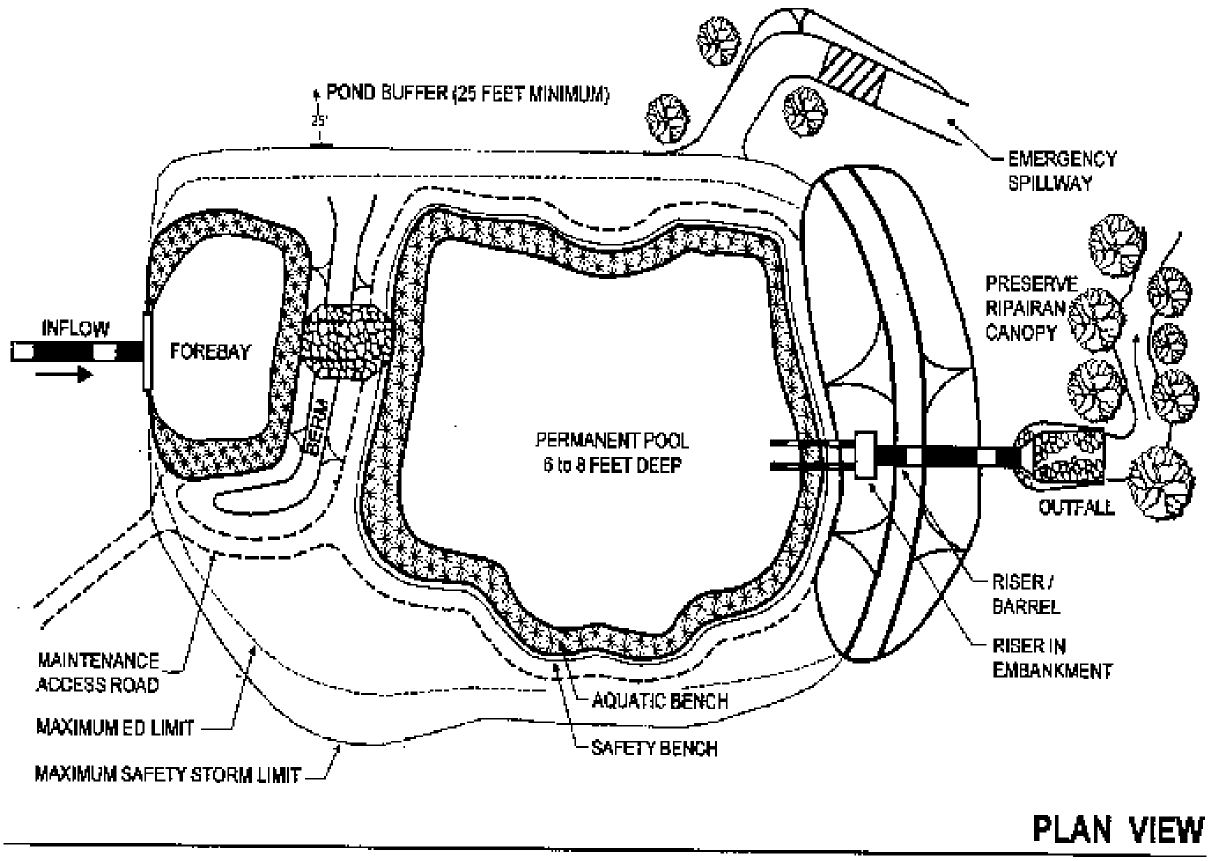


Figure 2. Wet Pond



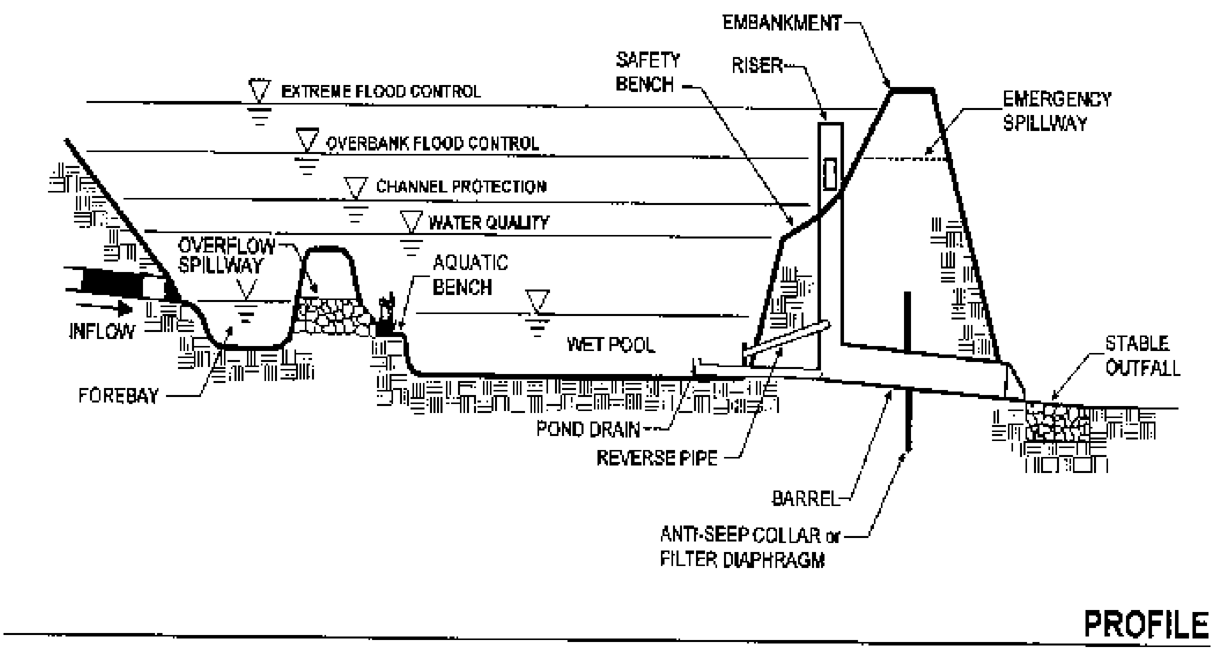


Figure 3. Wet Extended Detention Pond

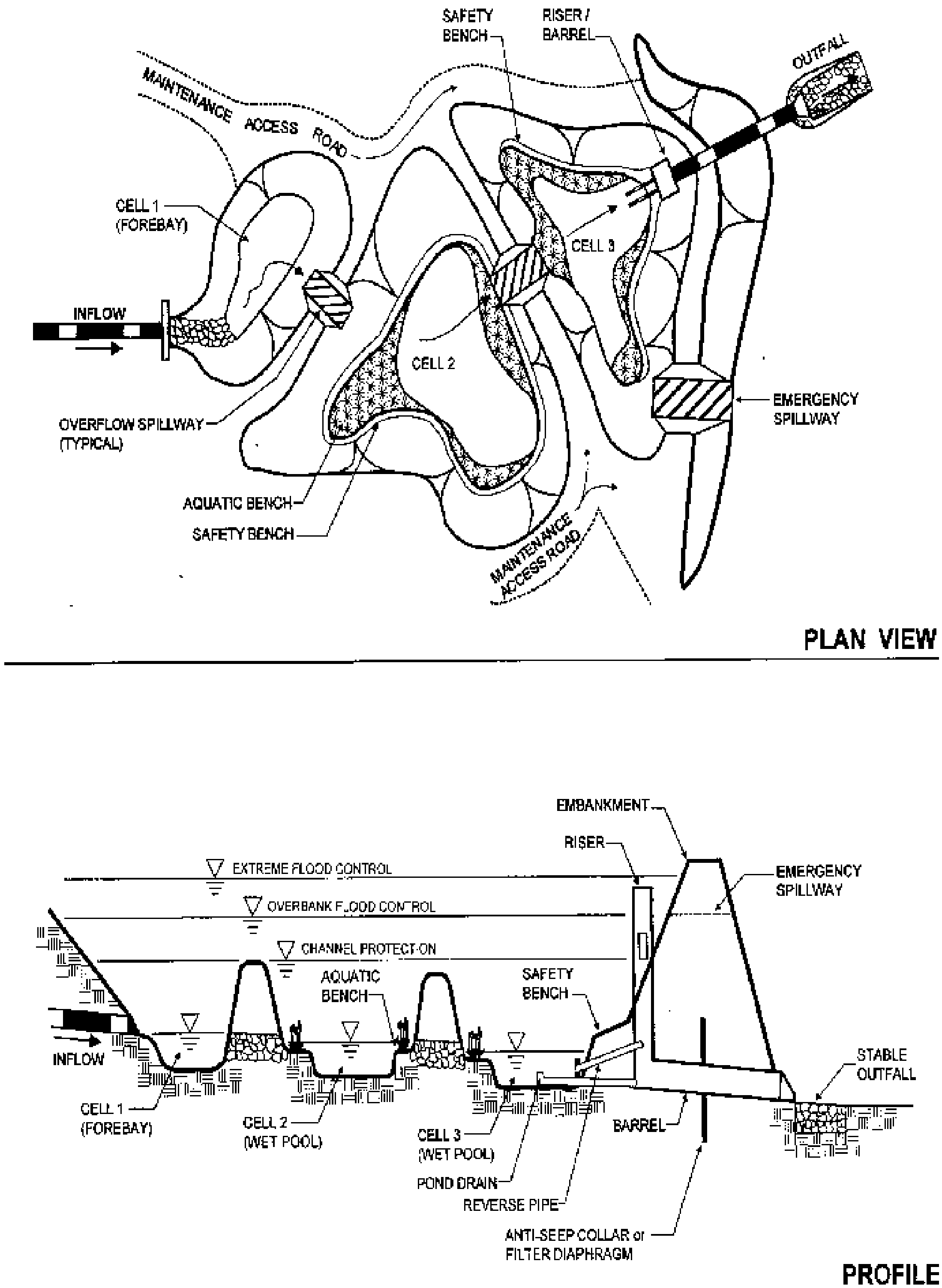


Figure 4. Multiple Pond System

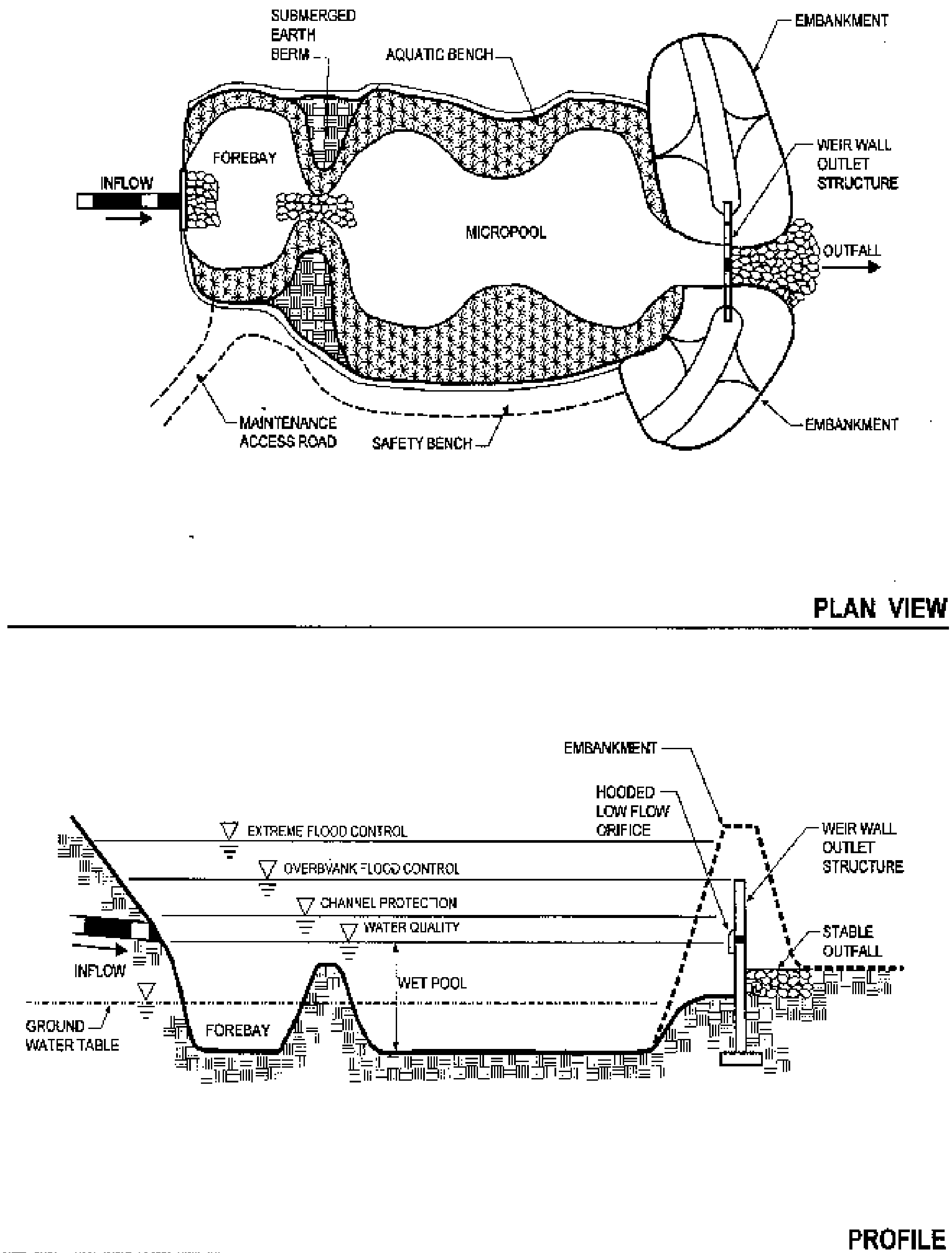


Figure 5. Pocket Pond

Pond Feasibility
Stormwater ponds should have a minimum contributing drainage area of ten acres or more unless groundwater is confirmed as the primary water source (i.e., pocket pond). This drainage area requirement ensures that the permanent pond can be maintained by the runoff from the contributing drainage. A water balance analysis may replace this requirement. In addition, the specific drainage area requirements will vary based on regional rainfall and temperature.

Stormwater ponds should not be located within jurisdictional waters, including wetlands.

Pond Conveyance
Conveyance should be provided which does not cause erosion.
When reinforced concrete pipe is used for the principal spillway to increase its longevity, "O-ring" gaskets (ASTM C361) should be used to create watertight joints.

Inlet Protection
A forebay should be provided at each inlet, unless the inlet provides less than 10% of the total design storm inflow to the pond. Inlet areas should be protected to reduce erosion. Inlet pipes to the pond can be partially submerged.

A sediment forebay is important for maintenance and longevity of a stormwater treatment pond. Each pond should have a sediment forebay or equivalent upstream pretreatment. The forebay should consist of a separate cell, formed by an acceptable barrier. ***The forebay shall be sized to contain 0.1 inches per impervious acre of contributing drainage, and should be 4 to 6 feet deep. The forebay storage volume can count toward the total WQ_v requirement. Exit velocities from the forebay should be non-erosive. Direct maintenance access for appropriate equipment should be provided to the forebay.*** A fixed vertical sediment depth marker should be installed in the forebay to measure sediment deposition over time. The bottom of the forebay may be hardened to make sediment removal easier.

Adequate Outfall Protection
Outfalls should be constructed such that they do not increase erosion or have undue influence on the downstream geomorphology of the stream. Flared pipe sections that discharge at or near the stream invert or into a step-pool arrangement should be used at the spillway outlet. The channel immediately below the pond outfall shall be modified to prevent erosion and conform to natural dimensions in the shortest possible distance, typically by use of large rip-rap placed over filter cloth. A stilling basin or outlet protection shall be used to reduce flow velocities from the principal spillway to non-erosive velocities.

If a pond daylights to a channel with dry weather flow, care should be taken to minimize tree clearing along the downstream channel, and to reestablish a forested riparian zone in the shortest possible distance. Excessive use of rip-rap should be avoided to reduce stream warming.

Pond Treatment Criteria

Minimum Water Quality Volume (WQ_v)

Provide water quality treatment storage to capture the computed WQ_v from the contributing drainage area through any combination of permanent pool, extended detention (WQ_v-ED) or marsh. The following design considerations must be made:

- If ED is provided in a pond, storage for Cp_v-ED and Wq_v-ED shall be computed and routed separately (i.e., the WQ_v cannot be met simply by providing Cp_v storage for the one year storm). (CPv=channel protection volume)
- In the Wet Extended Detention Pond Design, at least 50% of the (WQ_v) should be stored in the permanent pool.
- The minimum length to width ratio for the pond is 1.5:1 (i.e., length relative to width). Long flow paths and irregular shapes are recommended.
- The perimeter of all deep pool areas (four feet or greater in depth) should be surrounded by two benches:
    1. A safety bench that extends 15 feet outward from the normal water edge to the toe of the pond side slope. The maximum slope of the safety bench shall be 6%.
    2. An aquatic bench that extends up to 15 feet inward from the normal shoreline and has a maximum depth of eighteen inches below the normal pool water surface elevation.

Landscaping Plan

Wherever possible, wetland plants should be encouraged in a pond design, either along the aquatic bench (fringe wetlands), the safety bench and side slopes (ED wetlands) or within shallow areas of the pool itself. The soils of a pond buffer are often severely compacted during the construction process to ensure stability. The density of these compacted soils is so great that it effectively prevents root penetration, and therefore, may lead to premature mortality or loss of vigor. Consequently, it is advisable to excavate large and deep holes around the proposed planting sites, and backfill these with uncompacted topsoil. Existing trees should be preserved in the buffer area during construction. *Planting guidance is provided in Appendix A.*

Maintenance Measures

Establishment of a maintenance plan is an important aspect of STP guidance. Ongoing maintenance is essential to ensure that STPs operate properly and function as designed.

- Maintenance responsibility for a pond and its buffer should be vested with a responsible authority by means of a legally binding and enforceable maintenance agreement that is executed as a condition of plan approval.
- The principal spillway should be equipped with a removable trash rack.
- Sediment removal in the forebay should occur every 5 to 7 years or after 50% of total forebay capacity has been lost.
- A maintenance right of way or easement should extend to a pond from a public or private road. Maintenance access shall be at least 12 feet wide; have a maximum slope of no more than 15%; and should be appropriately stabilized to withstand maintenance equipment and vehicles.
- The maintenance access should extend to the forebay, safety bench, riser, and outlet.

Non-clogging Low Flow Orifice

A non-clogging low flow orifice must be provided.
The low flow orifice shall have a minimum diameter of 6 inches, and shall be adequately protected from clogging by an acceptable external trash rack. The preferred method is a submerged reverse-slope pipe that extends downward from the riser to an inflow point one foot below the normal pool elevation. An alternative method is to employ a broad crested rectangular, V-notch, or proportional weir, protected by a half-round corrugated metal pipe (CMP) that extends at least 12 inches below the normal pool.

Riser in Embankment
The riser shall be located within the embankment for maintenance access, safety and aesthetics. Access to the riser is to be provided to the SMD.

Pond Drain
Each pond shall have a drain pipe that can completely or partially drain the pond. The drain pipe shall have an elbow within the pond to prevent sediment deposition, and a diameter capable of draining the pond within 24 hours.

CHAPTER 3   CONSTRUCTED WETLANDS

Stormwater wetlands are practices that create shallow marsh areas to treat urban stormwater and often incorporate small permanent pools and/or extended detention storage to achieve the full WQ_v. Design variants include:

- Shallow Wetland (Figure 6)
- ED Shallow Wetland (Figure 7)
- Pond/Wetland System (Figure 8)
- "Pocket" Wetland (Figure 9)

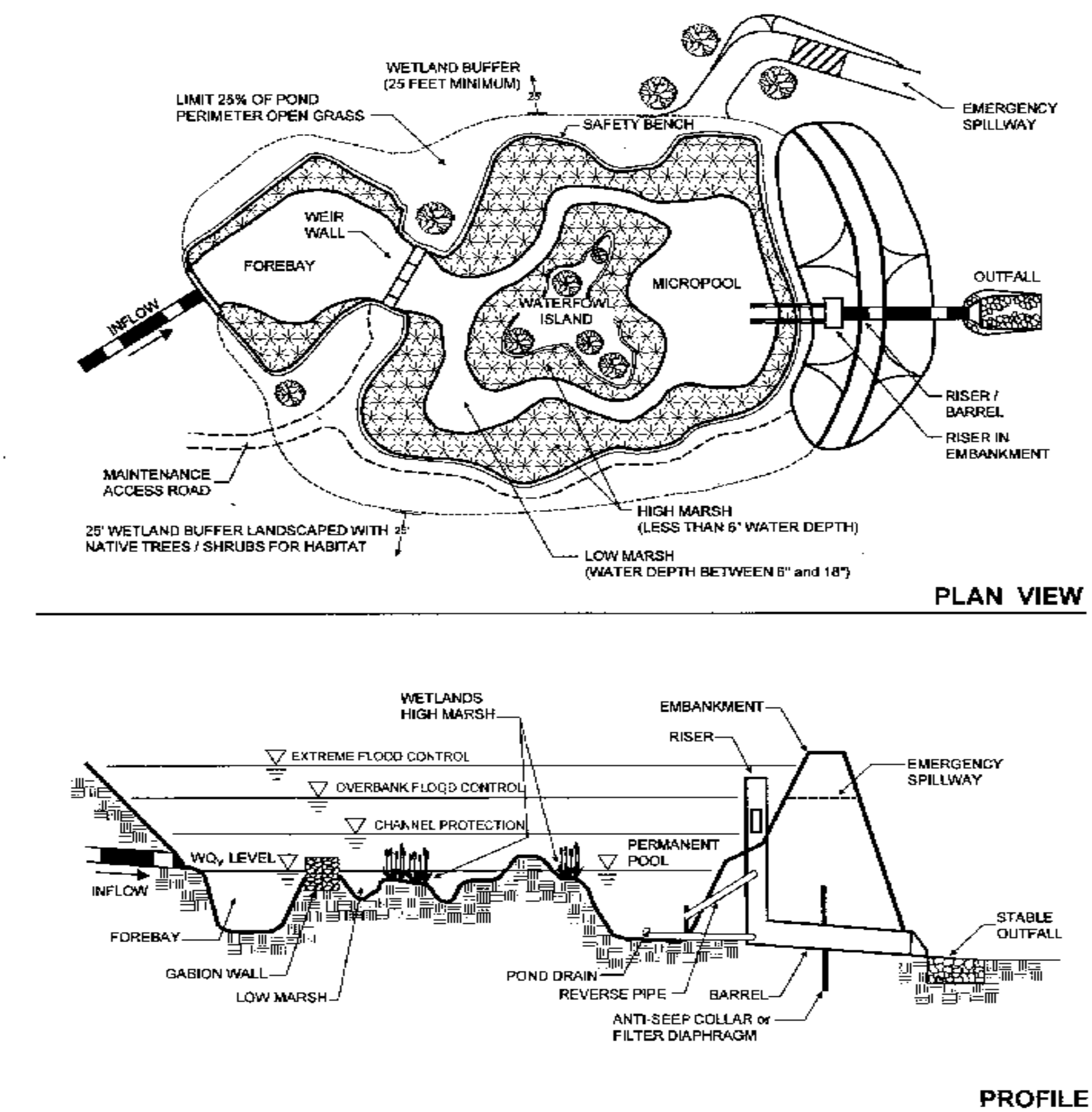
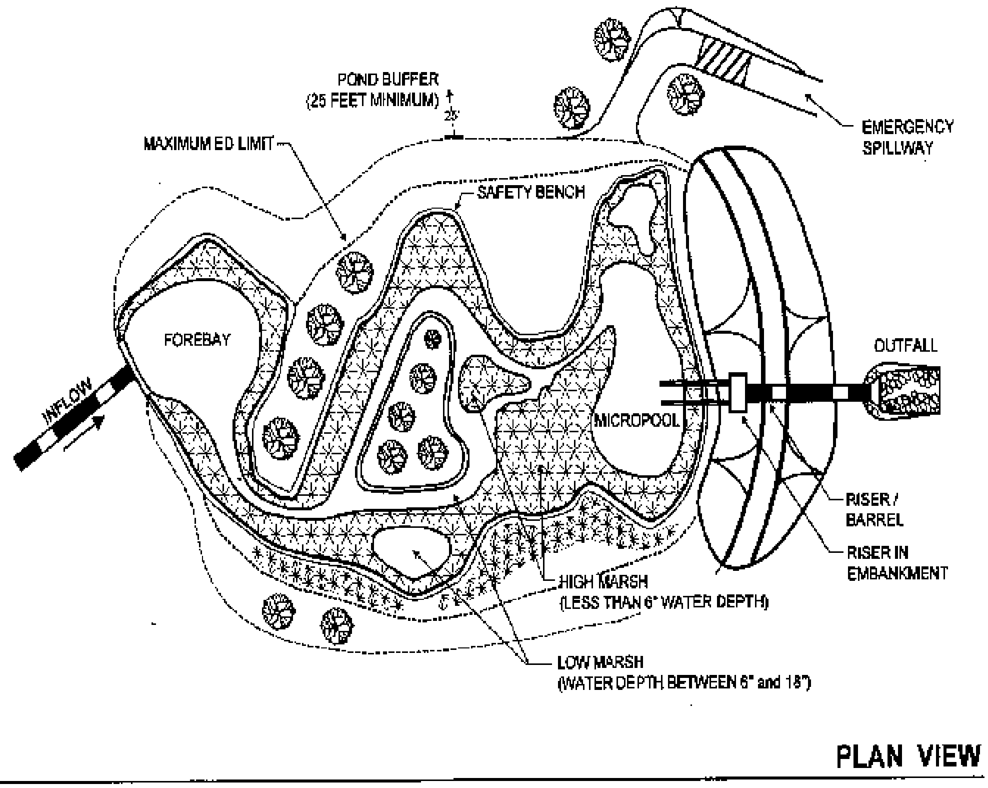


Figure 6.   Shallow Wetland



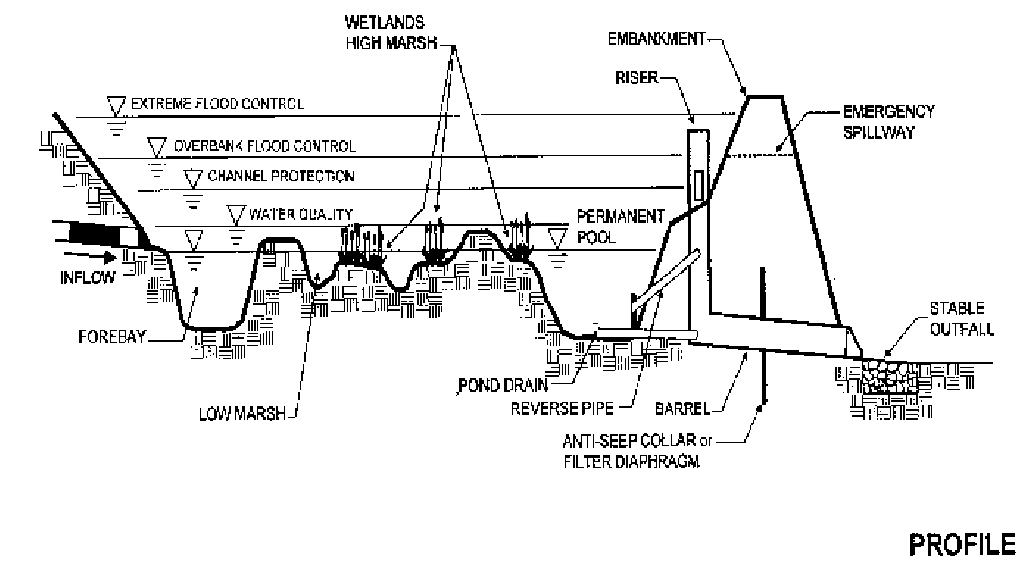


Figure 7. Extended Detention (ED) Shallow Wetland

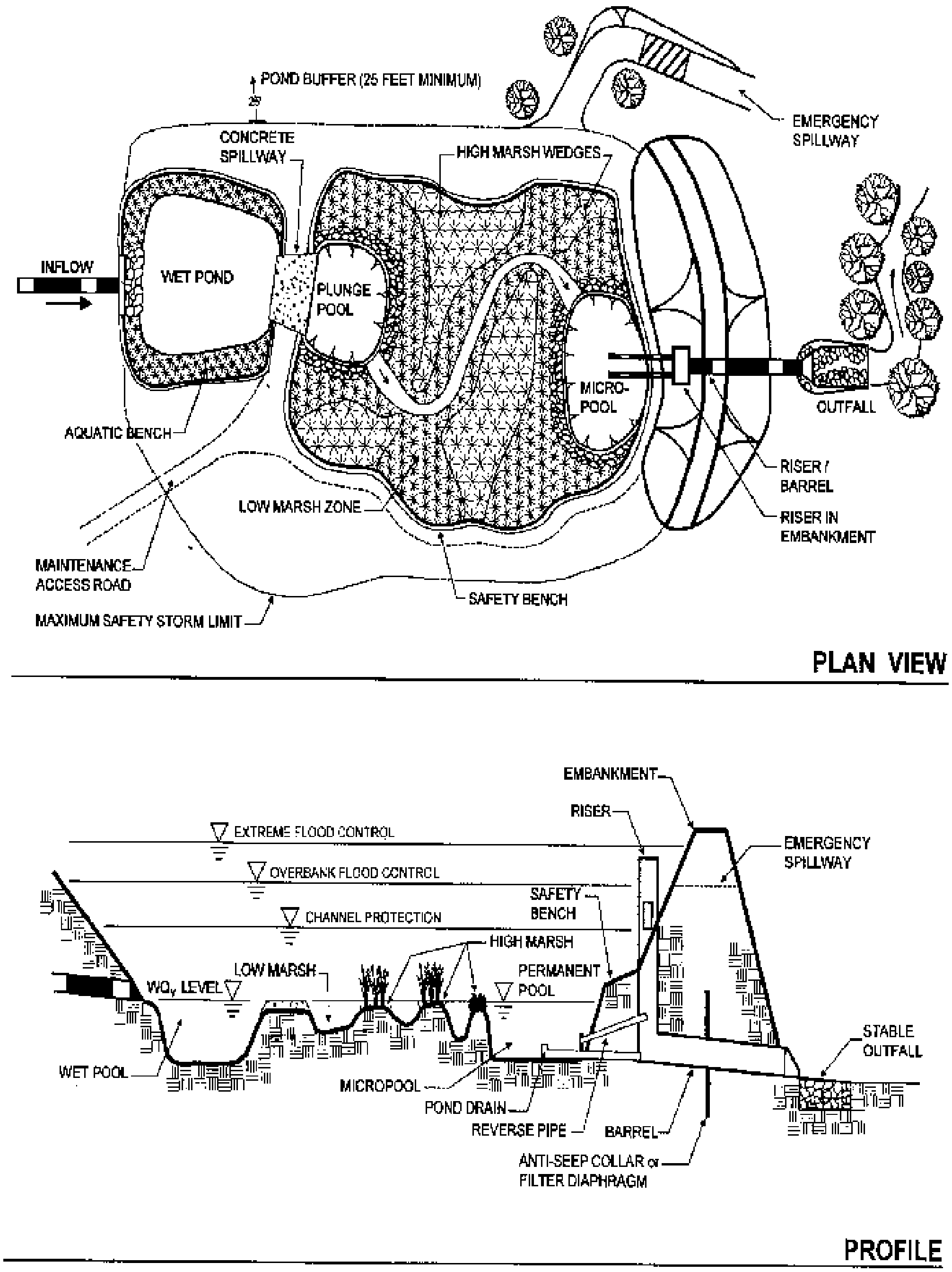


Figure 8. Pond / Wetland System

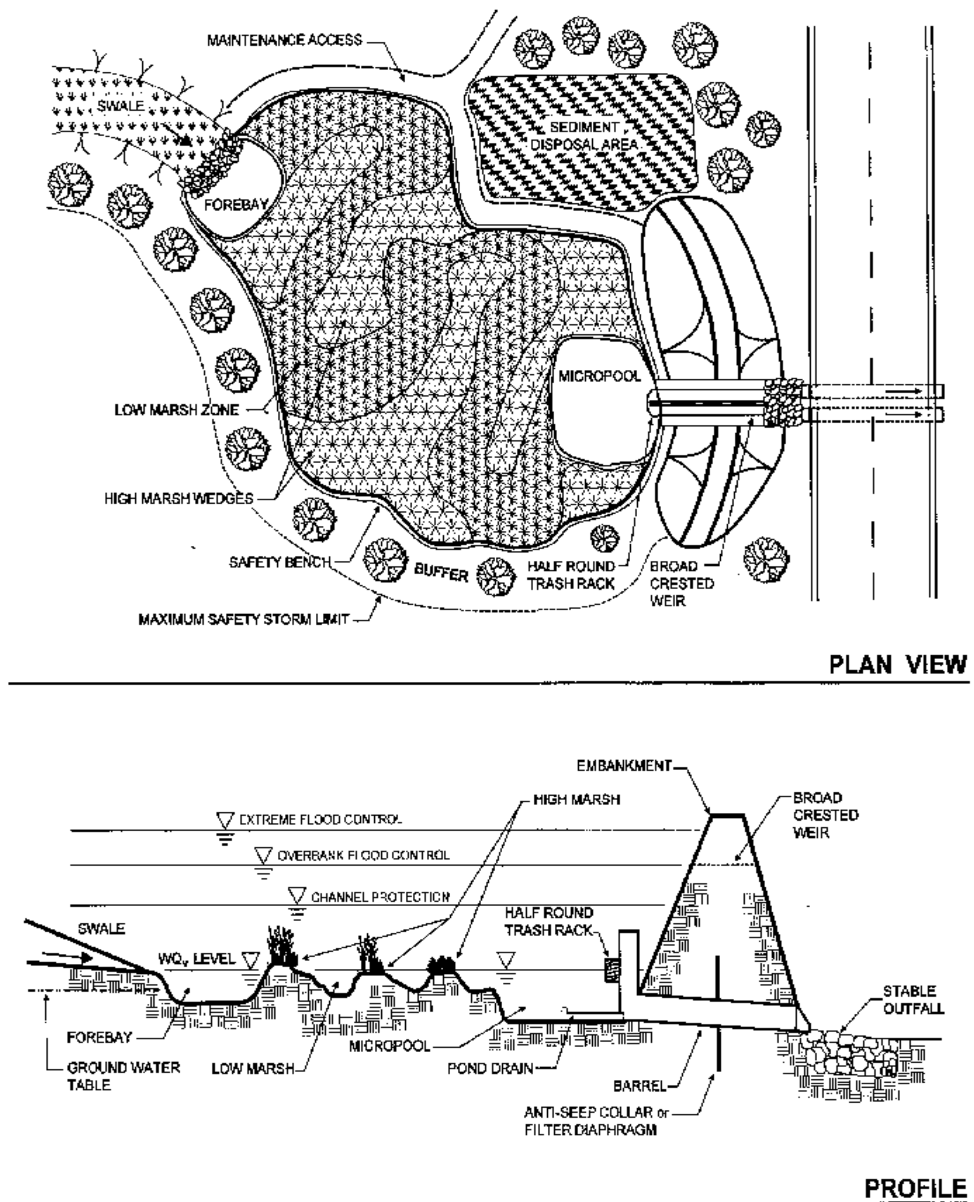


Figure 9. Pocket Wetland

Wetland Feasibility
A water balance should be performed to demonstrate that a stormwater wetland can withstand a significant drought at summer evaporation rates without completely drawing down***.***

Stormwater wetlands should not be located within existing jurisdictional wetlands. In some isolated cases, a permit may be granted to convert an existing degraded wetland in the context of local watershed restoration efforts.

Wetland Conveyance
Flowpaths from the inflow points to the outflow points of stormwater wetlands shall be maximized. A minimum flowpath of 2:1 (length to relative width) should be provided across the stormwater wetland. This path may be achieved by constructing internal berms (e.g., high marsh wedges or rock filter cells).

Wetland Pretreatment Criteria
Sediment regulation is critical to sustain stormwater wetlands. Consequently, **a forebay should be located at the inlet, and a micropool should be located at the outlet*.*** For forebay design criteria, consult the previous section on ponds. A micropool three to six feet deep should be used to protect the low flow pipe from clogging and prevent sediment resuspension.

Wetland Treatment
- At least 25% of the WQ_v should be in deepwater zones with a depth greater than four feet***.*** The forebay and micropool may meet this criteria. In addition, the deepwater zones serve to keep mosquito populations in check by providing habitat for fish and other pond life that prey on mosquito larvae.
- A minimum of 35% of the total surface area can have a depth of six inches or less, and at least 65% of the total surface area shall be shallower than 18 inches***.***
- If extended detention is utilized in a stormwater wetland, the WQ_v ED volume should not comprise more than 50% of the total WQ_V, and its maximum water surface elevation should not extend more than three feet above the permanent pool. Available data suggest that pond designs that rely entirely or primarily on detention have significantly compromised pollutant removal.

Wetland Landscaping
A landscaping plan should be provided that indicates the methods used to establish and maintain wetland coverage. Minimum elements of a plan include: delineation of pondscaping zones, a selection of corresponding plant species, a planting plan, a sequence for preparing wetland bed (including soil amendments, if needed) and sources of plant material***.*** A plant list is provided in Appendix A.

The most common and reliable technique for establishing an emergent wetland community in a stormwater wetland is to transplant nursery stock obtained from local aquatic plant nurseries. The following guidance is suggested when transplants are used to establish a wetland:

- To add diversity to the wetland, five to seven species of emergent wetland plants should be planted.
- No more than half the wetland surface area needs to be planted. If the appropriate planting depths are achieved, the entire wetland should be colonized within three years.
- Individual plants should be planted 18 inches on center in clumps.
- Because most stormwater wetlands are excavated to deep subsoils, they often lack the nutrients and organic matter needed to support vigorous growth of wetland plants. At these sites, three to six inches of topsoil or wetland mulch should be added to all depth zones in the wetland from one foot below the normal pool to six inches above.
- In some cases, the use of "volunteer wetlands," allowing cattails and phragmites to colonize may be appropriate. Typically it will be difficult to maintain diversity in this case, and volunteer wetlands may be a low cost alternative.

Wetland Maintenance Criteria

If a minimum coverage of 50% is not achieved in the planted wetland zones after the second growing season, a reinforcement planting will be required***.*** Stormwater wetlands that are separated from jurisdictional wetlands and regularly maintained are typically not regulated under State and Federal laws. Occasional removal of invasive species may be necessary.

CHAPTER 4   INFILTRATION PRACTICES

Stormwater infiltration practices capture and temporarily store the WQ_V before allowing it to infiltrate into the soil over a two day period. Design variants include:
Infiltration-Trench (Figure 10)
Infiltration-Basin (Figure 11)
Infiltration Planter Box (Figure 12)

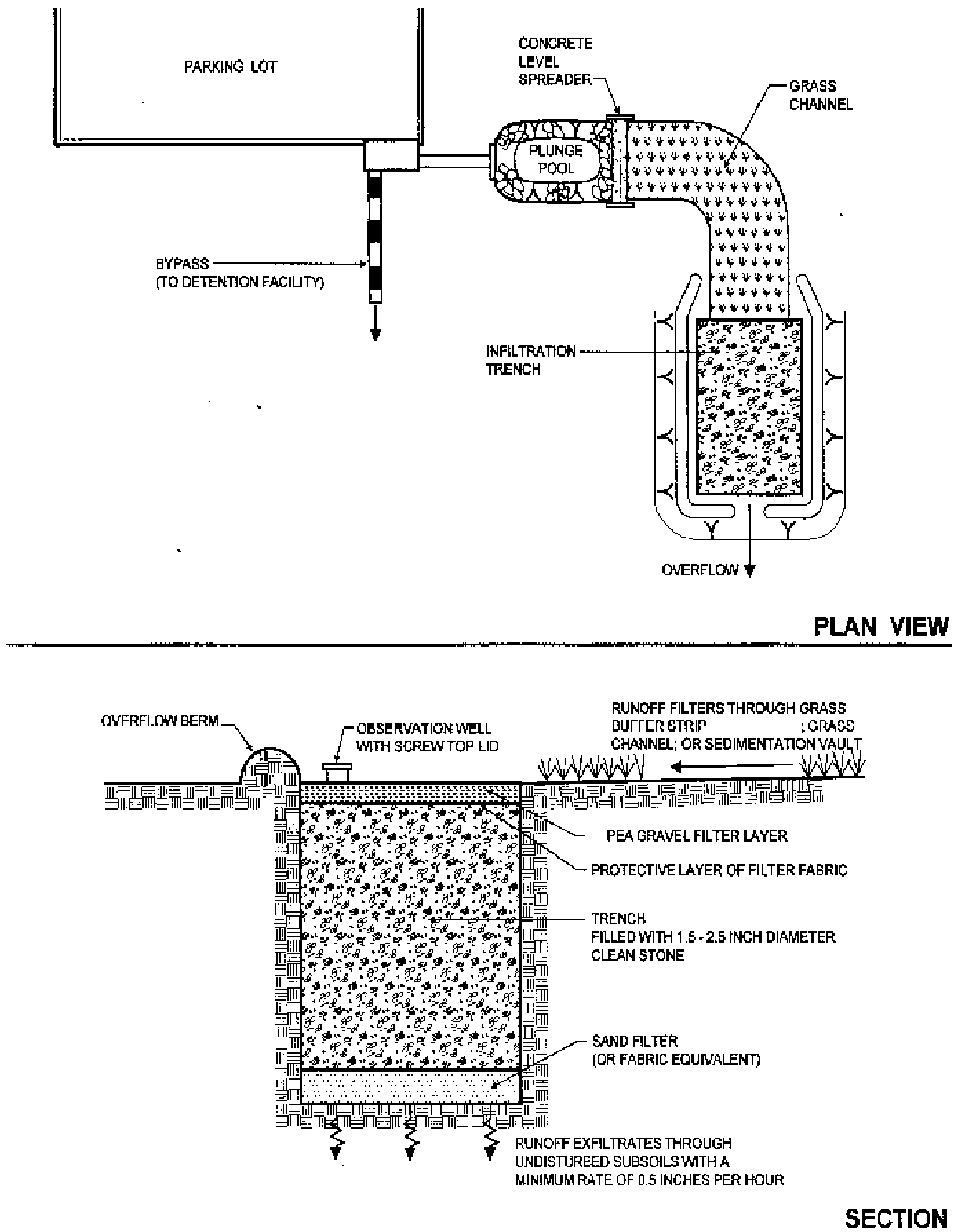


Figure 10. Infiltration Trench

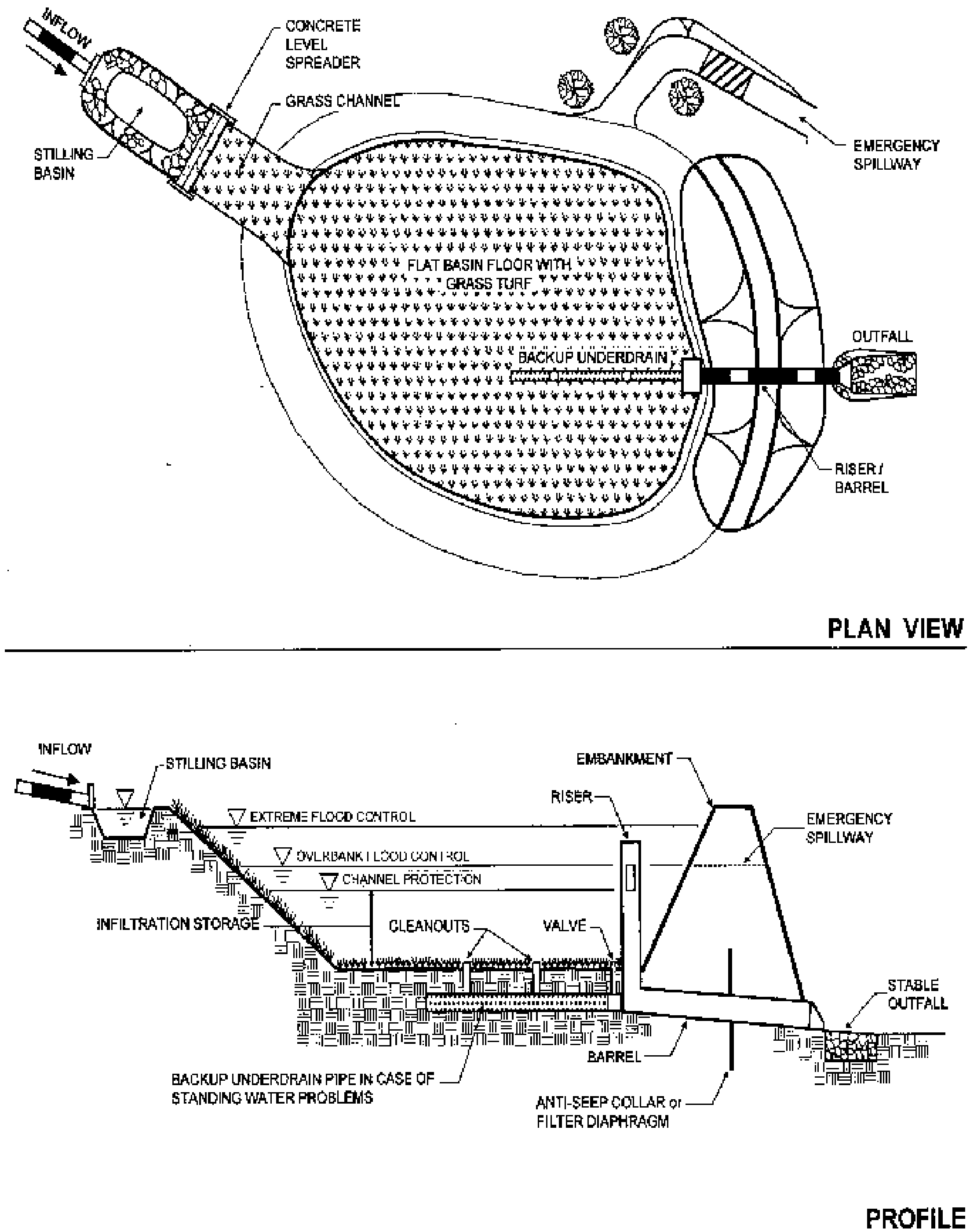


Figure 11. Infiltration Basin

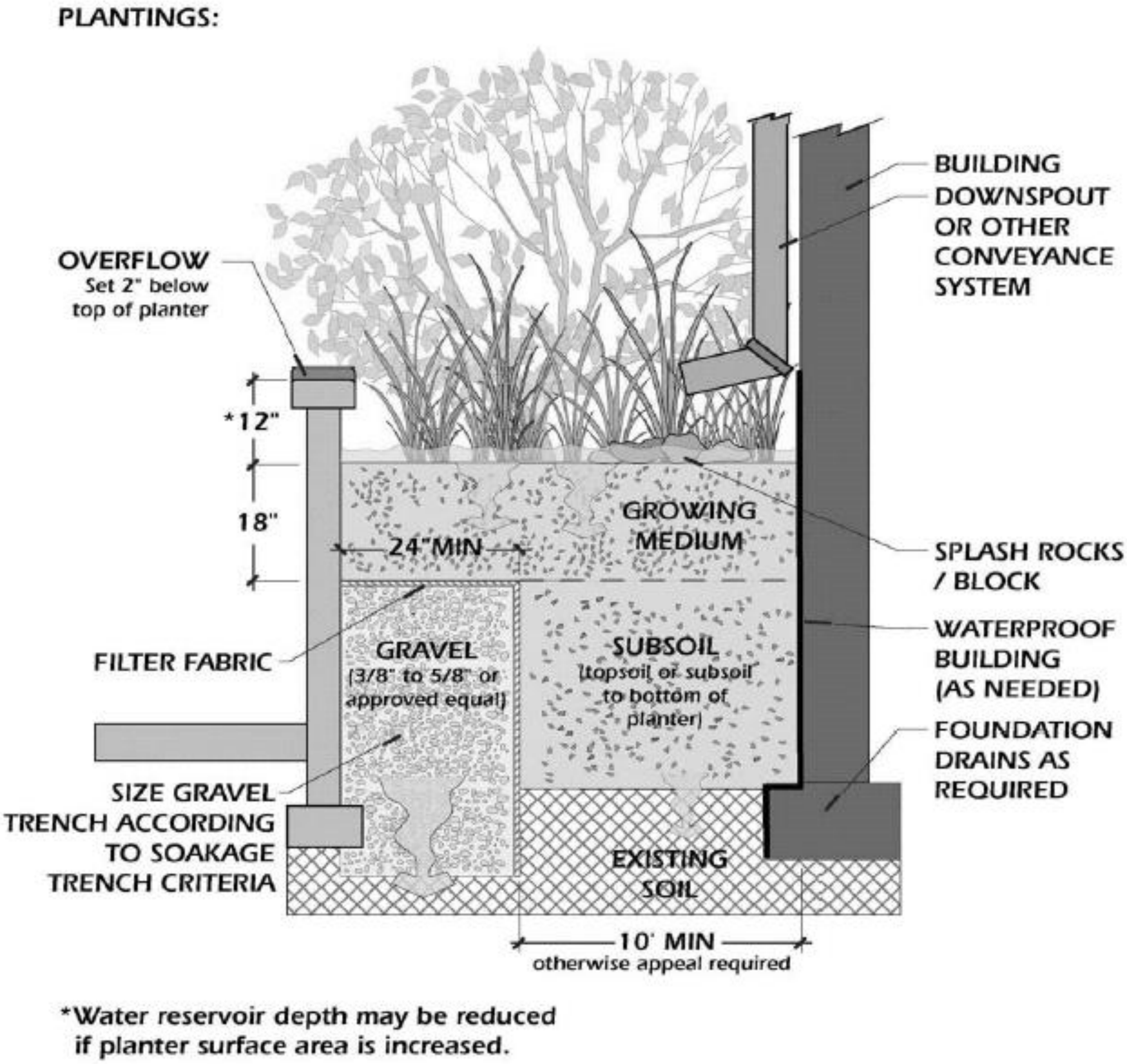


Figure 12. Infiltration Planter Box

<u>**Guidance for infiltration planter boxes**</u>

- Infiltration Planter Boxes are ideal for very small sites and redevelopment projects.
- The planters shall be designed to allow captured runoff to drain out in 3 to4 hours after a storm event.
- The sand/gravel area width, depth and length are to be determined by a qualified professional, or a drywell may be required for complete on-site infiltration.

- Minimum planter width is 30 inches; there is no minimum length or required shape. The structural elements of the planters shall be stone, concrete, brick, or pressure-treated wood. Treated wood shall not leach out toxic chemicals that can contaminate stormwater.
- Ideally planters should be located at least 10ft. from the building.

<u>Guidance for Infiltration Trenches and basins</u>

Infiltration Feasibility

To be suitable for an infiltration facility, underlying soils can have an infiltration rate (fc) of 0.52 inches per hour or greater, as initially determined from Natural Resource Conservation Service (NRCS) soil textural classification, and subsequently confirmed by field geotechnical tests. The minimum geotechnical testing is one test hole per 5000 square foot (sf), with a minimum of two borings per facility (taken within the proposed limits of the facility). The following conditions should also be placed on the use of infiltration:

- Soils shall also have a clay content of less than 20% and a silt/clay content of less than 40%.
- Infiltration cannot be located on slopes greater than 6% or within fill soils.
- The bottom of the infiltration facility shall be separated by at least four feet vertically from the seasonally high water table or bedrock layer, as documented by on-site soil testing.
- Infiltration facilities should be setback 25 feet down-gradient from structures.
- The maximum contributing area to an individual infiltration practice should generally be less than 2 acres.
- All infiltration practices must be equipped with and overflow as well as cleanouts.

Infiltration Conveyance Criteria

- All infiltration systems should be designed to fully de-water the entire WQ_v within 24 hours after the storm event.
- If runoff is delivered by a storm drain pipe or along the main conveyance system, the infiltration practice must be designed as an off-line practice.
- Pretreatment shall be provided for storm drain pipes systems discharging directly to infiltration systems. Adequate stormwater outfalls shall be provided for the overflow associated with the ten-year design storm event (non-erosive velocities on the down-slope).

Infiltration Pretreatment

- A minimum pretreatment volume of at least 25% of the WQ_v must be provided prior to entry to an infiltration facility, and can be provided in the form of a sedimentation basin, sump pit, grass channel, plunge pool or other measure. Note that extensive pretreatment is required because infiltration systems tend to clog easily.
- Exit velocities from pretreatment chambers shall be non-erosive during the two year storm.

Infiltration Treatment Criteria

Infiltration practices should be designed to exfiltrate the entire WQ_v through the floor of each practice. Infiltration practices are best used in conjunction with other practices. The longevity of infiltration practices is strongly influenced by the care taken during construction.

Infiltration Landscaping Criteria

A dense and vigorous vegetative cover should be established over the contributing pervious drainage areas before runoff can be accepted into the facility.

Infiltration Maintenance Criteria

An observation well should be installed in every infiltration trench, consisting of an anchored six-inch diameter perforated PVC pipe with a lockable cap installed flush with the ground surface.

CHAPTER 5 BIORETENTION

Stormwater filtering systems capture and temporarily store the WQ_v and pass it through a filter bed of sand, organic matter, soil or other media. Filtered runoff may be collected and returned to the conveyance system, or allowed to partially exfiltrate into the soil. Design variants include:
Various Sand Filters – not encouraged in North Augusta due to high failure rates.
Bioretention (Figure 13)

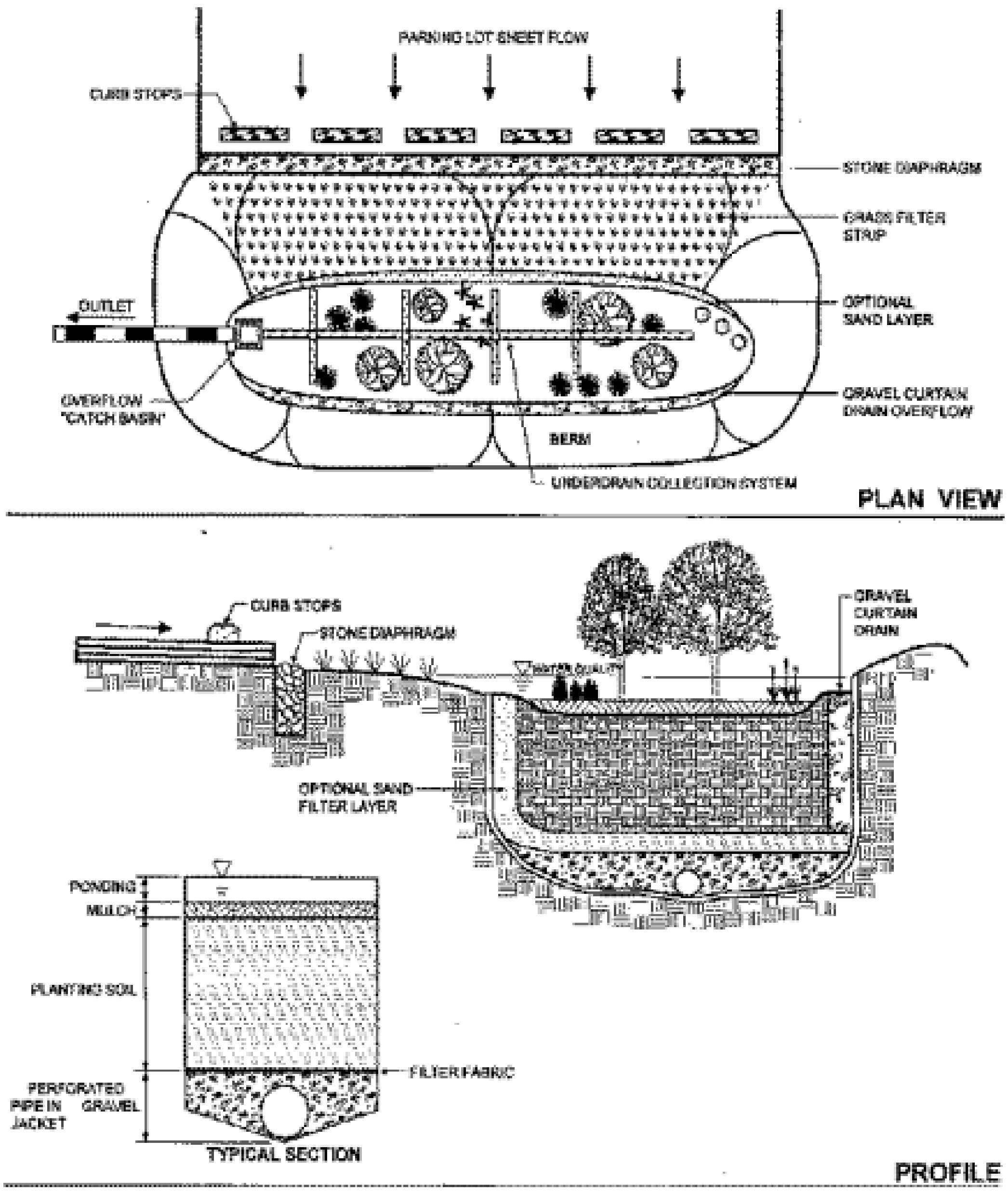


Figure 13. Bioretention

Filtering Feasibility Criteria

Bioretention is best suited for small watershed areas, stormwater retrofits for redevelopment, and use in conjunction with other practices such as water quantity detention.

Filtering Conveyance Criteria

- If runoff is delivered by a storm drain pipe or is along the main conveyance system, the filtering practice should be designed off-line.
- An overflow should be provided within the practice to pass a percentage of the WQ_v to a stabilized water course. In addition, overflow for the ten year storm should be provided to a non-erosive outlet point (i.e., prevent downstream slope erosion).
- A flow regulator (or flow splitter diversion structure) should be supplied to divert the WQ_v to the filtering practice.
- Bioretention filters should be equipped with a minimum 4" perforated pipe underdrain (6" is preferred) in a gravel layer. A permeable filter fabric should be placed between the gravel layer and the filter media.
- A sedimentation basin prior to the filter will improve performance.

Filtering Treatment Criteria

- The entire treatment system (including pretreatment) should temporarily hold at least 75% of the WQ_v prior to filtration.
- Most filtering practices cannot provide stormwater detention or downstream channel protection (Q_p and Cp_v) under most site conditions.
- The filter area for sand and organic filters should be sized based on the principles of Darcy's Law. A coefficient of permeability (k) should be used as follows:

The required filter bed area is computed using the following equation

$A_f = (WQ_v)\ (d_f)\ /\ [\ (k)\ (h_f + d_f)\ (t_f)]$ where

A_f = Surface area of filter bed (ft^2)

d_f = filter bed depth (ft)

k = coefficient of permeability of filter media (ft/day)

(0.5 ft/day for bioretention planting soil)

h_f = average height of water above filter bed (ft)

t_f = design filter bed drain time (days)

(1.67 days is recommended maximum for sand filters, 2 days for bioretention)

Filtering Landscaping Criteria

- A dense and vigorous vegetative cover should be established over the contributing pervious drainage areas before runoff can be accepted into the facility.
- Landscaping is critical to the performance and function of bioretention areas. Therefore, a landscaping plan must be provided for bioretention areas. Planting recommendations for bioretention facilities are as follows:
    1. Native plant species should be specified over non-native species.
    2. Vegetation should be selected based on a specified zone of hydric tolerance.
    3. A selection of trees with an understory of shrubs and herbaceous materials should be provided.

4. Woody vegetation should not be specified at inflow locations.
5. Trees should be planted primarily along the perimeter of the facility. (A plant list is included in Appendix A).

Bioretention Maintenance

- Silt/sediment shall be removed from the filter bed when the accumulation exceeds one inch.
- When the filtering capacity of the filter diminishes substantially (i.e., when water ponds on the surface of the filter bed for more than 48 hours), the top few inches of discolored material shall be removed and shall be replaced with fresh material. The removed sediments should be disposed in an acceptable manner (i.e., landfill).
- A stone drop of at least six inches shall be provided at the inlet of bioretention facilities (F-6) (pea gravel diaphragm).
- Areas devoid of mulch should be re-mulched on an annual basis.
- Dead or diseased plant material shall be replaced.
- Direct maintenance access shall be provided to the pretreatment area and the filter bed.

CHAPTER 6   OPEN CHANNEL SYSTEMS

Open channel systems are vegetated open channels that are explicitly designed to capture and treat the full WQ_v within dry or wet cells formed by checkdams or other means. Design variants include:
Dry Swale (Figure 14)
Wet Swale (Figure 15)
Grass Channels (Figure 16)

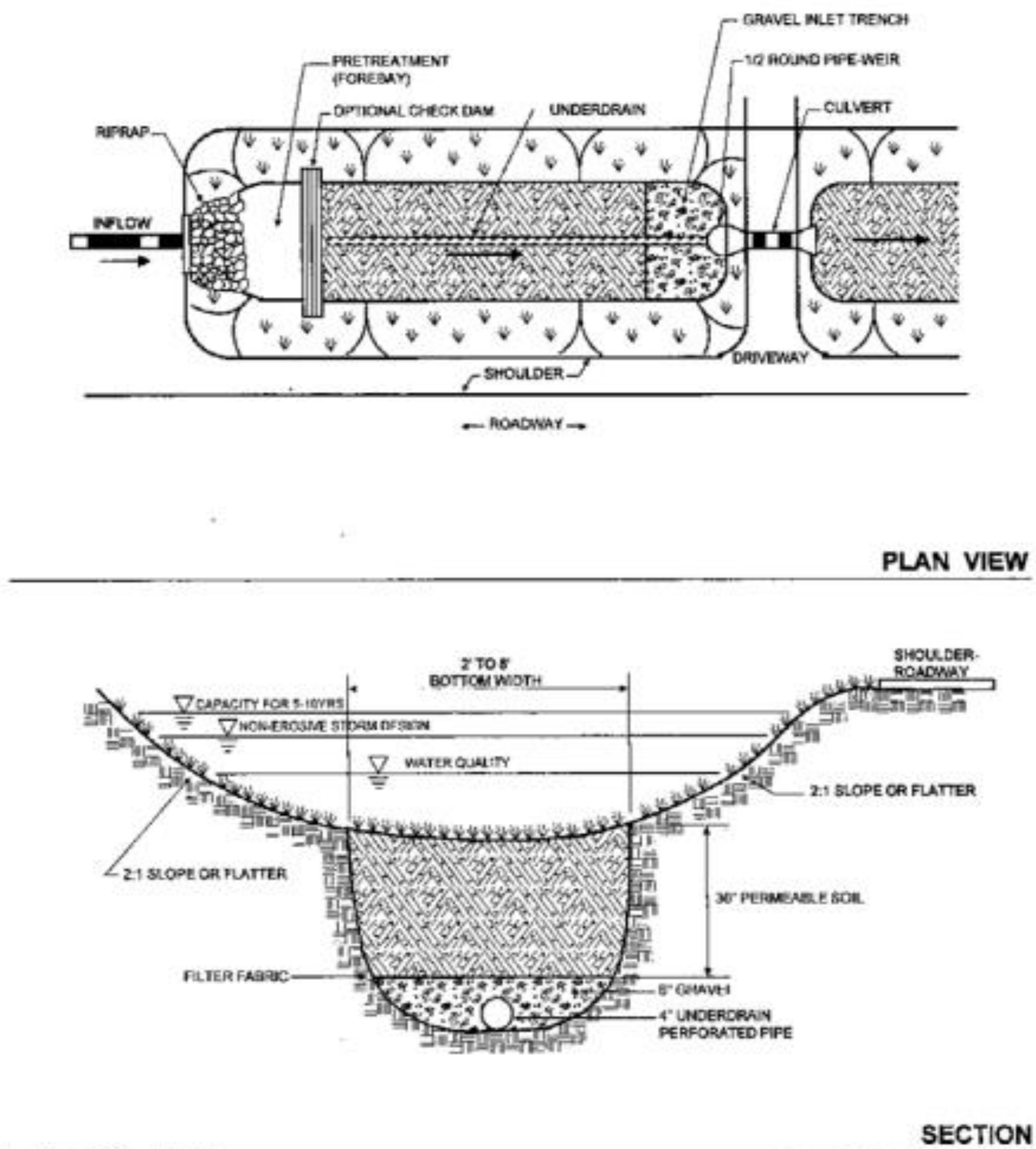
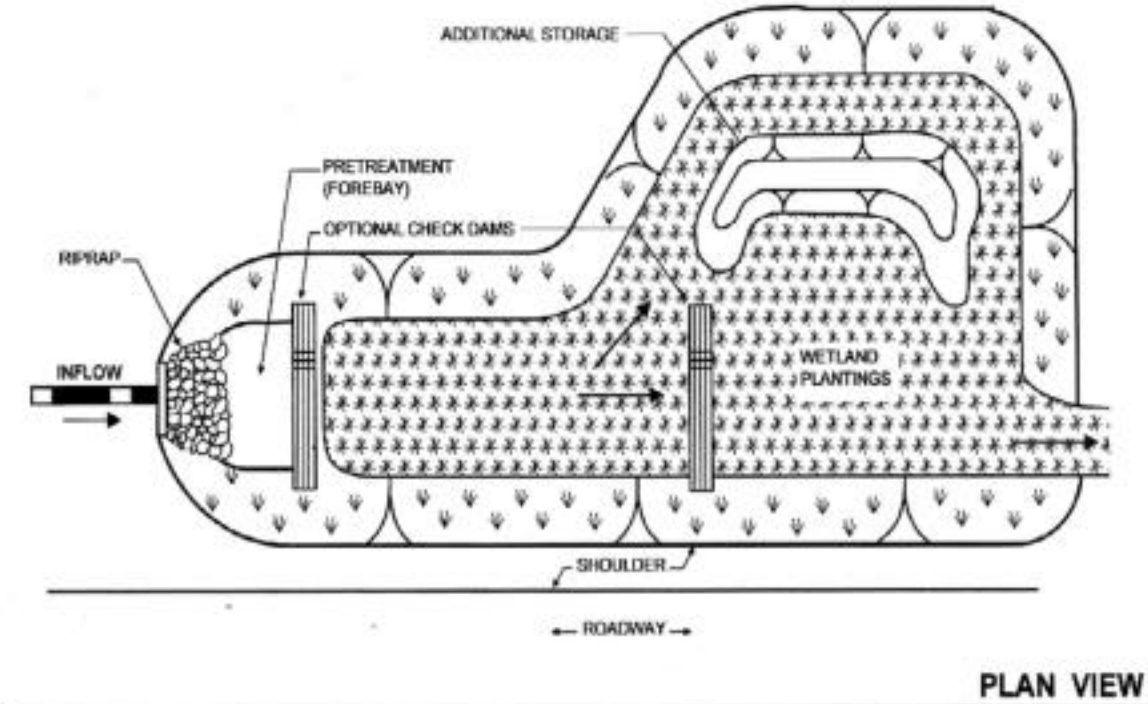


Figure 14. Dry Swale



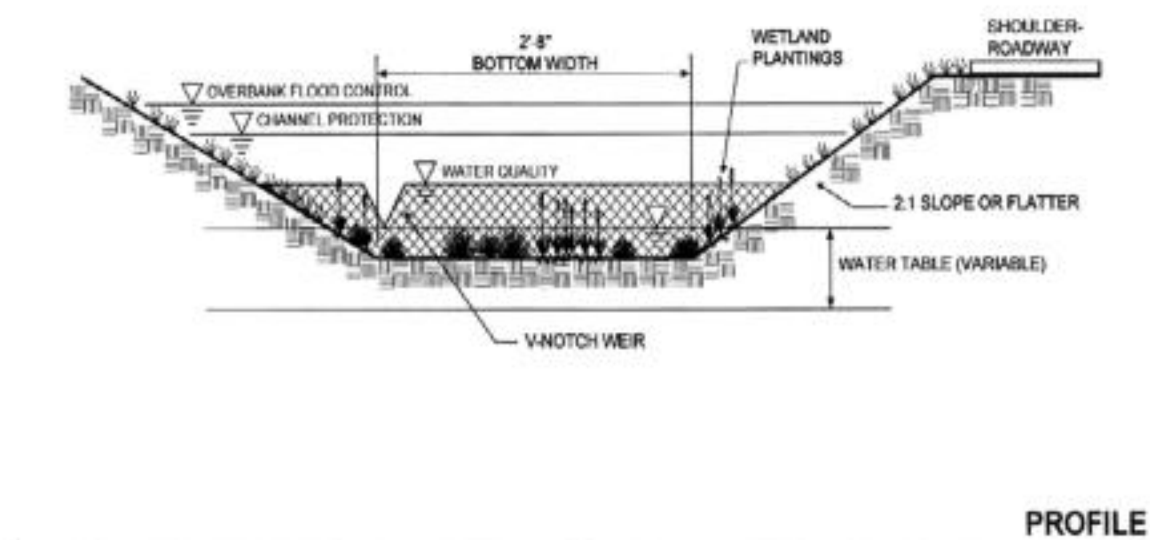


Figure 15. Wet Swale

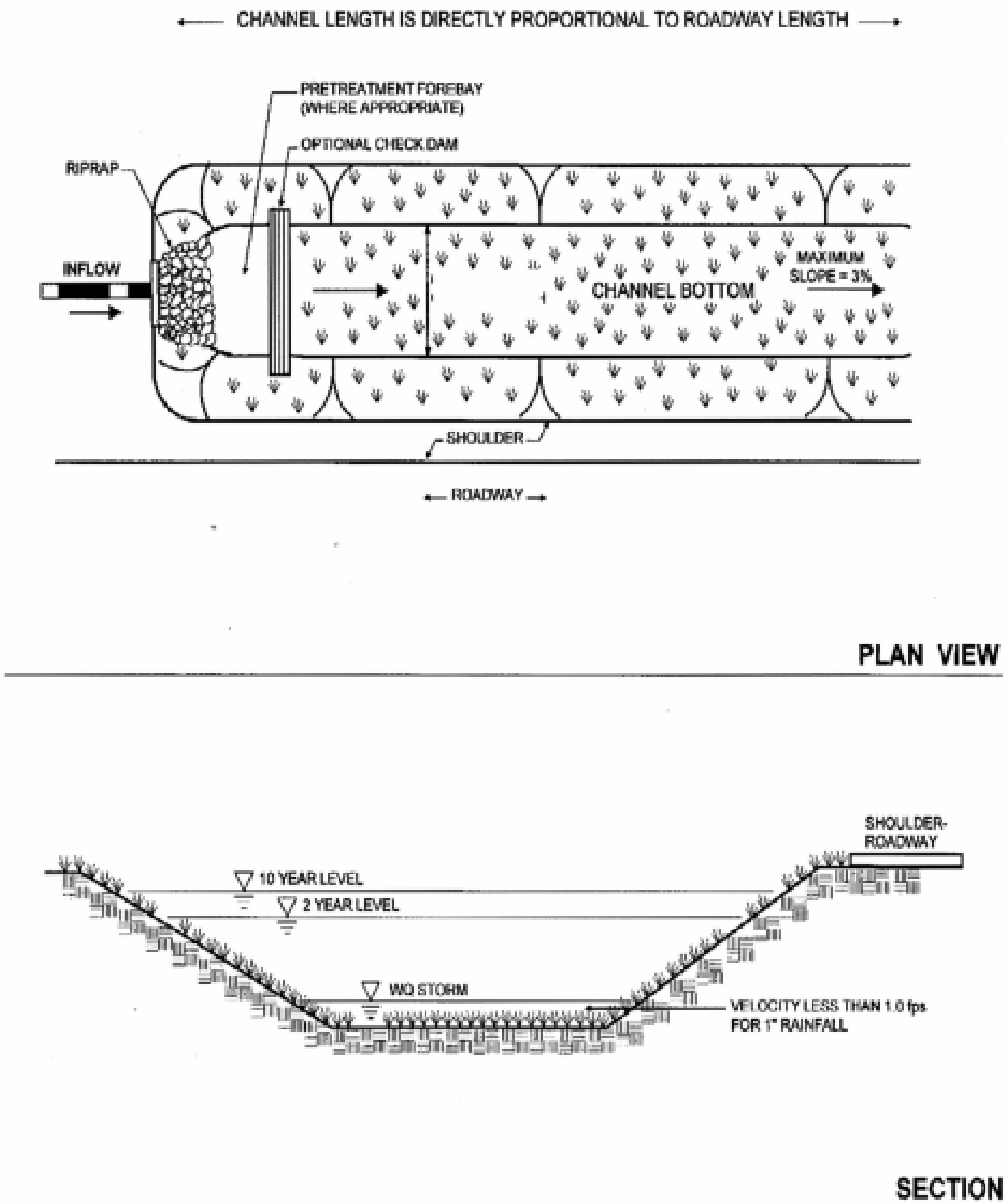


Figure 16. Grass Channel

Open Channel Feasibility Criteria

- Open channel systems should have longitudinal slopes less than 4.0% to qualify for WQ_v treatment.
- Open channel systems, designed for WQ_v treatment, are primarily applicable for land uses such as roads, highways, residential development, and pervious areas.
- Often used in conjunction with "parking lot" or dry detention.

Open Channel Conveyance Criteria

- The peak velocity for the 2 year storm must be non-erosive.
- Open channels should be designed to safely convey the ten year storm with a minimum of 6 inches of freeboard.
- Channels should be designed with moderate side slopes (flatter than 3:1) for most conditions.
- Side slopes should not be steeper than 2:1.
- The maximum allowable temporary ponding time within a channel should be less than 48 hours.
- Open channel systems which directly receive runoff from impervious surfaces may have a 6 inch drop onto a protected shelf (pea gravel diaphragm) to minimize the clogging potential of the inlet.
- An underdrain system should be provided for the dry swale to ensure a maximum ponding time of 48 hours.

Open Channel Pretreatment Criteria

- Pretreatment of 0.1 inch of runoff per impervious acre storage should be provided. This storage is usually obtained by providing checkdams at pipe inlets and/or driveway crossings.
- A pea gravel diaphragm and gentle side slopes should be provided along the top of channels to provide pretreatment for lateral sheet flows.

Open Channel Treatment Criteria

- Dry and wet swales should be designed to temporarily store the WQ_v within the facility to be released over a maximum of 48 hour duration.
- Open channels should have a bottom width no wider than 8 feet to avoid potential gullying and channel braiding.
- Dry and wet swales should maintain a maximum ponding depth of one foot at the "mid-point" of the channel, and a maximum depth of 18" at the end point of the channel (for storage of the WQ_v).
- Grass channels should be designed to retain the water quality volume in the practice for a minimum of 10 minutes, with no greater than a 1.0 fps velocity. Note that the grass channel design is the only practice with a "rate-based" design. The designer determines the peak flow rate from the water quality storm event, and then uses Manning's equation to ensure that the velocity required to retain flow can be achieved with the channel's cross section and slope.

Open Channel Landscaping Criteria

- Wet swales are not recommended for residential developments as they can create potential nuisance or mosquito breeding conditions.
- Landscape design should specify proper grass species and wetland plants based on specific site, soils and hydric conditions present along the channel.

Open Channel Maintenance Criteria

Open channel systems and grass filter strips should be mowed as required during the growing season, to maintain grass heights in the 4 to 6 inches range. Wet swales, employing wetland vegetation, do not require frequent mowing of the channel.

Sediment build-up within the bottom of the channel or filter strip should be removed when 25% of the original WQ_v volume has been exceeded.

CHAPTER 7   BETTER SITE DESIGN

Traditional Cul-de-sac Alternatives

Description
Cul-de-sac alternatives are designs for end-of-street vehicle turnaround that replace the traditional cul-de-sac and reduce the amount of impervious cover created in a residential neighborhood. Cul-de-sacs are local access streets with a closed circular end that allows for vehicle turnarounds. Many of these cul-de-sacs can have a radius of more than 40 feet. From a stormwater perspective, cul-de-sacs create a huge bulb of impervious cover, increasing the amount of stormwater runoff. For this reason, reducing the impervious area of cul-de-sacs through the use of islands or eliminating them altogether can reduce the amount of impervious cover created at a site.
There are two alternatives to the traditional 40-foot cul-de-sac approved for use in North Augusta, which create less impervious cover. These include loop roads (including the option of narrower one-way loop roads serving four to five homes) or creating pervious islands in the middle of the traditional cul-de-sac.

Applicability
Cul-de-sac alternatives can be applied in the design of residential, commercial and mixed-use developments. **A center island can also be used as an infiltration or bioretention water quality treatment practice.**

Maintenance Considerations
If islands are constructed as part of a turnaround, these areas will need to be maintained. Kept as a natural area, the costs could be minimal. Bioretention areas will also require maintenance.

Open Space Design

Description
Open space design, also known as conservation development or cluster development, is a better site design technique that concentrates dwelling units in a compact area in one portion of the development site in exchange for providing open space and natural areas elsewhere on the site. The minimum lot sizes, setbacks and frontage distances for the residential zone are relaxed in order to create the open space at the site. Open space designs have many benefits in comparison to the conventional subdivisions that they replace: they can reduce impervious cover, stormwater pollutants, construction costs, grading, and the loss of natural areas. In North Augusta, the Planned Development process is used to pursue this type of development.

It should also be noted that the benefits of open space design are amplified when combined with other better site design techniques such as cul-de-sac alternatives and open channels.

Maintenance Considerations
Once established, common open space and natural conservation areas must be managed by a responsible party able to maintain the areas in a natural state in perpetuity. Typically, the open space is protected by legally enforceable deed restrictions, conservation easements and maintenance agreements. In most communities, the authority for managing open space falls to a homeowner or community association or a land trust.
Annual maintenance tasks for open space managed as natural areas are almost non-existent, and the annual maintenance cost for managing an acre of natural area is less than $75 (CWP, 1998). It may be useful to develop a habitat plan for natural areas that may require periodic management actions.

Effectiveness
Recent redesign research indicates that open space design can provide impressive pollutant reduction benefits compared to the conventional subdivisions they replace. For example, the Center for Watershed Protection (1998) reported that nutrient export declined by 45% to 60% when two conventional subdivisions were redesigned as open space subdivisions. Other researchers have reported similar levels of pollutant reductions when conventional subdivisions were replaced by open space subdivisions (Maurer, 1996; DE DNREC, 1997; Dreher, 1994; and SCCCL, 1995). In all cases, the reduction in pollutants was due primarily to the sharp drop in runoff caused by the lower impervious cover associated with open space subdivisions. And indeed, in the redesign studies cited above, impervious cover declined by an average of 34% when open space designs were utilized.

Along with reduced imperviousness, open space designs provide a host of other environmental benefits lacking in most conventional designs. These developments reduce potential pressure to encroach on resource and buffer areas, as enough open space is usually reserved to accommodate resource protection areas. As less land is cleared during the construction process, the potential for soil erosion is also greatly diminished. Perhaps most importantly, open space design reserves 25% - 50% of the development site in green space that would not otherwise be protected, preserving a greater range of landscapes and habitat "islands" that can support considerable diversity in mammals, songbirds and other wildlife.

Cost Considerations
Open space developments can be significantly less expensive to build than conventional subdivisions. Most of the cost savings are due to savings in road building and stormwater management conveyance costs. In fact, the use of open space design techniques at a residential development in Davis, California provided an estimated infrastructure construction costs savings of $800 per home (Liptan and Brown, 1996). Other examples demonstrate infrastructure costs savings ranging from 11 to 66%.

While open space developments are frequently less expensive to build, developers find that these properties often command higher prices than homes in more conventional developments. Several regional studies estimate that residential properties in open space developments garner premiums that are 5 to 32% higher than conventional subdivisions and moreover, sell or lease at an increased rate. In Massachusetts, cluster developments were found to appreciate 12% faster than conventional subdivisions over a twenty year period (Lacey and Arendt, 1990).

In addition to being aesthetically pleasing, the reduced impervious cover and increased tree canopy associated with open space development reduces the size and cost of downstream stormwater treatment facilities.

Alternative Pavers

Description

Alternative pavers are permeable or semi-permeable surfaces that can replace asphalt and concrete and can be used for overflow parking lots and walkways. From a stormwater perspective, this is important because alternative pavers can replace impervious surfaces, creating less stormwater runoff. The two broad categories of alternative pavers are paving blocks and other surfaces including gravel, cobbles, wood, mulch, brick, and natural stone.

Porous pavement

Porous pavement is a more expensive but effective surface used to reduce runoff. These products may be especially applicable to redevelopment areas. Porous pavement is targeted for driveways, walking trails, parking lots, playgrounds, open spaces, and golf cart paths. Porous pavement techniques only work if the design engineer takes into account the proper selection of technique for the location, the design is correct, and the structure is built properly. If any of these considerations are not done correctly, the structure may fail. Researchers at the University of Georgia have identified nine categories of porous pavements. Below is a brief overview of each.

- *Decks* are level or elevated wooden structures that can serve as porous pavements. They are beneficial in situations where they can be built around existing environments such as wetlands.

- *Open celled paving grids* are open spaces with ribbing in between. They can be difficult to walk on and it takes time to grow turf over the grids. They work well in open spaces. They can be used in low-traffic areas such as loading areas and emergency access lanes.

- *Open-graded aggregate* is the most permeable material and the lowest-cost that you can get. About 30 to 40 percent of the material is void space and its permeability is measured in thousands of inches per hour.

- *Open-jointed paving blocks* are segmental pavers that can handle high weights and heavy traffic. Paving blocks are cement or plastic grids with gaps between them. Paving blocks make the surface more rigid and gravel or grass planted inside the holes allows for infiltration. Depending on the use and soil types, a gravel layer can be added underneath to prevent settling and allow further infiltration

- *Plastic geocells* are plastic cells held together with ribs and filled with aggregate or turf. They can be used for a variety of activities including emergency-access lanes, auxiliary parking areas, trails, pedestrian and wheelchair access ways, golf cart paths.

- *Porous asphalt* can be used as an overlay on parking lots.

- *Pervious concrete* is created by mixing water and cement-like materials into a paste that forms a thick coating around aggregate particles. It contains little or no sand and forms a highly permeable surface. It is advocated as a BMP by the EPA. It can be used in waste transfer stations and low traveled parking areas.

- *Porous turf* is used by itself and with reinforcements. It is used for parking lots and open spaces.

- *Soft paving materials* such as wood mulch, crushed shell, and other organic material can be used for areas of pedestrian traffic.

Applicability
Alternative pavers can replace conventional asphalt or concrete in parking lots, driveways, and walkways. At the same time, traffic volume and type can limit application. For this reason, alternative pavers for parking are recommended only for overflow areas. In residential areas, alternative surfaces can be used for walkways, but are not ideal for areas that require handicap accessibility.

Siting and Design Criteria
Accessibility, climate, soil type, traffic volume and long term performance should be considered along with costs and stormwater quality controls when choosing paving materials. Soil types will affect the infiltration rates and should also be considered when using alternative pavers. Clay soils (D soils) will limit the infiltration on a site. It is important to consider that failure of porous surfaces can occur. These failures can be a result of poor design, inadequate construction techniques, low soil permeability, heavier traffic use than designed for, or resurfacing with a non-porous material. If you are considering these techniques for your projects, strict adherence to the design standards and construction methods must be used.

The durability and maintenance cost of alternative pavers also limits use to low traffic volume areas. At the same time, alternative pavers can abate stormwater management costs. Used in combination with other better site design techniques, the cumulative effect on stormwater can be dramatic.

Benefits
The most obvious benefit of utilizing alternative pavers includes reduction or elimination of other stormwater management techniques. Applied in combination with techniques like bioretention, pollutant removal and stormwater management can be further improved.

Limitations
Alternative pavers are not recommended for high traffic volumes for durability reasons. Access for wheelchairs is limited with alternative pavers. In addition, snow removal is also difficult since plows cannot be used, sand can cause the system to clog, and salt can be a potential pollutant.

Effectiveness
Alternative pavers provide better water quality effectiveness than conventional asphalt or concrete and the range of effectiveness depends on the type of paver. Table 2 provides a list of pavers and the range of water quality effectiveness for different types of alternative pavers.

Table 2. Water Quality Effectiveness of Various Pavers (BASMAA, 1998)

Material	Water Quality Effectiveness
Conventional Asphalt/ Concrete	Low
Brick (in a loose configuration)	Medium
Natural Stone	Medium
Gravel	High
Wood Mulch	High
Cobbles	Medium

Costs
The range of installation and maintenance costs of various pavers is provided in Table 3. Depending on the material used, installation costs can be higher or lower for alternative pavers than conventional asphalt or concrete, but maintenance costs are almost always higher.

Table 3. Installation and Maintenance Costs (BASMAA, 1997)

Material	Installation Cost	Maintenance Cost
Conventional Asphalt/ Concrete	Medium	Low
Brick (in a loose configuration)	High	Medium
Natural Stone	High	Medium
Gravel	Low	Medium
Wood Mulch	Low	Medium

CHAPTER 8 PROPRIETARY TREATMENT PRACTICES

Water quality regulatory requirements affecting communities has created a need for new technologies that not only improve water quality from storm sewers and other devices but also remain cost effective. This chapter will give a brief overview of the types of technologies that are available for use in storm treatment processes. There are many other available techniques and technologies available.

Pollutant removal effectiveness of the practices found in this manual will obviously vary widely based on site conditions and practice design. There are many programs available to determine pollutant removal rates for all practices covered here. In addition, vendors of proprietary treatment practices size their product based on specific site conditions.

A general overview of pollutant removal rates for some of the more common STPs is presented in the following narrative. Most of the information presented regarding pollutant removal rates is represented by the company that promotes the specific product. The City of North Augusta has not verified that the removal rates are accurate and will expect that design engineers that intend to use these products verify the accuracy of the statements to the best of their ability.

In-ground Technologies

The following technologies are used within the storm water sewer system to separate and remove pollutants

Storm Pure™ Catch Basin Inserts
For areas where potential pollutant loads are higher (roadways, parking lots, loading areas), a catch basin insert will provide greater protection to by filtering stormwater. ADS's Nyoplast Division offers Storm-Pure inserts. The Storm-PURE catch basin insert (Figure 17), a two-stage unit that will fit into new or existing catch basins will remove suspended solids, hydrocarbons and other pollutants. Rates of removal are available from the company.

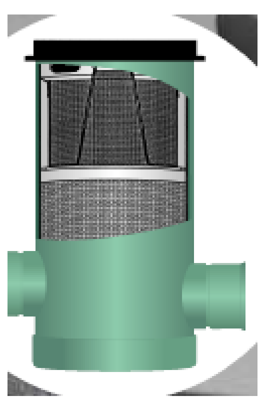


Figure 17: StormPure™ Catch Basin Insert

CDS Unit (Continuous deflective separation)

This technology that uses a non-blocking, non-mechanical screening process to remove pollutants from storm water flow and combined sewer overflows (Figure 18). The unit captures fine sands and solids and are capable of removing more than 80% of annual TSS from stormwater. It is said to move 100% of floatables and 100% of particles that are equal to or greater than one-half the size of the screen opening. The system comes in an off-line unit also. The units come with a conventional oil baffle to control oil and grease. They can be fitted with the CDS Media Filtration System cartridges that can target project specific pollutants as well.

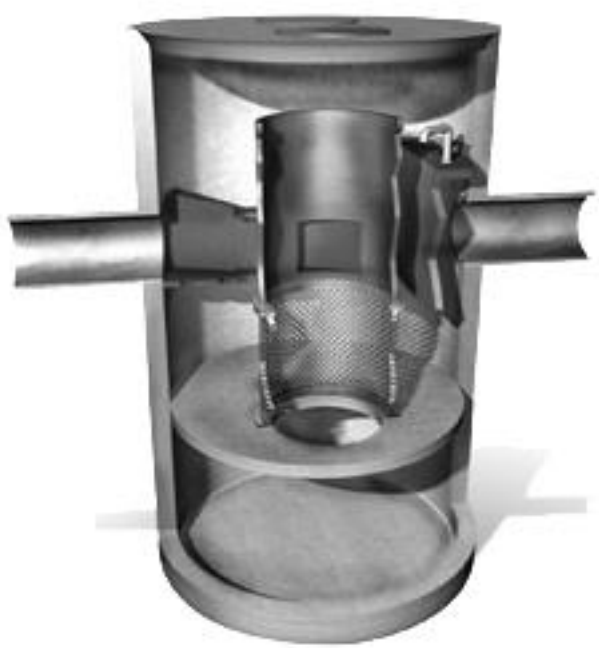


Figure 18. Inline CDS Unit

Nutrient Separating Baffle Box™: Suntree Technologies

Stormwater Treatment Structure
Designed to treat the entire stormwater flow, the Nutrient Separating Baffle (Figure 19) box meets or exceeds NPDES requirements for capturing a wide variety of pollutants including TSS, sediment, debris, organic material, hydrocarbons, and trash. Because water flow is not ducted off line for treatment, head loss is minimal and comparable to a large square catch basin. Existing stormwater systems can be easily retrofitted with a Nutrient Separating Baffle Box, without compromising the original design specifications of the current stormwater system.
The box can be made of either concrete or fiberglass in any size (Illustration 1).

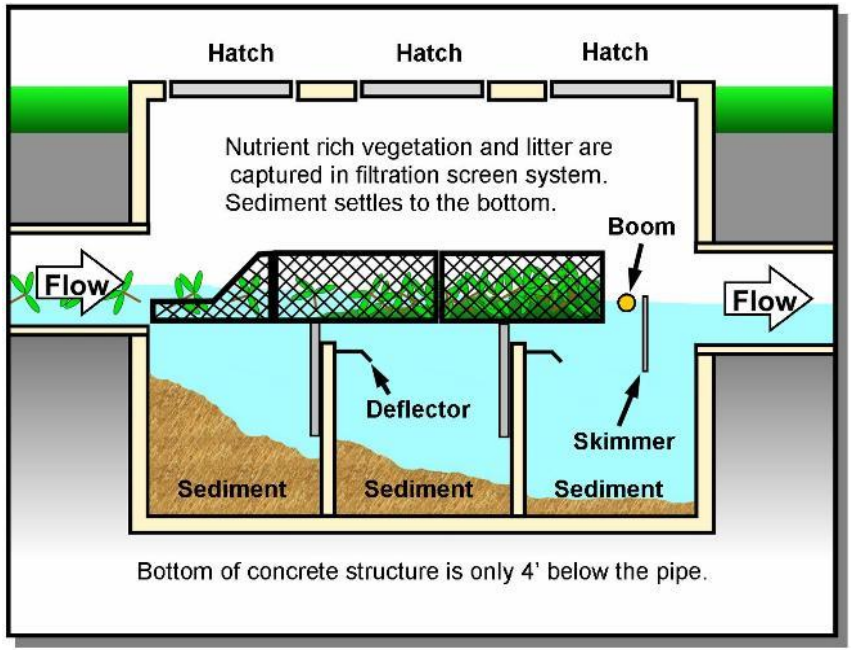


Figure 19: Nutrient Separating Baffle Box during storm

Illustration 1: Suntree Device being installed City of Kingsport, TN

Stormceptor®

The stormceptor captures pollutants from stormwater as it passes through the system. The system is based on an "internal" bypass system that eliminates up to 80% of TSS and 98% of free oils and hydrocarbons (Figure 19). Under normal operating conditions (more than 90% of all storm events), storm water flows into the upper chamber and is diverted by a sloped weir into the lower chamber. Flow is diverted by horizontal outlets around the walls of the lower chamber, settling out coarse and fine sediments to the floor of the chamber. Petroleum products rise and become trapped beneath the fiberglass insert. During infrequent, high flow events (less than 10% of all storm events), storm water flows pass over the diverting weir into the downstream sewer system, preventing scouring of previously trapped pollutants. The high flow by-pass prevents previously collected pollutants from scour and re-suspension.

The Inlet Stormceptor® takes the place of a traditional inlet structure in a storm sewer system. The Inlet Stormceptor® is ideal for small drainage areas, such as truck loading bays, electrical transformer stations, and vehicle refueling stations.

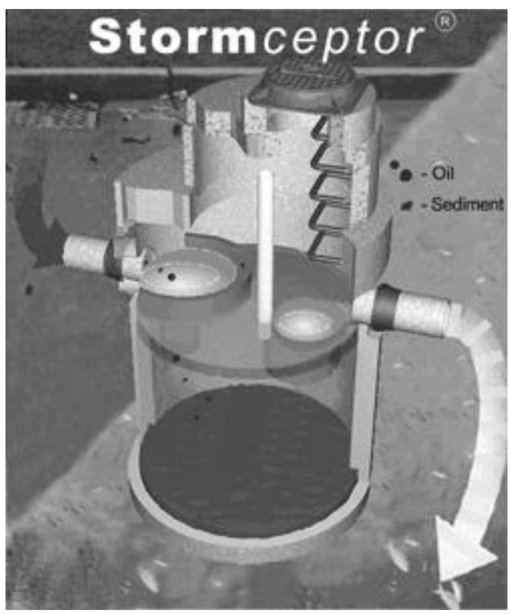


Figure 20. Stormceptor® Device

Vortechnics™

The Vortecnics™ system is available for manhole and vault configurations. It is a filter technology system that removes very fine particulates. It uses sedimentation, floatation, and filtration methods (Figure 20). Vortechnics™ System is a concrete, underground structure comprised of three chambers – an initial grit chamber that concentrates and deposits sediments, an oil chamber and baffle wall that traps floatables, and a flow control chamber. The system removes 80% of total suspended solids.

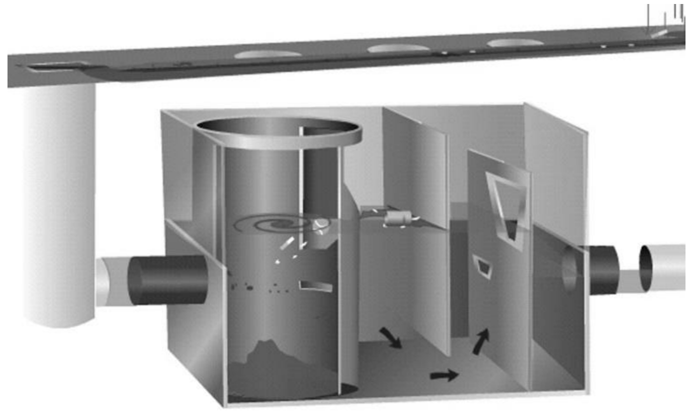


Figure 21. Vortechnics System

Ecostorm™

The Ecostorm consists of 2 circular concentric precast structures. An outer structure forms the swirl-chamber/vortex separator, the inner cylinder serves as a floatables collection chamber and outlet chamber (Figure 21). Swirl-chamber technology combined with vortex design principles, effectively treat the stormwater by removing and retaining sediments and floatables from site runoff.

Figure 22. Ecostorm™

StormTech™

StormTech develops control systems for stormwater runoff that maintain the balance between land development and the protection of natural resources.

StormTech chambers have been subjected to advanced in-ground testing protocols and high-level industry expert review. They have been evaluated to support HS-20 live loads following current AASHTO procedures for loads, structural capacity and factor of safety when installed per StormTech's Chamber Installation Instructions. StormTech chambers are molded from Polypropylene resin and chemicals typically found in stormwater runoff. StormTech recommends using the Isolator Row Inlet Control System or a treatment train approach. The Isolator Row has been tested for sediment removal efficiency and can be a stand-alone sediment control system. The treatment train approach incorporates a pretreatment device prior to the Isolator Row and an eccentric header for coarse or heavy materials removal.
The Isolator Row is a row of chambers wrapped in filter fabric. Runoff is directed into the Isolator Row via a manhole or basin with a diversion weir. When the Isolator Row reaches capacity, storm water overtops the weir and flows to the other chambers through a header system.

Figure 23. StormTech™ System

Conspan Stormvault™

The Stormvault™ Mitigation System by CON/SPAN® is a below grade detention and sedimentation vault. Stormwater is discharged with TSS concentration of less than 20 mg/L with a 95% level of confidence, independent of influent concentrations or inflow volume. Detention time promotes sedimentation of particles less than 70 microns

Filterra®

Filterra® relies on a specially engineered high flow rate treatment system to provide exceptional pollutant removal. Monitoring data shows Filterra® can treat over 90% of the total annual volume of rainfall with maximum pollutant removal rates reaching 95% for total suspended solids, 82% total phosphorus, 76% total nitrogen and 91% heavy metals (measured as Cu).
The high pollutant removal efficiency is primarily due the multiple treatment systems inherent in its unique plant / soil / microbe treatment media. Its unique design and use of typical landscape plants also provides many added values such as low maintenance costs, enhanced aesthetics, improved habitat value, and easy / safe inspection.

The system consists of a concrete container, a 3 inch mulch layer, 1.5 to 3.5 feet of a unique soil filter media, an observation / cleanout pipe, an under-drain system and an appropriate type of plant i.e., flowers, grasses, shrub, or tree (see photo in Figure 23). Stormwater runoff drains directly from impervious surfaces through an inlet structure in the concrete box and flows through the mulch, plant, and soil filter media. Treated water flows out of the system via an under-drain connected to a storm drain pipe or other appropriate outfall. The “at-the-source” treatment strategy is highly adaptable for any urban setting to achieve multiple stormwater management water quality and quantity goals including combined sewer overflow control.

Figure 24. Filtera System

Alternative paver systems

Grass Pave/ Gravel Pave

Grasspave[2] is a structure which provides incredible load bearing strength while protecting vegetation root systems from deadly compaction. High void spaces within the entire cross-section enable excellent root development, and storage capacity for rainfall from storm events

It is a turf based system that consists of a sandy gravel base course, a *Hydrogro*w polymer fertilizer mixture, the Grasspave ring and grid structure, sharp concrete sand, and grass seed or sod (Figure 24). Runoff moves through the surfaces allowing suspended sediments to drop out. Table 4 shows expected storage volumes.

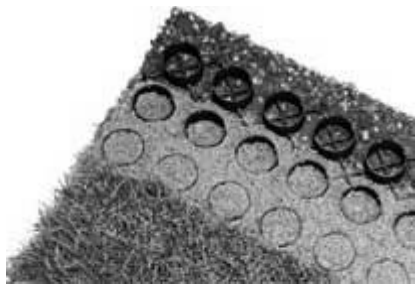


Figure 25. Grasspave[2]

Table 4 : Expected Storage Volumes of the Grass pave System

(source: Invisible Structures)

Base Depth (in)	Rainfall (in/ft^2)	Volume (in^3/ft^2)	Volume (ft^3/ft^2)	Volume ($gal/^{ft2}$)
4	1.0	144	0.08	0.62
5	1.3	180	0.10	0.78
6	1.5	216	0.13	0.94
7	1.8	252	0.15	1.09
8	2.0	288	0.17	1.25
9	2.3	324	0.19	1.40
10	2.5	360	0.21	1.56
11	1.8	396	0.23	1.71
12	3.0	432	0.25	1.87
13	3.3	468	0.27	2.03
14	3.5	504	0.29	2.18
15	3.8	540	0.31	2.34
16	4.0	576	0.33	2.49

Gravelpave[2] is comprised of a porous geotextile fabric, molded directly to the one inch high integrated ring and grid system (Figure 25). Gravelpave[2] sits atop an engineered porous base course, is anchored down with galvanized anchors, and is filled with decorative gravel. It is a structure to provide heavy load bearing support and true containment of gravel to create a porous pavement surface with unlimited traffic volume and/or duration time for parking. When used with a proper porous base course material, Gravelpave^2 can provide a void space of 35% for storage volume of rainfall during rain events.   For example, an 8" deep cross-section would store 2.8" of rain.

Figure 26. Gravelpave^2 system

To see an example of the product, visit the North Augusta Greeneway Trail Parking Lot (*Gravelpave*) off Martintown Road near The Rapids subdivision.

Installed in 2004.

PAVERS
Open-jointed paving blocks are segmental pavers that can handle high weights and heavy traffic. Paving blocks are cement or plastic grids with gaps between them. Paving blocks make the surface more rigid and gravel or grass planted inside the holes allows for infiltration. Depending on the use and soil types, a gravel layer can be added underneath to prevent settling and allow further infiltration

Figure 27: Aquablock (Photo: Belgrade Hardscapes, Atl. Ga)

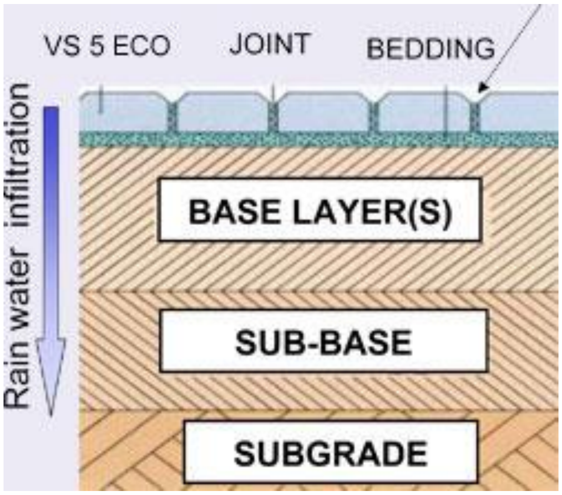
Figure 28: Subterra Stone Pavers (Photo: Belgrade Hardscapes, Atl., GA)

Figure 29: Subterra 9101 and Adams Turfstone **(Photo: Belgrade Hardscapes, Atl., GA)**

Figure 30: SF Technology Pavers in Hilton Head, SC / H2Flo Paver **(Photos: SFconcrete.com)**

SF Concrete Technology (from SFConcrete.com)

VS 5 – Eco, VS 5 – Drain and SF-Rima™ pavements are the solution to deal with stormwater runoff. They are very effective in providing infiltration at the spot, allowing rainwater to pass through joints between the stones, through aggregate layers for temporary storage, filtering, and treatment and eventually it is released to the ground water.
All SF permeable concrete pavements can reduce runoff of almost 100% from frequent, low intensity and short rainstorms. The long-term infiltration rate is estimated at 3.8 in./hr. for a 20-year life. It is recommended however, to provide drainage swales to handle flows that exceed the design rainstorm.



Rain and runoff from impervious areas

< Joint: Aggregate sizes 1-3 mm (approx. No. 10)

< Bedding: Aggregate 1-3mm,
bedding layer 1" to 1 ½" thick layer [20mm – 30mm]
< Base: smaller than No. 57 aggregate 4 in [100mm] thick
(No. 57 – 1 ¼" to 1/8" or 37mm to 3mm)
< Sub base: No. 2 aggregate (max.3")
min. 6 in. (150mm) thick layer for plaza applications or
min. 8 in (200mm) for vehicular applications
< Optional geo textile

Many of these pavers are manufactured in SC by Low Country Pavers, Hardeeville (www.lcpaver.com).

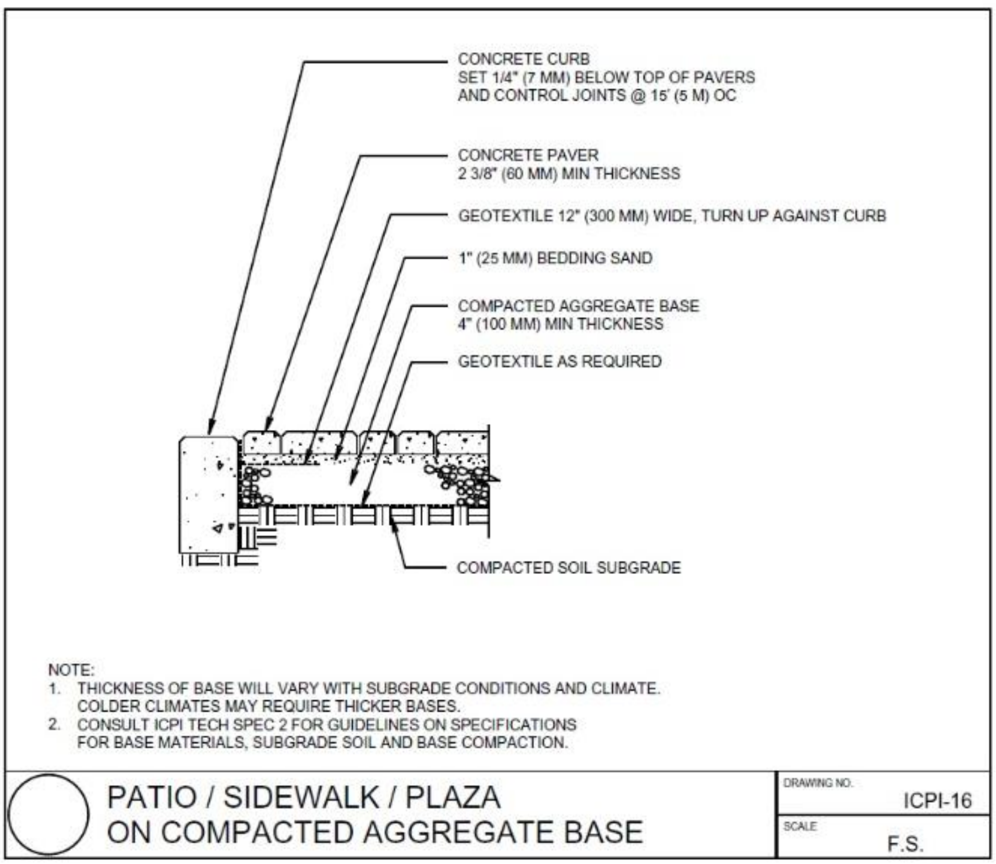


Figure 31: Example from Low Country Pavers Design Professionals/Detail Drawings

Porous Concrete

Pervious/Porous Pavements

Excerpts from the National Pervious Concrete Pavement Association Website (www.npcpa.org):
Pervious concrete is an innovative building material with many environmental, economic, and structural advantages. The proper utilization of pervious concrete is a recognized Best Management Practice by the U.S. Environmental Protection Agency (EPA) for providing first-flush pollution control and stormwater management.

To make pervious concrete, carefully controlled amounts of water and cementitious materials create a paste that forms a thick coating around aggregate particles. A pervious concrete mixture contains uniformed sized aggregate creating a substantial void content. Using sufficient paste to coat and bind the aggregate particles together creates a system of highly permeable, interconnected voids that drains quickly. Typically, between 15% and 25% voids are achieved in the hardened concrete, and flow rates for water through pervious concrete are typically around 480 in./hr. (0.34 cm/s, which is 5 gal/ft²/ min or 200 L/m²/min), although they can be much higher. The low paste content and high voids reduce strength compared to conventional concrete mixtures; however, sufficient strength for heavy duty applications is readily achieved.

Photo credit: South Dakota Ready Mixed Concrete Association (www.sdrmca.org)

Figure 32: Porous Concrete

Pervious/porous concrete information from ***SCDHEC Stormwater BMP Handbook 2005:***
Porous pavement options include porous asphalt, pervious concrete, and grass pavers. The ideal application for porous pavement is to treat low-traffic or overflow parking areas. Porous

pavement also has highway applications where it is used as a surface material to reduce hydroplaning.

Porous Concrete Design Criteria:

Take a soil boring to a depth of at least 4 feet below bottom of stone reservoir to check for soil permeability, porosity, depth of seasonally high water table and depth to bedrock.

- Not recommended on slopes greater than 5% and best with slopes as flat as possible.
- Minimum setback from water supply wells: 100 Feet
- Minimum setback from building foundations: 10 feet down gradient, 100 feet up gradient.
- Not recommended where wind erosion supplies significant amounts of sediment.
- Use on drainage areas less than 15 acres.
- Minimum soil infiltration rate of 0.3 – 0.5 inches per hour.

Typically design for storm water runoff volume produced in the tributary watershed by the 6 month 24 hour duration storm event.
A typical porous pavement cross-section consists of the following layers:

1. Porous asphalt course 2-4 inches think.
2. Reservoir course of 1.5 to 3 inch stone.
3. Filter aggregate course, and
4. Filter fabric.

Use a geotextile meeting AASHTO M288 Class 1, 2, or 3 in all cases as a filter to protect the long-term performance of the system.

Inspection and Maintenance:

- Porous pavement requires extensive maintenance compared with other practices.
- Avoid sealing or repaving with non-porous materials
- Ensure that paving area is clean of debris, paving dewaters between storms, and that the area is cleaned to remove sediments monthly (vacuumed).
- Mow upland and adjacent areas, and seed bare areas as needed.
- Vacuum sweep frequently to keep the surface free of sediment as needed.
- Inspect the surface for deterioration or spalling annually.
- Perform high pressure hosing to free pores in the top layer from clogging as needed.

Porous concrete is available in SC. Please visit the website:

http://secement.org/ for a list SC contractors or their pervious concrete page
http://secement.org/products/pervious-concrete/

Learn more about using porous concrete in our region and case studies, contact:

Carolinas Ready Mixed Concrete Association
Phone: (704) 717-9199
Geographical Area: North and South Carolina
http://www.crmca.com/

Local Firms that are certified installers of pervious concrete in our area:

- Construction Perfected, Inc., North Augusta, SC
- TT & S Concrete, Aiken and
- Quality Concrete of Aiken.

CHAPTER 9   WATER QUALITY CREDITS

Stream Buffer or Filter Strip Credit

This credit encourages the use of stream buffers and filter strips to treat stormwater runoff at the site level. Specific criteria for the buffer itself will vary between communities.

Stream Buffer or Filter Strip: Summary		
Goals	Preserve natural buffers Use green space and buffers to treat stormwater runoff	
Stormwater Management Objectives	Recharge, water quality	Subtract area draining to the buffer from the water quality requirements.
	Channel Protection/Flood Control	Treat the area draining to the buffer as "woods in good condition"

Designers can receive credit for treating stormwater runoff areas adjacent to a filter strip or designated stream buffer using site grading. Credits include:

- Area draining to the buffer is subtracted from the calculations for water quality and recharge volume.
- The curve number of areas draining to the buffer preserved in natural vegetation shall receive a curve number adjustment to reflect woods in good condition.

To receive the credit, the buffer must meet the following criteria:

- The minimum undisturbed buffer or filter strip width shall be 50 feet.
- The maximum contributing length to the buffer or filter strip shall be 150 feet for residential developments, and 75 feet for commercial developments.
- If the overland flow path is greater than 50 feet, a level spreader shall be used to establish sheet flow.
- The average contributing overland slope shall be less than or equal to 3 percent.
- The buffer shall be preserved in a conservation easement or similar protective mechanism.

The credit for water quality volume can be determined based on the required water quality volume, and the fraction of the site draining to buffers, such that:

$C = (A_B/A)WQ_v$

Where:

C = Buffer Credit (ac-ft)

A_b = Area Draining to the Buffer (Acres)

A = Total Site Area (Acres)

Wq_v = Original Water Quality Volume (ac-ft)

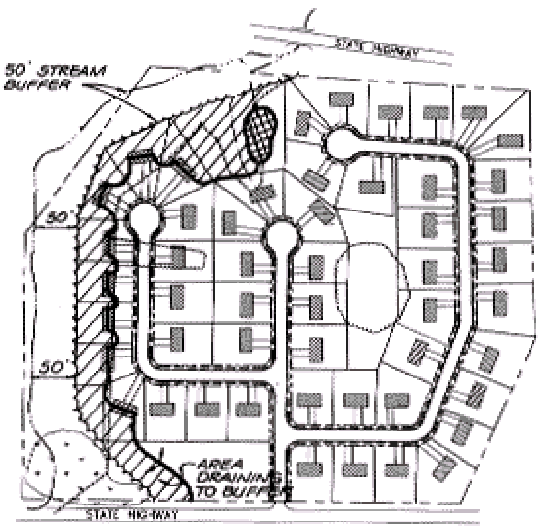
The water quality volumes can then be reduced by the volume of the credit (C). The example in Figure 33 below illustrates how this credit would be applied.

Stream Buffer Credit Example

Site Data - 51 Single Family
Area = 38.0 ac
Original Impervious Area = 13.8 ac = 36.3%
Post-dev. CN = 78

Original WQ_v = 1.08 ac-ft
Rechage Fraction (S) = 0.22
Original Re_v = 0.24 ac-ft
Original Cp_v = 1.65 ac-ft
Original Qp_v = 2.83 ac-ft

Credit
5.0 ac draining to buffer/filter strip



Computation of Stormwater Credits

$C = (5/38) \cdot (1.08 \text{ ac-ft}) = 0.14$ ac-ft

$WQ_v = (1.08 \text{ ac-ft}) - (0.14 \text{ ac-ft}) = 0.94$ ac-ft

$Re_v = (0.24 \text{ ac-ft}) - (0.14 \text{ ac-ft}) = 0.10$ ac-ft

Cp_v and Q_p : CN is slightly reduced.

Figure 33. Stream Buffer Credit Example

Conservation of Natural Areas Credit
This credit rewards protection of natural vegetation or critical resource areas on site.

Conservation of Natural Areas: Summary:		
Goals	Encourage the preservation of natural areas and critical resources on site.	
Stormwater Management Objectives	Water Quality	Credit area in natural conservation areas toward water quality requirements.
	Recharge	Express as a fraction of the water quality credit.
	Channel Protection, Flood Control	Use "woods in good condition" to characterize conservation areas.

A stormwater credit is given when natural areas are conserved at development sites, thereby retaining their pre development hydrologic and water quality characteristics. Examples of natural area conservation areas include:

- forest retention areas
- wetlands and associated buffers
- Areas known to contain threatened or endangered species
- other lands in protective easement (floodplains, open space, steep slopes)

Under the credit, a designer can subtract conservation areas from total site area when computing the water quality volume. As an additional incentive, the post development curve number (CN) used to compute water quantity parameters shall be forest in good condition.

The credit for the water quality volume can be based on the site area in natural conservation, such that:

$C_{WQ} = (A_{NA}/A)(WQ_v)$

Where:

C_{WQ} = Natural Area Credit for Water Quality (ac-ft)

A_{NA} = Natural Conservation Area (acres)

A = Total Site Area (acres)

WQ_v = Original Water Quality Volume (ac-ft)

Impervious Area Disconnection

This credit is applied to credit disconnection of impervious surfaces by encouraging drainage to overland treatment such as swales or filter strips.

Impervious Area Disconnection: Summary		
Goals	Encourage the use of overland flow or infiltration areas to treat rooftop runoff.	
Stormwater Management Objectives	Water Quality/ Recharge	Subtract the total disconnected area from the site's impervious cover.
	Channel Protection, Flood Control	Adjust disconnected impervious area to reflect woods in good condition.

In the impervious area disconnection credit, disconnected areas are subtracted from the total site impervious cover, and assigned a curve number for woods in good condition. In order to receive the credit, disconnections must meet the following criteria:

- The credit is not applicable for residential construction.
- The maximum contributing impervious flow path length shall be 75 feet.
- The disconnection must drain continuously through a vegetated channel, swale, or filter strip to the property line or STP.
- The length of the "disconnection" must be equal to or greater than the contributing length.
- The entire vegetative "disconnection" shall be on a slope less than or equal to 3.0%.
- The surface imperviousness area to any one discharge location cannot exceed 1,000 ft^2.

- Disconnections discharging over relatively permeable soils (HSGs A and B) do not require geotechnical testing.

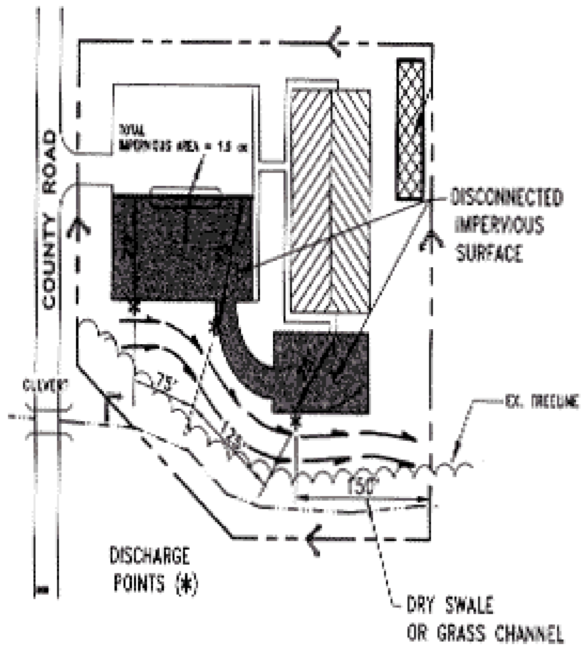
The water quality credit can be calculated with the following equation:
$C = (A_D/A_I)WQ_v$
Where:
C = Impervious area disconnection credit (ac-ft)
A_D = Disconnected Impervious Area (acres)
A = Total site area (acres)
A_I = Site Impervious Area (acres)
WQ_v = Original Water Quality Volume.

Water quality volumes are then reduced by the credit (C). Quantity credit is achieved by assigning disconnected rooftops a curve number equal to forest in good condition. The example in Figure 34 illustrates how this credit would be applied.

Non-Rooftop Disconnection Credit Example

Site Data - Community Center
Area = 3.0 ac
Original Impervious Area = 1.9 ac. = 63.3%
Post-dev. CN = 83
Original WQ_v = 6,752 ft^3
Recharge Fraction (S) = 0.25
Original Re_v = 1,688 ft^3
Original Cp_v = N/A
Original Qp_v = 10,630 ft^3

0.8 ac of surface imperviousness disconnected



Computation of Stormwater Credits

$C = (0.8/1.9) \cdot 6{,}752\ ft^3 = 2{,}843\ ft^3$

$WQ_c = 6{,}752\ ft^3 - 2{,}843\ ft^3 = 3{,}909\ ft^3$

Since the C value is greater than the original recharge volume, the recharge requirement is met by this credit.

Cp_v and Q_p : Post-dev CN reduced from 83 to 73

Figure 34. Non Rooftop Disconnection Credit Example

References

Anderson, L.M. and H.K. Cornell. "Residential Property Values Improved by Landscaping With Trees." *Southern Journal of Applied Forestry* pp 162-6.

Arendt, Randall. 1994. *Rural by Design*. American Planning Association. Planners Book Service. Chicago, IL

Arendt, Randall. 1996. *Conservation Design for Subdivisions: A Practical Guide to Creating Open Space Networks.* American Planning Association Planners Book Service. Chicago, IL
Center for Watershed Protection (CWP). 1998. *Better Site Design: A Handbook for Changing Development Rules in Your Community*. Ellicott City, MD.

Delaware Department of Natural Resources and Environmental Control (DE DNREC) and The Environmental Management Center of the Brandywine Conservancy. 1997. *Conservation Design for Stormwater Management.*

Dreher, D.W. and T.H. Price. 1994. *Reducing the Impacts of Urban Runoff: The Advantages of Alternative Site Design Approaches*. Northeastern Illinois Planning Commission. Chicago, Il.

Ferguson, Bruce K. 2005. *Porous Pavements*. Boca Raton, FL: CRC Press.

Hun-dorris, T. 2005. *Advances in Porous Pavement*. Stormwater, Vol. No. 2 March/April 2005 pp 82-88.

Lacey, J. and R. Arendt 1990. *An Examination of Market Appreciation for Clustered Housing with Permanently Protected Open Space*. Center for Rural Massachusetts, Amherst, MA. 14 pp.

Liptan, T. and C.K. Brown. 1996. *A Cost Comparison of Conventional and Water Quality-Based Stormwater Designs.* City of Portland. Bureau of Environmental Services. Portland, OR. 16 pp.

Maurer, George. 1996. *A Better Way to Grow: For More Livable Communities and a Healthier Chesapeake Bay.* Chesapeake Bay Foundation, Annapolis, MD.

Montgomery County (Pennsylvania) Planning Commission. *Guidelines for Open Space Management in the Land Preservation District.* Norristown, PA

National Association of Homebuilders (NAHB). 1986. *Cost Effective Site Planning*. Washington, D.C.

Schueler, Thomas R. 1995. *Site Planning for Urban Stream Protection.* Center for Watershed Protection. Ellicott City, MD.

South Carolina Coastal Conservation League (SCCCL). 1995. "Getting a Rein on Runoff: How Sprawl and Traditional Towns Compare." *SCCCL Land Development Bulletin* (Number 7). Charleston, SC.

Bay Area Stormwater Management Agencies Association (BASMAA). *Start at the Source: Residential Site Planning and Design Guidance Manual for Stormwater Quality Protection*. BASMAA, San Francisco, CA. January 1997.

Center for Watershed Protection. *Better Site Design: A Handbook for Changing Development Rules in Your Community.* Center for Watershed Protection, Inc., Ellicott City, MD. 1998.

Schueler, Thomas R. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*. Metropolitan Washington Council of Governments, Washington, DC. 1987.

Schueler, Thomas R. *Urban Runoff in the Washington Metropolitan Area.* Metropolitan Washington Council of Governments, Washington, DC. 1983.

Smith, David R. *Life Cycle and Energy Comparison of Grass Pavement and Asphalt Based on Data and Experience from the Green Parking Lot*. The Heritage Conservation and Recreation Service, Order No. A-4331-4. 1981.

Smith, David R. and Sholtis, David A. *An Experimental Installation of Grass Pavement.* The Heritage Conservation and Recreation Service, Order No. A-4331-4. 1981.

Appendix A: WET POND PLANTING GUIDE

Zone #	Zone Description	Hydrologic Conditions
Zone 1	Deep Water Pool	1-6 feet depth (permanent pool)
Zone 2	Shallow Water Bench	Normal pool elevation to 1 foot depth
Zone 3	Shoreline Fringe	Regularly inundated
Zone 4	Riparian Fringe	Periodically inundated
Zone 5	Floodplain Terrace	Infrequently inundated
Zone 6	Upland Slopes	Seldom or never inundated

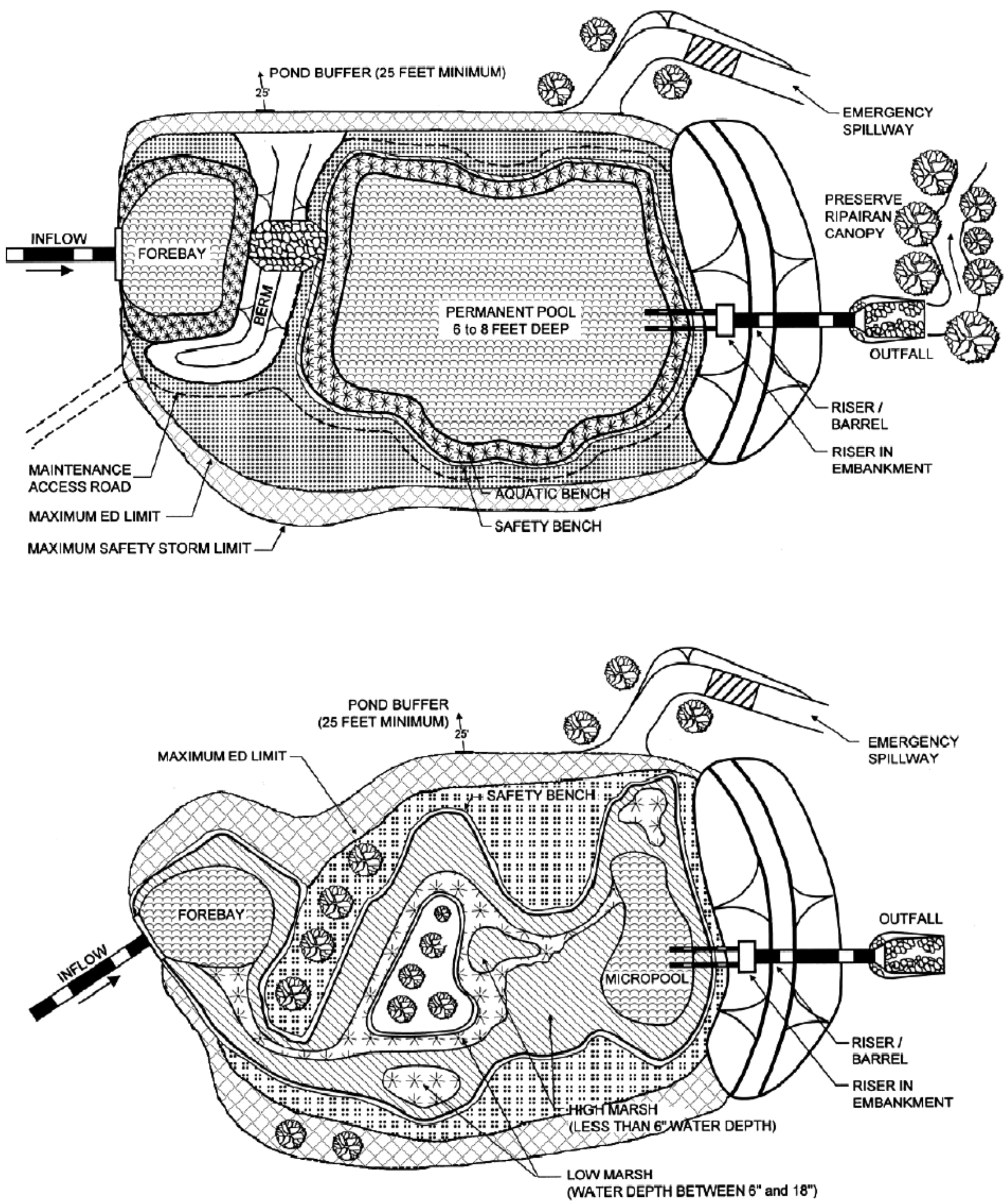
Grasses, Bulbs, Succulents

Scientific Name	Common Name	Hydrologic Zone
Acorus calumus	Sweetflag	2
Andropogon glomeratus	Bushy Broom Grass	3
Andropogon virginicus	Broom Grass	4
Canna flaccida	Golden Canna	2
Carex spp.	Caric Sedges	2
Chasmanthium latifolium	Upland Sea-Oats	3
Coreopsis leavenworthii	Tickseed	2
Coreopsis tinctoria	Dwarf Tickseed	3
Crinum americanum	Swamp Lily	2
Cyperus odoratus	Flat Sedge	2
Eleocharis cellulosa	Coastal Spikerush	2
Eleocharis interstincta	Jointed Spikerush	2
Eupatorium fistolosum	Joe Pye Weed	4
Helianthus angustifolius	Swamp Sunflower	2
Hibiscus coccinieus	Swamp Hibiscus	2
Iris louisiana	Louisiana Iris	2
Scientific Name	**Common Name**	**Hydrologic Zone**

Iris virginica	Southern Blue-Flag	2
Juncus effusus	Soft Rush	2
Leersia oryzoides	Rice Cut Grass	2
Liatris spicata	Spiked Gayfeather	3
Lobelia cardinalis	Cardinal Flower	3
Nuphar luteum	Spatterdock	1
Nymphaea mexicana	Yellow Water Lily	1
Nymphaea odorata	Fragrant Water Lily	1
Osmunda cinnamomea	Cinnamon Fern	3
Osmunda regalis	Royal Fern	3
Panicum virgatum	Switchgrass	2
Peltandra virginica	Green Arum	2
Polygonum hydropiperoides	Smartweed	2
Pontederia cordata	Pickerelweed	2
Pontederia lanceolata	Pickerelweed	2
Rudbeckia hirta	Black-eyed Susan	4
Sagittaria lancifolia	Lance-leaf Arrowhead	2
Sagittaria latifolia	Duck Potato	2
Saururus cernuus	Lizard’s Tail	2
Scirpus americanus	Three-square	2
Scirpus californicus	Giant Bulrush	2
Scirpus validus	Softstem Bulrush	2
Sorgham nutans	Yellow Indian Grass	4
Thalia geniculata	Alligator Flag	2
Typha spp.	Cat-tail	2
Vernonia gigantea	Ironweed	4
Woodwardia virginica	Virginia Chain Fern	2

Trees

Scientific Name	**Common Name**	**Zone**
Acer rubrum	Red Maple	4-5
Acer saccharium	Silver Maple	4-5
Betula nigra	River Birch	4-5
Catalpa bignonoides	Southern Catalpa	4-5
Liriodendron tulipifera	Tulip Poplar	4-5
Magnolia grandiflora	Southern Magnolia	4-5
Quercus michauxii	Swamp Chestnut Oak	4-5
Quercus nigra	Water Oak	4-5
Salix babylonica	Weeping Willow	4-5
Salix nigra	Black Willow	4-5
Taxodium distichum or Taxodium distichum var. nutans	Baldcypress Pondcypress	3-5



Hydrologic Planting Zones

Bioretention Planting Guide

Trees	**Shrubs**	**Herbaceous Species**
Acer rubrum Red Maple	*Aesculus pariviflora* Bottlebrush Buckeye	*Andropogon virginicus* Broomsedge
Betula nigra River Birch	*Aronia arbutifolia* Red Chokeberry	*Eupatorium perpurea* Joe Pye Weed
Juniperus virginiana Eastern Red Cedar	*Fothergilla gardenii* Fothergilla	*Hemerocalis spp.* Day Lily
Koelreuteria paniculata Golden Rain Tree	*Hamemelis virginiana* Witch Hazel	*Iris pseudacorus* Yellow Iris
Nyssa sylvatica Black Gum	*Hypericum densiflorum* Common St. Johns Wort	*Lobelia cardinalis* Cardinal Flower
Platanus acerifolia London Plane-Tree	*Ilex glabra* Inkberry	*Panicum virgatum* Switchgrass
Platanus occidentalis Sycamore	*Ilex verticillata* Winterberry	*Pennisetum alopecuroides* Fountaingrass
Quercus palustris Pin Oak	*Juniperus horizontalis* Creeping Juniper	*Rudbeckia laciniata* Greenhead Coneflower
Quercus phellos Willow Oak	*Lindera benzoin* Spicebush	*Scirpus cyperinus* Woolgrass
Salix nigra Black willow	*Myrica pennsylvanica* Bayberry	*Vernonia gigantea* Ironweed

Appendix B: CITY OF NORTH AUGUSTA ORDINANCE NO. 2021-22

ORDINANCE NO. 2021-22
AMENDING CHAPTER 14, ARTICLE V, DIVISION 3
OF THE CITY CODE OF THE
CITY OF NORTH AUGUSTA, SOUTH CAROLINA

BE IT ORDAINED BY THE MAYOR AND CITY COUNCIL OF THE CITY OF NORTH AUGUSTA, SOUTH CAROLINA, IN MEETING DULY ASSEMBLED AND BY THE AUTHORITY THEREOF, THAT:

I. Chapter 6, Article V, Division 3 entitled "Construction Permitting for Land Disturbing Activities," is hereby amended, and when amended shall read as follows:

DIVISION 3. CONSTUCTION PERMITTING FOR LAND DISTURBING ACTIVITIES

Section 14-170. Purpose/intent

(No Change)

Section 14-170.1 Definitions

Bioretention: A stormwater treatment practice that uses a combination of plants and pervious soils to treat water quality and, to a limited extent, may address water quantity.

Clearing: Any activity that removes the vegetative surface cover.

Constructed wetland: A shallow water quality pond that mimics natural wetland functions using wetland plants.

Drainage way: Any channel that conveys surface runoff throughout the site.

Erosion control: Measures that minimize or prevent erosion such as mulches, erosion control matting, and grassing.

Erosion and sediment control plan: A set of plans prepared by or under the direction of a licensed professional engineer that indicates the specific measures and sequencing to be used in controlling sediment and erosion on a development site both before, during and after construction.

Forebay: A small pond at the head of a detention pond for the purpose of collecting sediment and facilitating simplified sediment removal.

Grading: Excavation or fill of material, including the resulting conditions thereof.

Perimeter control: A barrier that prevents sediment from leaving a site either by filtering sediment-laden runoff, or diverting it to a sediment trap or basin.

Phasing: Clearing a parcel of land in distinct phases, with the stabilization of each phase before the clearing of the next.

Sediment control: Measures that prevent eroded sediment from leaving the site.

Site: A parcel of land, or a contiguous combination thereof, where grading work is performed as a single unified operation.

Stabilization: The use of practices that prevent exposed soil from eroding (usually grass, mulch, geotextile fabric, or rock).

Start of construction: The first land-disturbing activity associated with a development, including land preparation such as clearing, grading and filling; installation of streets and walkways; excavation for basements, footings, piers or foundations; erection of temporary forms; and installation of accessory buildings such as garages.

Stormwater management manual: The manual produced by the city stormwater management department that provides requirements, guidance, and technical specifications for complying with this division.

Stormwater Maintenance Agreement: A written agreement from the landowner or responsible party assuring the maintenance and inspection of storm water management facilities and/or Best Management Practices related to them are maintained in proper working condition as shown or described on the approved development site plan in order to serve the intended purposes as set forth in this Ordinance and state regulations. The agreement grants permission of City or State inspectors to verify compliance. The agreement must be recorded with the land record for the parcel in the county it is located.

Stormwater treatment practice (STP): Any structural method of treating stormwater quantity or quality.

Section 14-170.2. Stormwater management permit required; exceptions.

(a) The surface of land in the city shall not be disturbed or altered for any purpose whatsoever until a stormwater management permit is issued to the person responsible for such construction. No permit shall be issued until the applicant has submitted a plan to control erosion and sedimentation and such plan has been approved by the city engineer or his designated representative. Additional permits required, must be acquired prior to start of construction.

(b) Exemptions.

(1) Any emergency activity that is immediately necessary for the protection of life, property or natural resources.

(2) Existing nursery and agricultural operations conducted as a permitted main or accessory use.

(3) Land disturbing activities undertaken on forest land for the production and harvesting of timber and timber products.

(4) Land disturbing activities conducted pursuant to a federal environmental permit, including permits issued under section 404 of the Federal Clean Water Act.

(5) Projects regulated under the SC Mining Act.

(6) Construction, renovation or land improvement of single-family residences, one duplex dwelling or their accessory buildings which are separately built and not part of a

subdivision development, and not located within the designated 100-year floodplain, provided that such construction does not materially impede the runoff capability of the existing major drainage channels.

(7) Certain activities undertaken by utility providers that are not substantial land disturbing activities and are therefore not intended to be regulated by this chapter. These activities include but are not limited to the following:

a. Installation of utilities on sites of one acre or less.

b. Projects undertaken under jurisdiction of the state public service commission, and including work permitted by the Federal Energy Regulatory Commission.

c. Installation of utilities in a ditch section one foot or less in width.

d. Installation of utility poles.

e. Maintenance of easements and rights-of-way.

f. Service connections (i.e. tapping mains lines and/or setting meters, including installation of a manhole, valve box or fire hydrants).

g. Emergency repairs.

(8) Construction activities of the state department of transportation.

(9) Activities relating to the routine maintenance and/or repair or rebuilding of the tracks, rights-of-way, bridges, and any other related structures and facilities of a railroad company.

(10) Minor land disturbing activities, as determined by the city engineer, which would not violate the integrity of this chapter.

Section 14-170.3. Application, review and approval, and issuance of stormwater management permit.

(a) *Application.* All applications for stormwater management permits shall be submitted to the Stormwater Management Department (SWMD) through the Planning and Development Department for processing and permit issuance. Applications for permits shall be accompanied by three (3) copies of the applicants stormwater and erosion control plan. Stormwater and erosion control plans shall conform to the requirements of section 14-174.

(1) Each application shall bear the name(s) and address(es) of the owner or developer of the site, and of any consulting firm retained by the applicant together with the name of the applicant's principal contact at such firm.

(2) Each application shall include a statement that any land clearing, construction, or development involving the movement of earth shall be in accordance with the erosion and sediment control plan, and that an authorized representative shall inspect the site every seven (7) days and after every one-half-inch rain to ensure compliance with the plan.

(b) *Fee.* The application shall be accompanied by nonrefundable fee.

(c) *Review and approval.* The SWMD will review each application for a stormwater management permit to determine its conformance with the provisions of this regulation. Within ten (10) working days after receiving an application, the SWMD shall, in writing:

(1) Approve the permit application;

(2) Approve the permit application subject to such reasonable conditions as may be necessary to secure substantially the objectives of this regulation, and issue the permit subject to these conditions; or

(3) Disapprove the permit application, indicating the deficiencies and the procedure for submitting a revised application and/or submission.

Failure of the SWMD to act on original or revised applications within ten (10) working days of receipt shall authorize the applicant to proceed in accordance with the plans as filed unless such time is extended by agreement between the applicant and the SWMD.

Major amendments of the stormwater and erosion control plan shall be submitted to the SWMD and shall be processed and approved, or disapproved, in the same manner as the original plans for a fee assessed at fifty percent (50%) of the original stormwater review fee for the permit. Field modifications of a minor nature may be authorized by the SWMD by written authorization to the permittee.

<u>Transfer of ownership of permitted projects is allowed with proper notification to the stormwater department during the permit period.</u>

Section 14-170.4. Stormwater and erosion control plans

(a) *General requirements.*

(1) Stormwater and erosion control plans for land disturbance activities of one (1) acre or more must be prepared by a registered professional engineer, registered landscape architect, or tier B land surveyor licensed by the state.

(2) Applications shall include a natural resources map identifying soils, forest cover, and resources protected by other agencies having jurisdiction.

(3) A sequence of construction of the development site, including stripping and clearing, rough grading, construction of utilities, infrastructure, and buildings, and final grading and landscaping. Sequencing shall identify the expected date on which clearing will begin, the estimated duration of exposure of cleared areas, and the sequence of clearing, installation of temporary erosion and sediment measures, and establishment of permanent vegetation.

(4) Provisions for maintenance of stormwater control facilities, including easements and estimates of the cost of maintenance. An executed, signed, and notarized maintenance agreement and maintenance plan from the responsible party(ies) or individuals(s) accepting ownership and maintenance of permanent stormwater control devices/structures during construction must be provided prior to stormwater permit issuance.

a. A notarized permanent stormwater maintenance responsibility agreement and a maintenance plan for stormwater control facilities or treatment practices must be executed and must be recorded as part of the land/property record in the county where it is located and the agreement constitutes a covenant running with the land, and shall be binding on the Landowner, its administrators, executors, assigns, heirs and any other successors in interests, including but not limited to any homeowners' association. This step must be completed prior to requesting a notice of termination (NOT) for your stormwater permit.

b. Any changes in permanent maintenance responsibilities must be documented with a new notarized maintenance agreement and maintenance plan and recorded with the land in the county in which it resides as soon as approved by the city. The city must be notified of the change by providing a new notarized agreement and a letter of acceptance from the entity accepting permanent maintenance responsibilities. Prior to executing a change of ownership of maintenance responsibility, a letter of inspection may be requested by either party involved and obtained from the city SWMD at no fee. Subsequent inspection letters if requested will be available for a $50.00 fee to be paid prior to the inspection.

c. Failure to execute, record and/or acquire approval from the city for a change of ownership and maintenance responsibilities agreement for the stormwater control devices at a site constitutes leaving the original recorded agreement in force, and that agreement will be enforceable by the stormwater department for maintenance responsibility.

(b) *Water quantity design requirements.*

(1) Stormwater management requirements for a specific project shall be based on the entire area to be developed, or if phased, the initial submittal shall control that area proposed in the initial phase and establish a procedure and obligation for total site control.

(2) Post-development peak discharge rates shall not exceed pre-development discharge rates for the two-, ten-, and twenty-five-year frequency twenty-four-hour duration storm event.

(3) Discharge velocities shall be reduced to provide a nonerosive velocity flow from a structure, channel, or other control measure or the velocity of the twenty-five-year, twenty-four-hour storm runoff in the receiving waterway prior to the land disturbing activity, whichever is greater.

(4) Watersheds, other than designated watersheds, that have well documented water quantity problems may have more stringent, or modified, design criteria as determined by the SWMD for development or redevelopment.

(5) An emergency spillway should safely pass the 100-year storm event.

(6) Dry ponds must dewater within seventy-two (72) hours.

(7) Additional requirements are found in the stormwater management manual.

(c) *Water quality design requirements.*

(1) *Clearing and grading.*

a. Clearing and grading of natural resources, such as forests and wetlands, shall not begin until all applicable local, state, and federal permits have been granted.

b. Clearing techniques that retain natural vegetation and retain natural drainage patterns, as described in the stormwater management manual, should be used.

c. Phasing shall be required on all sites disturbing greater than twenty (20) acres, with the size of each phase to be established at plan review and as approved by the SWMD.

d. Clearing, except that necessary to establish sediment control devices, shall not begin until all sediment control devices have been installed and have been stabilized.

(2) *Erosion control.* Plans shall include all erosion and sediment control measures necessary to meet the objectives of this regulation throughout all phases of construction and permanently, after completion of development of the site.

a. Soil must be stabilized within fourteen (14) days of clearing or inactivity in construction.

b. If vegetative erosion control methods, such as seeding, have not become established within twenty-one (21) days, the SWMD may require that the site be reseeded, or that a non-vegetative option be employed.

c. On steep slopes or in drainage ways, special techniques that meet the design criteria outlined in the stormwater management manual shall be used to ensure stabilization.

d. Soil stockpiles must be stabilized or covered within twenty-one (21) days of inactivity.

e. Techniques shall be employed to prevent the blowing of dust or sediment from the site.

f. Techniques that divert upland runoff past disturbed slopes shall be employed.

g. Energy dissipation shall be provided at all outfalls.

(3) *Sediment control.*

a. Sediment controls shall be provided in the form of settling basins or sediment traps or tanks, and perimeter controls.

b. Where possible, settling basins shall be designed in a manner that allows adaptation to provide long-term stormwater management.

c. Adjacent properties shall be protected with perimeter controls.

d. A fifty-foot long by six-inch deep stone construction exit shall be provided.

(4) *Stormwater treatment practices.* Post-construction water quality must be addressed for all sites containing one or more acres of disturbance.

a. Water quality volume design requirements require implementation of the one-inch sizing criterion.

One-inch sizing: The first one inch of water from any storm event, draining from that portion of the site that discharges to the stormwater treatment unit, must be collected and released over a twenty-four-hour period.

b. Dry ponds are not an acceptable stand-alone water quality treatment technology. When used they should be proceeded by a forebay and used in conjunction with infiltration, vegetative filters, or inline treatment. Dry ponds must dewater within seventy-two (72) hours.

c. Technologies that may be used to meet water quality requirements include but are not limited to infiltration, bioretention, in-line treatment devices, disconnected impervious areas, vegetated filter strips, constructed wetlands, and wet ponds. Vegetative swales combined with bioretention or another infiltration technology is the preferred method of water quality treatment. Landscaped areas should be designed, where possible, to incorporate stormwater management. Peak flow control may be achieved by adding inline or overflow storage such as parking lot detention, pipe storage or a dry pond.

Sec. 14-170.5. Design guidelines.

Specific requirements, guidance and technical specifications for compliance with this ordinance are found in the city stormwater management manual. Although the intention of the plan is to establish uniform design practices, it neither replaces the need for engineering judgment nor precludes the use of information not presented. Other accepted engineering and construction procedures and practices may be used if approved by the SWMD.

Sec. 14-170.6. Variances.

The Stormwater Management Department may grant a written variance from any requirement of the stormwater management requirements if there are exceptional circumstances applicable to the site such that strict adherence to the provisions of these regulations will result in unnecessary hardship and not fulfill the intent of the policy. A written request for variance shall be provided to the SWMD and shall state the specific variances sought and the reasons with supporting data for their granting. The SWMD shall not grant a variance unless and until the applicant provides sufficient specific reasons justifying the variance. The SWMD will conduct its review of the request for variance within ten (10) working days. Failure of the SWMD to act by the end of the tenth working day will result in the automatic approval of the variance.

A project may be eligible for a waiver or variance of stormwater management for water quantity control if the applicant can demonstrate that:

(1) The proposed project will return the disturbed area to a pre-development runoff condition and the pre-development land use is unchanged at the conclusion of the project.

(2) The proposed project does not increase the rate of runoff from a site by more than one cfs for each of the two-, ten- and twenty-five-year storm events and the disturbed area is less than one acre.

(3) The proposed project will have no significant adverse impact on the receiving natural waterway or downstream properties; or

(4) The imposition of peak control requirements for rates of stormwater runoff would aggravate downstream flooding.

Sec. 14-170.7. Inspection.

(a) The SWMD shall conduct routine inspections and shall either approve that portion of the work completed or shall notify the permittee wherein the work fails to comply with the stormwater and sediment control plan as approved. Plans for grading, stripping, excavating, and filling work bearing the stamp of approval of the SWMD shall be maintained at the site during the progress of the work. The permittee shall notify the SWMD at least two (2) working days before the start of construction.

(b) The permittee or his/her agent shall make regular inspections of all control measures at least every seven (7) days and after every one-half-inch rain event. The purpose of such inspections will be to determine the overall effectiveness of the stormwater and sediment control plan, and the need for additional control measures. All inspections shall be documented in written form.

(c) The SWMD shall enter the property of the applicant as deemed necessary to make regular inspections to ensure the validity of the reports.

(d) If inspection of a project results in an "unsatisfactory" rating indicating noncompliance with the site permit, upon request one follow-up re-inspection to verify compliance will be conducted at no charge. All subsequent inspections requested by the permit holder or project manager to verify the site has been brought back into compliance will require a $50.00 re-inspection fee to be paid to the city prior to re-inspection. The city utilizes an Enforcement Response Plan (ERP) that fully explains the inspection protocols, ratings, time frames set to bring the site into compliance, and enforcement policy.

(e) The SWMD shall make regular post-construction maintenance inspections of stormwater treatment and control devices and provide a written report to the owner of record (per the stormwater maintenance agreement, or if none, the property owner) of such device outlining deficiencies and required corrective actions.

Section 14-170.8. Construction site pollution prevention

(No Change)

Section 14-170.9. Enforcement

(No Change)

II. All Ordinances or parts of Ordinances in conflict herewith are, to the extent of such conflict, hereby repealed.

III. This Ordinance shall become effective on second and final reading.

DONE, RATIFIED AND ADOPTED BY THE MAYOR AND CITY COUNCIL OF THE CITY OF NORTH AUGUSTA, SOUTH CAROLINA, ON THIS 20th DAY OF DECEMBER, 2021.

First Reading December 6, 2021

Second Reading December 20, 2021

Briton S. Williams, Mayor

ATTEST:

Sharon Lamar

Sharon Lamar, City Clerk

Appendix C: General Sizing Examples for Rain Gardens, Filter Strips and Infiltration Trenches

Excel Spreadsheet templates that correspond to the following are available and can be downloaded on the city website or other internet sites.

Note these spreadsheets and their development was produced by other entities (credit is on the spreadsheets). If you see a problem, let us know.

10/1/2007
Updated for 2007
NCDENR BMP Manual
as Amended

Rain Garden Sizing
Water Quality Volume WQv

Rv = runoff coefficient (Runoff/Rainfall)
Rv = 0.05 + 0.009(I) Where "I" = % Impervious
("Simple Method" - Schueler, 1987)
NCDENR April 1999

WQv = 1.0"RvA / 12

Fill in Values:

"I" =	100	Percent	Impervious of Site
"A" =	1	Acres	5 Acre Maximum

Answer:

WQv =	0.079	Ac. Ft.
	3448	Cubic Feet Required
Insert	1.71	CFS Peak Flow for 1"- 6 Hr. Storm
	21	Length of Level Spreader for 1" @ 1 fps

SCS	
Method	3013
	CF

Compute CNm

Rv=	0.95	
WQv=	0.95	inches
CNm=	99.6	Use to compute $Q_{1"}$

Rain Garden Area

Formula:
$$A_f = \frac{(WQv)(Df)}{((k)(Hf+Df)(Tf))}$$
From Georgia Design Manual
Section 3.2.3.6
(Based on Darcy's Law)
Maryland Design Manual
Page 3.40

Where:
Af = Surface area of Rain Garden (S.F.)
WQv = Water Quality Volume to be Captured
Df = Filter Bed Depth (2 feet min. for grasses, 3 to 4 feet for trees)
k = permeability coefficient of filter media (use 1 Ft./Day for amended soil mix)
*** See Maryland Stormwater Design Manual, Page 3.40**
Hf = Average height of water above filter bed
(use 3 to 6 inches, which is one-half of 6" to 12" pond depth)
Tf = Design filter bed drain time in days
*** (Use 1 Day)**

Fill in Values:

"k" =	1	Ft./Day*
Df =	3	Feet
Hf =	6	inches
Tf =	1.5	Days*

Soil Type	K (in./hr.)	K (Ft/Day)	
Sand	6	12	
Loamy Sand	2	4	
Sandy Loam	0.5 - 1	1 - 2	NCDENR recommends 1-2 in./Hr.
Silty Loam	0.02	0.05	

Required Size

Af = 1970 SF Required assuming infiltration during rainfall
3448 SF Req. by DENR Manual
22.11 SF Impervious Per SF of Rain Garden — 4.52 % of impervious site

31 Width — Approximate Size
63 Length
10' x 20' Minimum

5.25 Depth from top of water surface to invert of underdrain.

Water Draw Through Rate:
Darcy's Equation:
Q = (.0000232)*K*A*(H/L) — **Q = 0.0305 cfs**
Where:
Q = Flow (Rate of Draw) through Bioretention Soil (cfs)
K = Hydraulic Conductivity of soil (in./hr.) (Usually 1"/Hour)
A = Surface Area of Bio-Retention Area (SF)
H = Height of Water above Drainage Pipe (Underdrain)
L = Thickness of Soil Bed (Usually 4' for Trees, 2' for Shrubs)
Assume (H/L) ~ 1

Time to Drawdown water from Inundation to Saturation at Surface:

Volume/Q: 32328 Seconds
9.0 Hours to Saturation

Time to lower Water Table to 2.0 feet below surface:
Assume 40% Porosity
Volume = Area x 2' x 0.40
= 1576.4 Cubic Feet
= 51724 Seconds
= 14.4 Hours to Lower Water 2' below surface
23.3 Hours to Draw Water Through Soil Layer

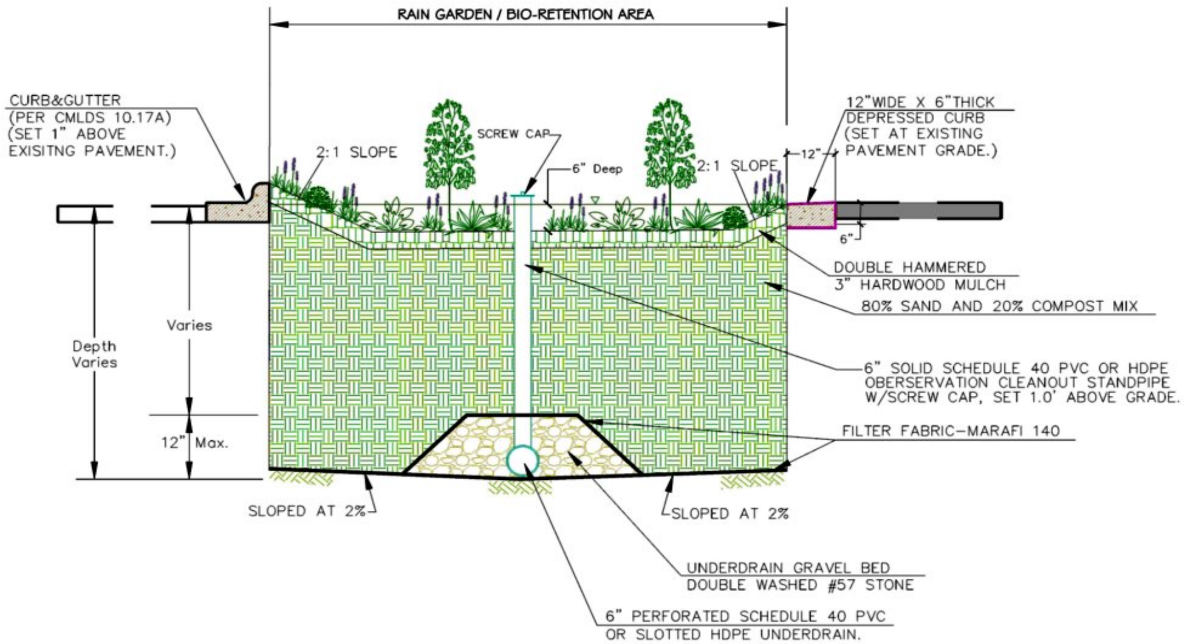
Size Underdrains

As a rule of thumb, the length of underdrain is based on 10% of Af
Source: (NY State Stormwater Manual)
L = 66 Feet in 3' wide stone bed

Required Diameter = 5.7 Inches (Minimum 6 Inches)
Source: (NCSU Rain Garden Design Worksheet, Bill Hunt, PHD)

2	Or More Underdrains required

Minimum of 2 Underdrains



RAIN GARDEN
X–SECTIONAL VIEW
NOT TO SCALE

Cost Estimate

Excavation	$4,378.87
Stone Bedding	$401.40
6" HDPE Pipe	$492.62
6" Cleanout	$250.00
Filter Fabric	$875.77
Soil Mix	$6,130.42
Mulch	$1,204.19
Plants	$3,166.54
Cost	**$16,899.82**
Cost/SF	$8.58
$0.39	Cost / SF Impervious

Infiltration Trench Design

Equation:

$$A = \frac{WQ}{(nd + kT/12)}$$

From Georgia Stormwater Management Manual Section 3.2.5 for Stormwater Infiltration Practices

Where:
A = Surface Area Served
WQ = Water Quality Volume in Cubic Feet
n = porosity (Assume 0.32)
d = trench depth in feet
k = percolation rate in inches/hour (Assume 0.5"/Hr.)
T = Time to fill in hours

Length of Trench:

L = A/W **Where W = allowable trench width**

Fill in Values:

WQ =	3448	Water Quality Volume (CF) (See Below)
n =	0.32	Porosity #57 Stone
d =	4	Depth of Trench
k =	0.2	Percolation Rate of Soil (In./Hr.)
T =	2	Fill Time in Hours
W =	4	Allowable Trench Width

Answer:

A =	2626	Square Feet Required
L =	656	Length of Trench

WATER QUALITY VOLUME (WQv)

Rv = runoff coefficient (Runoff/Rainfall)
Rv = 0.05 + 0.009(I) Where "I" = % Impervious
("Simple Method" - Schueler, 1987)
NCDENR April 1999

$$WQv = \frac{1.0"RvA}{12}$$

Fill in Values:

"I" =	100	Percent Impervious
"A" =	1	Acres

Answer:

WQv =	0.079	Ac. Ft.
	3448	Cubic Feet Required

Water Quality Vegetated Filter Strip

Manning's Equation:

$$q_w = \frac{1.49 \times d_f}{n} (R^{2/3} \times S^{0.50})$$

n = 0.40 Light Underbrush

$R = d_f * S_s / S_s + 2d_f$

S_s = 0.67 inches, 0.0558Feet

Source: SCDHEC - OCRM
"Post Development BMP Design Aid Manual"
Pages 69 - 70
Ss = spacing of grass media

$q_w = d_f V$ $V = q_w / d_f$

Where q_w = Flow Rate per Foot of Width
d_f = Flow Depth in Feet

Input Data:

Q=	2	CFS	From 1 inch Rainfall (6 Hr. Duration)
d_f =	0.08	Ft.	Use 1" Depth (0.08 Ft.)
Slope =	0.06	Ft./Ft.	Min. 0.02, Max. 0.10 Ft./Ft.
n =	0.4		See Table

Values of "n" for Various Vegetated Surfaces		
	Sheet Flow < 1" Depth	
Lawn	0.24	
Woods	0.40	Light Underbrush
	0.60	Heavy Underbrush