City of Memphis/Shelby County

STORM WATER MANAGEMENT MANUAL

City of Memphis Division of Public Works and Division of Engineering
Shelby County Public Works Department

Volume 1: Policy Manual
Volume 2: Drainage Manual
Volume 3: Best Management Practices Manual

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LIST OF ABBREVIATIONS AND ACRONYMS

BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
CFR	Code of Federal Register
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
ESCP	Erosion and Sediment Control Plan
MEP	Maximum Extent Practicable
MSDS	Material Safety Data Sheet
MS4	Municipal Separate Storm Sewer System
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resources Conservation Service
O&M	Operations & Maintenance
RUSLE	Revised Universal Soil Loss Equation
SWMM	Storm Water Management Manual (Volume 1: Policy Manual, Volume 2: Drainage Manual, Volume 3: Best Management Practices Manual)
SWPPP	Storm Water Pollution Prevention Plan
TDEC	Tennessee Department of Environment and Conservation
TDOT	Tennessee Department of Transportation
TR-55	Technical Release 55 (June 1986, SCS, see reference 175)
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UT	University of Tennessee

Abbreviations for units that are commonly used throughout the BMP Manual:

ac	Acres	Area
ac-ft	Acre-feet	Volume
cfs	Cubic feet per second	Flow
fps	Feet per second	Velocity
ft	Feet	Length
gpm	Gallons per minute	Flow
mg/L	Milligrams per liter	
µg/L	Micrograms per liter	Concentration
ppm	Parts per million	Concentration
sf	Square feet	Area
sq.mi.	Square miles	Area
°F	Degrees Fahrenheit	Temperature

1.0 INTRODUCTION

1.1 Purpose of Best Management Practices Manual

In 2006, the City of Memphis and Shelby County produced the Storm Water Management Manual (SWMM), which comprises the following volumes:

Volume 1 — Policy Manual
Volume 2 — Drainage Manual
Volume 3 — Best Management Practices (BMP) Manual

The purpose of the Best Management Practices (BMP) Manual is to establish minimum standards for the design and implementation of measures to prevent and control erosion, sediment, and other forms of storm water pollution. The BMP Manual is intended primarily to assist developers, engineers, contractors, inspectors, and property owners in the selection and use of BMPs for the design of new facilities. However, most of the BMPs can also be installed on an existing site or facility to improve the environmental quality of storm water.

It is important to realize that most BMPs are applicable to every type of land use (residential, commercial, industrial, and institutional) because it is everyone's responsibility to protect water resources. Therefore, it is important to look through all categories of BMPs to ensure that the most effective measures are selected.

The water quality of all of the major streams in Memphis and unincorporated Shelby County is limited due to siltation. To minimize storm water quality impacts, onsite storm water quality management practices are needed for all developments subject to review by the Memphis and/or Shelby County.

The extent and type of management practices implemented must be proportionate to the land use, pollutant discharge potential, and proximity to regional storm water quality management practices. Memphis and Shelby County encourage the implementation of a series of best management practices that optimize the use of required green and open spaces, especially along buildings and within or along parking lots. The storm water controls must be designed to limit the discharge of storm water pollutants offsite to those of predevelopment levels to the maximum extent practicable (MEP). Due to colloidal clay soils in the Memphis area, sediment removal BMPs may not yield clear storm water. The MEP for sediment removal in the Memphis area is to design and implement BMPs as indicated in the BMP Manual.

1.2 Organization of BMP Manual

The BMP Manual includes a brief introduction to storm water BMPs, the theory of erosion control, the steps in selecting which BMPs to use, and a series of focused and concise fact sheets for each type of BMP to be used in the City of Memphis and unincorporated Shelby County.

The fact sheets are categorized so that they may be used as quick references or for detailed design, inspection, and maintenance guidance. In this way, the fact sheets are designed to be stand-alone documents that may be distributed to facilitate focused discussion about each practice. The initial August 2006 publication of the BMP manual does not include any version number on BMP fact sheets. Subsequent publications will utilize version numbers to allow easy identification of the latest version of each BMP. It is common to categorize BMPs as either structural or nonstructural, depending upon whether there is a physical control or a management approach to reducing pollution. However, in this manual, BMPs are categorized as:

AM	Activities and Methods
ES	Erosion and Sediment
IC	Industrial and Commercial
RH	Residential and Homeowners
ST	Storm Water Treatment

Most practices listed as **AM** are nonstructural practices, which are activities performed in an attentive way with storm water quality in mind. Practices listed as **ES** or **ST** in the BMP Manual are mainly structural practices that involve installation or construction of a physical barrier or device to accomplish pollution reduction.

The BMPs listed under **AM** are generally applicable to all types of existing land uses, such as commercial establishments, industries, residences, institutions, or churches. Likewise, the BMPs listed under **IC** will apply to many properties other than industries or commercial facilities that involve material storage and handling, routine maintenance and repair, or waste disposal. The BMPs listed under **RH** are intended to help homeowners and owners/managers of other residential properties prevent pollution impacts.

1.3 References

The BMP fact sheets refer to the list of references by using the reference numbers only. In each case, it is the intention of Memphis and Shelby County to give appropriate credit whenever possible.

1.4 Storm Water Quantity and Quality

Historically, Memphis and Shelby County (City and County) have been addressing storm water quantity (drainage and flooding) through ordinances, which are approved by City Council and the County Commission. Storm water quantity management via the ordinances involved controlling the volume and flow rate of runoff from larger storm events.

Table 1-1 summarizes the legislation of storm water in the City and the County.

Table 1-1
Legislation of Storm Water in Memphis and Shelby County

Storm Water Regulations and Guidance Documents	City of Memphis	Shelby County
Joint Floodway Ordinance Special Use	Joint Ordinance No. 11 October 1980 (Codified in Section 25, FW of the Zoning Ordinances)	
Memphis Storm Water Drainage Manual	1987 (Revised 1990 and again revised 2006 and incorporated into the SWMM)	
Phase 1 National Pollutant Discharge Elimination System (NPDES) Storm Water Ordinance	Ordinance No. 4538 (January 1997)	Not Applicable
Joint Tree Ordinance	Ordinance 21 September 2001 (Codified in Section 33 of the Zoning Ordinances)	
Fletcher Creek Drainage Basin Zoning Ordinance	Joint Ordinance No. 5007 September 2003	
Phase 2 NPDES Storm Water Ordinance	Not Applicable	Ordinance No. 292 (December 2004)
Post-construction Runoff Control Technical Standards	2006 SWMM (originally issued as an Interim Guidance Document in September 2005)	
Construction Activity and Erosion and Sediment Control Storm Water Ordinance Revisions	Ordinance No. 5116 (August 2005)	Not Applicable
Storm Water Enterprise Fund	Ordinance No. 5135 and 5157 (December 2005 and May 2006)	Not Applicable
Storm Water Enterprise Fund Fee Adjustment and Credit Manual	January 2006	Not Applicable
Shelby County Code, Appendix A — Zoning	Adopted October 6, 1980 (Section 9 Landfill Floodplain Restrictions, Section 25 Floodway Special Purpose Districts, Section 26 Floodplain Overlay Regulations, Section 33 Tree Removal)	
Shelby County Code, Appendix B — Subdivisions	Adopted on December 19, 1983, as amended through January 8, 1990 (Section 301.3 — Preliminary plan requirements that plans indicate the floodplain and floodway boundaries, methods for accommodating drainage, and special requirements for subdivisions located in the floodplain or in the Fletcher Creek Drainage Basin; Section 301.7 — Final plat requirements for base flood elevations and added requirements for Fletcher Creek Drainage Basin; Section 501 — General provisions for improvements include requirements for construction plan submittal detailing drainage to Public Works; Section 503.3 — requires curbs and gutters for all urban subdivisions; Section 504 Drainage — requires the developer to provide easements, improve ditches, or pay a fee in lieu of improving ditches. Section 506 — Soil erosion plan submittal requirements.	

The BMP Manual helps to place new emphasis on storm water quality. The Tennessee Department of Environment and Conservation (TDEC), the City, and the County are now requiring that storm water quality management techniques be applied to new development and significant redevelopment in the form of structural and nonstructural BMPs. Storm water quality management involves pollutant control, capture, and/or treatment of storm water. Some of the pollutants are referred to as "point sources," which means that there is a recognizable source such as regulated discharges, accidental spills, illegal dumping, or illicit connections. The BMP Manual also includes some discussion on minimizing unregulated point sources, but primarily focuses on nonpoint source pollution.

Nonpoint source pollution results from particulates or dissolved pollutant matter being transported by runoff over surfaces and conveyed to the storm drain system, streams, and other waterways. Nonpoint source pollution principally includes sediment eroded from denuded areas during construction and pollutants from impervious surfaces, which can be easily transported or conveyed.

Nonpoint source pollution is most prevalent in runoff from frequent storm events that are smaller than design storm events used in sizing storm drainage structures. Typically, these events have less than 1 inch of rainfall. This is the rainfall amount generally considered in preparing the selection, size, approach, and maintenance criteria presented in the BMP fact sheets. During dry weather as well as during precipitation events, all BMPs must be carefully followed to ensure continued performance.

1.5 Background

The City and County, like many other municipalities across the United States, are required to have a National Pollutant Discharge Elimination System (NPDES) permit to discharge storm water from the municipal separate storm sewer system (MS4). The City of Memphis was issued a storm water permit by the State of Tennessee as a Phase 1 municipality on May 31, 1996. Shelby County was issued a storm water permit as a Phase 2 municipality on February 27, 2003. Because development activities may significantly contribute to the discharge of pollutants, the City and County NPDES permits require the municipalities to encourage, promote, and require implementation of certain practices and procedures for the purpose of reducing or limiting discharge of pollutants to storm water channels.

To accomplish this goal, the City and County have ordinances and standards, which require BMP implementation and inspections as part of land development activities. Some of these ordinances and standards have been developed and adopted specifically to address storm water quality concerns, while others were originally developed to address other concerns, but are also effective in promoting improved storm water quality in development activities. Development of a BMP Manual was required by NPDES Permit No. TNS068276 for the City of Memphis and NPDES Permit No. TNS075663 for Shelby County. Both permits will expire in 2008.

1.6 City of Memphis Storm Water Fee

In December 2005, the Memphis City Council approved the implementation of a monthly storm water fee. The fee, based on units of 3,147 square feet, will be applied to all users or owners of property with "impervious area" located within the City of Memphis. As part of NPDES Permit requirement to "encourage water quality," a Fee Adjustment and Credit Manual was issued by the City of Memphis in January 2006 to provide adjustments and credits against the user's storm water fee as a financial incentive to implement structural and nonstructural BMPs. The manual is available at www.stormwatermatters.com.

1.7 Erosion and Sediment Control Plan

Memphis and Shelby County require that an Erosion and Sediment Control Plan (ESCP) be submitted for most types of development. This plan should incorporate common erosion control BMPs (such as those in the ES section of this BMP Manual). The erosion control BMPs are intended to expand upon commonly used documents such as the Tennessee Erosion and Sediment Control Handbook (2^{nd} Edition reissued in March 2002), which is available on the TDEC web site.

Laws regarding erosion and sediment control are somewhat flexible and performance oriented. The property owner and developer shall choose methods and means necessary to prevent or reduce erosion and to control the amount of sediment leaving the site. A combination of structural control measures and nonstructural management practices generally will be the most cost-effective method to control erosion and sediment. The erosion process is described in detail in Chapter 2 and measures should be taken to reduce erosion and sediment at each step in the process.

The overall requirements of an ESCP are described in Chapter 5. In addition, typical checklists to review plan submittals are included. The use of checklists prior to plan review submittals will standardize the format for developers, engineers, contractors, inspectors, and owners.

1.8 Storm Water Pollution Prevention Plan

Memphis and Shelby County may require a Storm Water Pollution Prevention Plan (SWPPP), even if not required by TDEC. Guidance in preparing a SWPPP to be submitted to the City of Memphis and Shelby County is given in Chapter 6.

TDEC's General NPDES Permit for Discharges of Storm Water Associated with Construction Activities (Permit No. TNR100000) requires a SWPPP for all construction sites that disturb 1 or more acres of land. TDEC's General Permit for Discharges Associated with Industrial Activity (Permit No. TNR050000) also requires a SWPPP for industrial activity with the potential to pollute waters of the state. See the TDEC web site listed in Chapter 8 for additional information on these two general statewide permits and how to obtain coverage.

As part of the process of obtaining coverage under one of these statewide permits, a Notice of Intent (NOI) is required to be filed with Memphis and/or Shelby County within 60 days of permit issuance.

1.9 Post-Construction Runoff Control Plan

Memphis and Shelby County Engineering Departments require the submittal of a Post construction Runoff Control (PCRC) Plan for all new developments and significant redevelopment sites that disturb 1 acre or more, including projects less than 1 acre that are part of a larger common plan of development or sale and that discharge into the Memphis and/or Shelby County MS4. The PCRC Plan is to be included with the plan set provided to Memphis and/or Shelby County. The PCRC Plan shall be signed and sealed by a Tennessee Registered Professional Engineer. Further guidance on preparing a PCRC Plan is given in Chapter 7.

2.0 EROSION AND SEDIMENT CONTROL

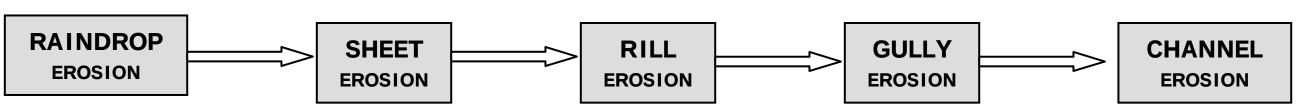
Shelby County typically has heavy precipitation in the winter and early spring caused by low-pressure systems resulting in widespread rains. A second period of heavy precipitation occurs in spring and early summer, when local showers and thunderstorms are more common. Precipitation is generally lightest in the late summer and early fall.

Soils in the Shelby County are typically characterized as nearly level to gently sloping, well-drained, and silty. However, there are a variety of soil types in Memphis and Shelby County and each site should be assessed by consulting the Shelby County soil survey and by conducting a site-specific evaluation. Silt deposits range from 5 to more than 20 feet thick. Often, a fragipan (caused by agricultural use) begins at a depth of 15 to 30 inches and needs to be broken to increase infiltration. Top soils are underlain by a layer of aeolian loess consisting of silt, clay, and silty clay. The thickness of the loess varies from location to location (Chapter 10, Reference 202).

In general, soils in Shelby County are susceptible to high rates of erosion and require careful management. The silt and silty clay soils in Shelby County are infamous for their colloidal properties, which do not filter or settle well.

One of the main tools available to help land users determine the potentials and limitations of soils is a soil survey. Soil surveys are available through the U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS). The surveys are made by NRCS in cooperation with other federal, state, and local agencies. The Shelby County soil survey is available on the internet at http://websoilsurvey.nrcs.usda.gov/app/. The Web Soil Survey program on the NRCS web site allows the user to produce a customized soil survey for a site. Detailed information about limitations for specific soils should be evaluated.

2.1 Erosion Process



Short-term storm water quality management predominantly focuses on erosion and sediment control for construction sites. However, erosion may occur on any site, even fully developed properties.

Soil erosion is the process by which wind, water, or gravity removes soil particles from land surfaces. Natural erosion generally occurs at slow rates; however, the rate of erosion increases whenever the land is cleared or disturbed. Clearing and grubbing activities during construction remove vegetation and disrupt the structure of the soil surface, leaving soil susceptible to overland erosion, stream and channel erosion, and wind erosion. Ultimately, the material suspended by erosion settles during the sedimentation process in downstream reaches. This can lead to an increase in maintenance needs, flooding problems, and water quality concerns.

2.2 Overland Erosion

The overland erosion process begins when raindrops impact the soil surface and dislodge minute soil particles, which then become suspended in the water droplet. The sediment-laden water droplets accumulate on the soil surface until a sufficient quantity has developed to begin flowing under the natural forces of gravity.

The initial flow of sediment-laden water generally consists of a thin, slow-moving sheet, known as sheet flow. While sheet flow is generally not highly erosive on its own, it does begin to transport previously immobile sediment particles. Due to irregularities in the soil surface and uneven topography, sheet flow will usually begin to concentrate into small grooves, or rills, where the flow picks up velocity and erosive energy because of gravitational forces.

Rill erosion of the soil surface tends to concentrate more water, which then flow faster and gain erosive energy. Typically, rills are oriented downslope parallel to other rills, and rills are generally small enough to be easily stepped across. The combination of several adjacent rills, or sufficient enlargement of a single rill, begins gully erosion. Gully erosion of the soil surface tends to further concentrate more water flow.

Gullies have four principal methods of increasing erosion. First, gullies often have a “head cut” at the upstream end, which progresses its way upstream as water flowing into the gully erodes away the lip of the head. This process is similar to a waterfall working its way upstream. Second, the flow in a gully tends to undercut the banks. Once sufficiently undercut, the banks collapse into the gully where the collapsed soil is then washed away. Third, when banks collapse into the gully, flowing water is diverted around the temporary blockage of soil, which then increases velocities along one or both banks. Fourth, the concentration of flows in the gully can result in scour of the gully floor until a stable slope is obtained.

2.3 Stream and Channel Erosion

Streams and channels are subject to the same types of erosion as gullies, with slightly different terminology. A stream develops naturally to handle the storm water and groundwater drainage of a particular watershed. The location, length, width, slope, sediment composition and size, amount of meandering, etc., are all determined by the characteristics of the precipitation and the landforms. The stream adjusts naturally to changes in rainfall, land cover, geology, and many other factors.

One or more of the following factors may disrupt the delicate balance required for stable streams and channels and could generally precipitate erosion within streams and channels:

- Disturbing the banks of streams and channels is often required during construction. Once vegetation or other bank protection measures are disturbed, flows may begin to erode the unprotected soil.

- Disturbing the flow within a stream or channel is often necessary to facilitate construction activities. However, this should only be allowed when traversing banks with a temporary stream crossing, culvert installation, bridge construction, etc. By diverting flows within the channel, velocities are generally increased in some areas to compensate for decreases in other areas. The increases in velocity may exceed those normally experienced by the channel, resulting in bank erosion and bottom scour.

- Increasing the quantity and rate of flow to streams and channels often results from construction activities and construction of facilities that increase the quantity and rate of runoff, as well as how runoff is conveyed to the discharge point. The increased quantity and rate of flow can cause bank erosion and bottom scour.

Soil characteristics play a key role in determining stream and channel flow. The tractive force or shear stress developed by flowing water over the channel banks and bottom can cause the soil particles to move and become suspended into the runoff. The permissible shear stress indicates the maximum stress that the channel banks and bottom can sustain without compromising stability. Determining the shear stress for a man-made channel is relatively easy, when compared to a stream, which is constantly changing shape, direction, material, etc.

Disturbing a stream or other natural channel should only be done as a last resort. TDEC requires permits for the disturbance of any blue-line stream. The U.S. Army Corps of Engineers (USCOE) may also require a permit for the disturbance of any blue-line stream. A blue-line stream is defined according to the 7.5-minute quadrangle maps published by the United States Geological Survey (USGS).

2.4 Dust Control

Wind erosion contributes to the degradation of storm water runoff by depositing dust over the land surfaces. This dust will generally be washed into the storm water drainage system during the first portion of a rainfall event. Dust is defined as solid particles or particulate matter small enough to remain suspended in the air for a period of time and large enough to eventually settle out of the air. Dust from a construction site originates as inorganic particulate matter from rock and soil surfaces and material storage piles. The majority of dust generated and emitted into the air at a construction site is related to earth moving, demolition, construction traffic on unpaved surfaces, and wind over disturbed soil surfaces.

Consult AM-11, Dust Control, for various methods of reducing dust and air pollution; however, many of the BMPs that reduce overland erosion also greatly reduce the generation of dust. Dust control for disturbed surfaces generally is accomplished by applying water or a chemical mixture to the surface. BMPs that capture the sediment from the disturbed areas should also take into account the dust control chemicals.

2.5 Factors Influencing Erosion

There are five primary factors that influence erosion: soil characteristics, vegetative cover, topography, climate, and rainfall. The five factors are components in the Revised Universal Soil Loss Equation (RUSLE), which was originally developed for the USDA with regard to soil losses on farm land. Volume 2, Chapter 2 of the SWMM (Drainage Manual, Hydrology Chapter) includes instruction on RUSLE. For more information on RUSLE, see the official web site listed in Chapter 8. The RUSLE formula is:

$$A = R\ K\ L\ S\ C\ P$$

where
A = predicted soil loss (tons per acre per year)
R = rainfall erosion index
K = soil erodibility factor
L = slope length factor
S = slope steepness factor
C = vegetative cover factor
P = erosion control practice factor

- Rainfall frequency, intensity, and duration are fundamental factors in determining the amounts of erosion produced. When storms are frequent, intense, or of long duration, erosion risks are high. In the City of Memphis and Shelby County, the months with highest rainfall are December through May, which coincide with the period of minimal vegetative cover. However, the most intense storms occur during the spring and summer months. This leads to the conclusion that the spring is potentially the most erosive season. Site grading and excavation occurs at the beginning of a construction project, which is also often during spring.

- Climate is a key factor that influences erosion. Factors such as humidity, temperature extremes, freeze/thaw cycles, and average wind speeds can have significant effects on soil stability and structure. In addition, these factors affect the permeability of the soil.

- Soil characteristics that determine the erodibility of the soil include particle size and shape, particle gradation, organic content, soil structure, and permeability. Less permeable soils have a higher likelihood for increased runoff and erosion, particularly soils with a high percentage of silt and clay. Fill soil and placed embankments are more likely to erode than cut areas and excavations, so fill areas are generally required to have a flatter slope than cut areas.

- Vegetative cover plays an important role in controlling erosion by shielding the soil surface from the impacts of falling rain and by slowing the velocity of runoff. This permits greater infiltration, maintains the soil's capacity to absorb water, and holds soil particles in place. Vegetative root structures create a favorable soil structure, improving its stability and permeability.

- Topography such as slope length and steepness are key elements in determining the volume and velocity of runoff. As slope length and steepness increases, so does the rate of runoff and the erosion potential. Steep slopes should be limited to short lengths whenever possible.

Application of a soil erosion equation such as RUSLE is generally not necessary on small construction projects, but may be required by the Memphis or Shelby County Engineer in situations involving very large areas or in extremely sensitive areas. However, the basic concepts such as limiting the gradient and length of steep slopes should be practiced whenever possible.

2.6 Sedimentation Process

The settling of soil particles is known as the process of sedimentation. Once soil particles are eroded by and suspended in water or wind, they can be carried a distance, from a few inches to many miles, before conditions allow the forces of gravity to cause the soil particles to settle. In other words, the sedimentation process usually occurs when the flow of water slows.

Larger particles, such as gravel and sand, will settle more rapidly than fine particles, such as silt and clay. Particles may be re-suspended when the flow of water increases. The pattern of the sedimentation process is often a good indication of the storm water flow that carried it. Excessive levels of sediment can plug storm drains, block streams and channels, reduce floodwater storage, damage habitats, and occasionally result in formation of habitats in undesirable locations. Sediment removal is an expensive task that must be performed regularly.

Generally, the sedimentation process can be forced to occur by creating conditions that slow the flow of water or air, thus allowing particles to settle. Conversely, creating conditions of rapid and turbulent flow will prevent particles from settling. Sediment traps and sediment basins are examples where sedimentation occurs at a designed location. Chemical flocculants can be used in Memphis and Shelby County in conjunction with sediment basins to help settle suspended sediments.

3.0 STORM WATER POLLUTANTS

Sediment from erosion is the pollutant most frequently associated with construction activities. However, other pollutants are also carried into the storm water system and streams. Storm water pollutants can be categorized into the following nine categories: sediments, nutrients, heavy metals, toxic materials (including pesticides and herbicides), oil and grease, bacteria and viruses, biological and chemical oxygen-demanding substances, floatable waste materials, and construction waste materials.

These pollutants originate from a variety of locations such as residences, commercial properties, industry, schools, offices, parking lots, roads, restaurants, and grocery stores. Automotive vehicles and other motorized equipment are a major source of pollutants, so that parking lots and roads are considered a major factor of nonpoint source pollution. A typical single-family household contains dozens of hazardous chemicals for indoor or outdoor use, which are often disposed incorrectly on the lawn or in the woods.

Typical construction activities that contribute storm water pollutants include: site grading, clearing and grubbing, paving operations, demolition, materials storage, equipment fueling, vehicle maintenance, painting, and use of other chemicals. Maintenance activities such as power washing without containment of rinsate can transport concentrated amounts of pollutants including detergents into the drainage system that would not necessarily be mobilized by normal rain events. By taking an activities inventory, the engineer/designer/contractor/owner can identify potential pollutant sources and then select appropriate BMPs to address these sources. Each of the BMP fact sheets includes a list of the targeted constituents. The list is a general guide to selecting BMPs and is not intended to address any particular type of residence, commercial property, industry, or institution. The designer must use care and common sense in evaluating potential BMPs, as discussed further in Chapter 4.

In addition to pollution, storm water runoff and streams can also suffer degradation from thermal effects and from pH changes. These basic water characteristics can degrade aquatic habitats such as streams and lakes. Concrete and asphalt tend to store large amounts of heat efficiently, which is then transferred to storm water runoff. Concrete and asphalt channel linings are often used for urban streams. In addition to the type of channel lining used, thermal pollution is also caused by a lack of natural shade.

Almost every BMP contains a graphical list of targeted constituents for BMP pollutant removal; this information is included on the first page of each BMP fact sheet. The list of targeted constituents is a subjective estimate of pollutant removal effectiveness for the average BMP installation. In some instances, the selected BMP may be very effective. In other instances, there may be mitigating factors that nullify the potential storm water quality benefits of a particular BMP. The list is a general guide to selecting BMPs and does not address every type of residential, commercial, industrial, or institutional property use.

Tables 3-1 through 3-5 summarize the BMP pollutant removal information in a matrix form. For ease of display, the legend symbology is slightly different than the BMP fact sheets.

BMP Fact sheets	**Effectiveness of Pollutant Removal**	**Tables 3-1 through 3-5**
¸	Significant Benefit	¸
Û	Partial Benefit	◑
¹	Low or Unknown Benefit	---

See Figure 4-2 of the BMP Manual for pollutant removal rates for dry detention basins (ST-01). See Table 4-5 of the BMP Manual for pollutant removal rates for typical urban BMPs.

3.1 Sediments

Most sediments are generated from soil and rock erosion, although some sediments are organic in nature. Man-made materials may also decompose or erode to create sediments. Sediments vary in terms of size and specific weight, which are the two main factors that determine when and how far sediment will travel. There are several complex equations that are used to predict how much sediment a stream or channel can carry. These equations generally yield different answers and rely on estimating several variables. In theory, a stream will deposit sediment if it tries to carry more than its sediment-carrying capacity, and a stream will pick up sediment if it has not yet reached its sediment-carrying capacity.

Sediment is harmful to aquatic life because it blocks sunlight that is necessary for photosynthesis and interferes with animal respiratory organs. Sediment can also accumulate on natural streambeds and other habitats, smothering the plants, and creatures that live there.

Table 3-1 Activities and Methods (AM) **Name of BMP**	**Number**	**Targeted Constituents** **Sediment**	**Nutrients**	**Heavy Metals**	**Toxic Materials**	**Oil and Grease**	**Bacteria and Viruses**	**Oxygen Demand**	**Floatable Materials**	**Construction Wastes**
Employee Training	**AM-01**	¸	¸	¸	¸	¸	¸	¸	¸	¸
Construction Scheduling	**AM-02**	¸	◑	---	---	---	---	---	---	◑
Preservation of Existing Vegetation	**AM-03**	¸	¸	---	---	---	---	¸	¸	---
Maintenance of Existing Drainage Systems	**AM-04**	¸	---	◑	---	◑	◑	¸	¸	---
Storm Drainage System Flushing	**AM-05**	¸	---	◑	---	◑	---	---	◑	---
Material Delivery and Storage	**AM-06**	◑	◑	◑	◑	◑	◑	◑	◑	◑
Spill Prevention and Control	**AM-07**	---	◑	¸	¸	¸	¸	¸	◑	---
Waste Management and Recycling	**AM-08**	---	¸	¸	¸	¸	¸	¸	¸	¸
Sanitary and Septic Waste Management	**AM-09**	---	¸	---	---	---	¸	¸	---	---
Contaminated Soil Management	**AM-10**	◑	---	¸	¸	---	---	---	---	---
Dust Control	**AM-11**	¸	---	---	◑	◑	---	---	---	---
Dewatering Operations	**AM-12**	¸	---	◑	◑	◑	---	---	---	---
Pesticides, Herbicides, and Fertilizer Use	**AM-13**	---	¸	---	¸	---	---	¸	---	---
Vehicle and Equipment Cleaning	**AM-14**	◑	◑	◑	◑	◑	---	◑	---	---
Vehicle and Equipment Fueling	**AM-15**	---	---	¸	¸	¸	---	---	---	---
Vehicle and Equipment Maintenance and Repair	**AM-16**	---	---	¸	¸	¸	---	---	---	---
Paving Operations	**AM-17**	◑	---	◑	◑	◑	---	---	---	---
Concrete Waste Management	**AM-18**	---	---	---	◑	◑	---	---	---	◑
Structure Construction and Painting	**AM-19**	---	---	---	◑	---	---	---	¸	¸

Table 3-2 Erosion and Sediment (ES)		**Targeted Constituents**								
Name of BMP	**Number**	**Sediment**	**Nutrients**	**Heavy Metals**	**Toxic Materials**	**Oil and Grease**	**Bacteria and Viruses**	**Oxygen Demand**	**Floatable Materials**	**Construction Wastes**
Stabilized Construction Site Access	**ES-01**	¸	---	---	---	◑	---	---	---	---
Tire Washrack	**ES-02**	¸	---	---	---	---	---	---	---	---
Construction Road Stabilization	**ES-03**	¸	---	---	---	---	---	---	---	---
Gradient Terraces and Silt Trenches	**ES-04**	¸	---	---	---	---	---	---	---	---
Surface Roughening	**ES-05**	¸	---	---	---	---	---	---	---	---
Topsoil	**ES-06**	¸	---	---	---	---	---	---	---	◑
Mulch	**ES-07**	¸	◑	---	---	---	---	---	---	---
Seeding	**ES-08**	¸	◑	---	◑	---	---	---	---	---
Sodding	**ES-09**	¸	---	---	---	---	---	---	---	---
Trees, Shrubs, and Vines	**ES-10**	¸	◑	---	---	---	---	---	---	---
Erosion Control Blankets and Mats	**ES-11**	¸	---	---	---	---	---	---	---	---
Geotextiles	**ES-12**	¸	---	---	---	---	---	---	---	---
Check Dams	**ES-13**	¸	---	---	---	---	---	---	---	---
Silt Fence	**ES-14**	¸	---	---	---	---	---	---	---	---
Straw Bale Barrier	**ES-15**	¸	---	---	---	---	---	---	---	---
Sandbag Barrier	**ES-16**	¸	---	---	---	---	---	---	---	---
Brush or Rock Filter Berm	**ES-17**	¸	---	---	---	---	---	---	---	---
Temporary Sediment Trap	**ES-18**	¸	---	---	---	---	---	---	---	◑
Sediment Basin	**ES-19**	¸	◑	---	---	---	---	---	◑	◑
Bank Stabilization and Soil Bioengineering	**ES-20**	¸	---	---	---	---	---	---	---	---

Table 3-2 (continued) **Erosion and Sediment** **(ES)** **Name of BMP**	**Number**	**Sediment**	**Nutrients**	**Heavy Metals**	**Toxic Materials**	**Oil and Grease**	**Bacteria and Viruses**	**Oxygen Demand**	**Floatable Materials**	**Construction Wastes**
Diversions and Downdrains	**ES-21**	¸	---	---	---	---	---	---	---	---
Channel Linings	**ES-22**	¸	◑	---	---	---	---	---	---	---
Riprap	**ES-23**	¸	---	---	---	---	---	---	---	---
Temporary Inlet Protection	**ES-24**	¸	---	---	---	---	---	---	◑	◑
Outlet Protection	**ES-25**	¸	---	---	---	---	---	---	---	---
Level Spreader	**ES-26**	¸	---	---	---	---	---	---	---	---
Floating Sediment Curtain	**ES-27**	¸	---	---	---	---	---	---	---	---
Gabions	**ES-28**	¸	---	---	---	---	---	---	---	---
TDOT Standard Details for Erosion Control	**ES-29**	¸	---	---	---	---	---	---	---	◑
TDEC Erosion and Sediment Control BMPs	**ES-30**	¸	---	---	---	---	---	---	---	◑

Table 3-3 Industrial and Commercial (IC)		Targeted Constituents								
Name of BMP	**Number**	**Sediment**	**Nutrients**	**Heavy Metals**	**Toxic Materials**	**Oil and Grease**	**Bacteria and Viruses**	**Oxygen Demand**	**Floatable Materials**	**Construction Wastes**
Non-Storm-Water Discharges to Storm Drains	**IC-01**	---	¸	¸	¸	¸	¸	¸	◑	◑
Outdoor Loading and Unloading of Materials	**IC-02**	---	¸	¸	¸	¸	---	¸	¸	---
Outdoor Container Storage of Liquid Materials	**IC-03**	---	---	¸	¸	¸	---	¸	---	---
Outdoor Process Equipment Operations	**IC-04**	¸	---	¸	¸	¸	---	---	---	---
Grounds Construction and Maintenance	**IC-05**	---	◑	¸	¸	◑	---	◑	◑	¸
Over-Water Operations	**IC-06**	◑	◑	◑	◑	¸	¸	◑	¸	---
Food Service and Handling	**IC-07**	---	¸	---	◑	¸	¸	¸	---	---
Power or Pressure Washing	**IC-08**	¸	◑	¸	¸	¸	---	◑	---	---
Swimming Pools and Spas	**IC-09**	---	---	---	¸	---	---	¸	---	---
Dumpsters	**IC-10**	◑	¸	◑	◑	¸	¸	¸	◑	◑
Kitchen Exhaust Cleaning	**IC-11**	---	¸	---	◑	¸	¸	¸	---	---
Air Conditioners and Refrigeration	**IC-12**	---	---	---	¸	---	---	◑	---	---
Farms and Agriculture	**IC-13**	¸	¸	---	¸	---	¸	◑	---	---
Response to Private Property Sanitary Sewer Overflows	**IC-14**	---	¸	---	◑	---	¸	¸	◑	---

Table 3-4 Residential and Homeowners (RH)		Targeted Constituents								
Name of BMP	**Number**	**Sediment**	**Nutrients**	**Heavy Metals**	**Toxic Materials**	**Oil and Grease**	**Bacteria and Viruses**	**Oxygen Demand**	**Floatable Materials**	**Construction Wastes**
Non-Storm-Water Discharges to Storm Drains	**RH-01**	¸	¸	¸	¸	¸	¸	¸	¸	◑
Vehicle Washing	**RH-02**	◑	◑	◑	◑	◑	---	◑	---	---
Vehicle Maintenance and Repairs	**RH-03**	◑	---	¸	¸	¸	---	◑	---	---
Landscape Irrigation and Lawn Watering	**RH-04**	---	¸	---	¸	---	---	◑	---	---
Pesticides and Fertilizers	**RH-05**	---	¸	◑	¸	---	---	¸	---	---
Household Solid and Hazardous Waste Mgmt	**RH-06**	---	---	¸	¸	¸	---	◑	---	---
Sanitary Sewer Laterals and Septic Tanks	**RH-07**	---	¸	---	---	---	¸	¸	---	---
Pet and Animal Wastes	**RH-08**	---	¸	---	---	---	¸	◑	---	---
Slope and Streambank Stabilization	**RH-09**	¸	¸	---	---	---	---	---	◑	---
Swimming Pools and Spas	**RH-10**	---	---	---	¸	---	---	¸	---	---
Boats and Marinas	**RH-11**	---	¸	◑	◑	◑	¸	¸	¸	---
Tips for Wet Basements and Crawl Spaces	**RH-12**	(no targeted constituents)								

Table 3-5 Storm Water Treatment (ST)		**Targeted Constituents**								
Name of BMP	**Number**	**Sediment**	**Nutrients**	**Heavy Metals**	**Toxic Materials**	**Oil and Grease**	**Bacteria and Viruses**	**Oxygen Demand**	**Floatable Materials**	**Construction Wastes**
Dry Detention Basin	**ST-01**	¸	◑	◑	◑	◑	---	◑	◑	---
Wet Detention Basin	**ST-02**	¸	¸	¸	¸	◑	◑	◑	¸	---
Infiltration Systems and Methods	**ST-03**	¸	◑	◑	◑	◑	---	◑	◑	---
Constructed Wetlands	**ST-04**	◑	◑	◑	◑	◑	◑	◑	◑	---
Filter Strips and Swales	**ST-05**	◑	◑	◑	◑	◑	---	◑	---	---
Water Quality and Media Infiltration Inlets	**ST-06**	¸	◑	◑	◑	◑	◑	◑	◑	---
Oil-Water Separator	**ST-07**	¸	---	¸	◑	¸	---	◑	¸	---
Underground Detention ***	**ST-08**	◑	---	---	---	---	---	---	◑	---
Multiple Systems	**ST-09**	◑	◑	◑	◑	◑	◑	◑	◑	◑

***Underground detention structures are only allowed in the City of Memphis and Shelby County by special permission.

3.2 Nutrients

Phosphorous, nitrogen, and other plant nutrients are generated naturally by organic activities in the soil, biological and chemical decomposition, etc. Streams and other natural channels have a limited ability to moderate and adjust to large amounts of man-made nutrients such as fertilizers. Nutrients are also generated by phosphorous-bearing soils, chemicals, food processing plants, lumber activities, restaurants, and wastewater treatment systems.

Nutrients can create excessive growth of vegetation or algae, which results in impaired use of water in lakes and other sources of water supply by creating taste and odor problems. Excess algae can also deplete dissolved oxygen levels, which results in fish kills. Collectively, the problems associated with excessive levels of nutrients in a receiving water are referred to as eutrophication impacts. The size of a receiving water is the principal factor in determining its ability to handle increased nutrients.

3.3 Heavy Metals

Heavy metals, even in low concentrations, are generally toxic to all life forms. Heavy metals are of particular concern because they are toxic to aquatic organisms, can be bio-accumulative, and have the potential to contaminate drinking water supplies. Significant portions of heavy metals in urban runoff are generated from cars and trucks. Gasoline and diesel fuels contain heavy metals, which are discharged through the vehicle exhaust and settle on the roadways and parking lots.

Most artificial surfaces (galvanized metal, paint, wood preservatives, roof shingles, plastic, asphalt) contain metals that can enter storm water as the surfaces corrode, flake, dissolve, decay, or leach. Careful maintenance, inspection, and repair can limit the cumulative effect from these surfaces.

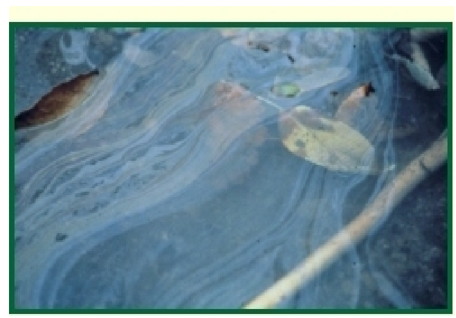
3.4 Toxic Materials

Toxic materials are commonly used in residences, commercial facilities, industry, etc. Toxic materials are often synthetic organic compounds, such as adhesives, cleaners, solvents, or sealants. Accidental spills and leakage or deliberate dumping of these chemicals onto the ground or into storm drains causes environmental harm in receiving waters. Memphis and Shelby County programs for the collection of household hazardous waste have reduced the amount of toxic materials released by residential properties.

Herbicides, insecticides, and rodenticides (collectively termed pesticides) are commonly used on construction sites, lawns, parks, golf courses, etc. Unnecessary, excessive, or improper application of these pesticides may result in direct water contamination. It is highly recommended that Memphis and Shelby County residents and businesses avoid these products whenever possible.

3.5 Oil and Grease

Oil and grease products are widely used throughout Memphis and Shelby County wherever automotive vehicles are found. Oil and grease can be spilled or leaked onto the ground and then washed into waterways. Sources include leakage during normal vehicle use, hydraulic line failure, spills during fueling, improper storage of used cooking oil, and inappropriate disposal of drained fluids. These products can cause severe harm to plant and animal life due to the additional effect of heavy metals and toxic hydrocarbon compounds contained in oil and grease products.



Oil and grease products have properties that affect the methods of capture and treatment. Most oil, grease, hydrocarbons, and other fuels are lighter than water. Therefore, skimmers and separators can be used to capture these pollutants. Oil and grease may form emulsions in turbulent or flowing water, an occurrence that makes this type of pollution very hard to remove. In addition, petroleum products and fuels create flammable vapors and are very detrimental to fish and other aquatic organisms.

3.6 Bacteria and Viruses

Bacteria and viruses are commonly found in organic materials that are part of storm water. Bacteria and viruses can come from multiple sources and often the exact cause cannot be pinpointed. Principal sources include sanitary sewer overflows and leakages; animal excrement from pets; livestock and feral animals; food particles; water used to prepare or clean food or food packaging; and restaurants. The presence of pathogens can make an otherwise attractive stream or lake into a public hazard that must be avoided.

Bacteria and viruses can cause fish kills and human illnesses. These pollutants are usually indicated by the fecal coliform count, which has been a source of concern for streams in Memphis and Shelby County. Sanitary sewers are sometimes the source of bacteria and viruses as well as septic systems and illicit sewer connections. Memphis and Shelby County MS4 NPDES permits require monitoring and/or program implementation elements for reduction of fecal coliform. The City of Memphis has on-going dry weather sampling, fecal coliform tracking studies (DNA typing) and infrared fly-over assessments to determine the sources of fecal coliforms in order to develop a strategy to minimize the pollutant.

3.7 Oxygen-Demanding Substances

Some chemicals and substances are classified as oxygen-demanding substances. This means that in the presence of water, they will extract dissolved oxygen (DO) or even liberate bound oxygen from the water molecule. In chemical terms, oxygen is a very active electron-acceptor and can react with most anything.

Lower DO levels are often the cause of fish kills in streams and reservoirs. The degree of DO depletion is measured by the biochemical oxygen demand (BOD) test that expresses the amount of easily oxidized organic matter present in water. The chemical oxygen demand (COD) test is less frequently used and it measures all of the oxidizable matter present in water. BOD is generally caused by the decomposition of organic matter in storm water; sometimes nonorganic materials in the water can intensify DO depletion. Dissolved oxygen in streams and lakes also depends heavily on temperature.

3.8 Floatable Materials

Floatable waste materials have the potential to be carried downstream easily. It is important that every contractor, business, commercial property, etc., have an effective plan to handle all waste materials. Floatable waste materials may or may not contain other storm water pollutants. Floatable waste materials will often clog drainage structures and should be prevented from reaching the storm water drainage system. Screens and floatable booms are the primary ways to capture these pollutants if they have already entered the storm water system. Floatable waste materials can harm aquatic animals that try to ingest small pieces of floating matter.

Floatable pollution currently the #1 water quality priority of the City of Memphis Storm Water Program

Photo: "Tip of the Iceberg" by James Baker, Chair, Bottle Bill Committee, Tennessee Chapter, Sierra Club; December 8, 2004 — North bank of McKellar Lake in Memphis downstream of Nonconnah Creek

3.9 Construction Waste

Common construction waste materials include: wash water from concrete mixers; paints and painting equipment cleaning activities; solid organic wastes resulting from trees and shrubs removed during land clearing; wood and paper materials derived from packaging of building products; food containers such as paper or aluminum cans; industrial or heavy commercial process water; cooling water; vehicle washing; and sanitary wastes. The discharge of these wastes can lead to unsightly and polluted receiving waters.

It is important that every contractor have an effective plan to handle all construction waste materials. Construction materials should be organized and secured at the end of each workday. Recycling programs and markets are commonly available and are usually profitable to the contractor in terms of waste reduction and lessened disposal costs.

4.0 SELECTING BEST MANAGEMENT PRACTICES

> Both erosion prevention practices and sediment control practices must be employed at all sites. **Due to the fine loess soil particles in the Memphis and Shelby County area that make sediment control difficult, property owners/developers must adequately address erosion prevention practices, such as scheduling and ground cover.** Sediment discharges must be in compliance with TDEC permits and must be controlled to the MEP, a technology-based discharge standard established for MS4s required by §402(b) of the Clean Water Act.

4.1 Construction Versus Post-Construction BMPs

The same level of care should be taken to select, install, and maintain construction (temporary) BMPs as is taken with post-construction (permanent) BMPs. The only difference is in the intended lifespan of the BMP. It is good to remember that, in the world of construction and industry, a temporary solution may be in place for a number of years due to oversight, neglect, good performance, etc. In general, temporary BMPs are intended to address construction activities, while permanent BMPs address long-term storm water management objectives.

Temporary BMPs may include a variety of "good housekeeping" measures and short-term erosion and sediment control activities. The contractor is responsible for properly constructing, implementing and maintaining the temporary practices and/or seeking guidance when the measures do not appear to be meeting the storm water management objectives (namely that sediment and other pollutants do not leave the construction site).

Permanent BMPs, which are designed to control long-term storm water pollution, are the final improvements to and configuration of the project. Permanent BMPs are selected by licensed professional engineers, incorporated into the plans and specifications for the project, and have long-term maintenance responsibilities identified. The contractor is responsible for properly constructing the permanent controls. Permanent BMPs are normally selected in the planning phase in conjunction with the approval of the tentative map designed during the design phase of a project and completed to the satisfaction of the City or County. Guidance on preparing a PCRC Plan is given in Chapter 7. Occasionally, unforeseen natural or man-made factors may require revisions to or additions of permanent BMPs during the construction phase. These revisions or additions must be approved by the City or County.

4.2 Identify Objectives

The objectives in pollution prevention for each property can vary widely. Therefore, a specific understanding of pollution risks for each activity is essential for selecting and implementing BMPs. Defining these risks requires review of the characteristics of the site and the nature of the construction process or industrial activity. This information should be carefully assembled and reviewed early in the design process. Once these pollution risks are defined, then BMP objectives are developed and specific BMPs can be selected. The BMP objectives for a typical construction project are as follows:

- Practice Good Housekeeping: Perform activities in a manner that keeps potential pollutants from either draining or being transported offsite by managing pollutant sources and modifying construction activities. Dispose of waste materials in designated areas and in designated containers away from rainfall and storm water runoff.

- Minimize Disturbed Areas: Determine project scheduling and only clear land that will be actively under construction in the near term (within the next 3 months). Minimize new land disturbance, and do not clear or disturb sensitive areas (e.g., steep slopes, buffers, and natural watercourses).

- Stabilize Disturbed Areas: Provide temporary stabilization of disturbed soils whenever active construction is not occurring on that portion of the site. Provide permanent stabilization during the final grading process and carefully landscape the site.

- Protect Slopes and Channels: Avoid disturbing steep or unstable slopes. Safely convey runoff from the top of the slope and stabilize disturbed slopes as quickly as possible. Avoid disturbing natural channels. Stabilize temporary and permanent channel crossings as quickly as possible and ensure that increases in runoff velocity caused by the project do not erode the channel.

- Control Site Perimeter: Upstream runoff should be diverted around or safely conveyed through the construction project, and must not cause downstream property damage. Runoff from the project site should be free of excessive sediment and other constituents.

- Control Internal Erosion and Drainage: Detain sediment-laden waters from actively disturbed areas within the site to minimize the risk of sediment leaving the site.

BMP objectives for an industrial or commercial facility already in operation will basically have all of the same BMP objectives. However, there will be greater emphasis placed on good housekeeping, institutional controls and procedures, good training methods and regular refresher classes, and using the best available technology. BMP objectives in this chapter are generally discussed from a construction point of view, but are applicable to all types of land uses. See Section 4.5 for pollution removal goals, and see Chapter 6 for pollution prevention plans for industrial and commercial sites.

Site characteristics and proposed contractor activities will affect the potential for site erosion and contamination by other constituents used on the construction site. It is important to plan the project to fit the topography and drainage patterns of the site. Before defining BMP objectives, these factors should be carefully considered:

1. Site conditions that affect erosion and sedimentation, which include:
    a. Soil type, including underlying soil strata that are likely to be exposed
    b. Natural terrain and slope
    c. Final slopes and grades
    d. Location of concentrated flows, storm drains, and streams
    e. Existing vegetation and ground cover

2. Climatic factors, which include:
    a. Seasonal rainfall patterns
    b. Appropriate design storm (quantity, intensity, duration)

3. Type of construction activity

4. Construction schedules, construction sequencing, and phasing of construction

5. Size of construction project and area to be graded

6. Location of the construction activity relative to adjacent uses and public improvements

7. Cost-effectiveness

8. Types of construction materials and potential pollutants present or that will be brought onsite

9. Floodplain, floodway, and buffer requirements

4.3 Select BMPs

Once the BMP objectives are defined, it is necessary to identify the BMPs that are best suited to meet each objective. To determine where to place BMPs, a map of the project site can be prepared with sufficient topographic detail to show existing and proposed drainage patterns and existing and proposed permanent storm water control structures. The project site map should identify the following:

- Locations where storm water enters and exits the site. Include both sheet and channel flow for the existing and final grading contours.

- Identify locations subject to high rates of erosion such as steep slopes and unlined channels. Long, steep slopes over 100 feet in length are considered as areas of moderate to high erosion potential.

- Categorize slopes as: low erosion potential (0 to 5 percent slope), moderate erosion potential (5 to 10 percent slope), or high erosion potential (slope greater than 10 percent).

- Use Volume 2, Chapter 2 of the SWMM (Drainage Manual, Hydrology Chapter) to properly size and design BMPs using soil loss equations and runoff calculations.

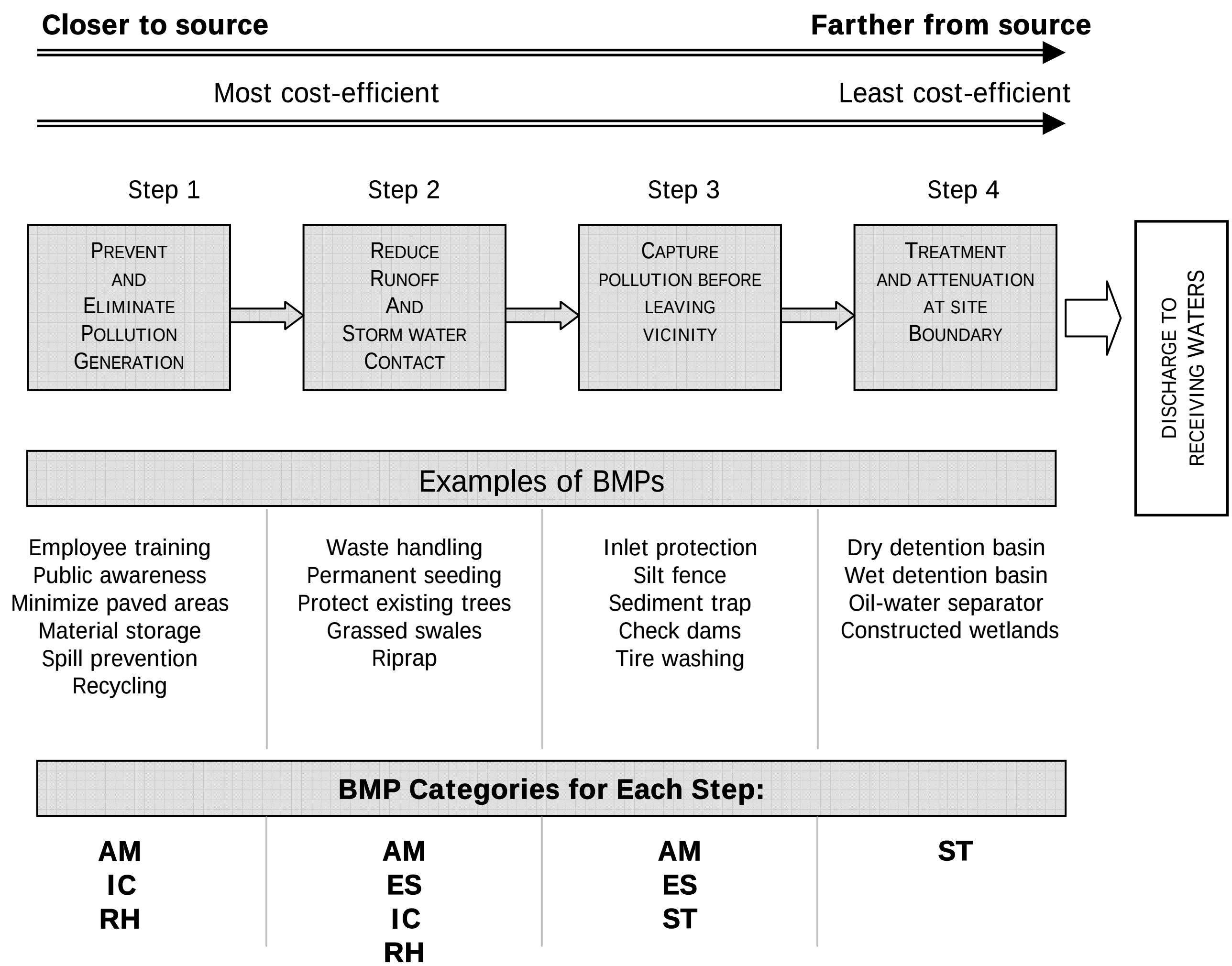
- Identify wetlands, springs, sinkholes, floodplains, floodways, sensitive areas, or buffers that must not be disturbed, as well as other areas where site improvements will not be constructed. Establish clearing limits around these areas to prevent disturbance by the construction activity.

- Identify the boundaries of tributary areas for each outfall location. Then calculate the approximate area of each tributary area. Define areas where various contractor activities have a probable risk of causing a runoff or pollutant discharge.

With this site map in hand, categories of BMPs can be selected and located. Detailed planning before construction begins and phasing construction activities achieve erosion and pollution prevention most cost effectively. It is more cost effective to prevent erosion and pollution than it is to remove sediment and pollutants. This is demonstrated in Figure 4-1 by first attempting to eliminate erosion and pollution generation (step 1) prior to reviewing the other alternatives in steps 2 through 4.

Figure 4-1

BMP Treatment Options



BMPs that can achieve multiple BMP objectives should be used to achieve cost-effective solutions. For instance, it is not always necessary to install extensive sediment trapping controls during initial grading. In fact, sediment trapping should be used only as a short-term measure for active construction areas and replaced by permanent stabilization measures as soon as possible. A permanent detention pond may be built first and used as temporary sediment control by placing a filter on the outlet. After construction is complete and the tributary area is stabilized, the permanent outlet configuration can be reestablished.

4.4 Factors for Construction Sites

Certain contractor activities may cause pollution if not properly managed. Not all BMPs will apply to every construction site; however, all of the suggested BMPs should be evaluated. Considerations for selecting BMPs for contractor activities include the following:

- Is it expected to rain? BMPs may be different on rainy days versus dry days, winter versus summer, etc. For instance, a material storage area may be covered with a tarp during the rainy season, but not in the summer. However, it should be noted that plans should be made for some amount of rain even if it is not expected to generate a flooding event.

- How much material is used? Less-intensive BMP implementation may be necessary if a "small" amount of pollutant-containing material is used. However, remember that even small amounts of some materials may be dangerous or have the potential to cause widespread pollution.

- How much water is used? The more water used and wastewater generated, the more likely that pollutants transported by this water will reach the storm water system or be transported offsite. Washing out one concrete truck on a flat area of the site may be sufficient (as long as the concrete is safely removed later), but a pit should be constructed if several trucks will be washed out at the same site.

- What are the site conditions? BMPs selected will differ depending on whether the activity is conducted on a slope or flat ground, near a storm water structure or watercourse, etc. Anticipating problems and conducting activities away from environmentally sensitive areas will reduce the cost and inconvenience of performing certain BMPs.

- In general, establishing a BMP for each conceivable pollutant discharge may be very costly and significantly disrupt construction. As a rule of thumb, establish controls for common (daily or weekly) activities and be prepared to respond quickly to accidents. This rule of thumb only applies to contractors handling unusual materials that are not usually at the project site. Industries and commercial facilities are expected to have contingency plans and spill measures for every material that is used regularly.

Therefore, keep in mind that the BMPs for contractor activities are suggested practices, which may or may not apply in every case. Construction personnel should be instructed to develop additional or alternative BMPs, which are more cost effective for a particular project.

The best BMP is a construction work force aware of the pollution potential of its activities and committed to a clean worksite.

4.5 Storm Water Treatment Removal Goals

Various BMPs will have different rates of effectiveness. For most BMPs, the goal is to discharge clear storm water with no visible pollutants (to the maximum extent practicable) and no known sources of man-made pollution (such as toxic substances, chemicals or fertilizers). The objective of this section is to establish a baseline for pollution removal goals to evaluate the storm water treatment BMPs (**ST**), especially manufactured BMP systems, oil-water separators, or other innovative methods of treating storm water runoff. Memphis and Shelby County encourage water quality treatment and reserve the right to require water quality treatment. As stated in Section 1.6, the City of Memphis allows storm water fee adjustments and credits against a user's storm water fee as a financial incentive to implement structural and nonstructural BMPs to encourage water quality improvement.

There is essentially a three-step approach to achieving water quality (simplified from the 4 steps shown in the BMP treatment train for Figure 4-1). The first step is large-scale prevention of pollution from entering or even contacting any storm water runoff (**AM**, **ES, IC, RH**). The second step is removal of the visible components of storm water runoff pollution, such as coarse sediment, oil and grease, bulk materials, and floating debris (**AM**, **ES**, **IC**, **ST**). The third step is the treatment and removal of the less obvious pollutants in storm water runoff, such as fine sediment, nutrients, and heavy metals from automotive emissions (**ST**).

Memphis and Shelby County do not currently require that the "first flush" volume be detained and treated; however, they require the use of volume control methods for detention that will reduce flows from structures and provide a water quality benefit for some storm events. Volume 2 of the SWMM details the detention requirements for volume control of the two- and five-year/24-hour storm events. In most cases, this type of detention will not provide treatment of the first flush, which usually represents the early stages of a storm event, that typically delivers a large amount of accumulated pollutants and sediments that have been deposited since the last storm event. In actuality, it is not possible to predict the manner in which rainfall will come. The first flush may be a steady drizzle that slowly dissolves oil, grease, or other automotive combustion by-products from the streets, or it may be a heavy downpour that really does flush all sediments and accumulated particulates into the storm drain. As previously stated, some water quality benefit may result from the water quantity detention requirements for larger storms.

As a frame of reference, management of first flush volumes are widely required throughout the United States and generally depend on the types of local rainfall patterns. The rainfall statistics in Table 4-1 for Zone 2 (Tennessee's zone) shows relative storm volumes, intensities, and durations and how a summer storm can differ from the annual storm.

Table 4-1
Representative Rainfall Statistics for Zone 2
(DE, MD, KY, NC, TN, VA, WV, and Parts of IL, IN, OH)

	Mean Volume	Mean Intensity	Mean Duration	Mean Interval between Storms
Annual	0.36 inches	0.066 in/hour	5.9 hours	77 hours
Summer	0.40 inches	0.101 in/hour	4.2 hours	77 hours

Source: City of Knoxville BMP Manual

The Table 4-2 represents a mechanism for estimating the amount of annual precipitation that is captured by an extended dry detention basin, based upon computer modeling performed by CDM using the U.S. Army Corps of Engineers program STORM for a study of dry detention basins in the Metropolitan Washington, D.C. area:

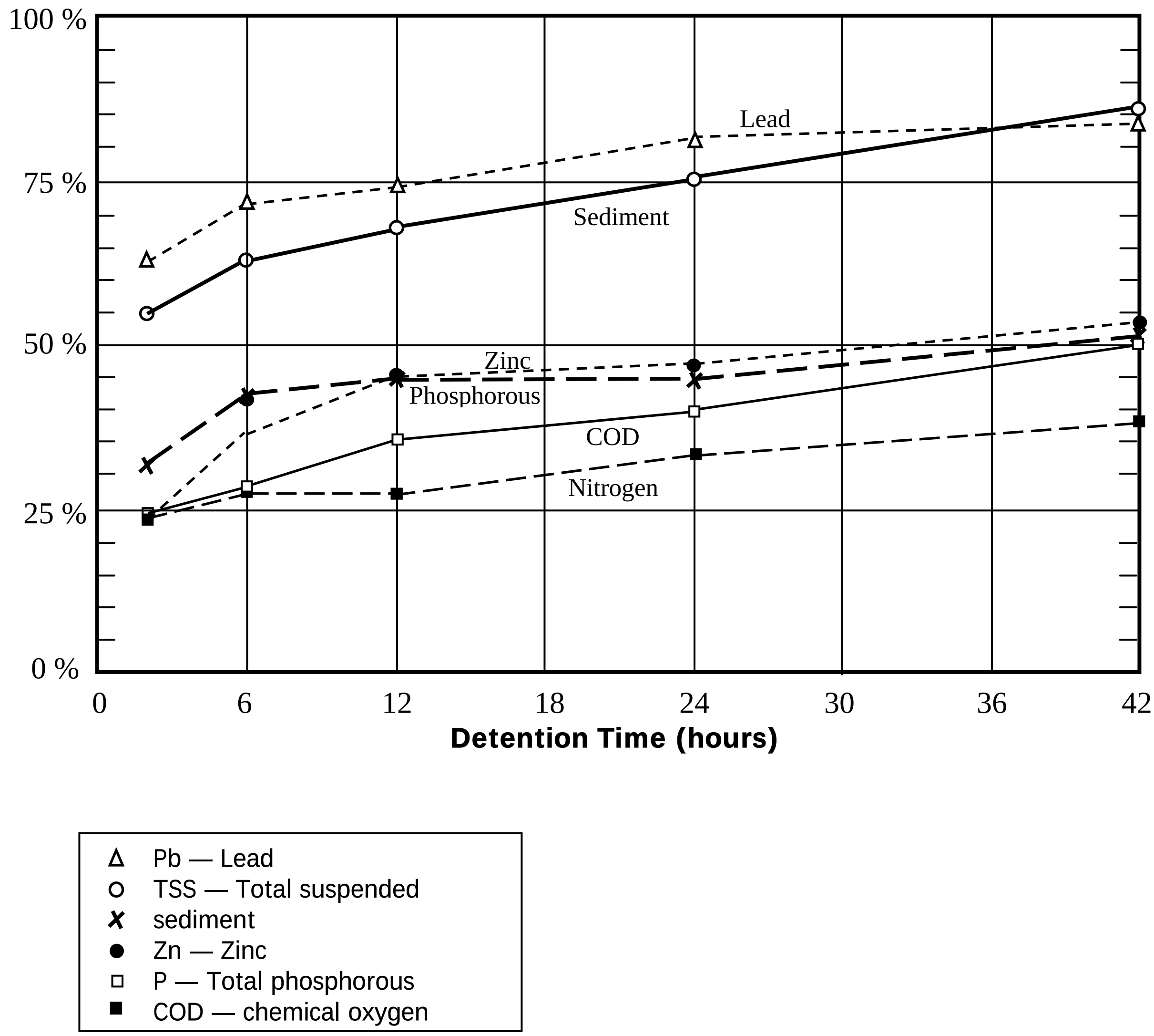
Table 4-2
Percentage of Capture for Average Annual Storm Water Runoff

Storage	Percent imperviousness for contributing watershed (I)					
(inches)	I = 0%	I = 20%	I = 40%	I = 60%	I = 80%	I = 100%
0.20	94%	77%	62%	52%	44%	38%
0.40	100%	94%	86%	77%	69%	62%
0.60	100%	99%	94%	89%	83%	77%
0.80	100%	100%	98%	94%	90%	86%
1.00	100%	100%	99%	97%	94%	91%
1.50	100%	100%	100%	100%	99%	97%

Source: Computer modeling by CDM

The overall basis for evaluating pollution removal efficiencies for an example storm water treatment BMP is shown in Figure 4-2 (taken from reference 152). These six categories represent some of

Figure 4-2
Pollutant Removal for Dry Detention Basins



the common pollutants found in an urban environment, with the principal category considered to be the total suspended sediments (TSS). Figure 4-2 shows that the dry detention basin with a 24-hour detention time will remove approximately 75% of the sediment. New construction and redevelopment projects in Memphis and Shelby County are required to have a 24-hour storm water detention of the two- and five-year storm volumes. Dissolved nutrients (phosphorous and nitrogen) are much harder to remove from storm water runoff, and a removal rate of 30% to 40% is reasonable for a detention time of 24 hours. A closer look shows that even two hours of detention time will accomplish a great deal of storm water treatment.

Typical pollutants from areas that carry automobile traffic (such as highways, streets, and parking lots) are shown in Table 4-3. Toxic pollutants such as polychlorinated biphenyls may also be present. Heavy metals, oil and grease, and coarse sediments can be removed efficiently through the use of oil-water separators or by media filtration inlets, provided that these manufactured systems are carefully chosen for each application.

Table 4-3
Typical Pollutants from Highways and Streets
(from Reference 40)

Sources	Parameters	Average Concentration mg/L	Range of Concentration mg/L
Particulates: (tires, brake pads, car exhaust, mud)	Total suspended solids (TSS)	261	4 - 1656
	Total volatile solids (TVS)	242	26 - 1522
Heavy Metals: (tires, brake pads, motor oil, rust, leaded fuel, additives to other types of vehicle fluids)	Cadmium (Cd)	0.04	0.01 - 0.40
	Copper (Cu)	0.10	0.01 - 0.88
	Chromium (Cr)	0.04	0.01 - 0.14
	Iron (Fe)	10.3	0.10 - 45
	Lead (Pb)	0.96	0.02 - 13
	Nickel (Ni)	9.92	0.10 - 49
	Zinc (Zn)	0.41	0.01 - 3.4
Organic Matter: (vegetation, litter, food, animal droppings, fuel, and oil)	Biochemical oxygen demand (BOD_5)	24	2 - 133
	Chemical oxygen demand (COD)	15	5 - 1058
	Oil and grease	9.5	1 - 104
	Total organic carbon (TOC)	41	5 - 290
Nutrients: (fertilizers, natural soils, chemicals)	Total kjeldahl nitrogen (TKN)	3.0	0.10 - 14
	Phosphorous (expressed as PO_4)	0.8	0.05 - 3.5

mg/L = milligrams per liter

Table 4-4 shows the expected pollution concentration for three typical land uses, based upon published data (1993) from the National Urban Runoff Program at many locations throughout the United States. These values are for illustrative purposes only, due to the many variables involved.

The total water hardness and the amount of storm water runoff dilution are major factors in determining concentrations. Table 4-5 shows a representative range of efficiencies for several types of storm water treatment BMPs. These efficiencies are typical for well-constructed detention basins and other structures that are properly inspected and maintained in good working order.

Table 4-4
Pollutant Concentration in Urban Runoff for Annual Exceedance Frequencies
(from Reference 166)

	Residential			**Mixed Land Use**			**Commercial**		
Pollutant	**25 %**	**10 %**	**1 %**	**25 %**	**10 %**	**1 %**	**25 %**	**10 %**	**1 %**
	(pollutants are measured in mg/L for each annual exceedance frequency)								
COD	103	141	241	93	130	228	63	97	199
Lead	0.23	0.34	0.68	0.23	0.42	1.22	0.16	0.23	0.44
Zinc	0.22	0.34	0.47	0.25	0.37	0.77	0.41	0.69	1.7

Table 4-5
Comparative Pollutant Removal Percentages of Urban BMP Designs
(from Reference 101)

BMP DESIGN	**TSS**	**Total P**	**Total N**	**Oxygen Demand**	**Trace Metals**
	(expressed in percentages)				
Dry detention basin, First flush held for 6 to 12 hours	60 – 80	20 – 40	20 – 40	20 – 40	40 – 60
Dry detention basin, 1” runoff volume held for 24 hours	80 - 100	40 – 60	20 – 40	40 – 60	60 – 80
Dry detention basin with shallow marsh and forebay, 1” runoff volume held for 24 hours	80 - 100	60 – 80	40 – 60	40 – 60	60 – 80
Wet detention basin, Permanent pool = 0.5” per impervious acre	60 – 80	40 – 60	20 – 40	20 – 40	20 – 40
Wet detention basin, Permanent pool = 2.5 x mean storm runoff	60 – 80	40 – 60	20 – 40	20 – 40	60 – 80
Wet detention basin, Permanent pool = 4.0 x mean storm runoff	80 - 100	60 – 80	40 – 60	40 – 60	60 – 80
Infiltration basin, Exfiltrates 0.5” per impervious acre	60 – 80	40 – 60	40 – 60	60 – 80	40 – 60
Infiltration basin, Exfiltrates 1” per impervious acre	80 - 100	40 – 60	40 – 60	60 – 80	80 - 100
Infiltration basin, Exfiltrates all runoff from 2-year design storm	80 - 100	60 – 80	60 – 80	80 - 100	80 - 100
Filter strip, 20’ wide turf strip	20 – 40	0 - 20	0 - 20	0 - 20	20 – 40
Filter strip, 100’ wide forested buffer with level spreader	80 - 100	40 – 60	40 – 60	60 – 80	80 - 100
Grass swale, Moderate slopes with no check dams	0 - 20	0 - 20	0 - 20	0 - 20	0 - 20
Grass swale, Low slopes with check dams	20 – 40	20 – 40	20 – 40	20 – 40	0 - 20
Water quality inlet or oil-water separator, (consult manufacturer)	Varies	Varies	Varies	Varies	Varies

5.0 EROSION AND SEDIMENT CONTROL PLANS

5.1 Overall Requirements

The use of source control BMPs to control erosion before it starts is the preferred method of long-term sediment control. However, the best protection on active construction sites is generally obtained through simultaneous application of both source control and sediment containment BMPs. This combination of controls is effective because it prevents most erosion before it starts and has the ability to capture sediments that become suspended before the transporting flows leave the construction site.

BMPs for erosion and sediment control are selected to meet the BMP objectives based on specific site conditions, construction activities, and cost effectiveness. Since construction site conditions are constantly changing, different BMPs may be needed at different times during construction.

In most cases, permanent BMPs can be implemented most effectively when they can be integrated into other aspects of the project design. This requires that storm water control be considered early in the design process. Storm water detention is required for most types of development and some types of redevelopment within Memphis and Shelby County. Some BMPs can be incorporated into storm water detention facilities with modest design refinements and limited increases in land area and cost. Some areas can be used for more than one purpose, usually in a cost-effective way. Landscaped open space, which is relatively flat, may be combined with storm water quality/ quantity facilities. Vegetated swales and buffer areas may be used as roadside corridors or along parking lots.

5.1.1 TDEC Requirements

TDEC's General Permit for Storm Water Discharges Associated with Construction Activities (Permit TNR100000) requires ESCPs be prepared as a part of a (SWPPP) for sites with disturbance of 1 acre or more of land. The ESCP plans and specifications that include the design of sediment basins or other sediment controls involving structural, hydraulic, hydrologic, or other engineering calculations must be prepared by a licensed professional engineer or landscape architect, certified, and registered by the State Board of Architectural and Engineer Examiners, pursuant to Section 62-202, Tennessee Code Annotated, to practice in Tennessee.[1]; however, portions of the ESCP that do not involve design may be prepared by a Certified Professional in Erosion and Sediment Control.

[1] Tennessee General Permit No. TNR100000 Storm Water Discharges Associated with Construction Activities, Section 3.1.1.

Review TDEC's general permit for storm water discharges for construction activities to ensure state requirements are met.

5.1.2 City/County Requirements

Memphis and Shelby County require ESCPs that are submitted for municipal review to meet all the requirements of TNR100000. Appendix A of the Policy Manual, Volume 1 of the SWMM, contains a form required for all plan submittals to Memphis and/or Shelby County certifying that planned development is in compliance with TNR100000.

Typically, the ESCP sent through review to Memphis and/or Shelby County is the same drawing that was sent to TDEC to obtain coverage under TNR100000. There are no additional requirements; however, the City and County require that ESCPs be submitted in conformance with the SWMM. The BMPs included in the SWMM have been approved by Memphis and Shelby County and should be adhered to in the development of ESCPs in Memphis and Shelby County.

5.2 Minimize Disturbed Areas

The first step for selecting BMPs is to compare the project layout and schedule with onsite management measures that, where appropriate, can limit the exposure of the project site to erosion and sedimentation. Scheduling and planning considerations are the least expensive way to limit the need for erosion and sediment control measures. Consider the following procedures to minimize disturbed areas:

1. Do not disturb any portion of the site unless an improvement is to be constructed there. Retain existing vegetation and ground cover where feasible, especially along streams and watercourses and along the downstream perimeter of the site.

2. Minimize the size of disturbed areas and time of exposure by careful phasing of construction. Minimize the amount of denuded areas and any new grading activities during the wet months of December through May. Do not clear any portion of the site until active construction begins. Use temporary cover (such as seeding or straw) whenever construction is halted or delayed.

3. Phased grading operations should limit the areas exposed to the process of erosion at any one time. Only areas that are actively involved in cut and fill operations or are

otherwise being graded should be exposed. Exposed areas should be stabilized as soon as grading is complete in that area.

4. Construct permanent storm water control facilities such as detention basins and perimeter channels early in the project and use these BMPs for sediment trapping, slope stabilization, and runoff velocity reduction throughout the construction period.

5. Quickly complete construction on each portion of the site. Install landscaping features and other improvements that permanently stabilize each part of the site immediately after the land has been graded to its final contour.

The purpose of site stabilization BMPs is to prevent erosion by covering disturbed soil. This covering may be vegetative, chemical, or physical. Any exposed soil is subject to erosion — either by rainfall striking the ground, runoff flowing over the soil, wind blowing across the soil, or vehicles driving on the soil. Thus all exposed soils should be stabilized except where active construction is in progress. Locations on a construction site that are particularly subject to erosion and should be stabilized as soon as possible include:

- Slopes
- Highly erosive soils
- Construction entrances
- Swales/wet weather conveyances
- Soil stockpiles

5.3 Site Perimeter Controls

The purpose of site perimeter controls is to protect downstream areas from erosion, sediment, flooding problems, and excessive runoff. By doing this, the contractor will not only be obeying the laws, but also making good neighbors. If construction phasing will allow, consider installing permanent storm water control facilities (detention basins and perimeter channels) early in the project and use these BMPs for sediment trapping, slope stabilization, and runoff velocity reduction throughout the construction period.

- Disturbed areas or slopes that drain toward adjacent properties, storm drain inlets or receiving waters should be protected with continuous berms, silt fences, sandbags, straw bales, etc., to prevent sediment discharge. The contractor should be prepared to stabilize those soils with additional protective measures prior to the onset of rain.

- When grading has been completed, the areas should be protected with vegetative measures such as mulching, seeding, planting, emulsifiers, or a combination of these methods. The combination of erosion protection measures and sediment control devices should remain in place until the area is permanently stabilized.

- Significant offsite flows (especially concentrated flows) that drain onto disturbed areas or slopes should be controlled through use of continuous berms, earth dikes, drainage swales, check dams, and lined ditches that will allow for controlled passage or containment of flows.

- Concentrated flows that are discharged offsite should be controlled through outlet protection and velocity dissipation devices to prevent erosion of downstream areas. See ES-25, Outlet Protection, for various types of velocity dissipation devices.

- Perimeter controls should be placed everywhere runoff enters or leaves the site, before clearing and grubbing begin. Both runoff and sediment typically overload perimeter controls so that constant monitoring and maintenance is required. Additional controls within the interior of the construction site (such as check dams and sediment traps, etc.), should supplement perimeter controls once rough grading is complete.

5.4 Internal Erosion and Drainage Design

When perimeter controls and outfall devices have been installed, internal erosion and drainage design can be addressed. Internal design elements are generally more time intensive. The middle of a project site is where construction phasing and sequencing becomes important. Until the permanent facilities are constructed, temporary storm water facilities will be subjected to erosion from concentrated flows.

- These facilities should be stabilized through temporary check dams and geotextile mats, and under extreme erosive conditions, by lining with concrete.

- Long or steep slopes should be terraced at regular intervals. Terraces will slow down the runoff and provide a place for small amounts of sediment to settle out.

- Slope benches may be constructed either with ditches along them or back-sloped at a gentle angle toward the hill. These benches and ditches intercept runoff before it can reach an erosive velocity and divert it to a stable outlet.

- Creating a rough surface for runoff to cross (such as tall grass) can reduce overland flow velocities.

5.5 Inspection and Maintenance

Inspection and maintenance are the key elements in controlling erosion and sediment. Erosion and sediment control devices are installed as necessary and moved around the project site. Inspection should be performed after each rainfall and at least weekly. Maintenance must be performed immediately whenever deficiencies are noted. Checklists can help to document the inspection and maintenance process. A sample Erosion and Sediment Control Plan Review Checklist and a sample Site Inspection Checklist are included at the end of this section.

Larger projects should generally arrange for a preconstruction assistance meeting in order to coordinate erosion control objectives and methods with the city or county inspector prior to commencing clearing and grading. The city or county inspector will visit the project periodically and will also be involved in the final inspection checklists and approval.

Many BMP controls work on the same principle; the velocity of sediment-laden runoff is slowed by temporary barriers or traps, which pond the storm water, allowing the sediments to settle out. Therefore, sediment removal is an important activity in maintaining several BMPs. Excessive sediment should be removed from the storm water both within and along the perimeter of the project site. Appropriate strategies for the inspection and maintenance of erosion and sediment control features include:

1. Verify that sediment-laden storm water is directed to temporary sediment traps or basins. Verify that sediment basins and traps are at low points below disturbed areas.

2. Protect all existing or newly installed storm drainage structures from sediment clogging by providing inlet protection for area drains and curb inlets. Storm water inlet protection can utilize sand bags, sediment traps, or other similar devices.

3. Excavate permanent storm water detention ponds early in the project, use them as sedimentation ponds during construction, remove accumulated sediment, and landscape the ponds when the upstream drainage area is stabilized.

4. Inspect temporary sediment barriers such as silt fences, straw bale barriers, rock filters, and continuous berms after each rainfall. These barriers should only be used in areas where

sheet flow runoff occurs. They are ineffective if the runoff is concentrated into rill or gully flow.

5. Internal outfalls must also be protected to reduce scour from high velocity flows leaving pipes or other drainage facilities.

5.6 ESCP Preparation Guidance

In general, the ESCP will consist of a narrative and a drawing. The project designer may choose to have the narrative included on a drawing or issued as a report. The owner of the land being developed has the ultimate responsibility for the ESCP preparation and submittal to TDEC, Memphis and Shelby County. The owner may designate someone to prepare the plan, but the owner still has the ultimate responsibility.

A narrative (limited to one paragraph on the plans submittal) is required to explain the decisions concerning erosion and sediment control. The narrative should be adequate to allow a reviewer to make intelligent judgments concerning the effectiveness of the controls. It should contain complete and concise information regarding information that is not usually shown on drawings, such as construction schedules, existing soils, calculations and computations, types of vegetation, inspection and maintenance of controls, etc.

The level of detail should be appropriate to the project size and complexity. Projects near streams and other sensitive areas will require a high level of detail. In general, properties with a high percentage of impervious area will need a higher level of detail than properties with a low percentage of impervious area. Steep slopes may also affect the amount of effort in preparing an ESCP.

The Tennessee Department of Transportation (TDOT) is an excellent source for erosion control details. There are over 300 TDOT Standard Roadway and Structure Drawings, grouped into the following categories: roadway design, culverts and endwalls, catch basins and endwalls, roadway and pavement appurtenances, safety appurtenances and fence, traffic control appurtenances, and erosion control and landscaping. Contact TDOT for further details on how to purchase this reference, or these details may also be viewed and downloaded as Acrobat files from http://www.tdot.state.tn.us/Chief_Engineer/engr library/design/Std_Drwg_Eng.htm. TDOT drawing RD-L-4 contains a standard legend that can be helpful in depicting erosion and sediment control items.

A typical checklist for preparing an ESCP is included at the end of this section. Many engineering firms and construction contractors have their own checklists or templates for preparing an ESCP.

Many engineering firms and construction contractors have a standard set of general notes, which are generally sufficient. The following list contains general notes for a typical small project.

Typical General Notes for Erosion and Sediment Control Plans:

1. As a minimum, all erosion and sediment control practices will be constructed and maintained according to the standards located in the Memphis and Shelby County SWMM, and as required by state and federal laws.

2. A copy of the approved erosion and sediment control plan shall be maintained at the project site at all times. This copy shall be made available to the City or County upon request.

3. Prior to commencing land-disturbing activities in any area not on the approved erosion and sediment control plan, the contractor shall submit a supplementary erosion control plan to TDEC and the City or County for review and approval.

4. All erosion and sediment control measures are to be placed prior to or as the first step in clearing and grading. The contractor is responsible for any additional erosion control measures necessary to prevent erosion and sedimentation.

5. The City or County must be notified prior to dewatering operations. Water must be pumped through an approved filtering device. The City or County may suspend dewatering operations if pollution is observed.

6. The contractor shall inspect all erosion and sediment control devices per TNR100000. The contractor shall perform any repairs or maintenance immediately in order to ensure effective erosion and sediment control.

7. The contractor shall maintain a record of all inspections and maintenance activities at the project site. This record shall be made available to the City or County upon request.

Typical Checklist for Preparing Erosion and Sediment Control Plan
Narrative (Sheet 1)

In a single paragraph on a 24” x 30” plan submittal, provide the following information. Make sure the site name and address are included in the paragraph and check the submittal for legibility, page numbers, and correct spelling.

_____ Describe existing site conditions (vegetation, drainage patterns, topography) and proposed site conditions (ground cover, drainage patterns, and site grading)
_____ Project description — Purpose of grading or construction activity, total area to be disturbed
_____ Adjacent property and uses
_____ Critical or sensitive areas — Steep slopes, streams, wetlands, sinkholes, etc.
_____ Construction scheduling — Duration of clearing, open grading, installation of permanent storm water controls
_____ Inspection and maintenance schedule for BMPs and erosion control devices
_____ Briefly describe the design standards used for any detention structures

Site Plan (Sheet 2)

_______ Basic drawing format — North arrow, scale, engineer stamp, site name and address, legibility, drawing legend, typical abbreviations
_____ Vicinity map — A small map showing the surrounding area, including landmarks, streams, and roads
_____ Existing vegetation and trees
_____ Limits of clearing and grading
_____ Existing and proposed contours — Appropriate interval, contours match together
_____ Site development — Show all buildings, roads, parking lots, and other structures
_____ Construction access routes, borrow areas, spoil areas
_____ Existing and proposed drainage structures — Sizes, materials, slopes, other important dimensions
_____ Drainage patterns and watershed boundaries — Indicate drainage area for each watershed
_____ Property boundaries and easements
_____ Location of critical or sensitive areas
_____ Location of BMPs and erosion control devices — Typical placement as construction work progresses
_____ Details for BMPs and erosion control devices

Storm Water Inspection Checklist
For a Construction Activity Subject to NPDES Requirements

Date:_____________________________________ **Time:**_________________________________

Site: ___________________________________ **Permit No:** _____________________________

Site Operator: ____________________________

Vehicle Ingress/Egress Locations (Construction Entrances):

Built per specification (2" to 3" stone, 20'W x 50'L x 6"D minimum, etc.)	Ç Yes Ç No Ç N/A
Maintenance is being performed (sweeping affected streets, etc.)	Ç Yes Ç No Ç N/A

Grading:

Clearing limits are defined and being maintained	Ç Yes Ç No Ç N/A
Areas designated as buffer zones are undisturbed	Ç Yes Ç No Ç N/A
Areas inactive for the past 15 days have been stabilized	Ç Yes Ç No Ç N/A
Graded area within 50-acre limit (phased is >50)	Ç Yes Ç No Ç N/A
Dust being properly controlled	Ç Yes Ç No Ç N/A

Silt Fencing:

Installed according to approved plans (reinforced, entrenched 6", etc.)	Ç Yes Ç No Ç N/A
Silt fencing being maintained (less than 50% capacity, etc.)	Ç Yes Ç No Ç N/A
Stakes spaced 6' apart and minimum 6" overlap between joints	Ç Yes Ç No Ç N/A

Temporary Sediment Basins/ Sediment Traps:

Required below disturbed areas with >5-acre drainage basin	Ç Yes Ç No Ç N/A
Designed for 5-yr/24-hr storm event	Ç Yes Ç No Ç N/A
Installed per design and specifications (outlet structure, etc.)	Ç Yes Ç No Ç N/A
Basin(s) being maintained (less than 50% capacity, etc.)	Ç Yes Ç No Ç N/A
Temporary berm (levee) in good condition (no erosion rills, etc.)	Ç Yes Ç No Ç N/A

Discharge Locations:

Sediments being maintained onsite	Ç Yes Ç No Ç N/A
Outlets free of obstructions (sediment, litter, etc.)	Ç Yes Ç No Ç N/A
Riprap and filter cloth properly installed	Ç Yes Ç No Ç N/A
Check dams required/installed according to plans and specifications	Ç Yes Ç No Ç N/A

Materials Storage Areas:

Debris and stockpiles maintained properly (covered, etc.)	Ç Yes Ç No Ç N/A
Construction site free of spills	Ç Yes Ç No Ç N/A

Other:

Streets free of sediment and debris	Ç Yes Ç No Ç N/A
Inlet protection properly installed and maintained	Ç Yes Ç No Ç N/A
Offsite areas free of adverse impacts due to construction (litter, silt, etc.)	Ç Yes Ç No Ç N/A
Sanitary facilities onsite	Ç Yes Ç No Ç N/A
Pollution Prevention Plan onsite	Ç Yes Ç No Ç N/A
60-foot buffer zone from top of stream bank maintained	Ç Yes Ç No Ç N/A

6.0 STORM WATER POLLUTION PREVENTION PLAN

6.1 Memphis and Shelby County Requirements

TDEC has specific requirements for any SWPPP that is part of the NPDES permit program. TDEC requires a contractor to submit a SWPPP for construction sites that disturb 1 acre or more, using the instructions under the statewide NPDES General Permit for Construction Storm Water. TDEC also requires a SWPPP for industrial activity with the potential to pollute waters of the state, using the instructions under the statewide NPDES General Permit for Industrial Storm Water. See the TDEC web site listed in Chapter 8 for additional information on these two general statewide permits and how to obtain coverage. The TDEC web site also has a summary of environmental permits that are required to meet state and federal regulations.

As part of the process of obtaining a NPDES Permit (construction or industrial), an NOI must be filed with the Memphis and/or Shelby County within 60 days of being issued by TDEC. TDEC permit holders must make SWPPPs available to Memphis and/or Shelby County upon request.

Memphis and Shelby County have the right to require a SWPPP be prepared, even when not required by TDEC, on the basis of: 1) sound engineering judgment, 2) type of business, or 3) a history of water pollution at this site or by this owner/operator at other sites. Typical properties or land uses that may require a SWPPP include:

- Vehicle fueling stations
- Vehicle service and maintenance facilities
- Vehicle and equipment cleaning facilities
- Fleet storage areas (for cars, buses, or trucks)
- Industrial and manufacturing sites
- Outdoor loading/storage/transfer facilities
- Salvage and recycling facilities (including junkyards)
- Marinas and boat maintenance facilities
- Commercial nurseries

The remainder of this section addresses requirements for preparing a SWPPP when required by the Memphis and/or Shelby County, but not by TDEC. SWPPP requirements are generally the same as described in the cited Tennessee Rule and in two U.S. Environmental Protection Agency (USEPA) documents that are both subtitled, “Developing Pollution Prevention Plans and Best Management Practices” (references 137 and 138).

The life history of a SWPPP includes three phases:

1. Site Evaluation
2. Planning and Design
3. Implementation and Monitoring

Preparing a SWPPP involves the first two phases of the life history but requires careful consideration of how the third phase will be handled. The SWPPP shall include a methodology for adding letters, memos, inspection reports, monitoring data, maintenance records, leak/spill information, etc. The SWPPP is intended to be a living document that will serve the site owner/ operator in meeting many environmental needs.

6.2 Phase 1: Site Evaluation

This requirement is intended to be a one-time event if a SWPPP is maintained properly. If the SWPPP is not maintained properly, then a complete site evaluation may be required again whenever new construction or redevelopment takes place.

Step 1: Select a pollution prevention team. A specific individual will be in charge of developing and maintaining the SWPPP. At a minimum, there must be one other team member who is familiar with the specifics of the SWPPP and who can take charge in the absence of the leader. Pollution prevention team members must be aware of all activities at the site. For large project sites, there may be many pollution team members.

Step 2: Conduct a site assessment, including a review of all available information and records. A site map must be developed that includes all known structures, drainage features, material storage, known leaks and spills, historical information such as date of construction, etc. Additional items to be shown include soil types, vegetation, contours, drainage outfalls, size and material of storm water pipes and manholes, floor drains, parking areas, and method of roof drainage. The site map must be drawn to scale, legible, properly labeled, and reproducible.

Step 3: Develop a comprehensive materials inventory to include material safety data sheets (MSDS). All materials and liquids should be included on the list, no matter how small the quantity involved. The list should include the name of material, location stored, type of container, volume of material, use of material, safeguards in place to prevent pollution, and whether a MSDS is required. The list should also indicate which materials are exposed to storm water and the quantities involved.

Step 4: Identify all non-storm-water discharges, including past spills and leaks. A non-storm-water discharge is any material that is released intentionally or unintentionally to the ground surface, to a storm drain system, or to a natural channel. Concrete truck washout must follow the guidance in BMP AM-18 (Concrete Waste Management). Provide a list of significant spills and leaks that have occurred within the last 3 years, using the federal definition of a reportable quantity. A reportable quantity of each material can be defined using the federal regulations contained in 40 CFR 302.4, 40 CFR 117.21, and 40 CFR 110.10.

Step 5: Provide monitoring data to identify non-storm-water discharges, past spills and leaks, and the current level of pollution from the various site outfalls. Storm water sampling must be conducted for parameters deemed to be important by Memphis and/or Shelby County. The parameters are subject to change: 1) from watershed to watershed, 2) over a period of time, and, 3) as directed by TDEC or the USEPA. Therefore, it is essential to contact the Memphis and/or Shelby County storm water programs for further guidance on storm water sampling parameters.

Step 6: Evaluate the gathered data and to write a site evaluation summary. The use of electronic drawings and spreadsheets is encouraged and will generally allow the SWPPP preparer to make changes as necessary. The narrative should concentrate on activities with a high potential for contaminating storm water.

6.3 Phase 2: Planning and Design

What changes can be made to improve storm water quality? What can be done to reduce the possibility of a spill or release? How can monitoring and sampling be made easier and more consistent?

Step 1: Identify BMPs and good housekeeping practices necessary to improve operations. The most effective BMP is to hire good employees and to provide them with consistent training. An employee training manual, as part of a well-designed training program, can be a simple and cost-effective method to ensure good housekeeping practices.

Step 2: Identify ways to improve work methods and ways to reduce storm water pollution. The second-most effective BMP is to use the proper equipment and materials. For instance, a commercial or industrial site should consider equipment upgrades and improvements as necessary. A construction site should identify erosion and sediment control measures. Most sites should consider the use of storm water control measures (grass buffer zones, detention basins, oil-water separators) to reduce storm water pollution leaving the site.

Step 3: Design a program for operation and maintenance, including regularly scheduled inspections and testing. Record keeping is essential to this program; an electronic database is almost a necessity for many types of sites. Ensure that inspection records have a standard format with complete information, in case of an audit. Inspection records must be kept for at least three years.

Step 4: Design a spill prevention and response program. Safety measures and emergency contact telephone numbers must be identified and then posted on the site for quick use. Include procedures for notifying regulatory authorities (Memphis or Shelby County, TDEC) and emergency responders (police, fire, hospital). Describe spill containment, isolation, and cleanup measures that would be used. Although the Memphis and Shelby County fire departments can assist with spill or leak containment, the responsible party will be expected to remediate any pollution. It is highly recommended that a spill response program include remediation contractors or emergency response contractors, such as are listed in Table AM-07-1.

6.4 Phase 3: Implementation and Monitoring

This phase essentially involves the actual implementation of the plan and design developed in Phase 2. It may be necessary to develop an implementation schedule and cost estimate if some items are being phased.

Step 1: Train employees properly in accordance with a good employee training program that is carefully documented, typically with tests or quizzes. State and federal agencies, depending on materials involved or the type of business may mandate additional training requirements.

Step 2: Use the BMPs identified previously in the SWPPP. Proper construction and installation is important to ensure proper function. Document each item as it is being installed; pictures are generally preferable to supplement sketches. Correctly store all written operating procedures, repair manuals, spare parts, and receipts for immediate use and/or reference.

Step 3: Purchase a spill containment kit or materials. Train all personnel about where materials are stored, when to use spill containment, emergency notification procedures, and the disposal of used spill containment materials.

Step 4: Inspect and maintain the site as described in the design phase. Inspection duties must be assigned to a responsible person in order to ensure proper inspection schedules and record keeping.

6.5 SWPPP Preparation Guidance

The following checklist is a short version containing some of the typical elements for SWPPP preparation. Additional information may be necessary due to the nature of the site. The TDEC web site has guidance on preparing a SWPPP for construction sites and for industrial sites. The USEPA documents for preparing pollution prevention plans (references 137 and 138) contain additional checklists and examples.

1. Complete site description, address, and purpose
2. Pollution prevention team with complete contact information
3. Signature page for responsible persons
4. Pertinent project correspondence and project history
5. Description of potential pollutant sources
6. Existing topography, grading, vegetation
7. Information on soils and groundwater
8. Site drainage map, including outfall locations and sinkholes
9. Existing and proposed drainage structures (size, material, dimensions, etc.)
10. Material storage areas
11. Inventory of exposed materials within the last three years ***
12. List of known spills and leaks within the last three years ***
13. List of non-storm-water discharges within the last three years ***
14. Sampling data within the last three years ***
15. Good housekeeping measures and BMPs
16. Inspection and maintenance schedule
17. Inspection and maintenance records
18. Spill prevention and response procedures
19. Material safety data sheets
20. Inventory and location of spill prevention materials
21. Employee training
22. Record keeping and reporting procedures
23. Copy of NPDES permit and/or application

*** The SWPPP shall include an appendix to keep ongoing records of all known spills, leaks, and non-storm-water discharges indefinitely.

7.0 POST-CONSTRUCTION RUNOFF CONTROL

As detailed in Appendix C of Volume 1 of the SWMM: Policy Manual, Memphis and Shelby County require a Storm Water BMP Operation and Maintenance (O&M) Agreement for any new development or significant redevelopment that includes post-construction BMPs that require long-term operation and maintenance. The O&M Agreement comprises an Inspection and Maintenance Agreement signed by the developer or BMP owner and the preparation of a PCRC Plan.

The PCRC Plan must include a description of the storm water system and its components, inspection priorities and inspection schedule for each component, and a schematic for each BMP.

Purposes of the PCRC Plan:

- To inform property owners about the system components on their properties, so that they will know the locations and maintenance needs of the components and structural BMPs
- To facilitate inspections
- To obtain storm water credits for BMPs (under the storm water enterprise fund)
- To ensure adequate operation and maintenance of post-construction BMPs that require maintenance (e.g., detention and retention ponds, including underground detention structures)

Requirements of the PCRC Plan:

The PCRC Plan is required for all development or significant redevelopment that includes the construction of post-construction storm water BMPs that require long-term operation and maintenance. The PCRC Plan must be submitted by the design engineer or plan designer as a separate plan sheet (and detail sheet if needed) in the plan set submitted to the Technical Committee for review. The PCRC Plan must include or address the following elements:

- Description and locations of storm water system components to be inspected, prepared by the engineer.
- Schedule of inspections and the techniques used to inspect and maintain the systems to ensure that they are functioning properly as designed. Documentation checklists for each type of BMP, including the inspection schedule and potential maintenance items that

must be addressed. Templates for checklists are found in Appendix C of Volume 1 of the SWMM: Policy Manual.

- Where and how the trash, sediment, oil, and other vehicle fluids and other pollutants removed from the storm water system will be disposed. This should include any parameters listed in the TDEC 303(d) list for the water bodies into which the development discharges and for which the development could be a reasonable source.

- Schematics of BMPs located on the site, including outlet structure details indicating design storm event.

- Person(s) and phone number(s) responsible for inspection and maintenance. If the organization that will be responsible is yet to be organized, list the name, address, and phone number of the person or entity with interim responsibility.

- Provisions for permanent access and maintenance easements.

- The PCRC Plan shall be signed and sealed by a Tennessee registered professional engineer.

- The PCRC Plan shall certify compliance with all required state or federal storm water permits.

General Information Requirements for PCRC Plans:

1. Intended use of the development (e.g., single-family residential, office park, etc.)
2. Vicinity map based on a USGS quadrangle map (adjusted to appropriate scale)

Site Information Summary Block Requirements for PCRC Plans:

1. Total site area (acreage).

2. Impervious area (square feet).

3. Dedicated open space (acres).

4. Total drainage area entering storm water detention (acres) [this number includes any offsite drainage area that is received].

5. Total drainage area (onsite only) entering storm water detention (acres).

6. Total onsite drainage area entering a water quality BMP.

7. Total combined offsite and onsite area entering a water quality BMP.

8. Tax ID number of the property.

9. If located within a larger development, state whether or not the discharge from the site flows into another detention structure farther downstream.

10. Indicate the name of the stream or water body that receives the discharge.

PCRC Plan Review Information:

Changes in the PCRC Plan may be required based on the review of the plan. In addition, supporting data/supplemental information may be required. It is expected that the PCRC Plan will be a modified version of the Grading and Drainage Plan being submitted and that a combination of structural and/or nonstructural BMPs shall be employed. Structural BMPs shall include, but not be limited to, grass swales and detention/retention ponds. In-ground premanufactured water quality units will be evaluated on a case-by-case basis. Nonstructural BMPs shall include but not be limited to administrative programs, street sweeping, employee training, material/waste handling practices, and measures to isolate pollutants from storm water (such as putting a roof over gasoline pump islands.) Note that the PCRC plan review will not cover non-storm-water quality elements related to the design such as load-bearing capacity, flooding potential, etc.

A "Standard PCRC Plan" for use as a guide may be obtained from the City of Memphis Division of Public Works or the Shelby County Department of Public Works. If you have any questions, contact the City at (901) 576-4349 or the County at (901) 545-4320.

PCRC As-Built Plan Requirements:

Before bonds will be released for new construction, a PCRC Plan with an as-built survey, certified by a licensed professional engineer as appropriate, must be submitted as georeferenced, electronic files for all public and private storm water management facilities. The licensed professional shall certify how the facilities should be operated, maintained, and inspected to continue to function as designed and must include the demonstration of fiduciary responsibility for ongoing maintenance. The licensed professional shall certify on the as-built plan that the facilities have been constructed in substantial and essential conformance to the design plan. As-built capacities must be verified with a survey. It is understood that as-builts will not include final grading by homebuilders on individual lots; however, the storm water infrastructure and direction to homebuilders and homebuyers regarding passive paths conveying storm water flows must be included.

PCRC Plan Annual Reports:

Annual inspection and maintenance reports are due to the City and/or County by July 1 of each year. Storm water BMP inspection checklist templates for typical post construction BMPs that require maintenance are contained in Appendix C of Volume 1 of the SWMM: Policy Manual. The inspection checklists can serve as annual reports. The template checklists are a general guideline of inspection elements; however, engineers may modify checklists to include inspections and maintenance elements as needed.

8.0 LIST OF RELATED WEB SITES

The following web sites are useful in understanding and applying BMPs in accordance with the BMP Manual. The first three sections contain web sites for local, state, and federal governments. Most of these Web sites contain laws and regulations that apply to all citizens and entities within the City of Memphis and Shelby County. These Web sites represent some of the general information available from the local, state, and federal governments. Users of this BMP Manual are encouraged to research particular topics of interest to them.

The last section has various informational sites that may suggest better ways and methods for implementing BMPs. A common reaction to local implementation of BMPs and pollution prevention measures is that it seems to be excessive and that other cities and states are not burdened by these regulations. BMPs are generally required for most large and medium-size municipalities with some differences in target development dates. BMPs are mandated as part of the issued NPDES storm water permits for the City of Memphis and Shelby County by TDEC.

The history of BMPs across the United States demonstrates that water pollution measures are making a significant difference in coastal waters (such as the Chesapeake Bay or Puget Sound) and in urban streams (such as the San Antonio River in downtown San Antonio). Closer to home, the cities of Knoxville, Nashville, and Chattanooga are also required to enact BMPs to improve water quality. It is greatly desired that this BMP Manual will contribute to the quality of life in communities near streams throughout the City of Memphis and Shelby County and also downstream along the Mississippi River.

8.1 Web Sites for the City of Memphis and Shelby County

a) http://www.stormwatermatters.com

This Web site is the storm water portal for both the City and the County. The BMP Manual is posted at this web site for quick and easy use by all citizens of Memphis and Shelby County, and the surrounding communities. Each page of the BMP Manual contains the month and year of issue that represent the current version. This information is also listed on the menu page for the online BMP Manual. The other volumes of the SWMM are posted at this Web site, as well as typical engineering details and standard specifications. The portal also links to the City of Memphis and Shelby County storm water programs, lists general telephone numbers for the various divisions within the Engineering Departments, and has information concerning the Water Quality Hotlines for both MS4s.

In addition, Memphis and Shelby County storm water programs have their own Web sites in addition:

www.cityofmemphis.org
www.shelbycountytn.gov

b) http://www.dpdgov.com

This Memphis and Shelby County Division of Planning and Development Web site contains plan review process information for the City of Memphis and Shelby County. The site includes online geographical information system (GIS) mapping information for the community.

c) Other Local MS4s:

- Germantown at http://www.ci.germantown.tn.us/communitydevelopment.html
- Collierville at http://www.collierville.com/gov_pub.html
- Bartlett at http://www.cityofbartlett.org
- Millington at http://www.cityofmillington.org
- Lakeland at http://www.lakelandtn.org
- Arlington at http://www.townofarlington.org

8.2 Web Sites for the State of Tennessee Government

a) http://www.state.tn.us/environment/

This Web site contains general information for TDEC along with links for further information such as a contact list for emergency numbers. The Web site has links to various divisions within TDEC as well as a site index with alphabetical list of contents (starting with aboveground storage tanks).

b) http://www.state.tn.us/environment/permits/

This Web site contains a list of environmental permits issued by TDEC along with links for further information. Environmental permits are classified under these categories: Air, Water, Waste, Radiological, and Natural Resources.

c) http://www.state.tn.us/environment/wpc/publications/

This Web site contains a list of publications which are available from the Division of Water Pollution Control, which is an entity within TDEC. In addition, the web site has links to the various state laws and regulations that involve water pollution control.

d) http://www.state.tn.us/environment/permits/cheklst.php

This Web site contains a checklist of various environmental considerations, along with the appropriate state or local government agency that can be contacted for further information.

e) http://www.state.tn.us/environment/wpc/publications/Streambank/strmbank.shtml

This Web site is titled "A Landowner's Guide to Streambank Protection and Stabilization." It has permit information, common questions, and an information video.

f) http://www.state.tn.us/environment/nh/species

This Web site contains the list of rare species found in Tennessee, as compiled by the Division of Natural Heritage. The list includes the federal status and state status of each species when available.

g) http://www.tdot.state.tn.us/construction

This Web site contains the TDOT Standard Specifications for Road and Bridge Construction, issued March 1995. This publication has erosion control practices and materials required on TDOT projects and by many local projects.

h) http://www.tdot.state.tn.us/Chief_Engineer/engr_library/design/Std_Drwg_Eng.htm

This Web site contains the TDOT Standard Drawings grouped under several categories. Of principal interest to BMP designers are all types of drainage structures, catch basins, manholes, culverts, landscaping practices, tree walls, sediment basins, and various other erosion control devices.

8.3 Web Sites for the United States Government

a) http://www.epa.gov/owm/mtb/mtbfact.htm

This USEPA Web site contains a comprehensive series of Municipal Technology BMPs under several categories including storm water, wastewater, and combined sewer overflows and storm water.

b) http://www.epa.gov/opptintr/library

This Web site contains a comprehensive series of publications (available for downloading in HTML or PDF formats) that deal with pollution prevention measures. Some publications are for various industries, such as printers and garment cleaning.

c) http://www.epa.gov/epahome/comm.htm

This Web site contains USEPA public databases that allow direct access to environmental information on air quality, chemicals, facilities information and addresses, hazardous waste, toxic releases, and drinking water quality. The databases are linked to a mapping feature to provide local data whenever queried. There are additional features to allow customized reports and data.

d) http://www.epa.gov/opptsmnt/

This Web site contains public information and publications from the USEPA Office of Prevention, Pesticides & Toxic Substances. Topics addressed include household chemicals, lead-based paints, pesticides and food. Includes access to 40 CFR (Protection of Environment).

e) http://www.epa.gov/epahome/lawregs.htm

This Web site contains a list of USEPA laws and regulations along with links to a summary and full text of each law and regulation. It contains access to the entire United States Code.

f) http://www.epa.gov/clariton/clhtml/pubtitle.html

This Web site contains a list of downloadable and printable USEPA documents, including references 137 and 138 concerning preparation of SWPPPs for construction and industrial activities.

g) http://www.fhwa.dot.gov/engineering/hydraulics/library_listing.cfm

This Web site contains a growing list of Federal Highway Administration design manuals that can be ordered online, including many documents that can be downloaded at no cost in Adobe Acrobat PDF format. Two very useful manuals are reference 158 (Hydraulic Design of Highway Culverts) and reference 160 (Hydraulic Design of Energy Dissipaters for Culverts and Channels).

g) http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-tr55.html

This Web site has a free downloadable Acrobat PDF file of Technical Release 55, published by NRCS (formerly known as the Soil Conservation Service) in June 1986. TR-55 is the basic document for defining NRCS drainage computations as required by Memphis Storm Water and Street Ordinance. The TR-55 computer program can also be downloaded, but is of limited value and does not perform detention routing.

h) http://www.wcc.nrcs.usda.gov/wtec/

This NRCS Web site contains the Watershed Technology Electronic Catalog, with a variety of publications and AutoCAD drawings to download. Categories include pollution control, hydraulic structures, plants, erosion, watershed details, etc.

i) http://www.wcc.nrcs.usda.gov/hydro/hydro-techref-neh-630.html

This Web site contains Part 630 (Hydrology) of the National Engineering Handbook, a classic reference on NRCS hydrology methods, drainage design, hydrograph selection and flood routing.

j) http://websoilsurvey.nrcs.usda.gov/app/

Shelby County's soil survey is available on the internet at "Web Soil Survey" allows you to produce a customized soil survey for your site.

8.4 Miscellaneous Web Sites

a) http://www.nashville.gov/storm water/index.htm

This Web site contains the storm water quality management program for the Department of Public Works for metropolitan Nashville. This web site also describes the various programs in Nashville (Illicit Investigation, Field Screening, Ambient Sampling, Wet Weather Sampling, Construction Inspection) that are very similar to those required of Memphis and Shelby County.

b) http://www.chattanooga.gov

This Web site contains information for the storm water management program in the City of Chattanooga, such as BMP brochures, contact information, and a list of the various programs. Chattanooga has a different approach than the other large cities in Tennessee, in that it collects a storm water utility fee from landowners to provide storm water services. Chattanooga has required the capture of 0.75" first flush runoff volume with a release time of four days, and has also mandated sand filtration units for detention pond design.

c) http://www.casqa.org/resourcelibrary

This Web site contains various links to local governments (cities and counties from across the U.S.) with storm water programs similar to the City of Memphis and Shelby County. Southeastern cities similar in size to Memphis (in addition to Nashville and Chattanooga) include: Birmingham, Alabama;, Louisville. Kentucky; Charlotte, North Carolina; Charlottesville, Virginia; and others.

d) http://www.cis.utk.edu/

This Web site represents the University of Tennessee Center for Industrial Services and contains a variety of methods to assist businesses and industries. In particular, it has additional Web links to many environmental sites to obtain publications, checklists, Standard Industrial Classification codes, etc. Information includes checklists of required business permits, information on recycling and waste reduction, and design guidance.

e) http://bioengr.ag.utk.edu/rusle2/download.htm

This Web site has a current version of RUSLE2 software is available for download at no cost.

f) http://www.utextension.utk.edu/publications/

This Web site contains many publications from the University of Tennessee Agricultural Extension Office. The Shelby County office is located at the Agricenter. The agricultural extension office has many free brochures and pamphlets concerning trees, grasses, forestry, horticulture, crops, and gardening. This office is also an excellent source of information for pest control, fishing, and environmental issues. Some publications are available online, generally in Adobe Acrobat PDF format.

g) http://www.bmpdatabase.org/

This Web site represents a national database of BMP performance statistics. It is being developed under the sponsorship of USEPA and the American Society of Civil Engineers. This database will continue to grow as additional data and statistics are submitted by local and state governments. Storm water pollutants are grouped into 12 categories.

h) http://www.igin.com/

This Web site (Irrigation & Green Industry Network) provides guidance for chemicals, power equipment, tree care, pesticides, and fertilizers. It also contains a glossary of various trees, shrubs, vines, bedding plants, and groundcover under the name Plant Search.

i) http://www.ehso.com/

This Web site (Environmental Health and Safety Online) is a comprehensive information source on federal regulations, emergency response, hazardous waste, chemicals, training, solid waste, and many other topics.

9.0 GLOSSARY OF TERMS

The following terms are included as a quick reference and to clarify meanings of words used in the BMP Manual. Some definitions pertaining to sanitary sewers are also included to emphasize that sanitary wastewater is an illicit discharge under all circumstances. See the other volumes of the SWMM for additional terms.

Aquifer — An underground geological formation that contains usable amounts of groundwater to supply wells or springs. The formation usually contains a stratum of sand, gravel, or fractured rock and will transmit water readily.

Bacteria — Single-celled microorganisms that lack chlorophyll. Bacteria are essential to all ecological habitats but some types are hazardous to human and animal life.

Baseflow — The portion of stream discharge that consists of underground water drainage and springs.

Benthic — Relating to or occurring at the bottom of a body of water, such as a stream or lake.

Best management practice — A method or activity that is determined to be the best solution to preventing the amount of pollution generated by nonpoint sources. BMPs are selected on the basis of existing site conditions and the economic/social/technical feasibility.

Biochemical oxygen demand — The quantity of oxygen consumed by biochemical oxidation of organic matter within a sample of water in a specified time and temperature. A typical value for BOD5 (a five-day test of a sample) at 20° C is 5 milligrams per liter. Oxygen is added to the sample so that the BOD measurement is not limited by the amount of available oxygen.

Blue-line stream — Any stream, creek, lake, pond or other body of water shown as a blue line on a 7.5 minute USGS quadrangle map, or any point downstream from where the blue line initially begins.

Chemical oxygen demand — The quantity of oxygen consumed by chemical oxidation of organic and inorganic matter within a sample of water in a specified time and temperature. Similar to BOD test, but value of COD is always equal to or greater than BOD.

Coliforms — Any of a number of organisms commonly found in the intestinal tract of humans and animals. The presence of coliforms is used as an indicator of potentially dangerous bacterial contamination.

Design storm — A typical rainfall event that is used to design a storm water structure. It is designated by the rainfall frequency (i.e., 10-year), the rainfall duration (i.e., 24-hour), and the type of rainfall distribution (i.e., NRCS Type II).

Detention — A practice to store storm water runoff by collection as a temporary pool of water and provide for its gradual (attenuated) release and thereby controlling peak discharge rates.

Development — To make a site available for use by physical alteration. Development includes but is not limited to providing access to a site, clearing of vegetation, grading, earthmoving, providing utilities and other services such as parking facilities, storm water management and erosion control systems, potable water and wastewater systems, altering land forms, or construction or demolition of a structure on the land.

Discharge — To dispose, deposit, spill, pour, inject, seep, dump, leak, or place by any means including direct or indirect entry of any solid or liquid matter into the municipal separate storm drain system, intentional or otherwise.

Dissolved oxygen — The concentration of free oxygen in water that has not been chemically combined. This parameter is vital to fish and other aquatic life. Low levels of dissolved oxygen indicate high levels of pollution.

Erosion — The removal of soil particles by the action of water, wind, ice, or other geological agents, whether naturally occurring or acting in conjunction with man-made activities or effects.

Extended detention — A practice to store storm water runoff by collection as a temporary pool of water and provide for its gradual (attenuated) release over a minimum of 24 hours and no more than 72 hours, and thereby control peak discharge rates and allow for gravity-driven settling of some types of pollutants.

Fecal coliform — Type of coliform usually known as Escherichia coli (E. coli) and related bacteria. E.coli is used as the basis of the coliform count, which is used as an indicator of water with fecal pollution and potentially dangerous pathogens.

First flush — The initial or early stages of storm water runoff that commonly delivers a disproportionately large amount of previously accumulated pollutants due to the rapid rate of runoff. The first flush is usually defined as a volume equaling the first one-half inch of direct runoff from the entire contributing onsite drainage basin.

Floodplain — For a given flood event, that area of land that is temporarily covered by water and that adjoins a watercourse and is necessary for the conveyance of the given flood event.

Good housekeeping — Keeping a clean, orderly construction site. One of the first steps towards preventing storm water contamination is improving housekeeping practices and using common sense. Good-housekeeping practices reduce the possibility of accidental spills, improve response time if there is a spill, and reduce safety hazards as well.

Heavy metals — Metals with a high molecular weight and high density. Heavy metals in relatively low concentrations are toxic to humans and animals. Examples include arsenic, mercury, and lead.

Hydraulic — Pertaining to, involving, moved, or operated by a fluid (especially water) under pressure or under a gravity-driving force.

Hydrologic — Pertaining to the scientific study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

Hydrograph — A graph of the time distribution of runoff from a watershed.

Hyetograph — A graph of the time distribution of rainfall from a watershed.

Illicit discharge — Any discharge to the storm water system that is not composed entirely of storm water and is not specifically exempted by the Storm Water Ordinances of the City of Memphis and Shelby County.

Impervious area — Impermeable surfaces, such as pavement or rooftops, that prevent the percolation of water into the soil and provide almost 100% runoff volumes.

Infiltration — A practice designed to promote the recharge of groundwater by containment and concentration of storm water in porous soils.

Infiltration basin — An impoundment made by excavation or embankment construction to contain and infiltrate runoff into the soil layer.

Intermittent stream — A stream that only flows part of the time. Flow may occur for an extended time due to seasonal rainfall and high groundwater, but it dries up during the summer.

Major storm — A storm which corresponds to a 100-year design storm or a storm that has a one% probability in any given year.

Municipal Separate Storm Sewer System (MS4) — The total system of storm water drainage conveyances within a municipal entity (City of Memphis and Shelby County are each separate MS4s) for which NPDES permits have been issued by the State of Tennessee for the purpose of reducing storm water pollution to the maximum extent possible. Memphis and Shelby County have the right to inspect all storm water drainage conveyances, whether located on public property or private property, in accordance with the City and County Storm Water Ordinances.

National Pollutant Discharge Elimination System (NPDES) — A nationwide system of storm water permitting, established by the USEPA and administered locally by the TDEC. The City of Memphis and Shelby County are required to address specific areas of storm water pollution as part of their NPDES permits.

National Resources Conservation Service (NRCS) — An organization within the U.S. Department of Agriculture that has published standard drainage procedures in the form of a publication called Technical Release No. 55 (commonly known as TR-55). Formerly known as the Soil Conservation Service (SCS).

Non-point source pollution — Pollution that does not appear to have a single source (such as an industrial outfall pipe or a gasoline tanker spill, which are point sources). Generally nonpoint source pollution is caused by rainfall upon human activities or upon a polluted surface.

Operator — The owner or contractor of a site who has control over everything that happens at the site. The operator is responsible for complying with storm water regulations in accordance with a NPDES permit or a SWPPP.

Outfall — The terminus of an enclosed storm drain system where the storm water is released to an open channel.

Peak flow — The maximum instantaneous rate of flow of water at a particular point resulting from a storm event.

Peak flow attenuation — The reduction of the peak discharge of a storm due to storm water detention.

Perennial stream — A stream that normally has water all year round.

Plat, final — An official survey instrument to be placed in the pubic records of Memphis and/or Shelby County and construction drawings of roads, utilities, site development, public improvements, detention basins, and other storm water structures.

Retention — A practice designed to store storm water runoff by collection as a permanent pool of water without release except by means of evaporation, infiltration, or attenuated release when runoff volume exceeds storage capacity of the permanent pool.

Riprap — A combination of large stone, cobbles, and boulders used to line channels, stabilize stream banks, and reduce runoff velocities.

Sanitary sewer — A system of underground conduits that collect and deliver sanitary wastewater to a wastewater treatment plant.

Sanitary wastewater — Human wastes carried by water from residences, buildings, industrial establishments or other places, together with such industrial wastes, washwater, or other unclean water generated by humans. Sanitary wastewater from residences typically comes from toilets, sinks, washing machines, and other plumbing fixtures.

Site development — See the definition for "Development."

Storm water — Runoff from rain, snow, or other forms of precipitation, resulting in surface runoff and drainage.

Storm water system — The system of roadside drainage, roadside curbs and gutters, curb inlets, swales, catch basins, manholes, ditches, pipes, lakes, ponds, sinkholes, channels, creeks, streams, storm drains, and similar conveyances and facilities, both natural and man-made, located within the Memphis and Shelby County through which storm water is collected, stored, or conveyed, whether owned or operated by the municipality or another entity.

Swale — A natural or man-made depression or wide shallow ditch used to route or to filter runoff.

Time of concentration — The maximum time required for storm water runoff to flow from the most remote point of the watershed to the location being analyzed, not necessarily the longest distance away.

Total dissolved solids — The concentration of particles (mass per volume) that are present in a sample of water and that chemically react with water to form cations and anions.

Total maximum daily load (TMDL) — A quantitative report on the types of water quality problems and sources for a particular watershed. The TMDL includes permitted source point discharges and nonpoint source pollution.

Total suspended solids — The concentration of fine particles (mass per volume) that is present in a sample of water but are not chemically bound to the water molecules.

Vegetation — The collection of plant life (including trees, shrubs, bushes, and grass) that is found on a project site or property. Vegetation is desirable because it helps to reduce the quantity of storm water runoff, encourages sediment settling and nutrient uptake, controls extreme temperatures, and provides habitat for natural animals.

Wastes, industrial/commercial — Liquid or other wastes resulting from any process of industry, manufacture, trade or business, or from the development of any natural resources.

Wastes, other — Decayed wood; sawdust; shavings; fallen bark; fallen leaves; lawn clippings; animal wastes; used or previously applied lime; garbage; trash; refuse; loose used paper, paper products, plastic containers, or metal containers; ashes, offal, discarded tar; discarded paint;

discarded or uncontained solvents; used, discarded, or spilled petroleum products, antifreeze, motor vehicle fluids; used or discarded tires, gas tanks, or chemicals; or other materials that are not allowed to be discharged to or otherwise enter the storm water system.

Watershed — The area that drains to a particular stream or to a particular point. A watershed is bounded by drainage divides.

1-year frequency storm — A storm event defined to be 3.3 inches in 24 hours using the Technical Paper No. 40 (TP-40) rainfall distribution, or as established by Memphis and/or Shelby County based upon scientific and engineering information.

2-year frequency storm — A storm event with a 50% chance of being equaled or exceeded in a given year. Defined to be 4 inches in 24 hours using the TP-40 rainfall distribution, or as established by Memphis and/or Shelby County based upon scientific and engineering information.

5-year frequency storm — A storm event with a 20% chance of being equaled or exceeded in any given year. Defined to be 4.9 inches in 24 hours using the TP-40 rainfall distribution, or as established by Memphis and/or Shelby County based upon scientific and engineering information.

10-year frequency storm — A storm event with a 10% chance of being equaled or exceeded in any given year. Defined to be 5.7 inches in 24 hours using the TP-40 rainfall distribution, or as established by Memphis and/or Shelby County based upon scientific and engineering information.

25-year frequency storm — A storm event with a 4% chance of being equaled or exceeded in any given year. Defined to be 6.5 inches in 24 hours using the TP-40 rainfall distribution, or as established by Memphis and/or Shelby County based upon scientific and engineering information.

50-year frequency storm — A storm event with a 2% chance of being equaled or exceeded in any given year. Defined to be 7.1 inches in 24 hours using the TP-40 rainfall distribution, or as established by Memphis and/or Shelby County based upon scientific and engineering information.

100-year frequency storm — A storm event with a 1% chance of being equaled or exceeded in any given year. Defined to be 8 inches in 24 hours the TP-40 rainfall distribution, or as established by Memphis and/or Shelby County based upon scientific and engineering information.

10.0 LIST OF REFERENCES

The original version of this manual was prepared for the City of Knoxville in March 2000 by Camp Dresser & McKee (CDM), Inc. The first 147 references were used by CDM in the preparation of the BMP Manual. Additional references were added to the list as necessary by the City of Knoxville, the City of Memphis, and Shelby County to update the BMP Manual. The BMP fact sheets refer to the list of references by using the reference numbers only. In each case, it is the intention of the City of Memphis and Shelby County to give appropriate credit whenever possible.

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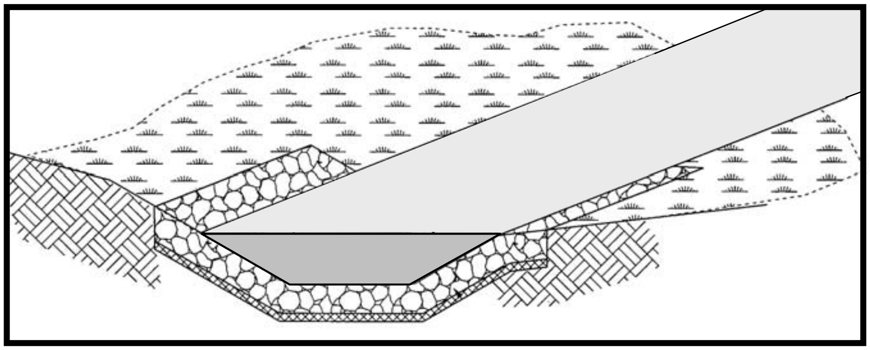
ACTIVITY: Channel Linings	ES – 22



Targeted Constituents

¸ Significant Benefit   Û Partial Benefit   ¹ Low or Unknown Benefit

¸ Sediment	¹ Heavy Metals	¹ Floatable Materials	¹ Oxygen Demanding Substances	
Û Nutrients	¹ Toxic Materials	¹ Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description

The selection of a channel lining will greatly influence how a drainage channel performs, the amount of erosion and scour, the frequency and cost of maintenance, its appearance and aesthetics, and even its safety. In addition, the amount of sediment and nutrients can be influenced greatly by the type of channel lining selected. This BMP will examine different factors and some basic design parameters for channels and channel linings.

Suitable Applications

Þ Any areas that regularly receive and convey concentrated storm water runoff, such as streams, drainage channels, ditches, or swales.

Þ Areas that occasionally convey storm water runoff, such as overland relief swales or emergency spillways.

Approach

Every drainage channel, ditch, or swale must have some type of channel lining. Unless otherwise specified, the existing channel lining must be native soil or rock. The least expensive and most beneficial lining is usually a grass channel if design parameters do not indicate excessive velocities, regular submergence, inadequate flow capacity, or potential maintenance problems. Grass channels are easy to maintain, flexible, self-healing, and attractive in appearance. They function as wildlife habitats, remove pollutants (see ST-05, Filter Strips and Swales), and decrease the amount of runoff by allowing storm water infiltration and evapotranspiration.

Grass channels are an example of a flexible lining (may also be called a “soft” or “green” lining) that includes vegetation as the principal means of preventing erosion. A variety of temporary and permanent geosynthetic products can help to establish a soft lining; common examples are erosion control matting, excelsior blankets, geogrids filled with soil, or turf reinforcement mats. Soft linings are aesthetically pleasing, flexible, and easy to install and maintain. The major drawbacks to soft linings are the potential for damage by heavy traffic, excessive heat or cold, excessive sunlight or shade, drought, severe storms, or pollution.

Due to the highly erodible loess soils in the Memphis area, concrete-lined channels are most commonly encountered. Due to state regulatory requirements, permits for concrete-lined channels are difficult to obtain. Concrete and asphalt channel linings are examples of rigid or "hard" linings. These channel linings are used when design velocities exceed permissible values for soft linings, or to improve flow capacity by reducing roughness and flow losses. Hard linings must be installed in a controlled manner with proper materials, compaction, bedding, and anchoring in order to prevent scour, undercutting, or settlement.

By law, anyone who works within or along a stream must obtain an Aquatic Resource Alteration Permit (ARAP) from the Tennessee Department of Environment and Conservation (TDEC) Division of Water Pollution Control. The ARAP is required for activities such as dredging, widening a channel, straightening a channel, building a dock or boat ramp, altering a wetland, utility line crossings, or stream bank stabilization. Visit the TDEC permitting Web site for more information.

http://www.state.tn.us/environment/permits/

Related BMPS that impact the selection of channel linings include:

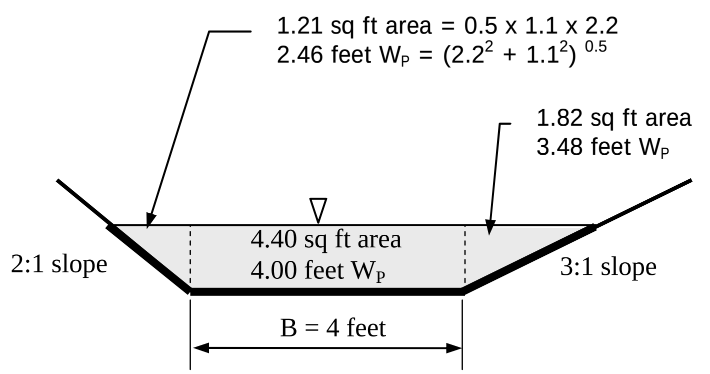
ES-11 Erosion Control Blankets and Mats
ES-12 Geotextiles
ES-20 Bank Stabilization and Soil Bioengineering
ES-21 Diversions and Downdrains
ES-23 Riprap
ES-25 Outlet Protection

Basic Flow Computation

This section contains a description of basic flow computations for use in designing an open channel, ditch, or swale. Drainage channels and ditches should generally be designed by a professional engineer to ensure that adequate drainage capacity and allowable flow velocities are provided. Open-channel computations are usually in the form of Manning's equation:

V	=	$(1.49 / n)\ R_H^{2/3}\ S^{1/2}$, where
V	=	average velocity in channel (feet per second)
n	=	Manning's roughness coefficient (dimensionless)
R_H	=	hydraulic radius of channel = A / W_P (expressed in feet)
S	=	energy grade line = channel slope for uniform flow (dimensionless)
A	=	cross-sectional flow area (square feet)
W_P	=	wetted perimeter of flow (feet)

The total flow through the channel (Q, expressed in cubic feet per second) is equal to the velocity times the cross-sectional flow area: $Q = V\ A$



Given:

D = 1.10 feet
n = 0.025
S = 0.01 ft / ft
channel geometry

Computed:

A = 7.43 sq ft
W_P = 9.94 feet
R_H = 0.747 feet
V = 4.91 fps
Q = 36.5 cfs

Figure ES-22-1
Basic Flow Computation — Manning's Equation

Manning's equation is for open-channel flow and assumes a constant uniform flow rate at a specified slope. There are many factors that can affect this assumption, such as varying channel widths and slopes, downstream flow constrictions, backwater from dams or other berms, culvert entrance and exit losses, headwater at culverts or bridges, channel bends, varying lining materials, etc. Any of these factors will generally require that a professional engineer with knowledge and experience should be responsible for design and analysis. In addition, channels with unusual shapes, composite materials, or uneven sections will generally require that a professional engineer with knowledge and experience be responsible for the design and analysis. The major difficulty in estimating velocity and flow is usually the selection of

Manning's roughness coefficient "n." Typical values are listed in Table ES-22-1 and Table ES-22-2. See Figure ES-22-2 for n values of grass channels, based upon type and height of vegetation, and product of velocity (V) and hydraulic radius (R_H).

Subcritical and Supercritical Flow

It is useful to know whether a flow is subcritical (also called tranquil flow, backwater flow, or downstream control) or supercritical (also called rapid flow or upstream control). This is determined by computing the Froude (Fr) number; a value of Fr less than 1 is subcritical and a value greater than 1 is supercritical. Subcritical flow is greatly preferred because it has a lower velocity than supercritical flow. A value of Fr between 0.8 and 1.2 indicates that the channel is close to critical flow, and that small changes in channel cross section, flows, slopes, etc., may cause the water surface to change radically or even create a hydraulic jump or standing wave. Open channels should not be designed at or near critical flow conditions.

Fr = $((Q^2 * T) / (g * A^3))^{1/2}$, where
Fr = Froude number (dimensionless)
Q = discharge or flow (cubic feet per second)
T = top width of water surface (feet)
g = gravitational constant = 32.2 feet/ second^2
A = cross-sectional flow area (square feet)

(for Figure ES-22-1) Fr = $((36.5^2 * 9.5) / (32.2 * 7.43^3))^{0.5} = 0.98$

The example channel in Figure ES-22-1 is approximately at critical flow and should be changed. Since subcritical flow is the preferred flow regime, this can be accomplished by widening the channel, flattening the side slopes, increasing the Manning's roughness coefficient n, or decreasing the channel slope.

Critical depth (D_C) indicates the flow depth for which the specific energy (E) is at a minimum value for a given discharge. Specific energy is computed by the equation:

$$E = D + V^2 / (2g)$$

For the example in Figure ES-22-1, the specific energy is 1.474 feet.

Table ES-22-1
Manning's Roughness Coefficient — Channels

Closed Conduits	**n**
Brick	0.016
Cast-iron pipe	0.013
Cemented rubble	0.021
Concrete pipe	0.013
Corrugated metal pipe, plain, regular corrugations	0.024
Corrugated metal pipe, asphalt-paved invert, flowing full	0.020
Corrugated metal pipe, asphalt-paved, 50% flow depth	0.015
Corrugate metal pipe, large corrugations (1" or 2" deep)	0.030
Plastic pipe, smooth/corrugated (consult manufacturer)	------
Polyvinyl chloride pipe	0.011
Steel pipe	0.010
Vitrified clay	0.013
Open Channels	**n**
Asphalt pavement	0.016
Bare earth, straight and uniform, no vegetation	0.020
Bare earth, straight and uniform, with some short grass	0.025
Bare earth, winding and sluggish	0.025
Bare earth, winding and sluggish, with some short grass	0.030
Brick	0.015
Cemented rubble	0.020
Concrete channel, unfinished	0.015
Concrete channel, troweled	0.013
Concrete channel, troweled with exposed gravel finish	0.017
Concrete channel with mortared or riprap sides	0.015 — 0.030
Concrete gutter, finished and troweled	0.013
Erosion control matting (excelsior mat or straw netting)	0.025 — 0.035
Erosion control matting (jute net)	0.022
Grass	***Figure ES-22-1***
Gravel or aggregate, compacted	0.030 — 0.050
Gravel bottom, with weeds on banks	0.035
Riprap, dumped (n chosen from D_{50} size)	***See ES-23 for n***
Riprap, grouted and placed as a smooth uniform	0.030 — 0.040
Rocky channel, smooth and uniform	0.025 — 0.035
Rocky channel, irregular and winding	0.040 — 0.050
Weeds and brush, uncut, only on banks	0.040 — 0.080
Weeds and brush, uncut, across entire channel	0.080 — 0.120

Grass channels are also frequently grouped into categories based upon the "retardance" that reflects the height and type of vegetation, flow characteristics of channel, etc. The retardance classification taken from Table ES-22-3 is then used in Figure ES-22-2 to select a Manning's roughness coeffficient based upon the product of velocity, V, and the hydraulic radius, R_H. Solving Manning's equation for a grass surface, due to the variable roughness coefficient, is an iterative process for which a spreadsheet may be helpful.

Table ES-22-2
Manning's Roughness Coefficient — Natural Channels

Natural Stream (less than 100 feet wide at flood stage)	n	
Clean, straight, no rifts or deep pools, grass banks	0.025 — 0.035	#
Clean, straight, grass with some stones, and weeds	0.030 — 0.040	#
Clean, winding, pools and shoals	0.033 — 0.045	#
Clean, winding, pools and shoals, some stones, and weeds	0.035 — 0.050	#

— Values may be increased by the largest of the 4 possible adjustments
1. adjust upward by 0.005 for lower stages or ineffective flow areas
2. adjust upward by 0.005 for larger stone and weeds
3. adjust upward by 0.010 to 0.020 for partially submerged trees branches
4. adjust upward by 0.030 to 0.050 for entire submerged trees in channel

Sluggish reaches, deep pools, many weeds	0.050 — 0.080
Sluggish, many deep pools, full of weeds, heavy timber	0.075 — 0.150
Mountain stream, gravel and cobbles, with steep banks	0.030 — 0.050
Mountain stream, cobbles and boulders, with steep banks	0.040 — 0.070

- In general, n values are lower for larger streams because the banks offer less resistance. Usually larger streams have been modeled by government agencies such as TVA, FEMA, or the City of Memphis and Shelby County so that some guidance is available on roughness coefficients used.
- Manning's n values can be substantially different during summer when vegetation may be overgrown and trees contain branches full of leaves. Adjust values upward if stream flow submerges trees and tree branches.

Floodplains (adjacent to natural streams)	n
Cleared land with tree stumps	0.040 — 0.050
Pasture, no brush, short grass	0.030 — 0.035
Pasture, no brush, high grass	0.035 — 0.050
Farmland, no crops	0.030 — 0.040
Farmland, mature crops	0.040 — 0.050
Heavy weeds, scattered brush	0.050 — 0.070
Light brush and trees	0.050 — 0.080
Medium to dense brush	0.070 — 0.110
Dense brush, thick trees, undergrowth, fallen logs	0.100 — 0.160

Natural streams have constantly varying cross sections and slopes, so that the Manning's equation should be used carefully with the understanding that other factors may affect flow depth. Therefore, the use of Manning's equation for natural streams should only be for rough estimating purposes.

Water surface profile programs, such as HEC-2 and HEC-RAS (developed by the U.S. Army Corps of Engineers Hydraulic Engineering Center) can handle multiple roughness coefficients, complex geometry, bridges, culverts, flow obstructions, and varied flow values into consideration.

Water surface profiles must be prepared by a professional engineer using the best available data.

Table ES-22-3
Retardance Classifications for Grass Channels

Class	Type of Vegetation	Condition
A	Yellow bluestem ischaemum	Excellent stand, tall, 36" average
	Weeping lovegrass	Excellent stand, tall, 30" average
B	Alfalfa	Good stand, uncut, 11"
	Bermudagrass	Good stand, tall, 12"
	Blue gamma	Good stand, uncut, 13"
	Kudzu	Very dense growth, uncut
	Reed canarygrass	Good stand, cut, 12" to 15"
	Sericea lespedeza	Good stand, not woody, tall, 19"
	Tall fescue	Good stand, uncut, 18"
	Weeping lovegrass	Good stand, uncut, 13"
	Grass mixture #1	Good stand, uncut
	Grass mixture #2	Good stand, uncut, 20"
C	Bahiagrass	Good stand, uncut, 6" to 8"
	Bermudagrass	Good stand, cut, 6" to 8"
	Centipedegrass	Very dense cover, 6" to 8"
	Crabgrass	Fair stand, uncut, 10" and longer
	Kentucky bluegrass	Good stand, headed, 8" to 10"
	Redtop	Good stand, uncut, 15" to 20"
	Tall fescue	Good stand, cut or uncut, 6" to 8"
	Grass mixture #3	Good stand, uncut, 6" to 8"
D	Bahiagrass	Good stand, cut, 3" to 4"
	Bermudagrass	Good stand, cut, 2.5"
	Buffalograss	Good stand, uncut, 3" to 6"
	Centipedegrass	Good stand, cut, 3" to 4"
	Kentucky bluegrass	Good stand, cut, 3" to 4"
	Red fescue	Good stand, uncut, 12"
	Sericea lespedeza	Good stand, cut, 2"
	Tall fescue	Good stand, cut, 3" to 4"
	Grass mixture #4	Good stand, uncut, 4" to 5"
E	Bermudagrass	Good stand, cut, 1.5"
	Any type of grass	Burned or trampled, any length

Native grass mixture #1 — prairie grasses, bluestem, blue gamma

Summer grass mixture #2 — tall fescue, red fescue, sericea lespedeza

Summer grass mixture #3 — timothygrass, smooth bromegrass, or orchardgrass

Spring/autumn grass mixture #4 — orchardgrass, redtop, annual lespedeza

Using the example in Figure ES-22-1, a roughness coefficient value of 0.025 corresponds to any of several channel linings in Table ES-22-1 such as:

- Bare earth, straight and uniform, short grass
- Erosion control matting (excelsior mat)
- Rocky channel, smooth and very uniform

Using the same geometry as shown in Figure ES-22-1 with a grass channel lining instead will yield the following two sets of answers for the same given flow of 36.5 cubic feet per second. In general, a conservative design will use unmowed grass to check conveyance and mowed grass to check for velocities. So the design depth would be 2.06 feet and the design velocity would be 3.56 feet per second.

UNMOWED Retardance B:	*MOWED* Retardance D:
Q = 36.5 cfs	Q = 36.5 cfs
n = 0.089	n = 0.039
D = 2.06 feet	D = 1.38 feet
A = 18.85 sq ft	A = 10.28 sq ft
W_P = 15.12 feet	W_P = 11.45 feet
R_H = 1.247 feet	R_H = 0.898 feet
V = 1.94 fps	V = 3.56 fps

Grass channels are often designed as a parabolic shape without any corners or slope breaks. The following formulas for cross-sectional flow area (A) and hydraulic radius (R_H) are based on the top width of flow (T) and maximum flow depth at the center of channel (D):

$$A = 2/3\ (T\ D)$$

$$R_H = (T^2\ D) / (1.5\ T^2 + 4\ D^2)$$

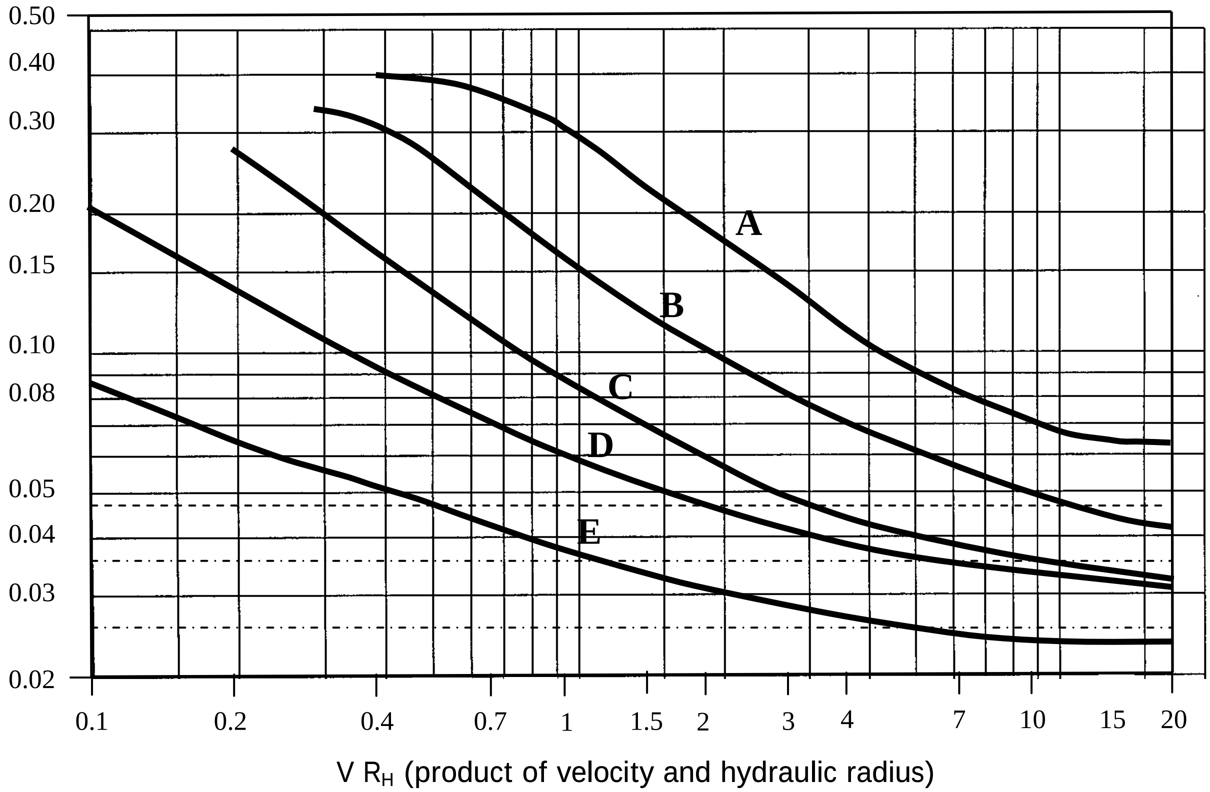


Figure ES-22-2
Manning's Roughness Coefficient — Grass Channels

Permissible Velocities

A channel lining may be judged adequate or permissible based on two possible criteria, either permissible shear stress or permissible velocity. Permissible shear stress is based on the force necessary to displace or move the soil, aggregate, or other type of channel lining. The formula for normal shear stress (T) at the bottom of a uniform channel is shown below. This value is adjusted for several factors such as side slope, bend angles, shape of channel, etc., before being compared to published values of permissible shear stress.

$$T = \gamma \; D \; S$$

T = shear stress (pounds per square foot)
γ = unit weight of water (62.4 pounds per cubic foot)
D = flow depth of water (feet)
S = channel slope (feet per foot)

The simpler design method is to specify a permissible velocity for each type of channel lining. Typical permissible velocities are listed in Table ES-22-4. In general, a temporary channel lining should be considered if the design flow velocity for bare soil is greater than 2 feet per second. For preliminary design, a soil may be considered erodible if it has a published K value of 0.35 or greater in the City of Memphis and Shelby County soils map.

Table ES-22-4
Permissible Velocities

Channel Lining Material	Permissible Velocity (fps)		
Silt or very fine-grained materials		1.5	
Fine sand, sandy loam, silty loam		2.0	
Undisturbed alluvial sediments		3.5	
Stiff clay		3.5	
Coarse sand or fine gravel (no silt)		4.0	
Coarse gravel		5.0	
Cobbles, hard pan, shale		5.5	
	0 to 5%	*5 to*	*Over 10%*
Erodible Soil (silt, loam, sand)			
Bermudagrass	5.5	4.5	3.5
Bahiagrass, Blue Gamma, Kentucky bluegrass Reed canarygrass, Tall fescue	4.5	3.5	2.5
Mixture (fescue, lespedeza., legumes)	3.5	3.0	----
Alfalfa, Crabgrass, Kudzu, Sericea lespedeza Weeping lovegrass, Yellow bluestem	3.0	2.5	----
Resistant Soil (gravel, clay, cohesive)			
Bermudagrass	6.5	5.5	4.5
Bahiagrass, Blue Gamma, Kentucky bluegrass Reed canarygrass, Tall fescue	5.5	4.5	3.5
Mixture (fescue, lespedeza., legumes)	4.5	3.5	----

Table ES-22-4 (Continued)
Permissible Velocities

Channel Lining Material	Permissible Velocity (fps)		
Alfalfa, Crabgrass, Kudzu, Sericea lespedeza Weeping lovegrass, Yellow bluestem	3.5	3.0	----

Maintenance

Þ Channel linings should be inspected at least weekly during the construction phases to ensure proper functioning and necessary control of erosion and sediment. Inspect channels monthly during the first year after construction to verify that drainage channels work properly as designed and constructed.

Þ After the first year, channel linings should be inspected at least quarterly on a permanent basis. Look for erosion, siltation, undercutting, or settlement throughout the length of channel. Verify that upstream and downstream portions of channel are not adversely affected.

Limitations

Þ Flexible channel linings need frequent maintenance and inspections to ensure adequate function and erosion control. Soft channel linings can be damaged or stressed due to many factors.

Þ Rigid permanent channel linings often result in prevention of habitat establishment. Hard linings may be damaged due to settlement, scour, or undercutting despite the best efforts and care taken during installation.

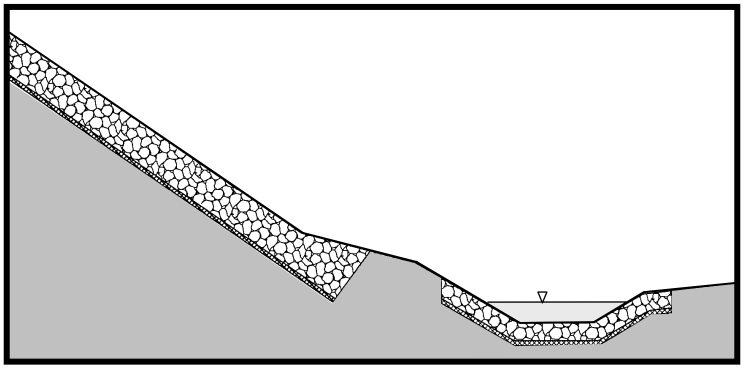
Þ Inadequate coverage or depth of channel linings will result in erosion, washout, and poor plant establishment. If the channel grade and liner are not appropriate for the amount of runoff, channel bottom erosion may result.

Þ Riprap must be sized correctly and installed according to correct procedures. If the channel slope is too steep or riprap is too small, displacement may occur. Displaced riprap may obstruct the channel or cause additional damage.

References

23, 20, 31, 32, 139, 141, 153, 162, 164, 167, 173, 174, 179 (see BMP Manual Chapter 10 for list)

ACTIVITY: Riprap	ES – 23



Targeted Constituents

¸ Significant Benefit	Û Partial Benefit		¹ Low or Unknown Benefit	
¸ Sediment	¹ Heavy Metals	¹ Floatable Materials	¹ Oxygen Demanding Substances	
¹ Nutrients	¹ Toxic Materials	¹ Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description

Riprap is the controlled placement of large rock material that will resist movement and erosion. Riprap is used to protect culvert inlets and outlets, stream banks, drainage channels, slopes, or other areas subject to erosion by storm water erosion. This practice will significantly reduce erosion and sediment movement.

Suitable Applications

Þ Along a stream or within drainage channels, as a stable lining resistant to erosion.

Þ On shorefronts and riverfronts, or other areas subject to wave action.

Þ Around culvert outlets and inlets to prevent scour and undercutting.

Þ In channels where infiltration is desirable, but velocities are too excessive for vegetative or geotextile lining.

Þ On slopes and areas where conditions may not allow vegetation to grow.

Approach

Riprap may be used in many different locations and many different ways. It is very resistant to erosion and has relatively few drawbacks when installed correctly. Riprap does not prevent erosion or sedimentation from occurring, but it can help to create a stable channel lining and to reduce velocities. Other types of riprap material can also include cement bags (with sand/ aggregate added) or concrete blocks, as described in Tennessee Department of Transportation (TDOT) Standard Specifications for Road and Bridge Construction (reference 172).

Stone riprap can either be placed as graded machine riprap (layers that can be placed by machine and then compacted) or as rubble (large pieces of rock are placed by hand). Graded riprap is often used for channel linings because it is flexible and can be compacted to a dense structure without manual sorting or placement. Rubble-stone riprap can be used for an attractive landscaped appearance but lacks flexibility to adapt to settlement, washing out of material, burrowing animals, etc.

Oftentimes there may be a "green" solution for slope stabilization problems or for drainage channels that would have typically required riprap. Erosion control matting, geotextiles, and flexible mattresses are just a few examples of how geosynthetics are providing alternatives for channels traditionally lined with riprap and concrete. Some alternatives to riprap for slopes include surface roughening, terracing, and mulching.

The selection of whether to use riprap may be dependent upon safety and maintenance considerations. Riprap could pose a hazard from snakes or burrowing animals for children who play in ditches or streams. Children may also be tempted to throw or drop rocks into water to see a big splash. Large rocks could settle or dislodge, endangering anyone in the immediate vicinity. Weeds may be difficult to control.

As a rough guideline, riprap can be specified for a design flow velocity that is over 5 feet per second (approximate upper limit of most vegetative channel linings). The upper limit for design flow velocity of a riprap channel lining depends primarily on the size of riprap specified and methods used for securing riprap material in place. Graded machined riprap is usually less expensive to install than hand-placed riprap and tends to be more flexible in case of settlement or movement.

Two common misuses of riprap:

Þ It is often specified incorrectly as an erosion control method just because the project designer has not performed drainage calculations. The project designer incorrectly assumes that a certain amount of "hard" material in a drainage channel will create a stable, non-eroding channel lining that is maintenance-free.

Þ Riprap is often installed incorrectly as a channel lining. A contractor may form and grade a drainage channel, and then dump some rock into it as an afterthought. This makes the channel have a much smaller flow capacity than was originally designed. If riprap is dumped without proper placement and compaction, it will act somewhat as a rock check dam. This will allow sedimentation to occur even more and thus further reduce flow capacity.

Materials

Riprap shall generally consist of machined shot rock that is angular and clean. Do not use rounded stones or cobbles for riprap (although cobble stones may be used in grouted channels for architectural appearances). Riprap shall not contain sand, dust, organic material, excessive cracks, mineral lenses and intrusions, or other impurities. Riprap is usually solid durable limestone rock quarried locally, which is generally resistant to erosion and to normal stream chemistry. Riprap material that is of questionable origin may be given a sodium sulfate soundness test to determine its durability. Riprap material shall have at least 2.5 specific gravity.

Table ES-23-1
Machined Riprap Specifications (TDOT Classification)

Class A-1	Class A-3	Class B	Class C
2" to 15" diameter (0.5 to 169 lbs) Dumped	2" to 6" diameter (0.5 to 11 lbs) Dumped	3" to 27" diameter (1.5 to 985 lbs) Dumped	5" to 36" diameter (6 to 2335 lbs) Dumped
20% by weight shall be at least 4" size (3 lbs) Typical thickness is 18" with surface tolerance of 3"	20% by weight shall be at least 4" size (3 lbs) Typical thickness is 12" with surface tolerance of 2"	20% by weight shall be at least 6" size (11 lbs) Typical thickness is 30" with a surface tolerance of 4"	20% by weight shall be at least 9" size (36 lbs) Typical thickness is 42" with a surface tolerance of 6"

The different classes of machined riprap are shown in Table ES-23-1 and are taken directly from the TDOT specifications. Gradations are commonly specified in terms of a specified percentage by weight being smaller than a diameter. For example, TDOT calls for Class B riprap to have a D_{20} of at least 6 inches. D_0 would be the smallest allowable size and D_{100} would be the largest allowable size for any specified gradation.

Alternate riprap sizes are listed in City of Memphis and Shelby County Technical Specification #25 (available on Civil Engineering Division webpage) as shown in Table ES-23-2. These classes are relatively narrow gradations for use as riprap placed by hand.

Table ES-23-2
Hand-Placed Riprap Specifications
(City of Memphis and Shelby County Classification)

Class I	Class II	Class III	Class IV
1.5" to 5" dia Hand-placed 75% by weight shall be at least 4" size 12" thickness	6" to 10" dia Hand-placed 75% by weight shall be at least 8" size 12" thickness	9" to 12" dia Hand-placed 75% by weight shall be at least 11" size 18" thickness	12" to 18" dia Hand-placed 75% by weight shall be at least 15" size 24" thickness

Other types of riprap materials are shown in Table ES-23-3. Rubble-stone riprap can be very attractive as well as functional, but requires a great deal of hand labor and time. Manufactured concrete products such as interlocking blocks, articulated blocks, and revetment mattresses can resist very high flow velocities and are usually designed to be flexible for handling settlement and subgrade irregularities. Sacked riprap (essentially a concrete lining) is also labor-intensive and expensive to install. Concrete linings are generally discouraged because they do not allow for wildlife habitats and may contribute to downstream drainage problems such as high velocities.

Table ES-23-3
Non-Machined Riprap Specifications (TDOT Classification)

Rubble-Stone (plain)	Rubble-Stone (grouted)	Concrete Blocks	Sacked Riprap (sand-cement)
Min 2" diameter (min 0.5 lbs) Placed by hand	Min 2" diameter (min 0.5 lbs) Placed by hand	Rectangular shapes that can be placed in the specified dimensions by hand	Approx 1 cubic ft (approx 100 lbs) Placed by hand
80% by weight shall be at least 10" in any dimension (prefer rectangular)	80% by weight shall be at least 10" in any dimension (prefer rectangular)	Class A concrete with 3,000 pounds per square inch 28-day strength	Sacks should be cotton or jute cloth that retains sand and dry cement mix
Remainder is 2" to 4" size for chinking	Remainder is 2" to 4" size for chinking	Various thickness from 4" upwards	Mix 1 bag cement (94 lbs) with 5 cubic feet of sand
Typical thickness is 12" with surface tolerance of 2"	Typical thickness is 12" with surface tolerance of 2"	Design and install per manufacturer's recommendations	Typical thickness is 10" with a surface tolerance of 2"

For smaller aggregates (less than 2 inches across), gradation is normally determined by mechanically shaking several pounds of material through a set of progressively smaller sieves. Then it can be stated that a certain percentage (by weight) is finer than a particular sieve with a defined opening size, which is then equated with an average diameter. However, riprap material cannot be mechanically shaken through sieves and thus it is more difficult to quantify the average size.

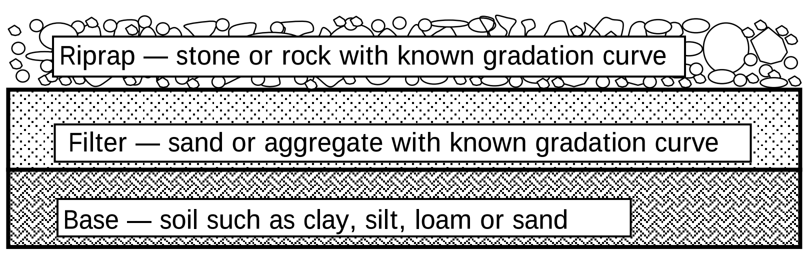
A geotextile filter fabric is usually placed beneath riprap to maintain separation from underlying soils. Also, geotextile filter fabric is necessary within stream channels to avoid loss of fine-grained soils. In particular, use geotextile filter fabric at the inlet and outlet of culverts, where turbulence is normally expected. Typical properties are listed in ES-12, Geotextiles. The equivalent opening size (EOS) of a geotextile filter fabric is typically between U.S. standard sieve size No. 40 and No. 70 for use with most soils. The minimum recommended size for a geotextile filter fabric is No. 100, intended for use with fine-grained silts and clays. The geotextile filter fabric should be anchored securely using anchor trenches, stakes, staples, or sewing or a combination of methods.

A layer of aggregate or sand can also be placed beneath riprap to maintain separation from underlying soils, either in addition to filter fabric or in place of filter fabric. The layer of aggregate or sand acts as a smooth bed to allow easier placement of riprap, and it can be used as a granular filter. The granular filter permits water to drain out or seep through it without allowing the adjacent soil or aggregate to bleed through. In general, a geotextile filter fabric will perform this function more reliably and with much smaller installation costs.

A granular filter should have the following properties with relation to the base soil underneath. The first and second properties are an application of the well-known filter criteria used by dam builders and other civil engineers for over a century. The third and fourth properties help ensure that the gradation curve of the granular filter is approximately the same shape as the gradation curve of the soil base.

1. D_{15} of filter must not be more than five times D_{85} of ase.
2. D_{15} of filter must not be less than five times D_{15} of base.
3. D_{15} of filter must not be more than 40 times D_{15} of ase.
4. D_{50} of filter must not be more than 40 times D_{50} f base.

The relationship of the riprap to an underlying granular filter layer should follow the same filter criteria as between the granular filter and the base soil. In other words, the term “filter” refers to the larger-grained material and the term “base” refers to the smaller-grained material. Due to the many problems associated with carefully placing 6” layers of graded aggregate or sand, the use of geotextile filter cloth is greatly preferred.



Design

There are many methods available for choosing riprap size, particularly for riprap channel linings. There are methods that make use of only one equation or nomograph, which can only account for three or four factors using assumptions and various rule-of-thumb guidelines. There are many methods that try to account for forces and momentum more exactly, with several equations and nomographs being used for factors such as rock-specific gravity, stream tractive force, drag force, etc.

Riprap design shall generally be performed by a professional engineer using drainage computations, field conditions, quality of materials, and construction placement. If possible, it is recommended that a few design methods should be used to verify reasonable results.

River Shorelines: Riprap for use on river or lake shorelines should be designed to conform with standards by the U.S. Army Corp of Engineers. Large riprap with approximate average sizes of 24 to 36 inches should be used, depending on locations of nearby bridges or other factors affecting velocity.

Slopes: Riprap applications for slope stabilization, where wave action or flowing water is not a concern, should be sized for stability. The natural angle of repose is defined as the angle at which material can be placed without sliding downhill due to gravity. Angular riprap or crushed rock typically has in the neighborhood of 40°, so that a slope of 1.5 to 1 for most slopes is reasonable when not subject to flowing water. Rounded stones such as river gravel have a lower angle of repose. See Figure ES-23-1 for angle of repose based on average stone size, D_{50} (using a chart from reference 153).

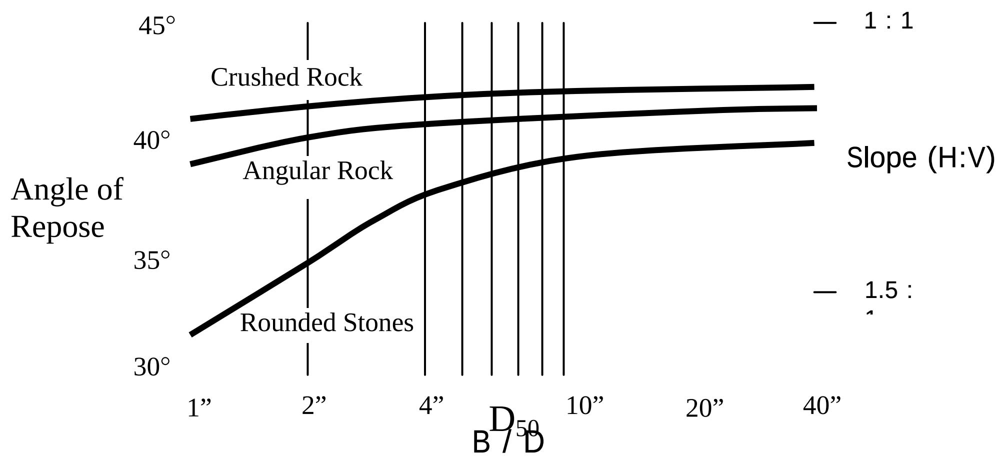


Figure ES-23-1
Angle of Repose for Riprap Based on Average

The angle of repose does not take into account any external forces (such as vehicles, people, storms, groundwater, earthquakes, other ground vibrations). Also, sliding will often occur at the interface between two layers, particularly on a geotextile filter fabric that is not sufficiently anchored. Slope stability analyses should be performed by a professional engineer for all sloped areas that are critical or potentially hazardous.

Channels (HEC-15 design method):

The following design method for sizing riprap is taken from Hydraulic Engineering Circular 15, Design of Stable Channels With Flexible Linings, by the Federal Highway Administration (1975). The mean riprap size is computed for tangent sections and curved sections of trapezoidal channels. Drainage computations are used to determine channel shape, channel slope, surface width, and design flow depth by using the Manning's n roughness coefficient equal to:

$n = 0.0395 \times (D_{50})^{1/6}$

1. Compute the channel bottom D_{50} riprap size based on the following equation where D_{50} and the maximum design flow depth have the same units (inches or feet) and channel slope is expressed in feet per foot:

Bottom D_{50} = 12.5 * Depth * Channel Slope

2. If the channel side slopes are steeper than 3:1, then the side slope D_{50} riprap size will be adjusted using the following equation where K_1 is obtained from Figure ES-23-2 and K_2 is obtained from an equation:

Bottom $D_{50} \times K_1 / K_2$ = side slope D_{50} $K_2 = (1 - \sin^2(\varphi)/\sin^2(\theta))^{0.5}$

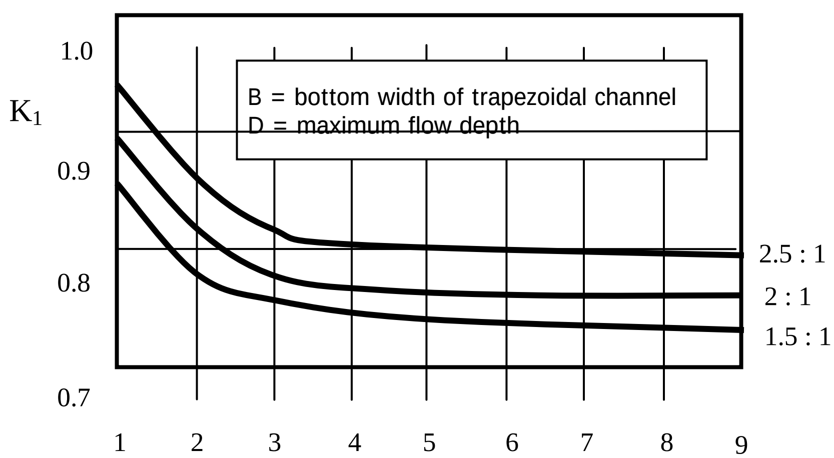


Figure ES-23-2
Distribution of Boundary Shear for Trapezoidal

The side slope D_{50} is the riprap size necessary for the sides slopes of tangent sections where side slope is steeper than 3:1 (18.5°), φ is the angle of the side slope in degrees, and θ is the angle of repose in degrees.

3. For curved sections of channel, compute the ratio $\Delta_{C,}$ which is the internal angle that differentiates between a short bend and a long bend. The value R_O is the radius of the channel centerline bend, and the value R_D is the average radius of the channel outside bend as computed by the following equation using T (top width of the channel) and B (bottom width of trapezoidal channel):

   $R_D = R_O + 0.25\ (T + B)$

   $\Delta_C = \cos^{-1}(R_O / R_D)$

4. Long bend (bend angle Δ is more than Δ_C): The tangent D_{50} riprap size (from Step 1 if side slopes are not steeper than 3:1, or Step 2 if side slopes are steeper than 3:1) will be adjusted using the coefficient K_3 which is obtained from an equation with V being the average velocity (using Manning's flow equation):

   Curved $D_{50} = K_3 \times$ tangent D_{50}

   $K_3 = 4 \times V^2 / R_D$

5. Short bend (bend angle Δ is less than Δ_C): The tangent D_{50} riprap size (from Step 1 if side slopes are not steeper than 3:1, or Step 2 if side slopes are steeper than 3:1) will be adjusted using the coefficient K_4 which is obtained from an equation using K_3 as computed above:

   Curved $D_{50} = K_4 \times$ tangent D_{50}

   $K_4 = 1 + (K_3 – 1)\ (\Delta / \Delta_C)$

The selection of a mean riprap size D_{50} will basically specify a gradation curve. The maximum riprap size should be 1.5 times the D_{50} riprap size. The riprap layer thickness should be approximately 1.7 to 2.0 times the D_{50} riprap size, in accordance with the TDOT riprap classifications in Table ES-23-1.

The minimum freeboard for a riprap channel shall generally be at least 6 inches, depending upon the type of computations and potential for damage. Always provide additional freeboard at culvert inlets and outlets, areas of potential turbulence, changes in slope or direction, etc. Super elevation of the flow surface may occur on the outside bank of a channel bend. The amount of super elevation, Δ_Y, can be estimated using the following equation where g is equal to 32.2 feet per second per second and the other terms have already been defined:

$\Delta_Y = (V^2\ T) / (g\ R_O)$

Installation

Installation of riprap should be accomplished within a short time frame (1 or 2 days) to minimize potential for damage from storm water runoff.

General Subgrade Preparation

Þ Clear and grade the area of trees, brush, vegetation, and unsuitable soils. Provide equipment access as necessary for earthwork and handling of large rocks.

Þ Prepare the subgrade to the specified depth necessary for installation of riprap. Compact subgrade firmly to prevent slumping or undercutting. Excavate anchor trenches as necessary for installation of geotextile filter fabric.

Þ Install geotextile filter fabric to maintain separation of rock material with the underlying soil. Geotextile filter fabric should be placed so that it is not stretched tight and conforms closely to the subgrade. Secure filter fabric by using anchor trenches, stakes, staples, sewing, or any other means necessary according to manufacturer's recommendations.

Þ Place a layer of aggregate or sand (if specified by design for use as a bedding layer or as a granular filter) so that the layer is smoothly graded and well-compacted. A typical layer of aggregate or sand is 4 inches thick when used only as a bedding material. A granular filter of aggregate or sand is usually 6 inches thick.

Rubble-Stone Riprap

Rubble-stone riprap is usually placed as one layer (12" deep), two layers (6" deep), or an interlocking mixture of one and two layers. Rubble-stone riprap should be hand placed so that the stones are close together, are staggered at all joints as far as possible, and are placed so as to reduce the voids to a minimum. The larger rocks should be thoroughly chinked or anchored in place by using 1" to 3" stones or aggregate placed over the surface and compacted in any manner practical.

When rubble-stone riprap is constructed in layers, the layers should be thoroughly tied together with large stones protruding from one layer into the other. The average depth is usually determined by frequent measurements throughout installation. Any change in thickness should be accomplished gradually.

Installation of grouted rubble-stone riprap includes hand placement of large rocks, chinking with smaller rocks and aggregate, filling with grout, surface finishing, and curing. When grouting is used, care should be taken to prevent earth or sand from filling the spaces between the stones before the grout is poured. Grout should be composed of one part Portland cement and four parts of sand measured by volume, and then mixed thoroughly with sufficient water to a consistency so that the grout can flow into and completely fill the voids.

Immediately before pouring grout, the stones should be wetted by sprinkling. Starting at the lower portion of the riprap channel, carefully pour grout into the voids between the stone and at a slow rate to prevent oozing to the surface. Do not pour grout over the entire surface of the riprap, but insert grout mixture by using vessels, chutes, tubes, or hoses of adequate size and shape. Carefully finish the grouted riprap surface using small hand tools. Remove excess grout without disturbing riprap structure. Allow grout to harden and set before any storm water is received. Keep grout moist with water that is free from salt or alkali for a period of not less than 72 hours.

Sacked Riprap (Sand-Cement)

Sand for sacked riprap may be either manufactured or natural clean sand, free from impurities and conforming to requirements for either cement sand or mortar sand. The basic requirements for sand are a maximum size (or D_{100}) to be approximately 3/8 inches and a minimum size (or D_0) to be equal to the No. 200 sieve or larger (i.e., no dust or clay). Portland cement should be manufactured dry-powdered hydraulic cement without impurities. Do not use hydraulic cement that is caked or otherwise moist. Sacks should be of either cotton or jute standard grade cloth that is able to hold the sand-cement mixture without leakage during handling and tamping.

Sand and hydraulic cement should be mixed dry, with a mechanical mixer, in the proportion of one bag (94 pounds) of cement to 5 cubic feet of dry sand, until the mixture is uniform in color. The sand-cement mix should be poured into sacks of approximately 1 cubic foot capacity until the sacks are approximately ¾ full. The sacks should then be securely fastened with hog rings, by sewing, or by other suitable methods that prohibit leakage of the mixture from the bags.

The sacks of sand-cement should be bedded by hand on the prepared grade with all the fastened ends on the grade and in a staggered pattern, with a minimum thickness of 10 inches. The sacks should be rammed and packed against each other in such a manner as to form close contact and secure a uniform surface. Immediately after placement, sand-cement sacks should be thoroughly soaked by sprinkling with water (but not high-pressure water flows). Sacks that are ripped or broken in placement should be removed and replaced before being soaked with water.

Machined Riprap

Machined riprap material is generally dumped and placed by the use of appropriate power equipment. Placement should avoid segregating material by minimizing drop heights and by dumping material in large quantities. Riprap is then graded and compacted (using hand or mechanical tamping) to produce a surface uniform in appearance. Handwork may be required to correct irregularities. Place riprap carefully to avoid puncturing or displacing geotextile fabric.

Typical layer thickness and allowable surface tolerances are shown in Table ES-23-1. Class A-2 machined riprap is the same as Class A-1 riprap except that the depth may be decreased to 12 or 15 inches when placed by hand in accordance with rubble-stone installation procedure. Other classes of hand-placed riprap are listed in Table ES-23-2.

Inspection

The final step in riprap installation is to verify that proper construction methods are used and that the specified gradation was installed. Visually inspect machined riprap to ensure that at least 20 percent of surface area consists of the D_{20} stone sizes specified within the materials section. Check that 50 percent of the surface area consists of stones no smaller than one-half of the maximum size specified.

Table ES-23-4 provides a rough guide to estimating the weight and equivalent diameter size of riprap material. A unit weight of 165 pounds per cubic foot is the same as a specific gravity of 2.65 with respect to water. Rectangular dimensions in a ratio of 3:2:1 are also listed as a frame of reference.

Table ES-23-4
Weight and Size Equivalents of Riprap
(assuming a unit weight of 165 pounds per cubic foot)

Weight	Equivalent diameter (spherical)	Rectangular dimensions (assuming 3:2:1 ratio)
1 pound	2.7 inches	3.6” x 2.4” x 1.2”
2 pounds	3.4 inches	4.6” x 3.0” x 1.5”
5 pounds	4.6 inches	6.2” x 4.1” x 2.1”
10 pounds	5.8 inches	7.8” x 5.2” x 2.6”
20 pounds	7.4 inches	9.8” x 6.5” x 3.3”
30 pounds	8.4 inches	11.2” x 7.5” x 3.7”
40 pounds	9.3 inches	12.4” x 8.2” x 4.1”
50 pounds	10.0 inches	13.3” x 8.9” x 4.4”
75 pounds	11.4 inches	15.2” x 10.1” x 5.1”
100 pounds	12.6 inches	16.8” x 11.2” x 5.6”
150 pounds	14.4 inches	19.2” x 12.8” x 6.4”
200 pounds	15.9 inches	21.2” x 14.1” x 7.1”
250 pounds	17.1 inches	22.8” x 15.2” x 7.6”
300 pounds	18.2 inches	24.2” x 16.1” x 8.1”
500 pounds	21.5 inches	28.7” x 19.1” x 9.6”

Limitations

- Þ Displacement may occur if the slope is too steep or if riprap is too small.
- Þ If no geotextile filter cloth is used, then scour may quickly occur and damage channel. Scour may also occur for improperly designed or installed geotextiles.
- Þ Riprap that is too small may experience movement within a drainage channel. This may create downstream blockages and excess sedimentation, in addition to allowing the channel to erode.

References **33, 34, 35, 141, 159, 161, 162, 167, 172, 179** (see BMP Manual Chapter 10 for list)

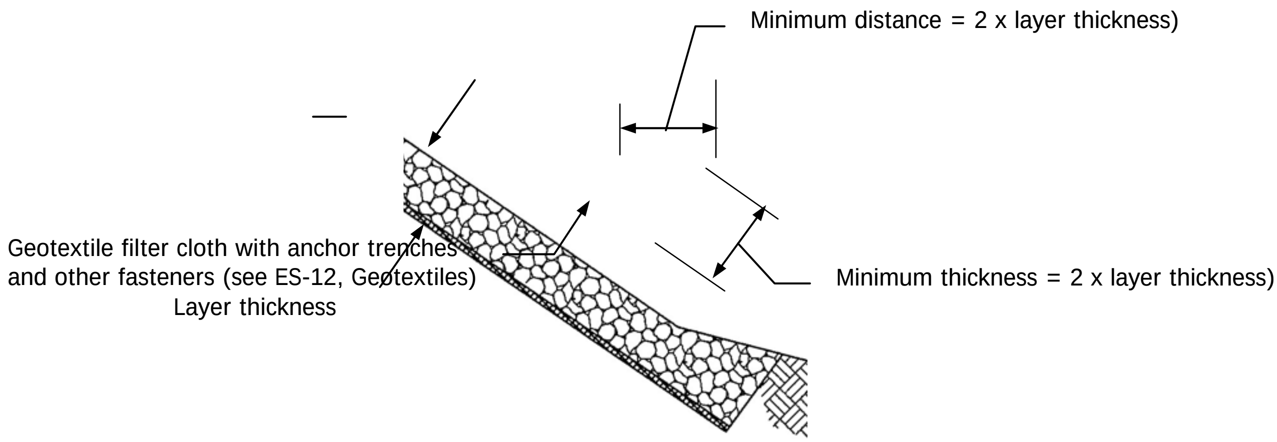
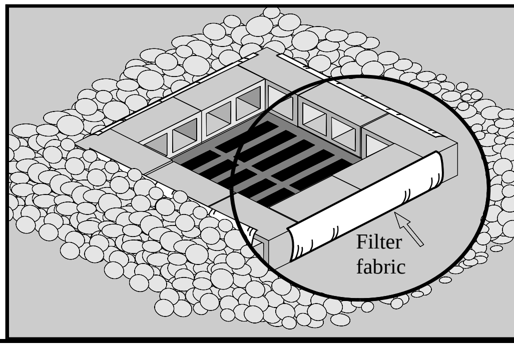


Figure ES-23-3
Base of Riprap Slope Protection

ACTIVITY: Temporary Inlet Protection	ES – 24



Targeted Constituents

¸ Significant Benefit		Û Partial Benefit	¹ Low or Unknown Benefit	
¸ Sediment	¹ Heavy Metals	Û Floatable Materials	¹ Oxygen Demanding Substances	
¹ Nutrients	¹ Toxic Materials	¹ Oil & Grease	¹ Bacteria & Viruses	Û Construction Wastes

Description

Temporary inlet protection during construction is helpful to settle sediment prior to the storm drainage system. Inlet protection can be installed at grate inlets, curb inlets, culverts, or other drainage features by creating a flooded, settling area that will allow mud to be cleaned up and properly disposed. This practice will significantly reduce sediment and will help control floatable waste materials and other construction wastes.

As described in ES-01 a stabilized construction exit is required to keep soil out of paved roads. Temporary inlet protection is typically used during construction when flooding of roadways can be tolerated. As always, construction site managers should focus on erosion prevention (stabilizing the site) and not reliance on soil removal.

Suitable Applications

Þ Every storm drain inlet, catch basin, curb inlet, culvert, or similar drainage structure that receives sediment-laden runoff must be protected by a combination of upstream erosion control and temporary inlet protection as needed. (Note: Paved streets with curb and gutter drainage systems are considered part of the storm drain system and discharges of sediment into the curb are an illegal discharge.)

Þ Where disturbed tributary areas have not yet been permanently stabilized, and where ponding water will not endanger highways, street traffic, houses or other buildings, parks, or other facilities. (Note: if water drains through the “inlet protection” quickly, so that the street/area is not flooded, then it is not removing sediment either.

Þ Small drainage areas, typically less than 0.5 acres, that have impervious surfaces that do not permit the construction of a sediment trap or sediment basin.

Approach

Design, build, and maintain inlet protection to contain the design storm, but allow a bypass at the required design storm. Temporary inlet protection generally consists of a means of damming/filtering (geotextile fabric, aggregate, straw bale) that is securely anchored and supported against the weight of ponded water by some type of support (wood posts, concrete blocks, wire mesh, the inlet structure itself). This can be accomplished in many different ways; the following details are included in this BMP and may be modified to meet site requirements.

Route offsite water around the area of construction if possible. If water flows off a paved street through the area construction, arrangements must be made during the Erosion Control Plan design phase to handle this water without causing a nuisance or backing the water into the street (such as through the installation of a detention pond).

Figure ES-24-1	Block and Gravel	(with filter fabric and gravel)
Figure ES-24-2	Sandbag Barrier	(also see ES-16, Sandbag Barrier)
Figure ES-24-3	Wire Miesh and Gravel	(also see ES-17 for rock filer berm)
Figure ES-24-4	Excavated Impoundment	(with wire mesh and gravel)
Figure ES-24-5	Geotextile Filter Bag	(premanufactured geotextile product)

Temporary inlet protection is appropriate for small areas of less than 1 acre, generally flat with less than 5% slope. Temporary inlet protection for paved or impervious areas should generally have smaller areas of less than half an acre. Inlet protection structures that pond water onto streets, parking lots, or driveways should be designed to have some method for allowing excess water from large storms to bypass or overflow.

The media (which is generally clean aggregate or silt fence fabric) should be inspected regularly to see if sediments and silt are clogging the material. Replace clogged aggregate with new clean aggregate regularly. Silt fence requires frequent maintenance and is not recommended. Straw bales float and are generally ineffective because they decompose rapidly and develop holes and cracks from routine storm water flows, requiring them to be maintained much more frequently than other types of temporary inlet protection.

Storm water runoff may bypass protected inlets on slopes. A berm or other type of wall can be used to capture some of the flow. Inlets that are downstream, particularly sump inlets, should be designed with an overflow as a means for handling large storms.

Installation

Block and Gravel

Place concrete blocks lengthwise on their sides in a single row around the perimeter of the inlet, so that the open ends face outward and not upward. Ends of adjacent blocks should abut. The height of the barrier can be varied by stacking combinations of blocks that are typically 6 or 8 inches high. Blocks that are stacked should be anchored against movement. Place geotextile filter fabric over the outside vertical face of the concrete blocks. If more than one strip is necessary, overlap the strips by at least 1 foot. Place clean stone against the geotextile filter fabric up to the top of the concrete blocks. Use ½" to ¾" gravel is selected, although other sizes of gravel will perform adequately to protect and weight filter fabric.

Sandbag Barrier
In general, sandbags are appropriate for gently sloping streets where ponded water will not endanger the public or cause property damage. Use sandbags made of geotextile fabric (not burlap) and fill with uniform material such as ½" rock or ¼" pea gravel.

Place one or two layers of overlapping sandbags, and pack them tightly together. A gap of one sandbag on the top row can serve as an overflow spillway from unexpected large storms. Install geotextile filter fabric and aggregate to filter sediment from storm water. Small pipes (2" diameter or smaller) can be placed through the sandbag barrier if covered by filter fabric. Verify that the sandbag barrier is sturdy and adequate to contain ponded water.

Wire Mesh and Gravel
Place hardware cloth or wire mesh over the inlet so that the wire extends a minimum of 1 foot beyond each side of inlet structure. Use hardware cloth or comparable wire mesh with openings from ¼" to ½" size. If more than one strip of mesh is necessary, overlap the strips. As an option, place filter fabric over wire mesh to ensure that sediment and loose fines do not enter the protected inlet. Place clean gravel that is ½" to ¾" size over the wire mesh. The depth of the gravel should be at least 12 inches over the entire inlet opening and extend at least 18 inches beyond the inlet opening in every direction.

Excavated Impoundment
An excavated impoundment can be used in areas where a manhole or inlet has been installed in the ground but possibly has not yet been backfilled. It can function as a sediment trap with a storage capacity of 67 cubic yards per acre of tributary area. Small holes can be drilled into the inlet structure and then later grouted when the temporary inlet protection is no longer needed. Filtering is accomplished by the appropriate size of clean gravel, geotextile filter fabric, or other means.

Geotextile Filter Bag
Install premanufactured product (such as Siltsack according to manufacturer's recommendations. A geotextile filter bag is intended for use in grate inlet structures that drain small areas less than 0.5 acres in size. Due to the potential for clogging, a geotextile filter bag should not be used as the primary device for controlling sediment and erosion. Regular inspection,

maintenance and cleaning is required. Do not use this product in city streets due to the potential for clogging and flooding.

Maintenance

Þ Inspect all inlet protection devices at least weekly and after every rainfall event. During extended rainfall events, inspect inlet protection devices at least once every 24 hours. Replace clogged aggregate or silt fence fabric immediately. Look for damage caused by large flows. Inspect downstream inlets, pipes, and other infrastructure downstream after severe storms to check for bypassed material.

Þ Remove sediment from temporary inlet protection methods when sediment reaches 2 or 3 inches deep. More frequent sediment removal is required from paved areas such as streets or parking lots.

Þ Remove all inlet protection devices within thirty days after the site is stabilized, or when the inlet protection is no longer needed. Bring the disturbed area to final grade and appropriately stabilize all bare areas around the inlet with vegetation. Clean storm drainage system of sediment and debris prior to final inspection.

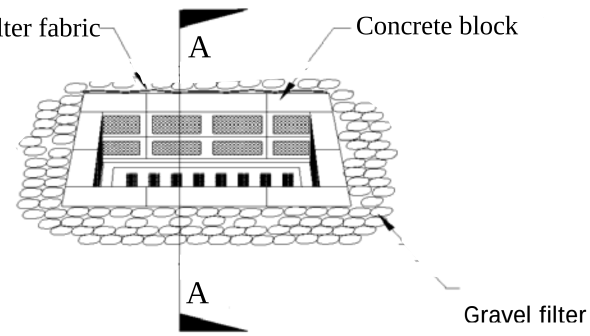
Limitations

Some forms of temporary inlet protection may encroach onto access roads, streets, parking lots, driveways, or highway traffic; modify designs to allow for emergency overflow or bypass for large storms that may endanger traffic or cause property damage. Sediment removal may be ineffective in high-flow conditions or if storm water runoff contains large amounts of sediment. For drainage areas larger than half an acre, storm water runoff should be routed to a sediment trap or sediment basin designed for larger flows.

Note: This method of inlet protection is applicable where heavy concentration of flows are expected, but not where ponding would cause flooding problems. The City of Memphis has signs that may be used for construction sites to educate potential home buyers in a new subdivision and alleviate flooding concerns during construction.

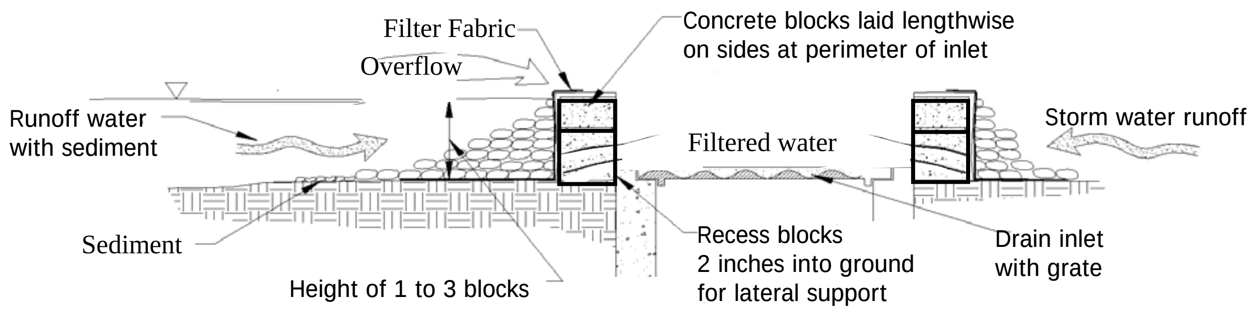
References

8, 25, 30, 33, 34, 35, 43, 54, 135, 136, 141, 144, 162, 167, 179 (see BMP Manual Chapter 10 for list)

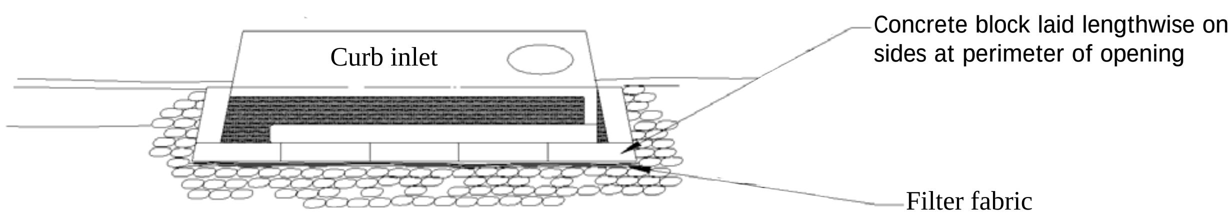


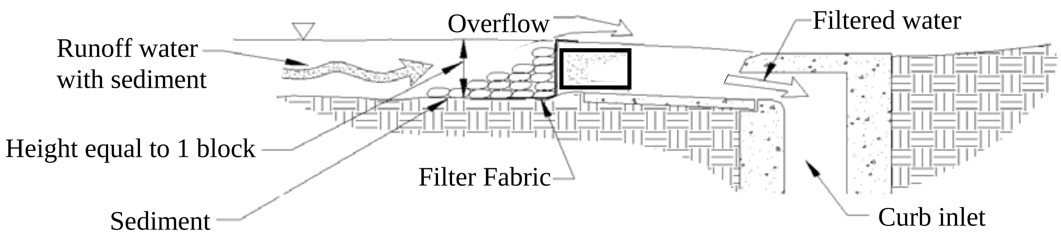
Notes:

1. Use clean aggregate (½" to ¾") such as TDOT #4 or #5 or washed #57.
2. Periodically change old gravel with new clean gravel. Old gravel may be used as backfill material.
3. Blocks stacked on each other must be secured from movement using techniques such as inserting a piece of 6" or 8" wood.



<u>INLET WITHOUT CURB</u>

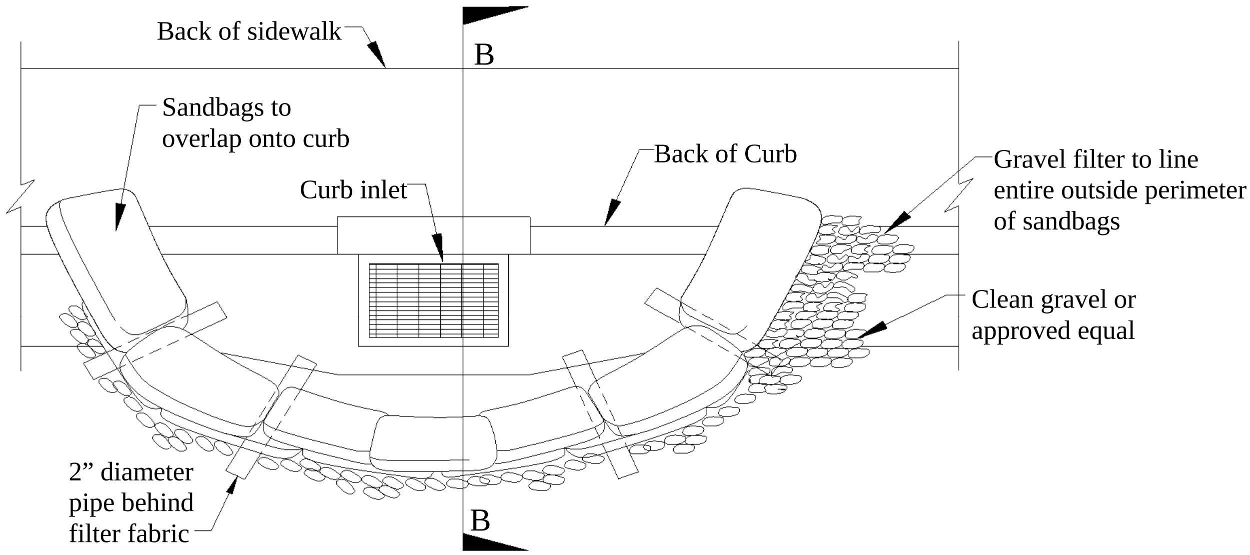




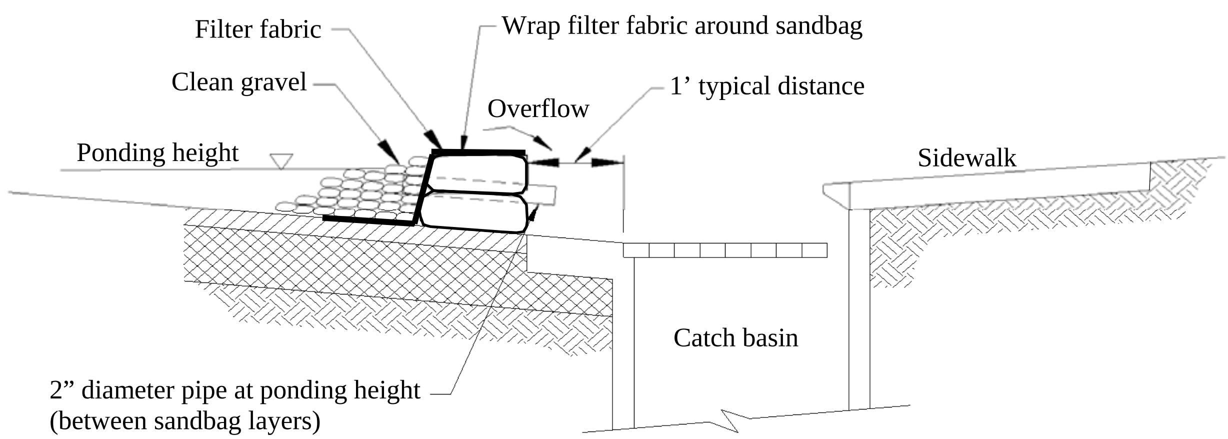
<u>INLET WITH CURB</u>

<u>NOT TO SCALE</u>

Figure ES-24-1
Inlet Protection — Block and Gravel



INLET AT TYPICAL PAVED AREAS



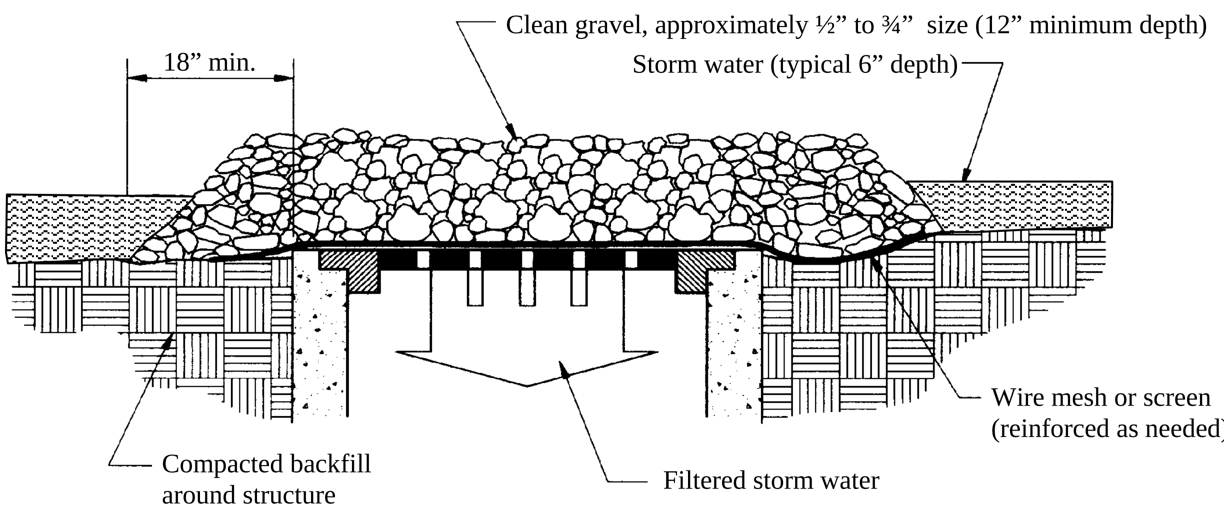
SECTION B-B

Notes:

1. See ES-16, Sandbag Barrier, for more information on sandbag materials and specifications.
2. Use clean aggregate (½” to ¾”) such as TDOT #4 or #5 or washed #57.
3. Periodically replace old gravel with new clean gravel. Old gravel may be used as backfill material.
4. Use geotextile filter fabric for storm water with high content of silt and clay (as shown in Section B-B).

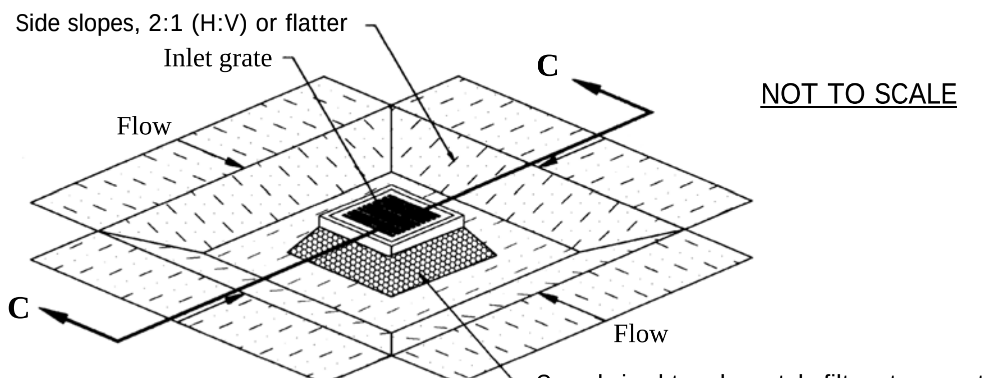
NOT TO SCALE

Figure ES-24-2
Inlet Protection — Sandbag Barrier

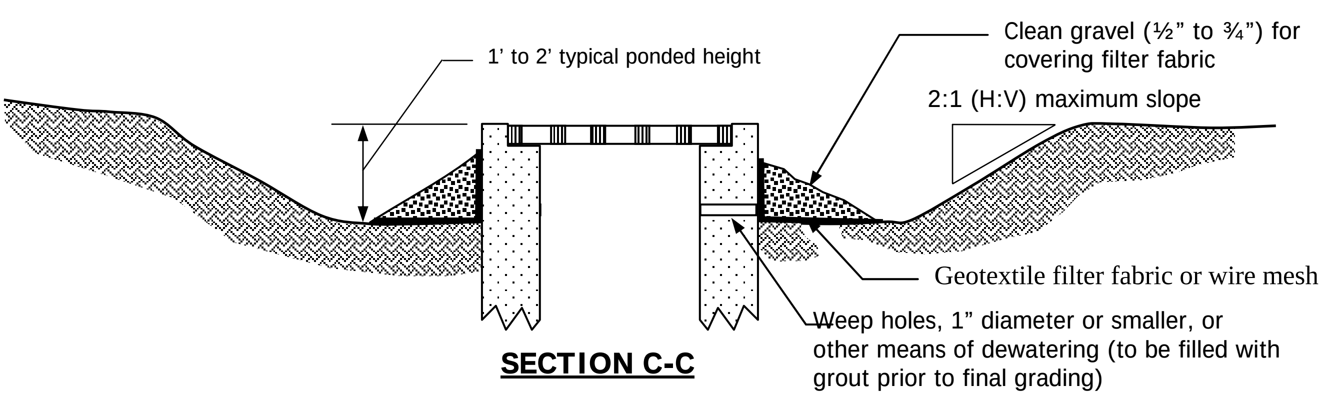


Note:
This method of inlet protection is applicable where heavy concentration of flows are expected, but not where ponding would cause flooding problems. The City of Memphis has signs that may be used for construction sites to educate potential home buyers in a new subdivision and alleviate flooding concerns during construction.

Figure ES-24-3
Inlet Protection — Wire Mesh and Gravel

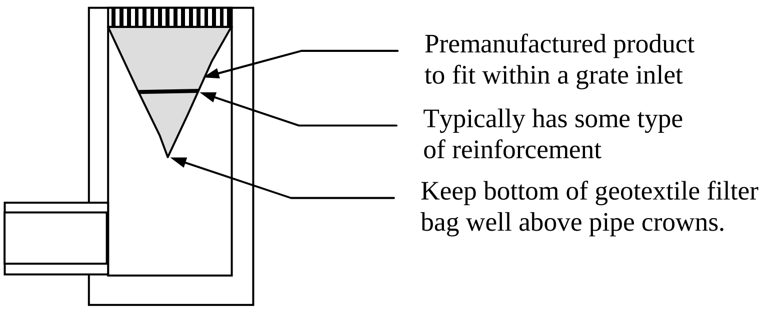


ISOMETRIC PLAN VIEW



SECTION C-C

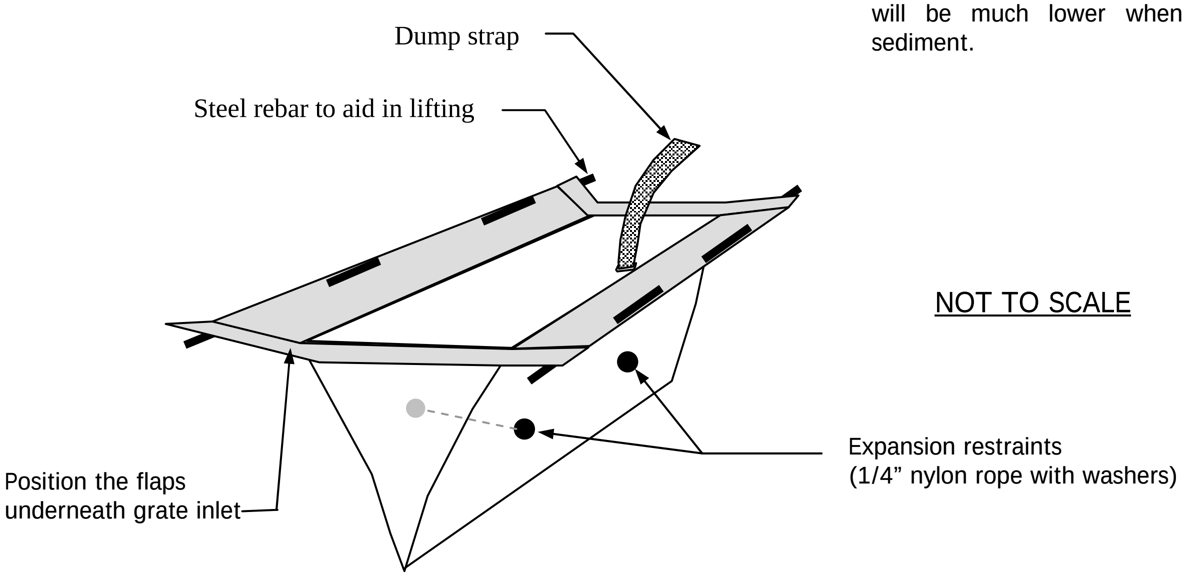
Figure ES-24-4
Inlet Protection — Excavated Impoundment



PROFILE VIEW

Notes:

1. Install and maintain geotextile filter bag in accordance with manufacturer's recommendations. Product shown is the Siltsack Sediment Control Device made by ACF Environmental.
2. Regular Siltsack has a grab tensile strength of 300 lbs and puncture strength of 120 lbs. Fabric is woven polypropylene with double stitch.
3. Inspect geotextile filter bag after each rainfall event. Remove sediment as recommended by manufacturer. Do not install geotextile filter bag at locations that may cause flooding in streets or adjacent properties.
4. Regular Siltsack has a flow rate of 40 gallons per minute per square foot of clean geotextile material. The flow rate will be much lower when filled with sediment.

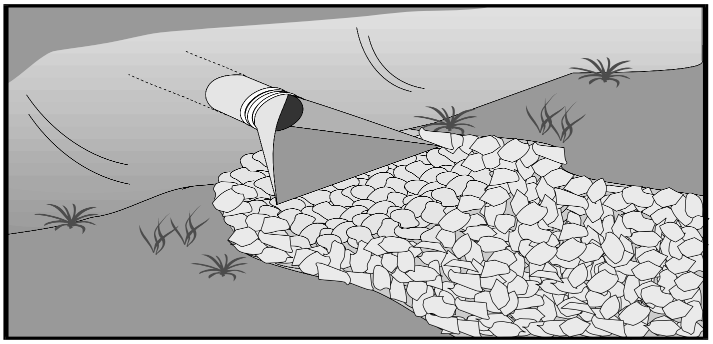


NOT TO SCALE

ISOMETRIC PLAN VIEW

Figure ES-24-5
Inlet Protection — Geotextile Filter Bag

ACTIVITY: Outlet Protection	ES – 25



City of Memphis and Shelby County

Targeted Constituents				
¸ Significant Benefit		Û Partial Benefit	¹ Low or Unknown Benefit	
¸ Sediment	¹ Heavy Metals	¹ Floatable Materials	¹ Oxygen Demanding Substances	
¹ Nutrients	¹ Toxic Materials	¹ Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description

Outlet protection for culverts, storm drains, or even steep ditches and flumes is essential to prevent major erosion from damaging downstream channels and drainage structures. Outlet protection can be a channel lining, structure, or flow barrier designed to lower excessive flow velocities from pipes and culverts, prevent scour, and dissipate energy. However, effective outlet protection must begin with efficient storm drainage system design that uses adequately sized pipes, culverts, ditches, and channels placed at the most efficient slopes and grades. Good outlet protection will significantly reduce erosion and sediment by reducing flow velocities.

Suitable Applications

Þ Outlet protection is needed wherever discharge velocities and energies at the outlets of culverts, pipes, conduits, channels, or ditches are sufficient to erode the immediate downstream reach.

Approach

The design and analysis of riprap protection, stilling basins, impact barriers, and other types of culvert outlets is a complex task to accomplish. The first step is to look for ways to reduce the need for outlet protection by efficient storm drainage system design. The last section of pipe (prior to the outlet of a culvert or storm drain) should not be placed at a steeper grade than necessary to adequately convey the design storm. This may require a deeper-than-usual manhole or inlet for the last section of pipe, but any additional costs are usually offset by reduced erosion and settlement due to lower outlet velocities.

In general, temporary outlet protection is usually specified as dumped riprap. See Figure ES-25-1 and Table ES-25-1 for the selection and size of riprap outlet protection for temporary or permanent installations. Permanent riprap protection should be sized by a professional engineer as part of the storm drainage design, using the guidelines in ES-23 to specify sound and durable crushed rock. Riprap outlet protection is usually less expensive and easier to install than concrete aprons or energy dissipaters. A riprap channel lining is flexible and adjusts to settlement; it also serves to trap sediment and reduce flow velocities. Due to the highly erodible loess soils in the Memphis area, filter fabric is recommended under the riprap.

Typical energy dissipaters are shown in Figure ES-25-2. There have been many types developed over the years by federal and state agencies such as U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation (USBR). Commonly used varieties of stilling basins (for handling hydraulic jumps in addition to dissipating energy) can include USBR Type II, USBR Type III, USBR Type IV, and USBR Type VI. Reference 160 contains procedures and charts for the detailed design of energy dissipating structures using considerations such as specific ranges for the Froude number, depth of flow, roughness, gradient, discharge rate, and velocity.

Outlet Velocity

The primary factor in selecting the type of outlet protection is determining the outlet velocity for culverts, which is dependent upon the type of flow profile associated with the design storm. The culvert flow may be controlled by the type of inlet, the throat section, the pipe capacity, or by the type of outlet. The type of control may change from outlet control to inlet control, for example, depending on the flow value. Culvert design is fully described in FHWA Hydraulic Design Series No. 5, Hydraulic Design of Highway Culverts (reference 158). For inlet control (including throat section), the outlet velocity is assumed to be normal depth as computed by Manning's equation. For outlet control, the outlet velocity is found by using Manning's equation with the computed tailwater depth or the critical flow depth of culvert, whichever is greater. The entire culvert cross-sectional area is used if the tailwater depth is higher than the top of the culvert opening.

Riprap Aprons

Riprap aprons should not be used to change the direction of outlet flow, for which an impact-type energy dissipater would be more effective. Riprap aprons rely primarily upon a higher Manning's roughness coefficient to slow water velocity into proportions that are manageable by a properly designed channel.

Place a heavy-duty geotextile filter fabric upon prepared subgrade, and carefully anchor to avoid damage or movement. Place riprap without excessive drop heights, avoiding damage by equipment tracks or blades. Dumped rock riprap generally has a higher Manning's roughness coefficient than grouted riprap and is, therefore, more effective at slowing storm water down. However, grouted riprap may be more useful in certain instances. Riprap is generally not adequate at the base of concrete flumes or chutes, and a concrete outlet protection structure is greatly preferred in these instances.

Construct riprap apron at zero percent grade for the specified length L_A and width W_A by using the appropriate D_{50} size of stones interpolated from Table ES-25-1. If a curve is needed within the riprap apron, place within the lower reach of the apron and use larger riprap sizes in the curved section. The basic design procedure is:

1. Compute tailwater depth (using normal flow with Manning's equation) for the downstream receiving channel. Select conditions as being Low Tailwater (typically for an undefined channel or greatly oversized channel) or as being High Tailwater (most defined channel shapes). If conditions are unknown, then compute parameters from both sections of table and use the most conservative value.

2. Compute depth of flow in culvert based upon the particular type of culvert flow control. For inlet control, the outlet velocity is assumed to be normal depth as computed by Manning's equation. For outlet control, the outlet velocity is found by using Manning's equation with the computed tailwater depth or the critical flow depth of culvert, whichever value is greater. The entire culvert cross-sectional area is used if the tailwater depth is higher than the top of the culvert opening.

3. Interpolate values for riprap apron length (L_A) and riprap median size (D_{50}) from the appropriate portion of Table ES-25-1. If the culvert is not flowing full, then adjust these values upwards by the following factors. The median riprap size D_{50} is more sensitive than the apron length L_A. The minimum riprap size D_{50} is 6 inches, which may be specified as TDOT machined Class A-1 riprap as described in ES-23.

Flow depth / Diameter	Increase D_{50} by:	Increase L_A by:
1.00	-----	-----
0.90	-----	-----
0.80	1.10	-----
0.70	1.20	1.05
0.60	1.30	1.10
0.55	1.40	1.15
0.50	1.50	1.20

Energy Dissipaters and Stilling Basins

Structural controls, generally made from precast concrete or from pour-in-place concrete, should be used whenever riprap aprons are inadequate. The design of the energy dissipaters and stilling basins shown in Figure ES-25-2 are discussed in the FHWA publication HEC-14, Hydraulic Design of Energy Dissipaters for Culverts and Channels (reference 160), which can be downloaded at:
http://www.fhwa.dot.gov/bridge/hydpub.htm

Stilling basins are used to convert flows from supercritical to subcritical depths by allowing a hydraulic jump to occur. The stilling basin allows a controlled hydraulic jump to occur within the structure over a wide range of flow conditions and depths. Energy dissipaters and stilling basins must be designed by a professional engineer using hydraulic computations. A primary concern for both energy dissipaters and stilling basins is whether sediment and trash can accumulate. The designs shown in Figure ES-25-2 have been tested thoroughly over the years and present a good starting point for any type of structural outlet protection. TDOT drawing standards include a riprap basin energy dissipater, based upon procedures in HEC-14.

Maintenance

Þ Inspect outlet protection on a regular basis for erosion, sedimentation, scour, or undercutting. Repair or replace riprap, geotextile, or concrete structures as necessary to handle design flows. Remove trash, debris, grass, sediment, or burrowing animals as needed. Maintenance may be more extensive if smaller riprap sizes are used, as children may tempted to throw or otherwise displace stones and rocks.

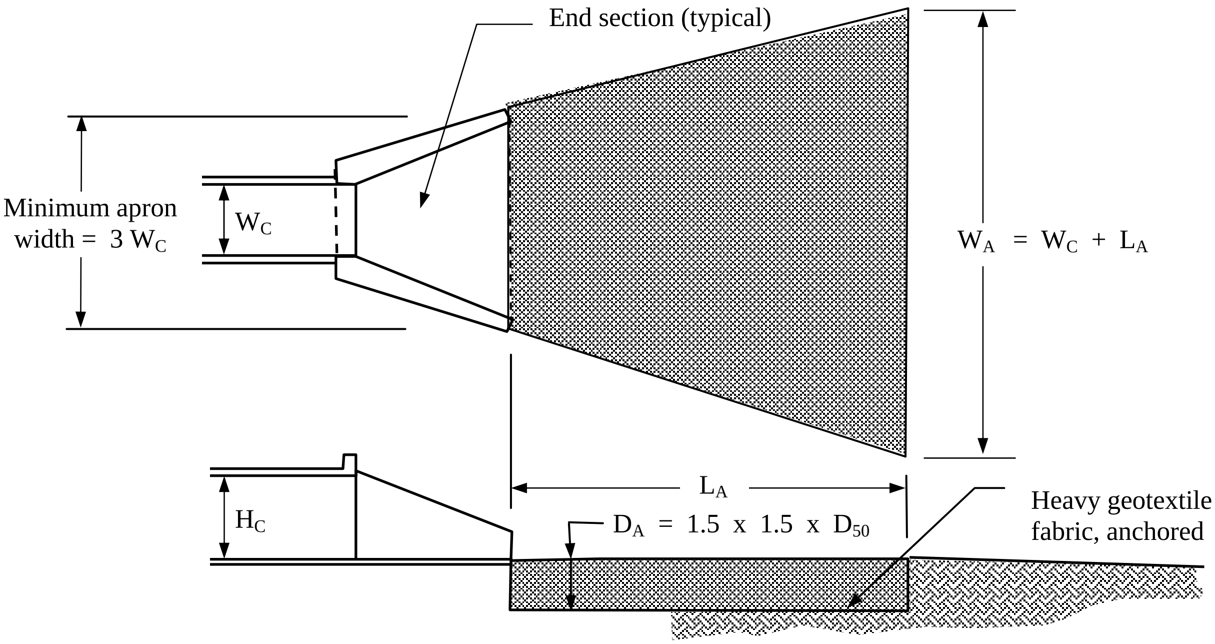
Limitations

Þ Riprap outlet protection may occupy a large area. The specified grade for a riprap apron is zero percent. It may be difficult to handle large amounts of riprap, given that designed outlet protection is usually at or near the project boundary or property line. An easement may be necessary to maintain riprap outlet protection.

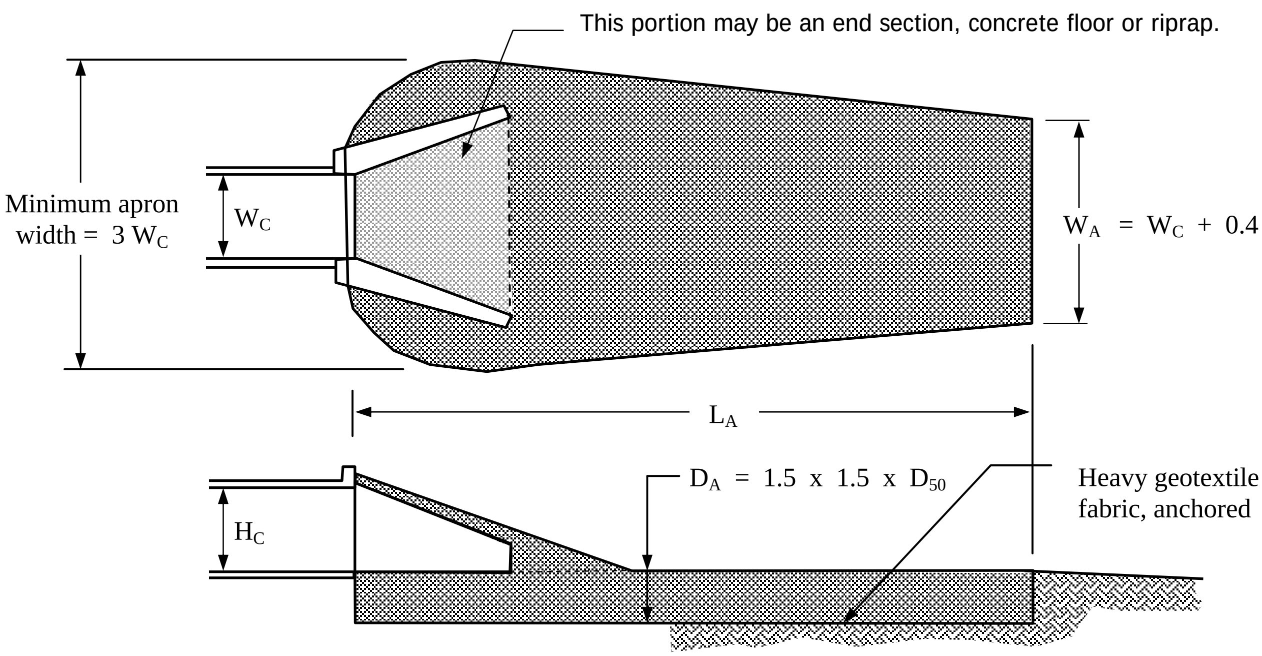
Þ Grouted riprap and concrete structures are subject to upheaval from freeze/thaw action. Weepholes and adequately drained foundations are necessary for these types of outlet protection.

References

30, 35, 139, 141, 158, 160, 162, 167, 179 (see BMP Manual Chapter 10 for list)



Tailwater $< 0.5\ H_C$ and Assuming Full Culvert Flow (Low Tailwater Conditions)



Tailwater $> 0.5\ H_C$ and Assuming Full Culvert Flow (High Tailwater Conditions)

NOT TO SCALE

Figure ES-25-1
Riprap Outlet Protection

H_C = height of culvert
W_C = width of culvert
L_A = length of riprap apron
W_A = width of riprap apron at end
D_{50} = median riprap size (Table ES-25-1)
D_{MAX} = maximum size of riprap = 1.5 D_{50}
D_A = depth of riprap apron = 1.5 D_{MAX}

TABLE ES-25-1
Selecting Riprap Apron Length (L_A) and Riprap Median Size (D_{50})
(for circular culverts flowing full)

This table is intended to select two parameters for the design of riprap outlet protection based upon outlet velocities that correspond with circular culverts flowing full. Flow values less than the lowest value for the culvert size usually indicate a full-flow velocity less than 5 feet per second, for which riprap is usually not necessary. Flow values greater than the highest value for the culvert size usually indicate that a concrete stilling basin or energy dissipater structure is necessary.

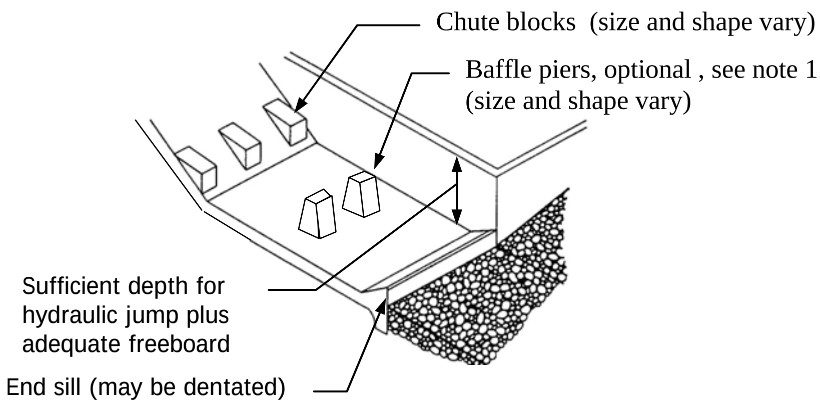
Adjust values upward if the circular culvert is not flowing full based upon outlet conditions. For noncircular pipe, convert into an equivalent cross-sectional area of circular culvert to continue design.

Riprap Aprons for Low Tailwater
(downstream flow depth < 0.5 x pipe diameter)

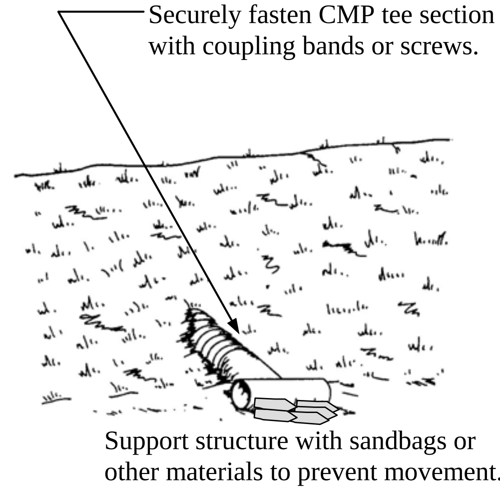
Culvert Diameter	Lowest value			Intermediate values to interpolate from:									Highest value		
	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}
	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In
12”	4	7	2.5	6	10	3.5	9	13	6	12	16	7	14	17	8.5
15”	6.5	8	3	10	12	5	15	16	7	20	18	10	25	20	12
18”	10	9	3.5	15	14	5.5	20	17	7	30	22	11	40	25	14
21”	15	11	4	25	18	7	35	22	10	45	26	13	60	29	18
24”	21	13	5	35	20	8.5	50	26	12	65	30	16	80	33	19
27”	27	14	5.5	50	24	9.5	70	29	14	90	34	18	110	37	22
30”	36	16	6	60	25	9.5	90	33	15.5	120	38	20	140	41	24
36”	56	20	7	100	32	13	140	40	18	180	45	23	220	50	28
42”	82	22	8.5	120	32	12	160	39	17	200	45	20	260	52	26
48”	120	26	10	170	37	14	220	46	19	270	54	23	320	64	37

Riprap Aprons for High Tailwater
(downstream flow depth > 0.5 x pipe diameter)

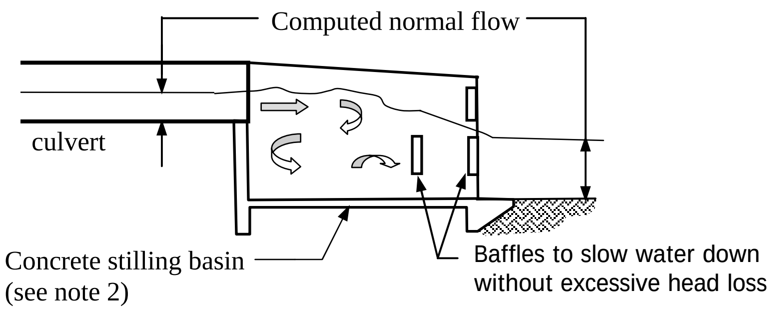
Culvert Diameter	Lowest value			Intermediate values to interpolate from:									Highest value		
	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}	Q	L_A	D_{50}
	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In	Cfs	Ft	In
12”	4	8	2	6	18	2.5	9	28	4.5	12	36	7	14	40	8
15”	7	8	2	10	20	2.5	15	34	5	20	42	7.5	25	50	10
18”	10	8	2	15	22	3	20	34	5	30	50	9	40	60	11
21”	15	8	2	25	32	4.5	35	48	7	45	58	11	60	72	14
24”	20	8	2	35	36	5	50	55	8.5	65	68	12	80	80	15
27”	27	10	2	50	41	6	70	58	10	90	70	14	110	82	17
30”	36	11	2	60	42	6	90	64	11	120	80	15	140	90	18
36”	56	13	2.5	100	60	7	140	85	13	180	104	18	220	120	23
42”	82	15	2.5	120	50	6	160	75	10	200	96	14	260	120	19
48”	120	20	2.5	170	58	7	220	85	12	270	105	16	320	120	20



Typical Stilling Basin At End of Paved Flume or Chute



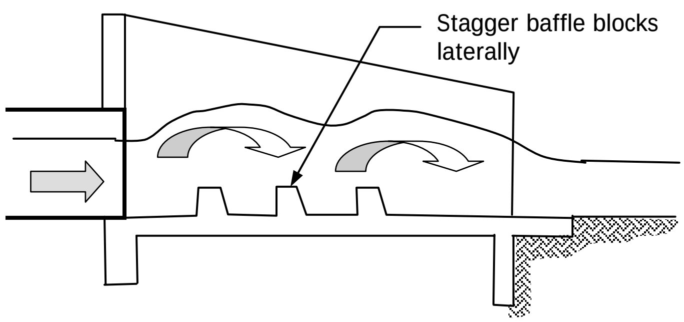
Temporary CMP Energy Dissipater



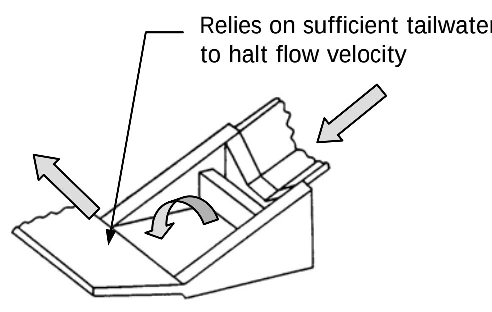
Typical Stilling Basin Using Baffles and Elevation Drop

Notes:

1. This is the basic format for several types of stilling basins. USBR Type II basin does not contain baffle piers, but does have a dentated end sill. USBR Type III basin has baffle piers and a smooth undentated end sill. See HEC-14 for detailed design of concrete structures.
2. Concrete stilling basin should be approximately as wide as the downstream channel. Design baffles to retain sufficient storm water to act as a plunge pool for a wide range of flow values.



Typical Energy Dissipater — Baffle Blocks Within Headwall

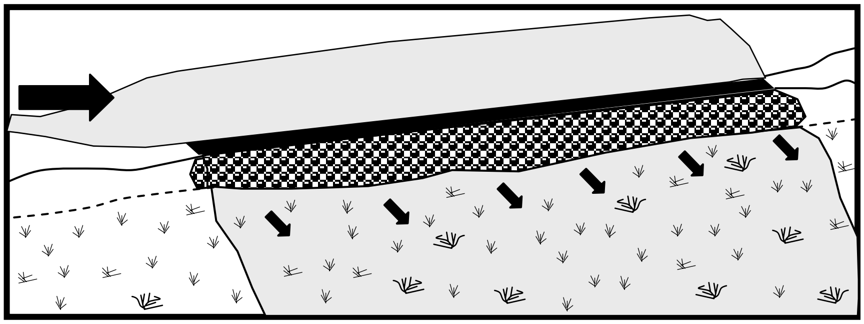


Typical Impact Energy Dissipater (Virginia DOT)

NOT TO SCALE

Figure ES-25-2
Various Energy Dissipaters and Stilling Basins

ACTIVITY: Level Spreader	ES – 26



Targeted Constituents

¸ Significant Benefit Û Partial Benefit ¹ Low or Unknown Benefit

¸ Sediment	¹ Heavy Metals	¹ Floatable Materials	¹ Oxygen Demanding Substances	
¹ Nutrients	¹ Toxic Materials	¹ Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description

A level spreader handles concentrated runoff from a ditch or temporary diversion channel and turns it into sheet flow. It should be used only for small flows where a gentle stabilized grass slope is available. A level spreader will significantly reduce erosion and sediment by reducing flow velocities.

Suitable Applications

Þ Temporary diversion channels with an adjacent gentle stabilized slope, for which downstream drainage infrastructure may not be completed.

Þ Permanent drainage channels with small flows and an adjacent gentle stabilized slope, for which downstream infrastructure may not be warranted.

Approach

The purpose of a level spreader is to turn concentrated storm water runoff from a ditch into sheet flow, for the purpose of increasing infiltration and reducing volume of runoff. It is meant for use on small flows, typically with a design storm flow less than 5 cubic feet per second (cfs). If storm water runoff is discharged through a culvert as large as 12” diameter, then this runoff is usually too large to be a candidate for a level spreader.

A level spreader (Figure ES-26-1) is essentially a widened portion of ditch, constructed at zero percent grade, with a carefully constructed side-release weir. Do not use fill material to construct a vegetated lip for a level spreader. The widened portion of ditch is triangular in shape, which increases the wetted perimeter and slows down the water.

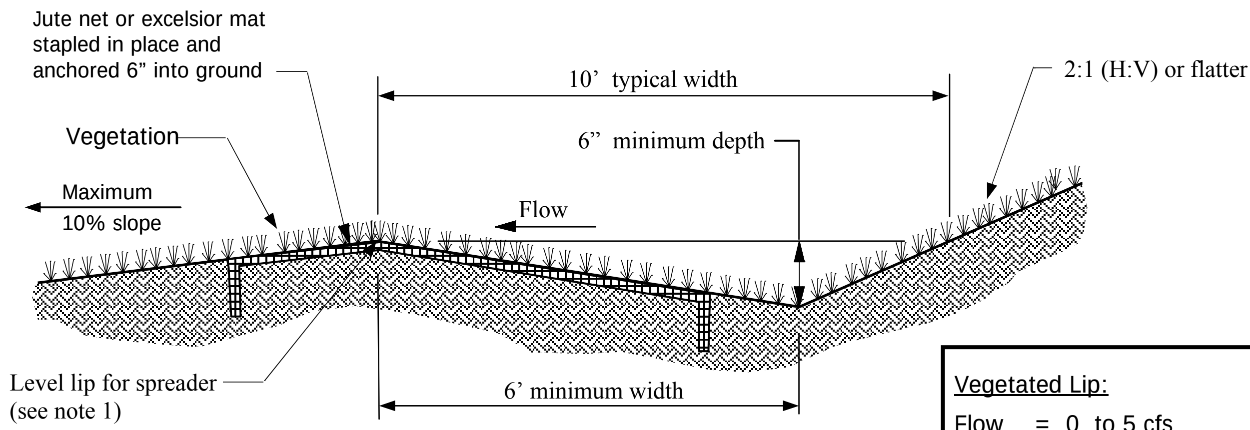
Maintenance

Inspect temporary level spreaders weekly and after rainfall events. Look for excessive sediment, scour or undercutting, and for concentrated flows downhill from level spreader. Since the level spreader is not a sediment-removing device, additional erosion controls may be necessary. Note any problems and correct promptly.

Inspect permanent level spreaders periodically for scour, undercutting, or settlement, and for concentrated flows downhill from level spreader. Repair or replace level spreader if it is damaged or inadequate to prevent erosion.

Limitations A level spreader can only handle small flows from ditches or channels. It may be prudent to have additional measures (or an emergency overflow or bypass) to handle larger storms. A level spreader with vegetated lip needs to be protected from traffic (even riding mowers) in order to maintain a smooth level surface for the overflow weir.

References **33, 141, 162, 167, 179** (see BMP Manual Chapter 10 for list)



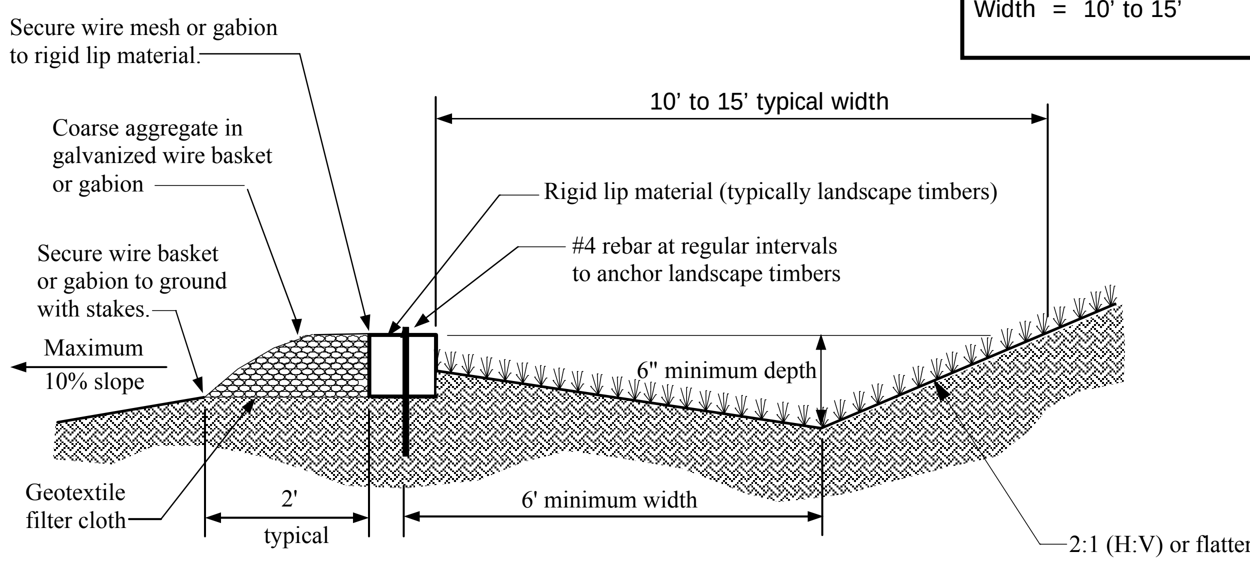
Level Spreader — Vegetated Lip

Vegetated Lip:

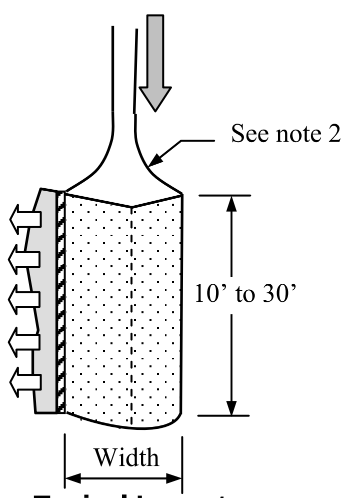
Flow = 0 to 5 cfs
Length = 10’
Width = 10’

Rigid Lip:

Flow = 5 to 15 cfs
Length = 2 x flow = 10’ to 30’
Width = 10’ to 15’



Level Spreader — Rigid Lip



Typical Layout

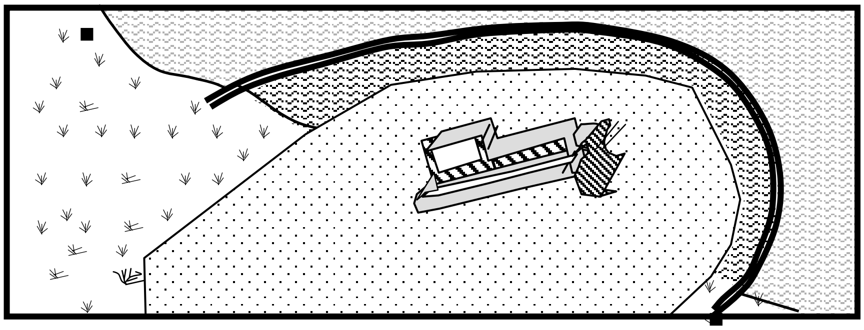
NOT TO SCALE

Notes:

1. Vegetated lip for level spreader should not be constructed from fill material. Do not allow any traffic (even riding mowers) onto vegetated lip.
2. The last 20’ of approach channel should have a grade less than 1%.

Figure ES-26-1
Level Spreaders

ACTIVITY: Floating Sediment Curtain — ES – 27



Targeted Constituents

¸ Significant Benefit Û Partial Benefit ¹ Low or Unknown Benefit

¸ Sediment	¹ Heavy Metals	¹ Floatable Materials	¹ Oxygen Demanding Substances	
¹ Nutrients	¹ Toxic Materials	¹ Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description

A floating sediment curtain is used within a stream, river, or lake as a last line of defense to capture sediment and silt. It can also be used in a sediment basin or a settling pond to ensure adequate capture of sediment and silt. A floating sediment curtain will significantly reduce sediment in critical areas such as streams, rivers, and aquatic habitats.

Suitable Applications

Þ Adjacent to banks where construction, grading or excavation will take place up to the edge of water or within the body of water.

Þ Within a temporary sediment basin or a settling pond to assist in capture of sediment and silt.

Þ For dredging projects.

Approach

A floating sediment curtain is made from a heavy geotextile fabric, typically 16 to 20 ounces per square yard, with sufficient properties to capture most types of silt and sediment. Floatation is often achieved by Styrofoam or other very light material that will not degrade in water. Geotextile panels are reinforced and sewn to include the flotation material, chains, hooks, and other connection equipment as needed. Geotextile fabric should have ultraviolet inhibitors and adequate strength to match the application without failing.

Any type of construction or project that takes place within "Waters of the State" is regulated by the Tennessee Department of Environment and Conservation (TDEC). The usual definition for Waters of the State is any blue-line stream that is shown on a U.S. Geological Survey quadrangle map, or any point downstream from where the blue-line stream begins, including lakes, ponds, and wetlands. See TDEC Web site for additional information on requirements for an Aquatic Resource Alteration Permit (ARAP), which must be obtained prior to construction, clearing, grading, or any other disturbance near a body of water.

http://www.state.tn.us/environment/permits/

Floating sediment curtains are not intended for use across flowing streams or rivers.

Although this may appear to be the easiest way to anchor a floating curtain, it is not designed to filter large quantities of flowing water nor can it resist the large forces involved. Floating sediment curtains should not be placed across navigation channels, streams with fish or other migrating aquatic life, or recreational streams.

Floating sediment curtains are commercially available with adequate sizes and strengths for almost any application. Follow manufacturer's recommendations and design guidelines when using these products. In most instances, installation will require boats and anchoring hardware for which an experienced subcontractor is recommended.

Design Considerations

Curtains should generally extend from the water surface to the bottom of the channel, with a reasonable effort to match the bottom profile of channel. Typically allow 10% extra depth for the curtain, and fold the extra depth toward the land side of the curtain. Allow 10% extra length to allow for some curtain flexibility, anchoring points, current, etc.

The choice of whether to use a pervious material (geotextile filter fabric) or an impervious material (nylon reinforced vinyl) depends on the type of silt or sediment expected. A pervious material will allow small amounts of water to pass through, but is generally insufficient to allow a moving stream to pass through.

Curtain joints (as shown in Figure ES-27-1) are typically 50 to 100 feet apart, which allows for flexible deployment choices, easier storage, and reduced stress on the fabric. The alternate connection detail is for situations that have moving water or other stresses, or to assist in anchoring. In general, the curtain should be anchored or staked at every joint using built-in fasteners and loops.

The floating sediment curtain should generally be made of bright colors, such as yellow or orange, for visibility or the curtain should have buoys or floats attached to increase visibility. The floating sediment curtain should have at least 3" freeboard above the water surface. The type and size of buoyant material should be computed to offset the weight of curtain, including the fabric, ropes, chains, and other fasteners used.

Maintenance

- Inspect floating sediment curtain daily to verify that silt and sediment are not bypassing the curtain. Repair or replace curtain as necessary, using materials and methods recommended by the geotextile manufacturer.

Þ In shallow areas, trapped sediment can be more easily removed than in deep waters. If the curtain has some excess length, it may be possible to carefully raise the bottom edge by swinging it slowly upstream and raising it. Otherwise, equipment with appropriate bucket attachments can be used. It may be less harmful to leave sediments in place than to dredge and remove them.

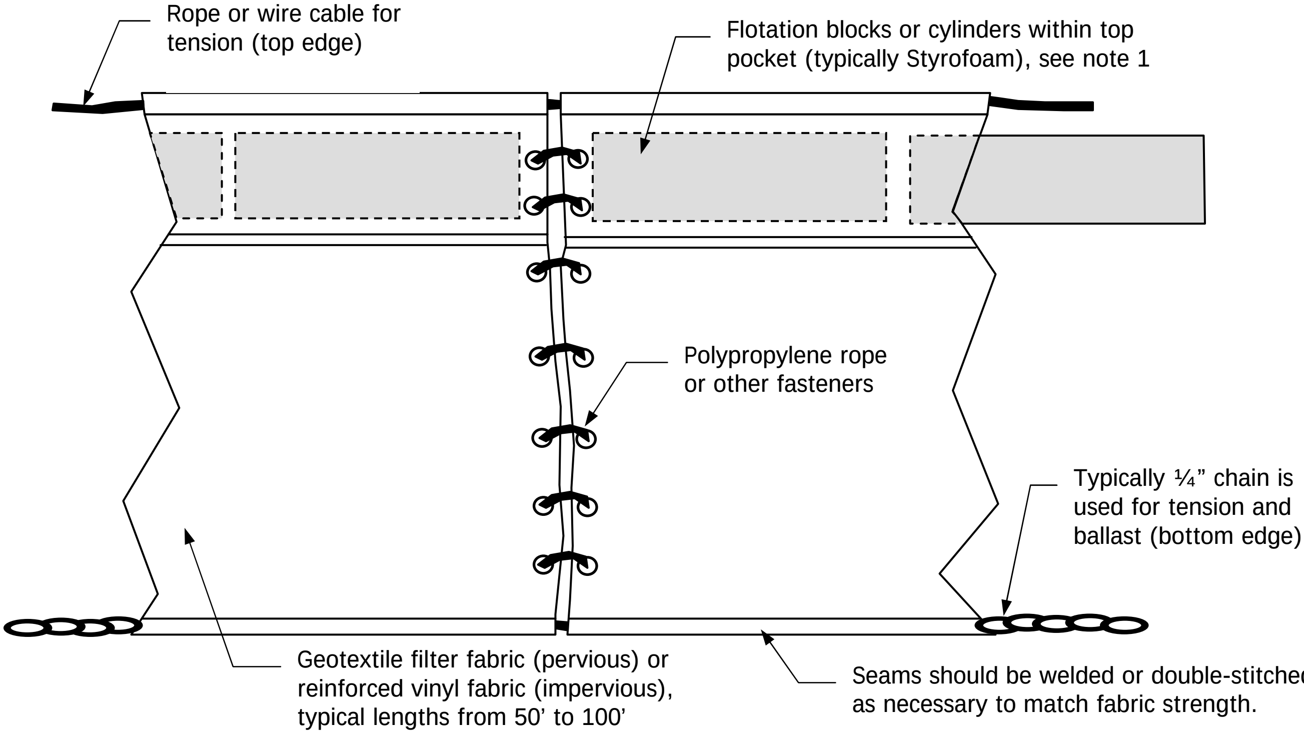
Limitations

Þ A floating sediment curtain is the last line of defense in controlling sediment. Use silt fence or straw bale barriers up to the edge of water. Silt fence can be installed in shallow water less than 1' deep, and may be adequate to replace a floating sediment curtain for some situations.

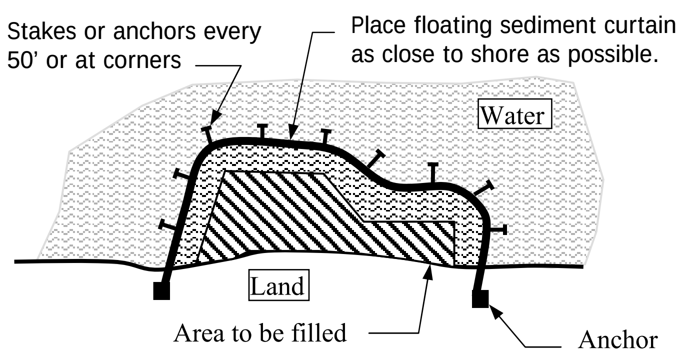
Þ Floating sediment curtains usually require design and installation by an experienced subcontractor. They are manufactured commercially and are highly recommended.

Þ Floating sediment curtains are not intended for petroleum spills, chemical spills, or other instances of floating liquids. Use an absorbent boom specifically made to capture the type of spilled liquid.

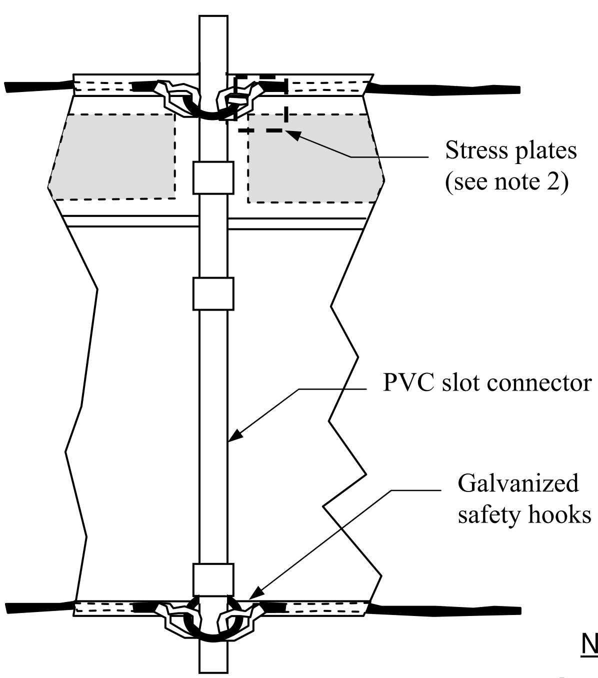
References **45, 115, 141** (see BMP Manual Chapter 10 for list)



Typical Floating Sediment Curtain



Typical Construction Layout



Alternate Connection Detail

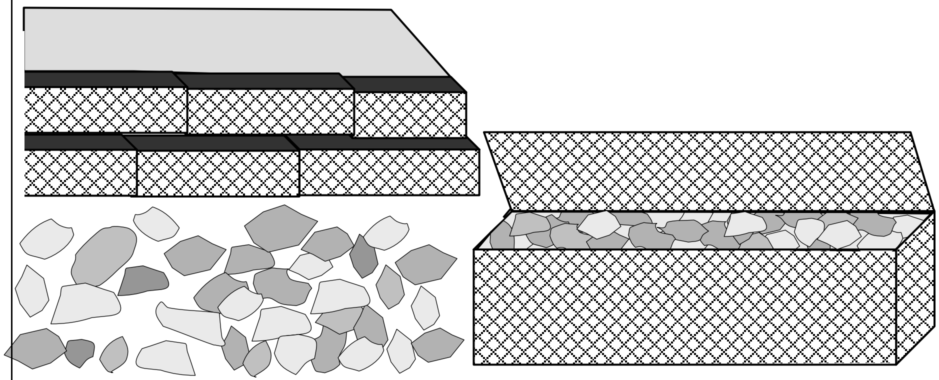
Notes:

1. Typical Styrofoam block size ranges from 4”x 4” up to 12”x 2”. Size and buoyancy requirements depend on weight and length of curtain.
2. Stress plates may be attached to the fabric and cable in situations with flowing water, high winds, or other strong loads.

NOT TO SCALE

Figure ES-27-1
Floating Sediment Curtain

ACTIVITY: Gabions	ES – 28



Targeted Constituents				
¸ Significant Benefit		Û Partial Benefit	¹ Low or Unknown Benefit	
¸ Sediment	¹ Heavy Metals	¹ Floatable Materials	¹ Oxygen Demanding Substances	
¹ Nutrients	¹ Toxic Materials	¹ Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description

Gabions are large rectangular wire mesh boxes that are filled with large stone or riprap. Gabions can be used as drainage channels, low retaining walls, bridge abutments, and approaches, culvert headwalls, flow aprons, or drop structures or as general landscaping elements. Thin gabions, typically called revet mattresses or reno mattresses, are used for drainage channels and slopes. The wire mesh is typically galvanized to resist corrosion and may also receive a polyvinyl chloride coating if intended for use in water.

Suitable Applications

- Along a stream bank or drainage channel, as a stable lining that resists erosion.
- On shorefronts and riverfronts, or other areas subject to wave action.
- Near bridge abutments or wingwalls.
- Around culvert outlets and inlets to prevent scour and undercutting.
- On slopes and areas where conditions may not allow vegetation to grow.
- As a low retaining wall in non-critical areas or as a landscaping element.

Advantages

Þ A gabion is a manufactured engineering product that can be installed in a variety of situations. The manufacturer provides design guidelines and detailed instructions.

Þ Gabions are flexible, and minor settling can be accommodated. Gabions can be easily adapted and fitted around pipes and other structures.

Þ Gabions are permeable and are not subject to hydrostatic pressure buildup. With careful maintenance, gabions allow vegetation to grow.

Þ Skilled labor (other than an equipment operator) is not needed for assembly and filling of gabions. Gabions can be assembled on the project site in difficult terrain. Gabions are inexpensive when compared to rigid structures and retaining walls.

Disadvantages

Þ Gabions must be carefully constructed in order to properly function for many years. There are many instances of gabion failure (see the "Limitations" section later in this BMP). Wire mesh is subject to corrosion and physical damage.

Þ Gabions are not very attractive in many situations, often due to poor maintenance.

Gabions are a structural element (similar to a retaining wall) that must be professionally designed. Foundations and surcharged loads must be considered.

Design Considerations

A gabion wall is the equivalent of a gravity-design retaining wall. Analysis for a gabion wall should include basic computations for structural failure such as sliding, overturning, and settlement. In structural situations for walls over 4 feet high, this will require the design of a professional engineer who will consider field conditions, quality of materials, surcharged loads such as vehicle traffic, adequate drainage, foundations, etc. A gabion wall should not be specified just because the project designer is not willing to perform structural calculations for a concrete retaining wall.

A geotextile filter fabric is usually placed beneath gabions to maintain separation from underlying soils. Also, a filter fabric is necessary within stream channels to avoid loss of fine-grained soils. The filter fabric should be anchored securely using anchor trenches, stakes, staples, sewing, or a combination of methods. A layer of aggregate or sand can also be placed beneath gabions to maintain separation from underlying soils, in addition to filter fabric. In general, a filter fabric is more reliable with much smaller installation costs. See ES-23, Riprap, for further discussion of using aggregate or sand as a granular drainage filter.

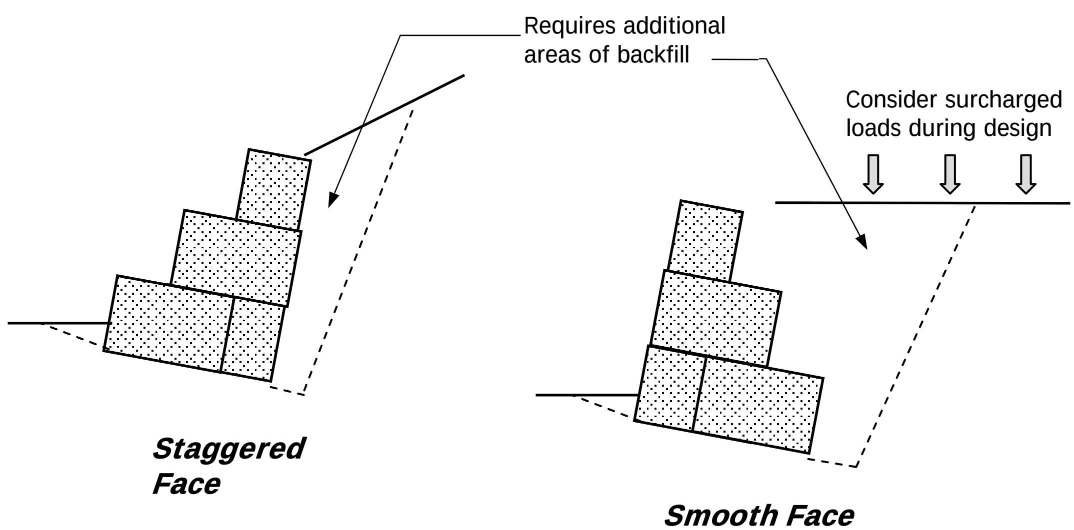


Figure ES-28-1
Typical Gabion Wall Geometry

The wire mesh, in addition to being galvanized, can also be coated with polyvinyl chloride to further resist deterioration. The wire mesh should have multiple twists in order to resist unraveling or falling apart. Since the wire mesh will eventually corrode and fail, gabion wall design should consider overall stability without the wire mesh. Soil and dirt may or may not fill the stone voids to act as a bonding agent. Or trees can help to reinforce a gabion structure. This will not generally occur at locations in or near flowing water, and grout can be specified in critical areas.

Gabion applications for slope stabilization, where wave action or flowing water is not a concern, should be sized for stability. Angular riprap or crushed rock typically has a natural angle of repose in the neighborhood of 40°, so that a slope of 1.5 to 1 would result for most slopes. See ES-23, Riprap, for discussion of slope stability and average stone size, D_{50}. The angle of repose does not take into account any external forces (such as vehicles, people, storms, groundwater, earthquakes, other ground vibrations). Sliding may occur on geotextile filter fabric that is not sufficiently anchored. Slope stability analyses should be performed by a professional engineer for all gabion installations that are critical or potentially hazardous.

Installation

Installation of gabions must be in accordance with the manufacturer's instructions and according to the design documents. Installation should be accomplished within a short time frame (one or two days) to minimize potential for damage from storm water runoff.

General Subgrade Preparation

Þ Clear and grade the area of trees, brush, vegetation, and unsuitable soils. Provide equipment access as necessary for earthwork and handling of large rocks. Prepare the subgrade to the specified depth necessary for installation of gabions. Compact subgrade firmly to prevent slumping or undercutting. Excavate anchor trenches as necessary for installation of geotextile filter fabric.

Þ Install geotextile filter fabric to maintain separation of rock material with the underlying soil. Geotextile filter fabric should be placed so that it is not stretched tight and conforms closely to the subgrade. Secure filter fabric by using anchor trenches, stakes, staples, sewing, or any other means necessary according to manufacturer's recommendations.

Þ Place a layer of aggregate or sand (if specified by design for use as a bedding layer or as a granular filter) so that the layer is smoothly graded and well-compacted. A typical layer of aggregate or sand is 4 inches thick when used only as a bedding material. A granular filter of aggregate or sand is usually 6 inches thick.

Wire Mesh and Stone

- Fold each gabion panel to the proper shape, using heavy gauge wire as recommended by the manufacturer. Reinforce panels as necessary. Lace all contact edges for adjacent gabions as construction proceeds. Joints are staggered and interlocked for gabion walls to provide maximum stability.

- Use external anchors and tensioning ropes as needed to ensure that the gabions are properly squared and vertical. Typically the manufacturer will specify that connecting wires should be used between each lift.

- Place hard durable stone in lifts 12 inches thick. The lifts should be thoroughly tied together with large stones protruding from one layer into the other. The average depth is usually determined by frequent measurements throughout installation. Any change in thickness should be accomplished gradually.

- Small gabion installations typically use a track loader bucket or a backhoe bucket. For large gabion installations, it may be beneficial to use a conveyor or crane. Minimize drop height to avoid damaging the wire mesh gabion or the underlying geotextile cloth. Adjust stones by hand in order to prevent large gaps or voids. Verify that the stone surfaces bear against each other for structural integrity.

- The typical stone gradation is between 4 to 8 inches, such that all stone will be retained by the particular mesh size. Hand placement of stones may be used at locations to improve the appearance of the exposed gabion faces.

- Close lids securely using lace or other fasteners as recommended by the manufacturer. If the wire mesh has been cut, then securely fasten to other parts of the gabion structure.

Grout (optional)

- In most cases, grouting is not necessary. Grouting may be desirable at some locations where flowing water may cause scour or settlement. Grout should be composed of one part Portland cement and four parts of sand measured by volume, and then mixed thoroughly with sufficient water to a consistency that allows the grout to flow into and completely fill the voids.

- When grouting is used, prevent earth or sand from filling the spaces between the stones before the grout is poured. Immediately before pouring grout, the stones should be wetted by sprinkling. Carefully finish the grouted surface using small hand tools, and remove excess grout without disturbing gabion structure. Allow grout to harden and set before any storm water is received. Keep grout moist with water that is free from salt or alkali for a period of not less than 72 hours.

Limitations

A gabion wall is a structural element (similar to a retaining wall) that must be professionally designed and carefully constructed. Gabion installations can fail or deteriorate for many of the following reasons:

Foundation —
- Soil is not suitable for use as a structural foundation.
- Foundation is not adequately compacted and prepared.
- Flowing water erodes the soil underneath or behind the gabion.
- Geotextile filter fabric is not used beneath gabion to retain fine soils.
- Erosion or scour occurs beneath the gabion structure.

Installation —
- Not following manufacturer's instructions for wires, fasteners, and lacing.
- Ordering the wrong gradations of large stone.
- Not using lifts to place stone, or not adjusting stones by hand to fill voids.
- Failure to protect the wire mesh gabion during the process of unloading stones.
- Improper or inadequate backfill.

Design —
- Prevent surcharged loads above gabion wall unless specifically designed.
- Displacement may occur if the slopes are too steep.

Maintenance

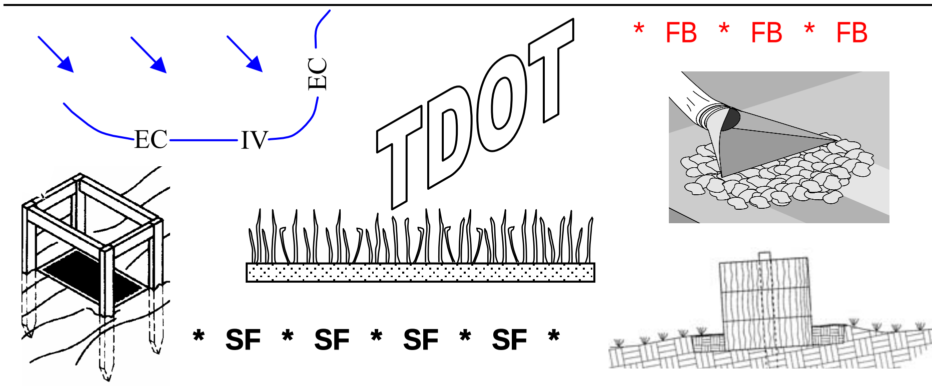
Gabions typically require very little maintenance. Inspect gabion installation regularly for settlement, scour, damaged wire mesh, or wire corrosion. Periodically check for excessive growth of bushes, trees, weeds, and other vegetation. Remove vegetation as needed to maintain channel flow capacity and prevent damage to gabions.

At many locations the wire mesh will eventually fail (particularly near flowing water), so it is important to design a gabion retaining wall to remain structurally sound without relying on the wire mesh. If long-term problems are noted, a major redesign and construction effort may be necessary.

References

141, 159, 161, 162, 167, 179 (see BMP Manual Chapter 10 for list)
Typical vendor information from: Maccaferri
http://www.maccaferri.com
TerraAqua http://www.terraaqua.com/

ACTIVITY: TDOT Standard Details for Erosion Control	ES – 29



Targeted Constituents				
¸ Significant Benefit		Û Partial Benefit	¹ Low or Unknown Benefit	
¸ Sediment	¹ Heavy Metals	¹ Floatable Materials	¹ Oxygen Demanding Substances	
¹ Nutrients	¹ Toxic Materials	¹ Oil & Grease	¹ Bacteria & Viruses	Û Construction Wastes

Description

Standard details can be obtained from the Tennessee Department of Transportation (TDOT) by contacting the main office in Nashville. Alternatively, TDOT standard details are available at the following Web site:

http://www.tdot.state.tn.us/Chief_Engineer/engr_library/design/Std_Drwg_Eng.htm

There are well over 300 standard detail drawings that are produced by TDOT. These drawings are primarily intended for state roadway construction projects, but are also widely used by public and private entities for all types of construction work.

TDOT standard details are grouped into seven categories. This BMP only lists the standard details for one category: Erosion Control and Landscaping. Other categories include various types of drainage items and structures (such as TDOT standard catch basins, manholes, headwalls, culverts, etc).

Approach

There are some differences between TDOT standard details and the various details in the City of Memphis and Shelby County BMP Manual. In most cases, the differences are relatively minor. Use the more stringent standard whenever possible to ensure adequate erosion and sediment control. The phrase “If something is worth doing, then it is worth doing right” is always applicable to every type of construction project, including erosion control.

TDOT standard details may not be altered or modified without the express consent of the TDOT organization. Portions of TDOT standard details may be redrawn, as long as the resulting detail is not then labeled as being a TDOT standard detail.

Most standard details refer to the various sections and pay items in the TDOT Standard Specifications for Road and Bridge Construction (reference 172). This reference can be obtained from TDOT by contacting the main TDOT office in Nashville, or by downloading from the following Web site: http://www.tdot.state.tn.us/construction/specs.htm

Limitations Verify that the TDOT standard detail is appropriate for the situation. Verify that the dimensions and slopes allow for proper installation of erosion control measures. Erosion control measures must be regularly inspected and maintained in the field. Consult the TDOT Standard Specifications for Road and Bridge Construction for a complete description of materials.

List of Details The following list only contains the TDOT standard details under the category Erosion Control and Landscaping.

Drawing #	**Title**
RD-L-4	Standard Legend for Erosion and Sediment Control
EC-STR-1	Pay Items, General Notes & Temporary Dewatering Structure
EC-STR-2	Temporary Sediment Filter Bags
EC-STR-3D	Temporary Enhanced Silt Fence
EC-STR-3E	Erosion Control Fabric Joining Details
EC-STR-4	Temporary Erosion Ditch Check Using Enhanced Silt Fence
EC-STR-4A	Temporary Erosion Ditch Check Using Enhanced Silt Fence In A Triangular Cross-Section Ditch
EC-STR-5	Straw or Hay Bale or Fabric Temporary Erosion Checks
EC-STR-6	Rock Check Dams
EC-STR-7	Temporary Sediment Trap with Temporary Silt Screen Check Dam
EC-STR-11	Rock Silt Screens
EC-STR-12	Temporary Rock Sediment Dam
EC-STR-13	Temporary or Permanent Rock and Earth Sediment Dam
EC-STR-15	Sediment Basin Type I
EC-STR-16	Sediment Basins Riser and Collar Appurtenances
EC-STR-17	Sediment Basin Type I Dam Details
EC-STR-19	Catch Basin Protection
EC-STR-21	Permanent Rip-Rap Basin Energy Dissipater
EC-STR-25	Temporary Road Stabilization and Temporary Culvert Crossing
EC-STR-27	Temporary Slope Drains and Berms
EC-STR-29	Permanent Erosion Pipe (Slope Drain)
EC-STR-31	Temporary Diversion Channels
EC-STR-34	Installation Detail for Erosion Control Blankets
EC-STR-36	Installation Detail for Flexible Channel Liner
EC-P-10	Typical Roadway Landscape Planting Details
EC-P-11	Typical Mature Plant Spread and Criteria for Proximity to Roadway
EL-W-1	Details of Tree Walls
EL-W-2	Standard Gravity-Type Retaining Walls

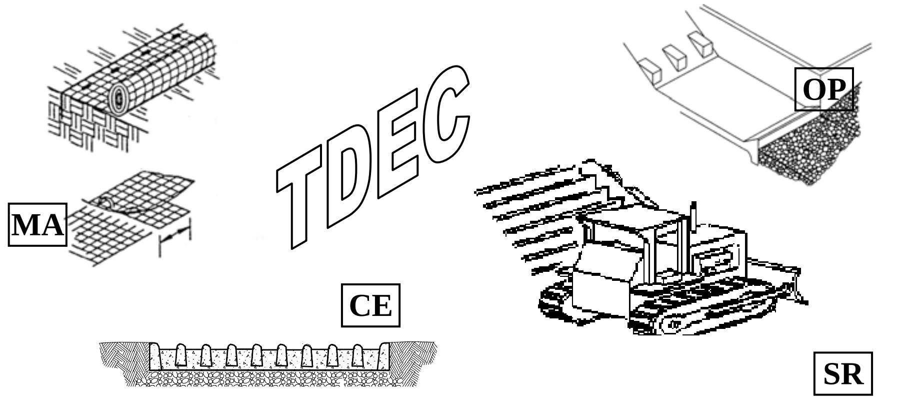
The first drawing (RD-L-4) contains a standardized legend for TDOT projects. This legend is not required for erosion control drawings in the City of Memphis and Shelby County, and is only listed here as an example.

Remember to check the TDOT website to verify the latest revision date prior to using the TDOT standard details in a set of construction plans.

http://www.tdot.state.tn.us/Chief_Engineer/engr_library/design/Std_Drwg_Eng.htm

References **172, TDOT Web sites** (see BMP Manual Chapter 10 for list)

ACTIVITY: TDEC Erosion & Sediment Control BMPs	ES – 30



Targeted Constituents				
¸ Significant Benefit		Û Partial Benefit	¹ Low or Unknown Benefit	
¸ Sediment	¹ Heavy Metals	¹ Floatable Materials	¹ Oxygen Demanding Substances	
¹ Nutrients	¹ Toxic Materials	¹ Oil & Grease	¹ Bacteria & Viruses	Û Construction Wastes

Description

Statewide BMPs are available in the Tennessee Erosion and Sediment Control Handbook (reference 196). This reference is available from the Tennessee Department of Environment and Conservation (TDEC) at the following Web site:

http://www.state.tn.us/environment/wpc/sed_ero_controlhandbook

There are three basic categories for the statewide erosion control BMPs: Vegetative Practices, Structural Practices, and Stream Alteration Practices.

Approach

There are many differences between the TDEC statewide BMPs and the various details in the Memphis and Shelby County BMP Manual. In most cases, the differences are relatively minor. Use the more stringent standard whenever possible to ensure adequate erosion and sediment control. In cases where dimensions or methods conflict, use the Memphis and Shelby County BMP Manual.

TDEC BMPs may not be altered or modified without the express consent of the TDEC organization. A portion of the TDEC BMP may be redrawn, as long as the resulting detail is not then labeled as being a standard TDEC BMP.

Verify that the TDEC BMP is appropriate for the situation. Verify that the dimensions and slopes allow for proper installation of erosion control measures. Erosion control measures must be regularly inspected and maintained in the field. Consult the Memphis and Shelby County BMP Manual for additional information and to compare dimensions.

List of BMPs

The following tables contain the TDEC BMPs as organized in the Tennessee Erosion and Sediment Control Handbook (reference 196). For each BMP, the most similar BMP is also listed from the Memphis and Shelby County BMP Manual.

TDEC Code	# Pages	Vegetative Practices (7 BMPs)	Most Similar Memphis and Shelby County BMP
BF	3	Buffer Zone	------
MU	2	Disturbed Area Stabilization With Mulch	ES-07
PS	6	Disturbed Area Stabilization With Permanent Vegetation	ES-10
SO	4	Disturbed Area Stabilization With Sod	ES-09
TS	2	Disturbed Area Stabilization With Temporary Vegetation	ES-08
MA	6	Erosion Control Blanket/Matting	ES-11
PAM	2	Polyacrylamide	------

TDEC Code	# Pages	Structural Practices (17 BMPs)	Most Similar Memphis and Shelby County BMP
CD	3	Check Dam	ES-13
CE	4	Stabilized Construction Site Access	ES-01
CRS	3	Construction Road Stabilization	ES-03
DW	5	Dewatering Structure	AM-12
DI	4	Diversion	ES-21
FR	3	Filter Ring	------
GA	3	Gabion	ES-28
GE	2	Geotextile	ES-12
GT	5	Gradient Treatment	ES-04
RR	9	Riprap	ES-23
SB	24	Sediment Basin	ES-19
ST	5	Sediment Trap	ES-18
SF	8	Silt Fence	ES-14
SD	3	Slope Drain	ES-21
IP	8	Storm Drain Inlet Protection	ES-24
OP	6	Storm Drain Outlet Protection	ES-25
SR	2	Surface Roughening	ES-05

TDEC Code	# Pages	Stream Alteration Practices (3 BMPs)	Most Similar Memphis and Shelby County BMP
SDC	4	Stream Diversion Channel	------
TSC	5	Temporary Stream Crossing	ES-03
SBS	3	Bioengineered Stream Bank Stabilization	ES-20

In addition to the BMPs, the Tennessee Erosion and Sediment Control Handbook has appendices to provide guidance for state requirements on construction permits. The handbook can be obtained free from the TDEC Web site, or purchased for a reasonable fee at the TDEC office at 2510 Mt. Moriah Road, Suite E-645 in Memphis.

Appendix A — Construction General Permit (CGP)
Appendix B — Example Storm Water Pollution Prevention Plan (SWPPP)
Appendix C — Aquatic Resource Alteration Permit (ARAP)
Appendix D — Additional Resources and References

The statewide NPDES program requires TDEC permits for all construction with disturbed areas greater than one acre.

References **196, TDEC Web site** (see BMP Manual Chapter 10 for list)

ACTIVITY: Non-Storm-Water Discharges to Storm Drains | IC – 01

Targeted Constituents				
¸ Significant Benefit		Û Partial Benefit		¹ Low or Unknown Benefit
¹ Sediment	¸ Heavy Metals	Û Floatable Materials	¸ Oxygen Demanding Substances	
¸ Nutrients	¸ Toxic Materials	¸ Oil & Grease	¸ Bacteria & Viruses	Û Construction Wastes

Description Eliminate non-storm-water discharges to the storm water collection system. Non-storm-water discharges may include oils, paints, acids, solvents, process wastewaters, cooling waters, wash waters, and sanitary wastewater. This task will help eliminate all types of pollution such as nutrients, heavy metals, toxic materials, floatable debris, oil and grease, bacteria and viruses, and oxygen demanding substances.

Approach Non-storm-water discharges to the storm water collection system may include any water used directly in the manufacturing process (process wastewater), non-contact cooling water, outdoor secondary containment water, vehicle and equipment wash water, sink and drinking fountain wastewater, sanitary wastes (including "gray water" discharged from washing machines or dishwashers), or other wastewaters.

In addition to mechanical discharges, employees or subcontractors could dump or pour materials directly into a storm drain or open channel. Common substances illegally dumped on the street or directly into the storm drain system and creeks include: paint, used oil, automotive fluids, construction debris, chemicals, fresh concrete, leaves or grass, mop water, and pet wastes. All of these wastes can cause quality problems for storm water and receiving waters as well as clog the storm drain system itself. Table AM-01-1 in the Employee Training BMP fact sheet has disposal alternatives for common types of waste. The principal goal is to eliminate all substances (liquid or solid) that do not belong in storm water.

Many businesses, commercial facilities and industries are required to obtain a National Pollutant Discharge Elimination System (NPDES) permit as part of their operations. Requirements to identify and eliminate non-storm-water discharges are integral to every NPDES permit. Keys to this activity are information and investigation.

Application

The current storm water ordinance specifically describes what is allowable to discharge into the storm water; all other discharges are prohibited by ordinance. The following non-storm-water discharges are allowable:

(1) Potable water
(2) Potable water line flushing
(3) Air-conditioning condensate
(4) Discharges from emergency firefighting activities and exercises (a storm water pollution prevention plan should be prepared to address discharges or flows from firefighting only where such discharges are identified as significant sources of pollutants to waters of the United States)
(5) Uncontaminated water from crawl space, pumps, or footing drains
(6) Lawn watering
(7) Residential car and boat washing
(8) Dechlorinated swimming pool water
(9) Materials placed as part of an approved habitat restoration or bank stabilization project
(10) Rising ground waters, uncontaminated ground water infiltration, uncontaminated pumped ground water, uncontaminated springs, diverted stream flows; riparian habitats and wetlands
(11) Flows from riparian habitats and wetlands
(12) Common practices for water well disinfections
(13) Discharges within the constraints of an NPDES permit from the Tennessee Department of Environment and Conservation (TDEC)
(14) Unless otherwise prohibited by this ordinance, any discharge that could be made directly to waters of the state without a federal or state permits being required
(15) Dye testing in compliance with section 30-28(b)
(16) Other types of discharges as determined by the manager

(Ord. No. 292, § 30-109, 12-6-04)

The engineering directors for the City of Memphis and Shelby County, or their representatives, have the authority to order the above listed activities to be stopped or modified if sewage, industrial wastes, or other objectionable wastes are being discharged to the storm water system. Non-storm-water discharges, even if there are no pollutants present, may have different temperatures than the ambient stream temperature. Man-made temperature variations, whether continuous or intermittent, in a natural stream may cause loss of habitat to aquatic organisms and to vegetation.

<u>The following non-storm-water discharges are explicitly prohibited</u> by the City of Memphis and Shelby County Storm Water Ordinances. The list of prohibited discharges is not all-inclusive since any type of discharge not specifically exempted (see list of 16 items above) is prohibited by law.

(1) Trash or debris
(2) Construction materials
(3) Petroleum products including but not limited to oil, gasoline, grease, fuel oil, or hydraulic fluids
(4) Antifreeze and other automotive products
(5) Metals in either particulate or dissolved form
(6) Flammable or explosive materials
(7) Radioactive material
(8) Batteries, including but not limited to, lead acid automobile batteries, alkaline batteries, lithium batteries, or mercury batteries
(9) Acids, alkalis, or bases
(10) Paints, stains, resins, lacquers, or varnishes
(11) Degreasers and/or solvents
(12) Drain cleaners
(13) Pesticides, herbicides, or fertilizers
(14) Steam cleaning wastes
(15) Soaps, detergents, or ammonia
(16) Swimming pool backwash including chlorinated swimming pool discharge
(17) Chlorine, bromine, and other disinfectants
(18) Heated water
(19) Animal waste from commercial animal or feeder lot operations
(20) Any industrial and sanitary wastewater, including leaking sewers or connections
(21) Recreational vehicle waste
(22) Animal carcasses
(23) Food wastes
(24) Medical wastes
(25) Collected lawn clippings, leaves, branches, bark, and other fibrous materials
(26) Collected silt, sediment, or gravel
(27) Dyes, except as stated in subsection (b)
(28) Chemicals, not normally found in uncontaminated water
(29) Any hazardous material or waste, not listed above
(30) Washing of fresh concrete for cleaning and/or finishing purposes or to expose aggregates
(31) Junk motor vehicles, as defined in subsection (c)
(32) Liquid from solid waste disposal containers

Penalties for minor discharges that have no significant adverse impact on safety, health, the welfare of the environment, or the functionality of the county's storm water collection system may be waived at the discretion of the manager.

(b) Dye testing is allowed but requires verbal notification to the manager a minimum of 24 hours prior to the date of the test. The City of Memphis and Shelby County governmental agencies are exempt from this requirement.
(c) Junk motor vehicle means any vehicle that shall include by way of example but not be limited to: automobiles, construction equipment, motorcycles, and trucks that meet all of the following requirements:
(1) Is three years old or older
(2) Is extensively damaged, such damage including, but not limited to any of the following: a broken window or windshield or missing wheels, engine or transmission
(3) Is apparently inoperable
(4) Is without a valid current registration
(5) Has a fair market value equivalent only to the value of the scrap in it

(Ord. No. 292, § 30-108, 12-6-04)

General Guidelines

To ensure that the storm water system discharge contains only storm water, commercial and industrial facilities should:

Þ Locate all discharge points from the property. Identify where discharges lead into the municipal storm drain system or into “Waters of the State” (as defined by the blue-line streams and lakes from the U.S. Geological Survey quadrangle map). At a minimum, use construction drawings, as-built drawings, pipeline schematics, and visual observation by walking the property boundary and by examining all indoor pipes.

Þ Use additional methods as appropriate for locating discharge points.
- — Dye tracing
- — Inserting TV camera
- — Chemical field test kits
- — Smoke tests
- — Surface water sampling
- — Groundwater sampling
- — Isolate discharges one at a time to verify source

Þ Develop a plan to eliminate illicit connections.
- — Plug illicit discharge points.
- — Repair or replace discharge lines as necessary. Examine types of disposal options. Use alternative products or methods to reduce the amount of pollution.
- — Repair sewer lines or connect to sanitary sewer system. Coordinate with the sanitary sewer system operator for permission to connect to sanitary system.

- Þ Document that non-storm-water discharges have been eliminated by recording tests performed, methods used, dates of testing, and onsite drainage points observed.

- Þ Refer to Reference 201 for more information.

Investigation

The following lists include further information on investigation activities.

- Þ A piping schematic or sketch will show pipes and storm water systems used to carry wastewater, cooling water, sanitary wastes, etc. Look carefully at the drawing to determine date, accuracy, and level of information. Sometimes it may be necessary to interview the field engineer or a construction worker to determine what was built.

- Þ Visual observation of the property boundary should be conducted during daylight hours in both dry weather and wet weather. Ideally, visual observation should also include different times of the year that may affect the groundwater level and the amount of heavy vegetation.

- Þ Visual observation of indoor pipes includes inspecting the path of floor drains in older buildings, where it is not uncommon to find cross-connections. Examine materials, condition, and repairs for each pipe as a clue to what it may carry.

- Þ A dye test can be performed by simply releasing a non-harmful tracing dye into a sanitary or process wastewater system and examining potential discharge points into the storm water collection system for discoloration.

- Þ TV and visual inspections can identify illicit connections to the storm drain, but further testing is usually required (dye, smoke, isolation) to identify sources.

- Þ Smoke testing of wastewater and storm water collection systems is commonly used to detect connections between the two systems. During dry weather, a storm water collection system is filled with smoke and then traced to sources. The appearance of smoke in a waste vent pipe, sewer manhole, or even the base of a toilet indicates that there may be a connection between the sanitary and storm water systems.

Limitations

- Þ Many facilities do not have accurate, up-to-date schematic drawings. Mistakes in construction may not be reflected in the schematics. It can be difficult to locate illicit connections especially if there is groundwater infiltration.

Þ The easiest method is to inspect each discharge point during dry weather. Keep in mind that flow from a storm event can continue for three days or more, and that groundwater often infiltrates the underground storm water collection system.

Related BMPs The following BMPs are closely related to this BMP:

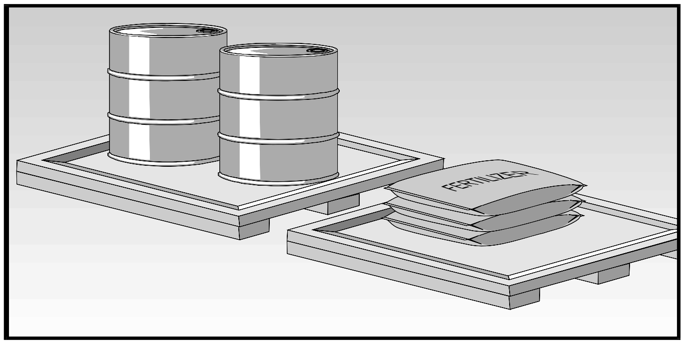
AM-01 — Employee Training

AM-01-01 — (Table) Quick Reference for Disposal Alternatives

RH-01 — Non-Storm-Water Discharges to Storm Drains (Residential/ Home owner)

References **27, 31, 33, 34, 35, 94, 138** (see BMP Manual Chapter 10 for list)

ACTIVITY: Outdoor Loading and Unloading of Materials	IC – 02



Targeted Constituents

¸ Significant Benefit   Û Partial Benefit   ¹ Low or Unknown Benefit

¹ Sediment	¸ Heavy Metals	Û Floatable Materials	¸ Oxygen Demanding Substances	
¸ Nutrients	¸ Toxic Materials	¸ Oil & Grease	¸ Bacteria & Viruses	Û Construction Wastes

Description

Prevent or reduce the discharge of pollutants to storm water from outdoor loading and unloading of materials by enclosing or covering materials, installing secondary containment, preventing contact with storm water, training, and spill prevention. This management practice will create a significant reduction in most types of pollution.

Approach

Loading and unloading of materials, commonly involving truck or rail transfer, may take place inside or outside of an enclosed area or building. Loading or unloading of materials occurs in two ways: the movement of materials in containers or direct liquid transfer. Loading and unloading of materials preferably should occur within a manufactured building so that any leaks or spills can be completely contained.

Materials spilled, leaked, or lost during loading or unloading may collect in the soil or on paved surfaces. Material may be carried away by storm water runoff, wind, or other air movement, or when the area is cleaned. Rainfall may wash pollutants from machinery used to unload or move materials. The most important factors in preventing pollution from entering storm water runoff are:

— Maintain organized and safe working conditions.
— Train employees.
— Limit exposure of material to rainfall and storm water runoff.
— Contain leaks and spills during transfer operations.
— Check and maintain equipment regularly for proper operation.

Related BMPs include:

AM-06	Material Delivery and Storage
AM-07	Spill Prevention and Control
IC-03	Outdoor Container Storage of Liquid Materials

Training

Þ Train employees and subcontractors on the proper material delivery and storage practices, including review of a Spills Prevention, Control, and Countermeasure (SPCC) Plan, if in effect. Make sure forklift operators are properly trained to limit spills or damaged containers, using spotters as necessary.

Þ Employees should periodically review material safety data sheets (MSDS). They should be aware of material content, potential hazards, and safety procedures required in the event of a spill or leak.

Þ Hold regular meetings to discuss and reinforce appropriate disposal procedures (incorporate into regular safety meetings). Designate a foreman or supervisor to oversee and enforce proper spill prevention and control measures.

Material Delivery Practices

Þ Keep an accurate, up-to-date inventory of material delivered and stored onsite. Verify that MSDS data is updated. Train employees in emergency spill cleanup procedures for dangerous materials or liquid chemicals that may be handled.

Þ Park tank trucks or delivery vehicles so that spills or leaks can be contained with drip pans under hoses or other secondary containment.

Þ Cover loading/unloading docks to reduce exposure of materials to rain. Place a seal or door skirt between trailer and building to prevent exposure to rain. Position roof downspouts to direct storm water away from loading/unloading areas.

Þ Look for dust or fumes during loading or unloading operations.

Þ When transferring material from tank trucks or rail cars into aboveground or underground storage tanks, the following procedures should be used:

— The area where the transfer takes place should be paved, preferably with Portland cement concrete.
— Transfer area should be designed to prevent storm water runoff from adjacent areas. Install curbs or swales uphill from transfer area.
— Slope transfer area to a controlled drain or a dead-end sump with a positive control valve and posted instructions.
— Place drip pans at locations where spillage may occur, such as hose connections, hose reels, and filler nozzles. Use drip pans when making and breaking connections.

Þ Material storage should be located away from busy areas and posted with conspicuous signs. Locate storage away from storm drains and open channels. Store materials indoors within existing structures or sheds when available. Have proper storage instructions posted at all times in an open conspicuous location.

Þ Minimize the amount of hazardous material inventory stored onsite. Schedule more frequent deliveries of less material.

Þ Do not store hazardous chemicals, drums, or bagged materials directly on the ground. Place these items on a pallet under cover with secondary containment as required. Keep hazardous chemicals in original containers that are securely shut and well-labeled. Hazardous materials should be protected from vandalism.

Þ Parking lots or other surfaces near bulk materials storage areas should be swept periodically to remove debris blown or washed from storage area. Install pellet traps at storm water discharge points where plastic pellets are loaded and unloaded.

Þ Keep ample supply of storm drain seals near drains and inlets. Maintain an adequate supply of appropriate spill cleanup material near storage areas.

Spill Cleanup

Þ Different materials pollute in different amounts. Make sure that each employee knows what a "significant spill" is for each material they use and what is the appropriate response for "significant" and "minor" spills. Memphis and Shelby County Storm Water Programs and the Tennessee Department of Environment and Conservation (TDEC) require immediate notification of all spills or leaks, in any amount, to the water or soil. A significant spill should be defined after review of MSDS or other documentation of the contents and proper handling procedures. Consult AM-07, Spill Prevention and Control, for general information on what constitutes a minor spill or a significant spill and Tables AM-07-1 and AM-07-2 for response and notification contact information.

Þ Place a stockpile of spill cleanup materials where it will be readily accessible. Train employees in spill prevention and cleanup procedures for the site. Educate employees and subcontractors on potential dangers to humans and the environment from spills and leaks.

Þ Clean up leaks and spills immediately using dry methods when possible. Use a rag for small spills, a damp mop for general cleanup, and absorbent material for larger spills. If the spilled material is hazardous, then the used cleanup materials are also hazardous and must be sent to either a certified laundry or disposed of as hazardous waste. Do not discharge hazardous materials into sanitary sewer system without the sanitary sewer system authority to obtain written permission.

Þ Businesses, commercial facilities, and industries with at least 1,320 gallons of oil storage in 55-gallon drums or larger containers are required to have an SPCC Plan, in compliance with Title 40 of the Code of Federal Regulations, Part 1112.

Maintenance

Þ Inspect storage areas at least weekly if not in use and after rainfall events to be sure that storm water pollution is not being generated. Verify that designated storage areas are kept clean and well organized. Repair and replace perimeter controls, containment structures, and enclosures as needed to keep them properly functioning. The frequency of repairs may depend on the age of the facility.

Þ Check loading and unloading equipment regularly for leaks. Concentrate on valves, pumps, flanges, and other connections. Repair and replace parts immediately to prevent spills and leaks.

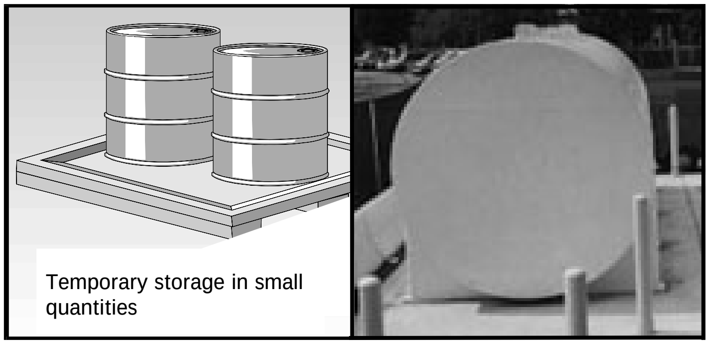
Limitations

Þ Ideally, most materials should be stored in climate-controlled areas away from storm water contact. Space limitation may preclude indoor storage. Storage sheds and other buildings must meet structural codes and fire codes. It may not be possible to conduct transfers only during dry weather.

References

31, 33, 34, 35, 99, 100, 103, 137, 138 (see BMP Manual Chapter 10 for list)

ACTIVITY: Outdoor Container Storage of Liquid Materials	IC – 03



Temporary storage in small quantities

Targeted Constituents				
¸ Significant Benefit		¸ Significant Benefit	¸ Significant Benefit	
¹ Sediment	¹ Sediment	¹ Sediment	¹ Sediment	
¸ Nutrients	¸ Nutrients	¸ Nutrients	¸ Nutrients	¸ Nutrients

Description Prevent or reduce the discharge of pollutants to storm water from outdoor container storage areas by installing safeguards against accidental releases, installing secondary containment, conducting regular inspections, and training employees in standard operating procedures and spill cleanup techniques. This management practice is likely to create a significant reduction in heavy metals, toxic materials, oil and grease, and oxygen demanding substances.

Approach Accidental releases of materials from aboveground liquid storage tanks, drums, Dumpsters, or other containers have the potential for contaminating storm waters with many different pollutants. Materials spilled, leaked, or lost from storage containers and Dumpsters may accumulate in soils or on the surfaces and be carried away by storm water runoff.

Storage of liquid containers should preferably occur within a manufactured building so that any leaks or spills can be completely contained. In addition, a manufactured building will provide a degree of protection against natural disasters, vandalism, and other damage. It should be noted that the storage of reactive, ignitable, or flammable liquids must comply with all safety regulations and fire codes.

The most important factors in preventing pollution from entering storm water runoff are:

— Maintain organized and safe working conditions.
— Train all employees in proper methods and procedures.
— Limit exposure of material to rainfall and storm water runoff.
— Contain leaks and spills during transfer operations.
— Check and maintain equipment regularly for proper operation.

Related BMPs include:

AM-06	Material Delivery and Storage
AM-07	Spill Prevention and Control
IC-02	Outdoor Loading and Unloading of Materials

The most common causes of unintentional releases are:

- External corrosion and structural failure
- Installation problems
- Spills and overfills due to operator error
- Failure of piping systems (pipes, pumps, flanges, couplings, hoses, and valves)

Training

Þ Well-trained employees can reduce human errors that lead to accidental releases or spills. Operator errors can be prevented by using engineering safeguards and thus reducing accidental releases of pollutant.

Þ Employees should be familiar with the Spill Prevention Control, and Countermeasure (SPCC) Plan. The employee should have the tools and knowledge to begin immediately cleaning up a spill if one should occur.

Þ Employees should periodically review material safety data sheets (MSDS). They should be aware of material content, potential hazards, and safety procedures required in the event of a spill or leak.

Þ Hold regular meetings to discuss and reinforce appropriate disposal procedures (incorporate into regular safety meetings). Designate a foreman or supervisor to oversee and enforce proper spill prevention and control.

Liquid Container Management

Þ To limit the possibility of storm water pollution, containers used to store dangerous waste or other liquids should be kept inside a manufactured building. However, this may be impractical due to site constraints. Small inexpensive storage buildings can often be used when a permanent building is not feasible. Service bays, shacks, or even doghouses are also alternatives to be considered, provided that safety and fire codes are not violated.

Þ Protect outdoor liquid containers from rainfall and storm water runoff with the following measures:

- Cover storage area with a roof.
- Minimize storm water runoff by enclosing area with a berm or ditch.
- Use covered Dumpsters to store liquid containers.

- Storage of any threshold quantity of oil or hazardous materials must meet specific federal and state standards that include, as a minimum:
  - SPCC Plan
  - Secondary containment
  - Leak-detection monitoring and inspections
  - Emergency preparedness plans

- Safeguard against accidental releases by using the following equipment:
  - Overflow protection devices to warn operator
  - Automatic shutdown transfer pumps
  - Guard posts/bollards around tanks and piping to prevent vehicle or forklift damage
  - Clearly labeled tags and other identifiers, including color coding
  - Restricting access to valves

- Large storage tanks, piping systems, and other types of storage systems must be inspected regularly by specially trained professionals, such as a registered structural or mechanical engineer. An engineer can identify and correct potential problems such as loose fittings, poor welding, and improper gaskets. Tank foundations, connections, and coatings should also be inspected. Document all inspections, including photographs when appropriate.

- Regular inspection for corrosion, leaks, cracks, or other physical damage may require that the tank or piping system be emptied. Closely observe structural reactions during filling and unfilling of tanks and piping systems in order to verify integrity; this is usually the time of greatest stress for a system.

Secondary Containment

- Some common measures that are used for secondary containment include berms, dikes, vaults, double-walled tanks, and Dumpsters. Some secondary containment structures need to be designed by a professional engineer with experience and training. The hydrostatic pressure of a few feet of water or other liquids can be very heavy.

- Secondary containment structures must be made of materials that will not react or degrade with the liquids in storage. Strong acids or bases may react with metal containers, concrete, and some plastics. Some organic chemicals may need certain special liners for dikes. Earthen dikes are strongly discouraged but may be okay for some applications. A variety of coatings is available for tanks or dikes.

- Secondary containment measures will generally require a positive means of control, such as a clearly labeled valve or plug, to prevent the release of storm water contaminated by spills or leaks.

- Secondary containment structures should provide at least 10% of the volume of all of the containers or 110% of the volume of the largest container, whichever is greater. Secondary containment structures that allow access for a truck or railcar may need to consider the truck or railcar to be the largest container.

- Secondary containment structures open to the weather must provide an additional allowance for rainfall (freeboard). Recent U.S. Environmental Protection Agency guidance suggest that the volume that corresponds to a 25-year, 24-hour storm (6.5 inches of rainfall in the Memphis area) should be used; however it is not a regulatory requirement.

- Containment dikes may consist of berms, curbs, retaining walls, or manufactured walls that are designed to hold spills. Dikes are an effective pollution prevention measure for aboveground storage tanks, provided that an effective plan for managing storm water is in place. Dikes must be inspected daily and there must be clearly designated responsibilities for releasing storm water. Sampling of storm water may be required prior to its release from a diked area.

- For small volumes of storage, the least expensive form of dikes is probably curbing. Curbing is commonly used beneath piping systems that contain small-diameter pipes. Curbing can redirect contaminated storm water away from the storage area. Common curbing materials are asphalt, concrete, synthetic materials, metal, or other impenetrable materials. Inspection and maintenance should be conducted frequently on curbing, as vehicles and equipment can easily damage curbing so as to reduce the impounded storage volume.

- Dumpsters may be used as secondary containment, provided that they are properly labeled and are in good condition and without corrosion or leaky seams. All drain valves should be closed. Do not allow garbage to be placed into secondary containment Dumpsters. Do not use garbage Dumpsters as a temporary place for secondary containment.

- Facilities with “spill ponds” designed to intercept, treat, or divert spills should contact the Tennessee Department of Environment and Conservation (TDEC) regarding environmental compliance. Spill ponds are not currently an environmentally acceptable means of ensuring secondary containment.

Spill Cleanup

- Þ The City of Memphis and Shelby County engineering departments and the Tennessee Department of Environment and Conservation (TDEC) require immediate notification of all spills or leaks, in any amount, to the water or soil.

- Þ Different amounts of spilled material may require different levels of response. Make sure that each employee knows what a "significant spill" is for each material they use, and what the appropriate response is for "significant" and "minor" spills. A significant spill should be defined after review of MSDS or other descriptive documentation that presents the contents and proper handling procedures. Consult AM-07, Spill Prevention and Control, for general information on what constitutes a minor spill or a significant spill.

- Þ Place a stockpile of spill cleanup materials where it will be readily accessible. Train employees in spill prevention and cleanup procedures for the site. Educate employees and subcontractors on potential dangers to humans and the environment from spills and leaks.

- Þ Clean up leaks and spills immediately using dry methods when possible. Use a rag for small spills, a damp mop for general cleanup, and absorbent material for larger spills. If the spilled material is hazardous, then used cleanup materials are also hazardous and must be sent to either a certified laundry or disposed as hazardous waste. Do not discharge hazardous materials into sanitary sewer system without contacting the sanitary sewer authority and receiving written permission.

- Þ Many businesses, commercial facilities and industries are required to have an SPCC Plan. The SPCC Plan must have procedures for specific chemicals that are frequently used. The SPCC Plan must contain emergency contact numbers in addition to telephone numbers for emergency response organizations and regulatory agencies.

Maintenance

- Þ Inspect storage areas at least weekly and during rainfall events to be sure that storm water pollution is not being generated. Verify that designated storage areas are kept clean and well organized. Verify that dikes and curbing maintain the ability to retain storm water.

- Þ Repair and replace perimeter controls, containment structures, and enclosures as needed to keep them properly functioning. The frequency of repairs may depend on the age of the facility.

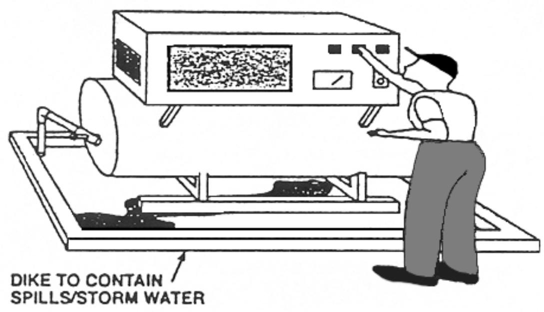
- Þ Conduct routine weekly inspections that include the following items:
  - — External corrosion and structural failure
  - — Evidence of spills and overfills due to operator error
  - — Piping system (pipes, pumps, flanges, coupling, hoses, and valves)
  - — Loose fittings and improper or poorly fitted gaskets
  - — Tank foundations, connections, and coatings

Limitations

- Þ Space limitations or site constraints may preclude indoor storage.
- Þ Storage sheds must meet building & fire code requirements.
- Þ Costs may be prohibitive when covering a large loading/unloading area.

References **31, 33, 34, 35, 98, 99, 103, 138** (see BMP Manual Chapter 10 for list)

ACTIVITY: Outdoor Process Equipment Operations	IC – 04



Targeted Constituents

¸ Significant Benefit		¸ Significant Benefit	¸ Significant Benefit	
1 Sediment	1 Sediment	1 Sediment	1 Sediment	
¸ Nutrients	¸ Nutrients	¸ Nutrients	¸ Nutrients	¸ Nutrients

Description

Prevent or reduce the discharge of pollutants to storm water from outdoor process equipment operations and maintenance by reducing the amount of waste created, enclosing or covering all or some of the equipment, installing secondary containment, and training employees. This management practice is likely to create significant reductions in sediment, heavy metals, toxic materials, and oil and grease.

Approach

Outside process equipment operations can contaminate storm water runoff. Activities such as rock grinding or crushing, painting, coating, grinding, sanding, degreasing or parts cleaning, landfills, wastewater, solid waste treatment and disposal, and lumber mills are examples of process operations that use hazardous materials that could cause contamination of storm water runoff. To explain one example in detail, pollutants from wastewater treatment and disposal areas may be generated by pumping stations, storage of chemicals, addition of treatment chemicals, solids dewatering and land application, emergency generators, and discharge of treated wastewater.

Waste spilled, leaked, or lost from outdoor process equipment operations may build up in soils or on other surfaces and be carried away by storm water runoff. There may also be a potential for liquid waste from lagoons or impoundments to overflow into surface waters or contaminate soil and groundwater.

An industry that generates large volumes of process wastewater will typically have an onsite treatment system that discharges directly to the nearest receiving water. A National Pollutant Discharge Elimination System (NPDES) permit must be obtained from the Tennessee Department of Environment and Conservation (TDEC) for most industries (see TDEC Web site for additional information). Alternatively, the industry may discharge to the municipal wastewater collection system with permission from the wastewater system operator. In most areas within Memphis and Shelby County, this entity is the City of Memphis, which may require pretreatment, depending on the pollutant loading. The city also has to meet requirements for NPDES permitting and may require monitoring and sampling programs.

The preferred (and the most economical) action to reduce storm water pollution is to alter the nature of each activity such that pollutants are not exposed to storm water. This often means performing the activity during dry periods only or substituting benign materials for more toxic ones.

General Guidelines

- Design each activity to prevent exposure of pollutants to storm water. It is preferable to move activities with potential for pollution indoors or cover with a permanent roof.

- Minimize contact of storm water runoff with outside manufacturing operations through curbs, berms, and swales.

- Connect drains in the process equipment area to the public sanitary sewer or to the facility wastewater treatment system. Curbs (for secondary containment) are usually placed around the immediate boundaries of the process equipment.

- Regularly inspect and clean the storm water drainage system. Additional BMPs may be required for storm water treatment prior to allowing storm water runoff to leave the site. For example, consider the use of catch basin filtration inserts (see ST-06, Water Quality Inlets and Media Filtration Inlets) as a means to capture particulate pollutants that are not likely to dissolve in water. Oil-water separators (see ST-07) are necessary for many types of industries and commercial facilities.

- Reducing the amount of waste that is created and consequently the amount that must be stored or treated is another way to reduce the potential for storm water contamination from outside manufacturing activities.

Considerations for Connecting to Sanitary Sewer System

If storm water runoff becomes polluted, is used in a mechanical process, or as a cooling or cleaning solution, then it must be captured and treated. The preferred option is to treat wastewater onsite. If there is not an onsite process wastewater treatment system, consider discharging to the public sanitary sewer system. Any connections to the sanitary sewer system must be approved by the wastewater system operator. The following conditions may receive favorable consideration from the city for such a connection:

- If a surge tank is used to limit discharge to the sanitary sewer system to acceptable levels of minimal flows.

- If a bypass control valve is installed to route clean storm water away from sanitary sewer into the storm drainage system.

Maintenance

- Routine inspections and preventive maintenance should be performed daily on all outdoor process equipment areas. Check process equipment for leaks and spills, particularly at valves, flanges, seams and welds, gaskets, and other connections.

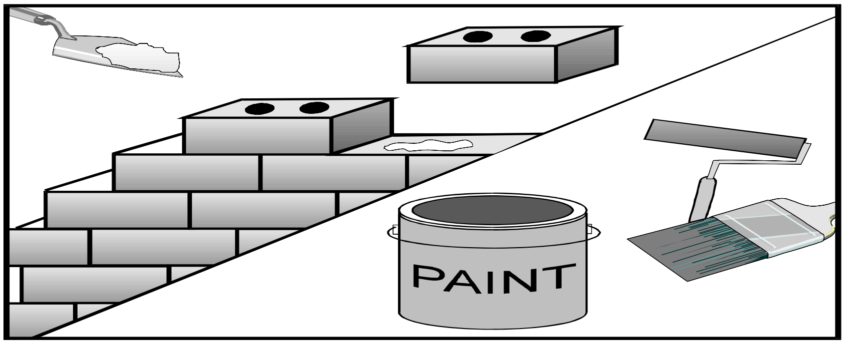
Limitations

- Providing an enclosed structure or permanent roof may be very expensive for processes with large volumes of material.
- Storage sheds must meet building code and fire code requirements.

References

21, 33, 99, 103, 138 (see BMP Manual Chapter 10 for list)

ACTIVITY: Grounds Construction and Maintenance	IC – 05



Targeted Constituents				
¸ Significant Benefit		¸ Significant Benefit	¸ Significant Benefit	
¹ Sediment	¹ Sediment	¹ Sediment	¹ Sediment	
¸ Nutrients	¸ Nutrients	¸ Nutrients	¸ Nutrients	¸ Nutrients

Description Prevent or reduce the discharge of pollutants to storm water from grounds construction and maintenance by using soil erosion controls, enclosing or covering building material storage areas, using good housekeeping practices, using safer alternative products, training employees, washing and cleaning up with as little water as possible, preventing and cleaning up spills immediately, keeping debris from entering the storm drains, and maintaining the storm water collection system.

Approach This BMP is intended for minor construction only; larger construction projects should be analyzed using a much larger checklist of potential pollution sources. Modifications are a common occurrence at all types of industrial and commercial facilities. There may be maintenance personnel or even an entire maintenance crew at large industrial sites. The activity may vary from landscaping maintenance to minor building repairs or from major remodeling to the installation of new facilities on currently open space.

Construction and maintenance activities can generate pollutants that can reach storm water if proper care is not taken. Common types of contaminants may be pesticides, herbicides, fertilizers, solvents, paints, and varnish removers, finishing residues, spent thinners, soap cleaners, kerosene, asphalt and concrete materials, adhesive residues, and old asbestos installation.

Related BMPs include:

— AM-01 Employee Training
— AM-08 Waste Management and Recycling
— AM-13 Pesticides, Herbicides, and Fertilizer Use
— AM-19 Structure Construction and Painting

Training

- Þ Educate employees who are doing the work about the importance of keeping pollutants out of the storm water system including review of the Spill Prevention, Control, and Countermeasure (SPCC) Plan.
- Þ Make material safety data sheets (MSDS) available to all employees and review in periodic safety training.
- Þ Inform subcontractors, such as garbage collection or material delivery, of company policy on these matters and include appropriate provisions in their contract to make certain proper housekeeping and disposal practices are implemented.

Good Housekeeping

- Þ Keep the work site clean and orderly. Remove debris in a timely fashion and sweep the area. Properly dispose of wash water, sweepings, and sediment.
- Þ Store materials to prevent contact with rainfall and storm water runoff.
- Þ Make sure that nearby storm drains are well marked, either with a color code or a painted stencil, to minimize the chance of inadvertent disposal of residual paints and other liquids.
- Þ Use soil erosion control techniques wherever bare ground is temporarily exposed. See BMPs relating to erosion and sediment to select best methods and procedures.
- Þ Use the entire product before disposing of the container.
- Þ For a quick reference on disposal alternatives for specific wastes see AM-01-1 presented in employee training BMP fact sheet. Dispose of any paint, thinners, residue, and sludges that cannot be recycled as hazardous waste.
- Þ Latex paint and paint cans, used brushes, rags, absorbent materials, and drop cloths, when thoroughly dry and no longer hazardous, may be disposed of with other construction debris.
- Þ Recycle residual paints, solvents, lumber, and other materials to the maximum extent practical. Buy recycled products to the maximum extent practical.
- Þ Inform employees and subcontractors of acceptable housekeeping, disposal, and other storm water management practices and include

appropriate provisions in subcontracts to make certain proper housekeeping disposal and other storm water management practices are implemented.

Þ Do not remove original product labels from containers. Product labels contain important safety and disposal information.

Landscaping

Þ Landscape maintenance involves the use of pesticides and fertilizers. Proper use of these materials in the correct amounts will reduce the risk of storm water pollution. In particular, do not apply these materials immediately prior to or during rainfall. When irrigating landscaped areas, avoid using too much water so that excess nutrients and herbicides do not wash away. Efficient use of nutrients and pesticides can save a great deal of money and will help preserve the natural streams and lakes.

Þ It is important to properly store pesticides and application equipment and to dispose of the used containers in a responsible manner. Personnel who apply fertilizers and pesticides should be trained in their use. Integrated pest management can be used to reduce use of pesticides.

Þ Keep as much wooded area as possible. Natural wooded areas require very little maintenance and generate no storm water pollutants. The next best option is to plant native vegetation and trees in order to reduce water, fertilizer, and pesticide needs.

Þ Collect and dispose of grass clippings that may enter the storm drainage system or into natural streams.

Painting

Þ Painting operations should be properly enclosed or covered to avoid drift, typically by handing drop cloths or sheets from temporary scaffolding. Use paint application equipment that minimizes overspray. If painting requires scraping or sand blasting of the existing surface, use a ground cloth to collect the chips. If the paint chips contain lead or tributyl tin, they are considered hazardous waste.

Þ Mix paint indoors before using so that any spill will not be exposed to rain. Do so even during dry weather because cleanup of a spill will never be 100% effective. Dried paint will erode from a surface and be washed away.

Þ If using a small amount of water-based paints, clean the application equipment in a sink that is connected to the sanitary sewer. Properly store leftover paints if they are to be kept for the next job or properly dispose of the leftover paints. For oil-based paints, paint out brushes to the extent practical, and then filter and reuse thinners. Oil-based paints must not be disposed into the sanitary sewer. Never clean paintbrushes or rinse paint containers into a street, gutter, storm drain, or watercourse.

Þ When using sealants on wood, pavement, roofs, etc., quickly clean up spills. Remove excess liquid with absorbent material or rags.

Building Maintenance

Þ Collect and properly dispose of roofing debris prior to rainfall and upon completion of work to prevent entry of debris and materials into gutter downspouts.

Þ When small particles have accumulated in the roof gutter, either sweep out the gutter or wash the gutter and trap the particles at the outlet of the downspout. A sock or geofabric, which can be securely fastened over the outlet, may effectively trap the materials.

Þ Larger buildings may have the downspouts connected directly to an underground header or a storm drain. In this case, place a temporary plug at the first convenient point in the storm drain. Wash the gutters and downspouts, then pump out the wash water with a vacuum truck. Clean the catch basin sump where the plug had been placed.

Parking Area Maintenance

Þ Storm water runoff from parking lots and roads may contain undesirable concentrations of oil, grease, suspended particulates, and metals such as copper, lead, cadmium, and zinc, as well as the petroleum by-products of engine combustion. Deposition of air particulates, generated by the facility or by adjacent industries, may contribute significant amounts of pollutants.

Þ An appropriate method for removing pollutants from parking areas is to conduct periodic sweeping. A vacuum sweeper is a better method of sweeping than mechanical brush sweeping. The mechanical brush sweeper is not as effective at removing the fine particulates.

Þ Some form of storm water treatment may be necessary to reduce pollutants from sizable parking lots. An oil-water separator (ST-07) is highly recommended for most parking lots. Filter strips and swales (ST-05) will reduce the amount of pollutants by using vegetation and permeable soils. If some employees have cars that are leaking visible amounts of engine fluids, encourage them to have the problem corrected.

Storm Drain Maintenance

Þ Catch basins and storm drain pipes generally need to be cleaned every six to 12 months. If the storm drain lines have a flat gradient, typically less than 1%, more frequent inspection and cleaning will be necessary.

Þ Install skimmers, "turn-down" elbows, or similar devices on outlets of the catch basins. These are very inexpensive measures to help retain floatable materials, oil, and grease.

Þ If a vacuum truck is used to clean the storm drainage system, dirty water will be generated. The wash water should not be discharged to the storm drainage system. Disposal options include: 1) an onsite process wastewater system, 2) sanitary sewer system, if permission is granted by the city, or 3) an onsite sediment basin or other form of storm water treatment. Do not discharge to an onsite sediment basin prior to or during a rainfall event; allow wash water to infiltrate into the ground or to evaporate.

Maintenance

Þ Inspect the work zone daily to ensure that good housekeeping practices are being followed. Spot-check employees and subcontractors regularly (typically monthly) to ensure appropriate practices are being employed.

Limitations

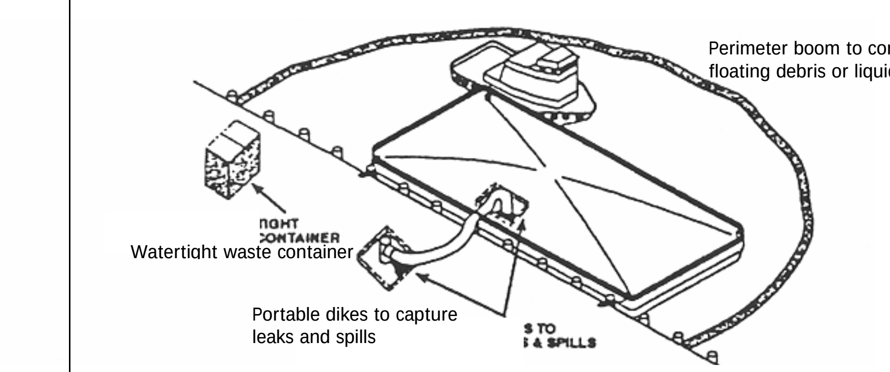
Þ Alternative pest or weed controls may not be available, suitable, or effective in every case. Safer alternative building and construction products may not be available or suitable in every instance.

Þ Hazardous substances that cannot be used or recycled must be disposed of and handled by a licensed hazardous waste hauler.

References

33, 99 (see BMP Manual Chapter 10 for list)

ACTIVITY: Over-Water Operations	IC – 06



Targeted Constituents				
¸ Significant Benefit		Û Partial Benefit	¹ Low or Unknown Benefit	
Û Sediment	Û Heavy Metals	¹ Floatable Materials	Û Oxygen Demanding Substances	
Û Nutrients	Û Toxic Materials	¹ Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description

Prevent or reduce the discharge of pollutants to storm water and receiving waters from over-water activities by minimizing repairs and maintenance, proper disposal of wastes, cleaning up spills and wastes immediately, training and educating employees and visitors, and structural improvements.

Suitable Applications

Over-water industries include channel dredging or the use of some natural resource within a stream, river, or lake. Commercial activities in or near rivers and lakes involve boat and ship repair yards, marinas and boat docks, tourist boats and cruises, and restaurants or other businesses on a dock or pier.

Over-water industries must be permitted by Tennessee Department of Environment and Conservation (TDEC) in order to operate within “waters of the state,” defined as any blue-line stream on the U.S. Geological Survey quadrangle map. Typical measures include the use of silt curtains, floating booms, specialized material handling equipment, filter boxes, cofferdams, and dikes. The methods and approach must carefully consider currents, volume of flow, velocity, types of sediment, aquatic life and distribution, etc. Operations must be continuously monitored to prevent pollution from being generated. Consult TDEC for additional requirements and permit application process.

Activities of concern for marine activities include chipping and painting of hulls, on board maintenance of engines, and the disposal of domestic wastewater and ballast water. With few exceptions, BMPs to protect water quality are common-sense and low-cost changes to normal day-to-day procedures.

Commercial facilities and restaurants that are located on a boat or a dock are subject to the same pollution requirements as outlined elsewhere in the BMP Manual. Utility connections are problematic and need special design solutions. Related BMPs include:

AM-06	Material Delivery and Storage
AM-08	Waste Management and Recycling
AM-09	Sanitary and Septic Waste Management
IC-07	Food Service and Handling
RH-11	Boating and Marinas

Approach

Fish Waste

Fish waste is defined as the by-product of cleaning fresh-caught fish. Fish waste must be managed properly. Recycling small amounts of fish waste caught for personal use back into the water is encouraged when disposal will not result in water quality or public nuisance problems, such as wastes washing up on shore and causing odor or bacteria problems. Fish wastes should not be recycled in any dead-end lagoons or other poorly flushed areas.

Marina owners should generally provide fish cleaning stations where waste recycling can occur without adversely affecting water quality. People participating in fishing tournaments and other authorized events should follow the guidelines presented by the sponsors. Follow all rules and regulations that are issued by the Tennessee Wildlife Resources Agency or the U.S. Coast Guard (Mississippi River).

Restaurants are specifically prohibited from discharging fish wastes into a storm water conveyance or a natural body of water.

Marine Activities

Þ Properly dispose of domestic and sanitary wastewater by using holding tanks. Empty holding tanks at approved wastewater collection facilities at marinas and boatyards. Verify ballast water is clean before discharging to natural body of water.

Þ Limit over-water hull surface maintenance to minor sanding and minor painting using hand tools and a small can of paint or other surface agent. In general, conduct most boat repair and maintenance items by removing the boat from the water into an organized maintenance area.

Þ Use phosphate-free and biodegradable detergents for hull washing. Limit the amount of detergents used by first scrubbing and cleaning with water.

Þ Use secondary containment on paint cans. Have available spill containment and cleanup materials. Use tarps, ground cloths, or plastic sheeting when sandblasting or painting boats on land. Spray applicators may be used when painting on land.

- Properly dispose of surface chips, used blasting sand, residual paints, and other materials. Use temporary storage containment that is not exposed to rain. Sweep dry docks each day or after maintenance is completed.

- Boats with inboard engines should have oil absorption pads in bilge areas. The pads should be changed at least once a year or as needed.

- Automotive fuel, fluids, and oil should be kept in secure containers. Recycle used oil in properly labeled containers. Inspect and repair engine valves, pipes, and hoses as necessary. Use drip pans when conducting maintenance and repair.

- Immediately clean up spills on docks or boats using absorbent materials. Keep ample supply of spill cleanup materials on hand and conspicuously marked. Dispose of cleanup materials properly.

- Clean catch basins and the storm drains at regular intervals. Post signs to indicate proper use and disposal of residual paints, rags, used oil, and other engine fluids.

- Educate visitors and employees on spill prevention and cleanup. Include appropriate language in tenant and user contracts that indicates the tenant's responsibility to guard against spills, properly dispose waste materials, and limit practices that may pollute storm water.

- Painting should be limited to spot work. In marinas, tenant maintenance over water should be limited to work requiring the opening of no more than a pint-size paint can. Paint mixing should not occur on the dock.

- Marinas must provide wastewater disposal facilities onsite or close by. Wastewater facilities typically consist of either dockside lines or a pump-out station. Marinas should post signs at the entrance and through the facility indicating maintenance rules and reminders.

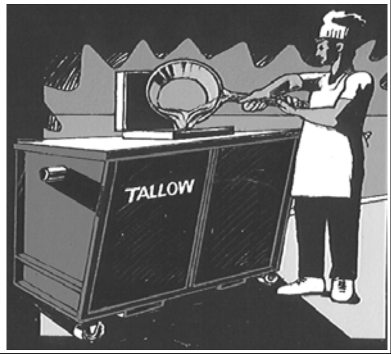
Limitations

- Private tenants at marinas may resist restrictions on shipboard painting and maintenance. Existing contracts with tenants should be updated to require that tenants abide by new rules that benefit water quality.

- Even small amounts of biodegradable cleaning agents have been found to be toxic to fish. Disposal of small amounts of cleaning agents should be done through the sanitary sewer system.

References **33, 95, 135, 192** (see BMP Manual Chapter 10 for list)

ACTIVITY: Food Service and Handling	IC – 07



Targeted Constituents

¸ Significant Benefit Û Partial Benefit ¹ Low or Unknown Benefit

¹ Sediment	¹ Heavy Metals	¸ Floatable Materials	Û Oxygen Demanding Substances	
Û Nutrients	Û Toxic Materials	¸ Oil & Grease	¸ Bacteria & Viruses	¹ Construction Wastes

Description

Prevent or reduce the discharge of pollutants to storm drainage systems and to natural streams from businesses or industries that deal with food or food by-products. Food and food by-products damage natural streams by promoting harmful pathogens and depleting the dissolved oxygen.

Approach

There are many types of commercial and industrial establishments that are involved in the processing and handling of food. Some common examples are restaurants, grocery stores, convenience stores, fruit stands, meat packing plants, bakeries, etc. Due to the shear number of establishments that concern food, this BMP has the potential to make a huge impact on storm water quality. Effective employee training is essential.

Memphis and Shelby County have separate sanitary sewer systems and storm drainage systems. Storm drains located outdoors are intended to channel rainwater runoff directly to the nearest stream to prevent ponding and flooding. Anything that leaks or is washed into the storm drainage system goes untreated into natural streams.

Illegal Discharges or Dumping

Disposal of food or food by-products into the storm drainage system or natural streams is a direct violation of the Memphis and Shelby County Storm Water Ordinances. Refer to IC-01, Non-Storm-Water Discharges to Storm Drains. Report illegal dumping into the storm drains or local waterways to the Storm Water Hotlines at 576-6721 for City of Memphis and 545-3870 for Shelby County. The Memphis and Shelby County Health Department (MSCHD) regulators can be reached at 544-7776

It is a common misperception that disposal of food and food by-products into the storm drainage system is not a problem because these products are generally considered to be biodegradable. This assumption is wrong because contaminated or spoiled food is an extreme danger to both humans and animals. Harmful bacteria and viruses can pollute natural streams and creeks, making humans and animals sick. Decaying food uses dissolved oxygen in natural streams, depleting oxygen levels and causing fish kills. Food contributes to nutrients in downstream rivers and lakes, which can lead to excessive aquatic vegetation, eutrophication, and other environmental problems.

Illicit Connections

Many restaurants and other smaller businesses may not know whether a particular drain leads to the storm drain system or the sanitary sewer system. Contact the property owner for plans indicating which pipes are connected to storm drains and which to the sanitary sewer. If plans are not available, then contact the City of Memphis sanitary sewer authority for assistance. The MSCHD also offers assistance at 544-7776.

All drains inside of a building or under a covered structure must be connected to the sanitary sewer. All drains outside a building and exposed to rainfall should be connected to the storm drain system. This common-sense approach was not generally in effect for older buildings and neighborhoods, so it is important to verify that each pipe connects to the proper drain. Even newer buildings may not be configured in the correct way, due to shortcuts or assumptions on the behalf of a building contractor. Smoke testing or dye tracing can be used to identify sanitary sewer lines.

Methods

Dumpsters

Dumpsters are a major source of storm water pollution throughout the Memphis and Shelby County. As a result, city inspectors are often called to investigate leaking Dumpsters. Restaurants, grocery stores, and other businesses that deal with food handling and services must take extra care in dealing with waste and Dumpsters due to the potential for rodents, insects, other animals, diseases, etc. Restaurants, grocery stores, and other food handling businesses must include regular Dumpster inspection and maintenance as part of the daily checklists. See IC-10, Dumpsters, for additional information and guidelines on using and maintaining Dumpsters. New facilities should include special curbed areas to reduce storm water pollution.

Þ Locate the Dumpster away from storm drainage inlets and channels. In addition to being accessible for the Dumpster waste contractor trucks, the Dumpster must be easily accessible to employees. Consider placing the Dumpster in a shaded area. New Dumpster pads should incorporate curbed/diked areas to redirect storm water.

Þ Keep loading areas and surrounding parking lot clean. Pick up trash and litter as needed (at least daily). Sweep areas clean using a broom and dustpan; do not use a pressure washer or a leaf blower to collect litter.

- Never place leaky bags or liquid waste into the Dumpster. Drain liquids into an indoor drain that leads to the sanitary sewer system. Use a dry method, such as absorbents or kitty litter, to absorb liquid wastes and spills. Sweep up promptly.

- Keep Dumpster lids and hatches closed to keep out rainwater. Insist on a fully functional Dumpster with adequate lids and doors. Verify that the drain plug at the bottom of a Dumpster is securely in place to prevent discharges. Call the Dumpster leasing company to replace faulty equipment or fittings.

- Keep Dumpster secured to prevent illegal dumping. A lockable enclosure may be needed if the Dumpster is not behind a secured fence or otherwise protected.

- Do not put used fats, oils, and grease into a Dumpster. These substances never wash away completely; the Dumpster will become a source of odors, disease vectors, and storm water pollution.

Fats, Oils, and Grease

Fats, oils, and grease are destructive to natural creeks and streams, and should not be discharged onto the ground or any surface that drains toward the storm drainage system, ditches, swales, or culverts.

Fats, oils, and grease are also very harmful to the sanitary sewer system. The City of Memphis and Shelby County closely regulate any business or establishment with the potential to generate large amounts of grease. When grease is washed into a sanitary sewer drain, it is likely to congeal on the cool internal surfaces of sanitary sewer lines. Eventually a grease blockage will occur; the sewage may back up into a business or residence. Manholes and laterals may need to be cleaned out; however, the problem will recur unless the problem source is located and then eliminated. The use of solvents, detergents, and enzymes does not eliminate the problem of clogging grease. Grease and oils may congeal farther down the line, particularly as the temperature decreases downstream.

The Tennessee Department of Environment and Conservation (TDEC) has published a useful report titled “Tennessee Oil and Grease Control Guidance Document” (reference 197). Topics include: food disposal, grease traps, grease interceptors, grease recycling, garbage grinders, sewage blockages, definitions, etc.

Section 33-112 of the City of Memphis, Division of Public Works Sewer Use Ordinance (revised in 2005) details the requirements for food establishments regarding this issue. Source control and field inspection programs are important to reduce grease impacts. Property owners should document inspections and maintenance, and ensure that grease pumping and disposal is performed by authorized haulers using waste manifest certifications.

The following general guidelines are recommended:

Þ Train employees to handle fats, oils, and grease correctly. Include written materials as well as verbal training. Post signs at grease disposal locations in order to encourage proper disposal.

Þ Minimize the use of fats, oils, and grease in the cooking process. If possible, use grease and oil multiple times when cooking similar foods to reduce the amount generated.

Þ When possible, recycle used grease and oils in a special container. Do not pour grease and oils into a Dumpster, or dispose outside on surfaces that drain to city storm water drainage systems or to natural creeks.

Þ Clean grease traps, grease interceptors, and similar equipment frequently in order to prevent sanitary sewer system backups. Follow city and county requirements for inspections, maintenance, and documentation.

Food Storage

Some businesses, such as fast-food restaurants and fruit stands, keep food products in sheds or outside in containers. Storage of food is closely regulated by local and state officials. In addition, storage of flammable materials and hazardous materials must comply with local building and fire codes. The following guidelines outline the basic points of preventing food or food by-products from contaminating storm water runoff:

— Keep storage away from exposure to rainfall and weather. Locate storage in an area where leaks and spills will not reach storm drain.

— Maintain storage containers in good condition. Use original containers if possible. Properly label all storage containers.

Cleaning Procedures

A major source of pollution from restaurants and grocery stores stems for the cleaning and scrubbing of indoor equipment (such as pots, pans, grills, cooking hoods, etc) outside in the parking lot. Restaurants, grocery stores, and all facilities that deal with food must have an indoor area with a floor drain connected to the sanitary sewer system, specifically for the purpose of cleaning equipment and supplies.

- Þ Verify that the requirements and guidelines of IC-11, Kitchen Exhaust Cleaning, are being followed for grease removal from ventilation systems.

- Þ Clean floor mats, air filters, air vents, hoods, meat trays, garbage cans, and other equipment indoors in a mop sink or near a floor drain connected to the sanitary sewer system. Do not dump hazardous waste liquids down the storm drain.

- Þ Buy the least-toxic cleaning products available; look for the words "non-toxic," "free of ammonia, phosphates, dye or perfumes," or "biodegradable." Avoid products containing chlorinated compounds, petroleum-based substances, phenols, and formaldehyde. Use environmentally friendly products whenever possible.

- Þ Do not allow oil and grease to spill onto the ground during transport to the proper grease disposal bin.

- Þ Recycle food containers wherever possible, such as paper, cardboard, plastic, or metal. Clean food containers thoroughly before placing in a recycling container.

Response to Spills and Leaks

Pollution prevention plans are recommended that include cleanup procedures for different types of spills, schedule of employee training, and cleanup materials that are properly labeled and in an easily accessible area. Post the pollution prevention plan in a central area and discuss with employees as needed.

- — Report any discharges to the City of Memphis Storm Water Hotline at 576-6721 and the Shelby County Storm Water Hotline at 545-3870 as soon as possible.
- — Use dry methods for cleanup (absorbent rags or granular materials such as kitty litter). Sweep up and dispose of absorbent in the proper trash receptacle.
- — Protect storm drains with special covers or berms as necessary. Never wash any spilled material into the municipal storm drain system.

Maintenance

- Þ Inspection and maintenance of Dumpsters should occur on a daily basis.

- Þ Storm drain berms and covers should be inspected regularly for necessary repair and replacement.

- Þ Catch basins, detention facilities, or drainage structures need to be maintained and periodically cleaned out, particularly after significant rainfall events.

Related BMPs

The following list of BMPs are also helpful for kitchens, restaurants, food handling services, and businesses:

AM-01 Employee Training
IC-01 Non-Storm-Water Discharges to Storm Drain
IC-08 Power or Pressure Washing
IC-10 Dumpsters
IC-11 Kitchen Exhaust Cleaning

Limitations

- Some restaurants or convenience stores may have space limitations that hamper efforts to clean equipment indoors. Structural or plumbing modifications may be necessary to create an indoor cleaning area with sanitary sewer connections.

References

31, 33, 34, 35, 99, 103, 138, 193, 197 (see BMP Manual Chapter 10 for list)

ACTIVITY: Power or Pressure Washing	**IC – 08**

Power Washing
Pressure Washing
Steam Cleaning

Capture & Recycle

Targeted Constituents				
¹ Significant Benefit		Û Partial Benefit	¹ Low or Unknown Benefit	
Sediment	Heavy Metals	¹ Floatable Materials	Û Oxygen Demanding Substances	
Û Nutrients	¸ Toxic Materials	¸ Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description The purpose of this BMP is to reduce pollution impacts from power washing, pressure washing, and steam cleaning of buildings, roofs, fences, floors, driveways, parking lots, etc. These practices dislodge pollutants such as grease, oil, paint chips, sediments, and food particles through the use of high-pressure water sprays, water containing a cleaning solution, or by heated water. Prevent or reduce the discharge of pollutants from power washing activities to storm water by: employee training and education, identification of alternatives, and control of wash water.

Approach Pollution from these types of washing activities comes from two sources:

— Cleaning solutions
— Pollutants and dislodged materials

Cleaning solutions generally contain chemicals that are able to dissolve and dislodge grease and oils. These cleaning solutions are very dangerous to aquatic life and are likely to cause fish kills. It should be noted that all soaps, even biodegradable soaps, are harmful to fish and other aquatic organisms.

Pollutants and dislodged materials will also pollute the aquatic environment and harm fish. Materials such as paint chips or automotive fluid leaks are toxic to all creatures.

Alternatives to Power or Pressure Washing

The primary approach for most applications is to avoid the need for power washing, pressure washing, or steam cleaning by using other methods such as:

— Dry methods for cleanup of liquid wastes and dry materials
— Scrapers for removing mud, dirt, or old paint
— Nonpressurized water in small amounts and preventing its discharge to storm drain

Dry methods for cleanup of liquid wastes include the use of absorbents and dry rags to contain the liquid. Then the area can be cleaned with a small amount of water using a mop or a scrub brush. Small amounts of wash water can generally be discharged to the sanitary sewer system if it does not contain hazardous chemicals or toxic materials.

Scrapers should be used for removing old paint from buildings or moss from rooftops. If the old paint contains lead or tributyl tin, then it is considered a hazardous waste and must be disposed at a facility licensed to handle hazardous waste. Use tarps and ground cloths to collect paint chips, and then carefully verify that there are no paint chips on the ground or other surfaces prior to washing.

Squeegees may be appropriate for cleaning mud or dirt from some surfaces. Scrubbing with sponges or rags will ensure that the surface is cleaned with the correct amount of pressure.

Manage wash water appropriately. Use sandbags, portable berms, or other means to direct the wash water so it flows to one of the following:

— a grassy or vegetated area (if there are no oil or hazardous materials)
— a catch basin with an insert to filter out pollutant
— a sump or an enclosed area where wash water will be trapped and then pumped for transport to an appropriate disposal location

The storm drain system can also be protected using water-filled berms or water-filled storm drain covers. These types of barriers are reusable and generally conform to the ground or pavement surface, creating a tight seal.

Do not dump mop water or carpet cleaning water outdoors. It can be poured into the sanitary sewer using an indoor drain, as long as it is not contaminated with hazardous materials. Mop water or carpet-cleaning water may need to be filtered if it contains large particles or sludge.

Power or pressure washing is very inefficient in water usage because it is not evident how much pressure is needed to clean the surface. This is particularly true for rental equipment or for recently purchased equipment. Someone may try to clean a building for an hour with a pressure washer prior to concluding that the pressure washer is ineffective. Therefore, it is best to examine all alternatives prior to using a pressure washer or steam cleaner.

Commercial Power Washing, Pressure Washing, and Steam Cleaning

Use a licensed commercial washing business that has modern equipment. Verify that the business protects the environment by isolating the area to be cleaned from draining into storm drains. A commercial washing business must collect wash water and dispose of it properly. Oftentimes, the wash water will be filtered and recycled.

It is the responsibility of the property owner to make sure that a mobile washing service manages wash water properly. Mobile washing services are generally required to haul the wash water and rinse water offsite; pretreatment may be required prior to discharging into the sanitary sewer system.

Persons engaged in the discharge of non-storm-water discharges that do not have a direct discharge to any surface or subsurface waters must obtain a State Operation Permit (SOP) from the Tennessee Division of Water Pollution Control (WPC). The permit is for anyone generating wastewater who does not have a direct discharge, but rather is land-applying by spray or drip irrigation, or collecting and temporarily holding discharges. Mobile car washes or other pressure washing operations require a permit.

The SOP requires that all soaps, detergents, and other chemicals used should be nontoxic and biodegradable. In addition, "chemically enhanced" (soaps, detergents, or other chemicals) waste wash waters being discharged by mobile wash operations must be collected for proper disposal. If a discharge is composed entirely of wash water that is not "chemically enhanced," the permit allows the discharge to travel by sheet flow to a gravel or grassy area where there is no opportunity to enter waters of the state. In no case does the permit allow a discharge to a storm water inlet, ditch, conveyance, or stream. Permitting information and forms may be found at http://www.tennessee.gov/environment/permits/wqoperm.php . Contact TDEC at (888) 891-8332 for additional information.

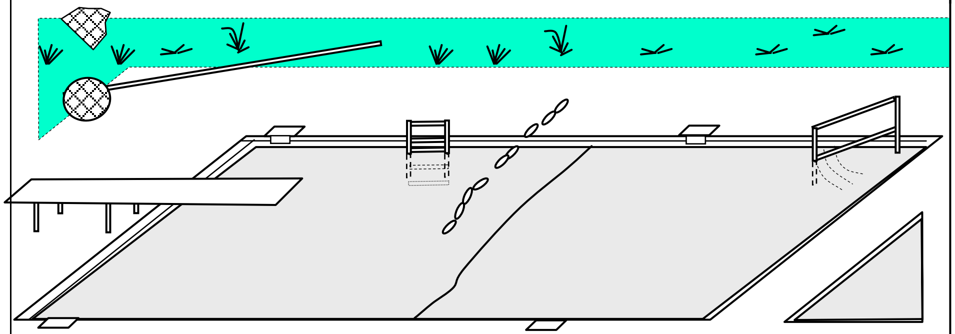
Limitations

- It is difficult to estimate the effectiveness of power or pressure washing prior to attempting the effort.
- It takes a substantial effort to control wash water generated on a rooftop or the side of a building.

References **31, 33, 34, 35, 99, 103, 138** (see BMP Manual Chapter 10 for list)

ACTIVITY: Swimming Pools and Spas

IC – 09



Targeted Constituents

¸ Significant Benefit   Û Partial Benefit   ¹ Low or Unknown Benefit

¹ Sediment	¹ Heavy Metals	¹ Floatable Materials	¸ Oxygen Demanding Substances	
¹ Nutrients	¸ Toxic Materials	¹ Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description

Chemical treatment of swimming pools and spas may prevent health concerns to bathers by killing organisms that live in the water. However, the chemicals that kill such organisms in pools and spas also kill aquatic life (fish, minnows, salamanders, crayfish) in creeks and streams that receive water with chemicals such as chlorine.

Suitable Applications

Þ Businesses or residential properties that own or maintain a swimming pool or spa

Þ Commercial contractors that clean and maintain pools and spas

Approach

Since a variety of pool and spa treatment chemicals exists, it would be impossible to address proper disposal methods for every available chemical used in the treatment of pool and spa water. Due to federal mandates, Memphis and Shelby County adopted Storm Water Ordinances to prohibit discharge of non-storm-water materials (see IC-01, Non-Storm-Water Discharges to Storm Drains) such as chlorine, Baquacil, and other treatment chemicals into streets, ditches, storm drains, and natural streams.

The most common pool treatment is chlorine, which dissolves in water and is then very slowly released to the atmosphere as chlorine gas. This process is usually inhibited by the addition of other chemicals. Bromine is another type of pool chemical that is also commonly used. There is a large variety of chemical products that are frequently used to reduce algae growth, adjust pH, remove hardness or metals, remove stains, etc. Memphis and Shelby County swimming pool and spa owners should use pool testing kits to monitor water conditions, and choose environmentally friendly products if available.

Swimming pool water will naturally release chlorine gas at a rate that is dependent upon water and air temperature, presence of chemical inhibitors, amount of sunlight, amount of wind, water depth and circulation, etc. The process typically takes many days and requires that water should be periodically tested to monitor chlorine levels.

Reducing or Eliminating Discharges

- Before buying chemicals, select a method of pool treatment that has been successfully used in the Memphis and Shelby County area. Investigate and compare products to ensure that a proven method is selected. Select a method with the least toxic chemicals or chemicals that can be easily neutralized and removed from water.

- Retailers and manufacturers must make information readily available to customers, such as material safety data sheets (MSDS), with each chemical product to cover proper use of chemicals, safety issues, and safe disposal methods. All users of pool and spa chemicals should verify that the discharge and disposal process for any water treated with chemical products will be able to comply with federal and state regulations in addition to the manufacturer's recommendation.

- Do not overfill swimming pools and spas so that water is discharged with every splash and wave. Allow adequate freeboard for rainfall and storms. Splashes and waves should drain to a grassy area for ground infiltration.

- Most in-ground pool owners do not choose to drain the pool each year. It is beneficial to leave an adequate weight of water for in-ground swimming pool or spa to prevent cracking or uplift.

Recommended Disposal Alternatives

- Any swimming pool or spa water that has been treated by chlorine only and dechlorinated may then be discharged to grassy yards, streets, or the storm water system. Before discharging dechlorinated pool or spa water, check the water with a pool test kit to verify that it is completely dechlorinated. Dechlorinated discharges to streets and driveways should only occur in dry weather when it will not contribute to flooding for neighbors who live downstream. Do not discharge water during winter months for safety reasons if there is a potential for water freezing in the streets, curbs, and gutters.

- Any swimming pool or spa water that has been treated by chemicals other than chlorine is expressly prohibited from discharge to the storm drain system, even if the chemical has been neutralized. Disposal options include: 1) discharging to the sanitary sewer system, 2) drain pool and spa water at a very slow rate to grassy yards where the water will soak into the ground, and 3) constructing an infiltration well or trench to allow water to soak into ground. Typical disposal method is to connect a hose from swimming pool to sanitary sewer system. Connection to sanitary sewer system must be approved by City of Memphis and Shelby County Code Enforcement (379-4270). Do not discharge water onto or through neighbor's yard or property. Due to clay soil types, infiltration rates will be very low and a percolation test may be necessary. An infiltration system may dissolve underlying natural limestone rock; geological information and advice should be consulted.

- Backwash water cannot be discharged directly to the storm water system unless it is completely dechlorinated and not treated with any other chemicals. Typical disposal method for backwash is to connect backwash hose from swimming pool or spa to the sanitary sewer system using a licensed plumbing contractor to install backflow prevention devices. Connections to sanitary system must be approved by City of Memphis and Shelby County Code Enforcement (379-4270) prior to installation. Alternate disposal method for backwash is to construct an infiltration well or trench as described in ST-03.

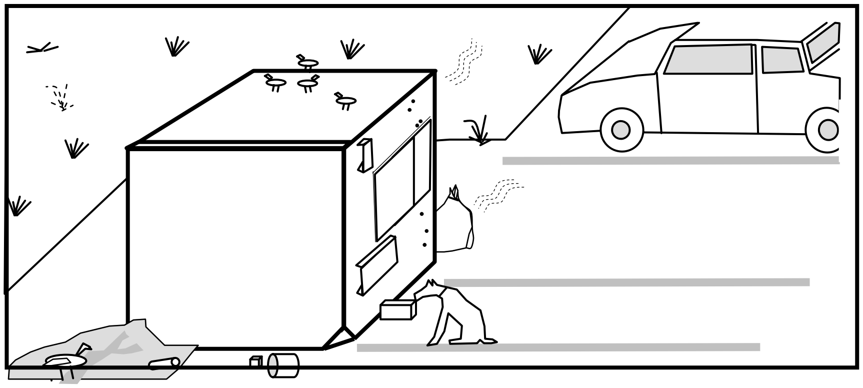
Limitations

- Disposal methods that comply with the City of Memphis and Shelby County Storm Water Ordinances may not necessarily comply with federal, state, and county regulations. Resolve compliance issues prior to discharging water from swimming pool or spa.

References

30, 31, 32, vendor information (see BMP Manual Chapter 10 for list of references)

ACTIVITY: Dumpsters	IC – 10



Targeted Constituents

¸ Significant Benefit   Û Partial Benefit   ¹ Low or Unknown Benefit

Û Sediment	Û Heavy Metals	Û Floatable Materials	Oxygen Demanding Substances	
Nutrients	Û Toxic Materials	Oil & Grease	Bacteria & Viruses	Û Construction Wastes

Description

Dumpsters are a major source of pollution throughout the City of Memphis and Shelby County, usually due to improper use and maintenance. Dumpsters are intended for solid waste only. In most cases, liquid waste should be poured into an indoor drain connected to the sanitary sewer system. Dumpsters are designed specifically to keep solid waste dry (away from rainfall) by closing the top, side doors, and drain plug. Methods to reduce storm water impact from Dumpsters contribute to the many other benefits of Dumpsters: rodent and insect control, reducing odors, neat appearances, efficient waste removal.

Approach

> The Dumpster was invented prior to 1940 by native Tennessean George Dempster (who later became mayor of City of Knoxville in the 1950s). The novel feature of the Dempster Dumpster was that a metal container could be detached and transported as needed. The detachable metal bins were originally developed for the mining industry, but were adapted for solid waste collection in 1938.

A Dumpster is a large metal trash bin that is designed to be transported or emptied by specially-equipped trucks. Many types of Dumpsters are currently available. Smaller businesses often choose a cube-shaped Dumpster that can be emptied by front-end loader trucks (with hydraulic forks). Larger businesses and industries may choose a larger roll-off Dumpster; when full, the Dumpster is loaded onto a truck and transported to the landfill. Construction companies usually select a roll-off-type Dumpster.

Dumpsters are intended for solid waste only. Therefore, do not dispose of liquid wastes into a Dumpster. Do not put containers or bags with liquid waste into a Dumpster. For most commercial Dumpsters, a front-end loader truck will raise and tilt the Dumpster, at which point any liquids would spill onto the truck and surrounding pavement. The truck hydraulically compacts the trash, which would then release any liquids that were inside containers and bottles.

Reasons for proper disposal of solid waste and maintenance of Dumpster areas are:

Â Dumpsters are usually visible to the general public, and especially the patrons!

Â Dumpsters can cause odors.

Â Dumpsters can harbor insects, rodents, and other pests.

Â Dumpsters can cause bacteria and viruses that will harmfully impact employees, patrons, visitors, etc.

Â Protect the environment by protecting natural creeks and streams.

Â Health inspectors and storm water inspectors will regularly check Dumpsters for inadequate conditions. Fines or other penalties may be issued.

Do not use Dumpsters to get rid of used fats, oils, and grease (typically used by kitchens and restaurants). In some cases used fats, oils, and grease can be recycled using special containers. These substances are not only harmful to natural waterways and the environment, they also clog sanitary sewer lines. See IC-07, Food Service and Handling, for additional information about grease traps, grease interceptors, sizing requirements, inspections, maintenance, etc.

City and county storm water inspectors are often called to investigate leaking Dumpsters. Memphis and Shelby County Storm Water Ordinances allow the assessment of civil penalties up to the maximum allowable per day (during which the act or omission continues or occurs) for illegal discharges. Tennessee Department of Environment and Conservation (TDEC) can also assess fines for Dumpster violations include. City and county storm water inspectors may or may not issue a Notice of Violation, depending on the amount of pollution, intent to pollute, and other factors.

Disposal of any non-storm-water discharges to the ground or to the storm drainage system is illegal; refer to IC-01 for more information. Report illegal dumping to the storm drains or local waterways to the Storm Water Hotlines at 576-6721 (City of Memphis) or 545-3870 (Shelby County).

Common Waste Types

Â Dumpsters are intended for solid waste only. Most Dumpsters are emptied by a front-end loader truck that raises and tilts the Dumpster. Any liquid wastes would then splash onto the ground, resulting in pollution, odors, harmful bacteria, and viruses, stains, etc.

- Do not pour liquid waste into a Dumpster. Liquid waste must be handled separately, usually by pouring into an indoor drain connected to the sanitary sewer system. Some types of liquid waste can be recycled, such as automotive fluids and restaurant grease. Some liquids are considered to be hazardous wastes. Hazardous wastes can be handled at the waste collection center at Shelby Farms for household hazardous waste or by using a licensed waste contractor.

- Fats, oils, and grease should not be poured into a Dumpster. See IC-07, Food Service and Handling, for more information on grease interceptors, grease traps, and recycling. The city closely monitors businesses and restaurants for fats, oils, and grease due to the high potential for clogging sanitary sewers.

- Automotive fluids can be recycled at automotive retailers, service stations, and at the city waste collection center at Shelby Farms. Automotive fluids are considered as hazardous waste; just a small amount can kill fish, pollute streets, coat storm drains, etc.

Maintenance and Use

- Locate the Dumpster away from storm drainage inlets and channels. In addition to being accessible for the Dumpster waste contractor trucks, the Dumpster must be easily accessible to employees. Consider placing the Dumpster in a shaded area.

- Keep Dumpster lids and hatches closed to keep out rainwater. Insist on a fully functional Dumpster with adequate lids and doors. Verify that the drain plug at the bottom of a Dumpster is securely in place to prevent discharges. Call the Dumpster leasing company to replace faulty equipment or fittings.

- Keep Dumpster secured to prevent illegal dumping and scavenging. A lockable enclosure may be needed if the Dumpster is not behind a secured fence or otherwise protected. A fence may also be desirable if placing a Dumpster in a visible area.

- Keep loading areas and surrounding parking lot clean. Pick up trash and litter as needed (at least daily). Sweep areas clean using a broom and dustpan; do not use a pressure washer or a leaf blower to collect litter.

- Never place leaky bags or liquid waste into the Dumpster. Drain liquids into an indoor drain that leads to the sanitary sewer system. Use a dry method, such as absorbents or kitty litter, to absorb liquid wastes and spills. Sweep up absorbents promptly and dispose as solid waste.

- Dumpsters must be inspected on a regular basis, preferably daily and at the end of each shift.

- Dumpsters should be cleaned periodically in a manner that does not generate a lot of wash water. In general, do not use power or pressure washing to clean Dumpsters or Dumpster pads. Use a bucket of water with brushes, sponges, and cloths. Minimize the use of detergents and toxic cleaning agents.

Design for New Projects

- New development or redevelopment projects should include a paved Dumpster pad. The pad should incorporate curbs or dikes around the Dumpster pad to redirect storm water.

- Locate the Dumpster pad away from storm drainage inlets and ditches. When possible, the Dumpster pad should drain to a grassy area with a gentle slope, which functions as a filter. See ST-05, Filter Strips and Swales, for additional ideas and information.

- Locate the Dumpster pad in an area easily accessible for employees and for the Dumpster waste contractor trucks. Consider placing the Dumpster in a shaded area. Use fences and/or lockable enclosures to prevent illegal dumping and scavenging. Fences and enclosures also improve site aesthetics.

- For areas that require frequent cleaning, a diversion drain can be constructed that will flow to the sanitary sewer system. The diversion drain can function automatically or manually, and is available as a commercially produced unit.

- Fox Environmental Systems makes a wash water diversion valve that allows wash water to automatically divert to a sanitary sewer drain when the sprayer hose is used (see Figure IC-10-1). Otherwise, the valve will divert flow to the storm drainage system. See http://www.foxenviro.com.au for additional information and details on this product or other types of diversion drains.

Summary of Benefits

Proper placement and use of Dumpsters has many benefits. By reducing exposure to rodents and insects, the Dumpster user will also prevent storm water pollution and the generation of liquid wastes. Dumpsters are designed to minimize opportunities for rodents and insects, as long as the lids and doors are closed at all times. Keep drain plugs, located at the bottom of a Dumpster, closed in order to prevent rodents. Place Dumpsters on pavement rather on soil, to minimize the number of pests living immediately adjacent to a Dumpster.

References

31, 33, 34, 35, 197 (see BMP Manual Chapter 10 for list)

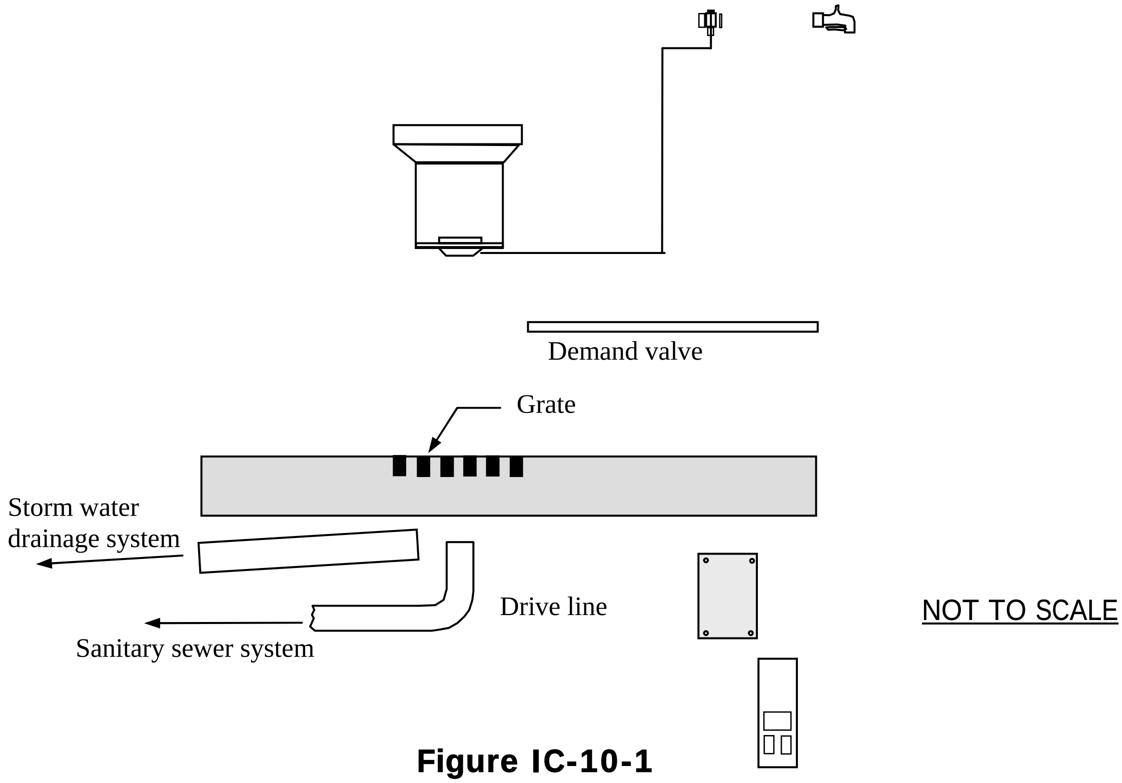


Figure IC-10-1
Hydraulically Activated Wash Water Diversion System

Notes:

1. An automated wash water diversion system represents one method of controlling Dumpster runoff. Other methods may include manually controlled systems.
2. The two figures show products manufactured by Fox Environmental Systems (http://www.foxenviro.com.au).
3. Connections to a sanitary sewer system must be approved by the City of Memphis Sanitary Sewer Department prior to construction.

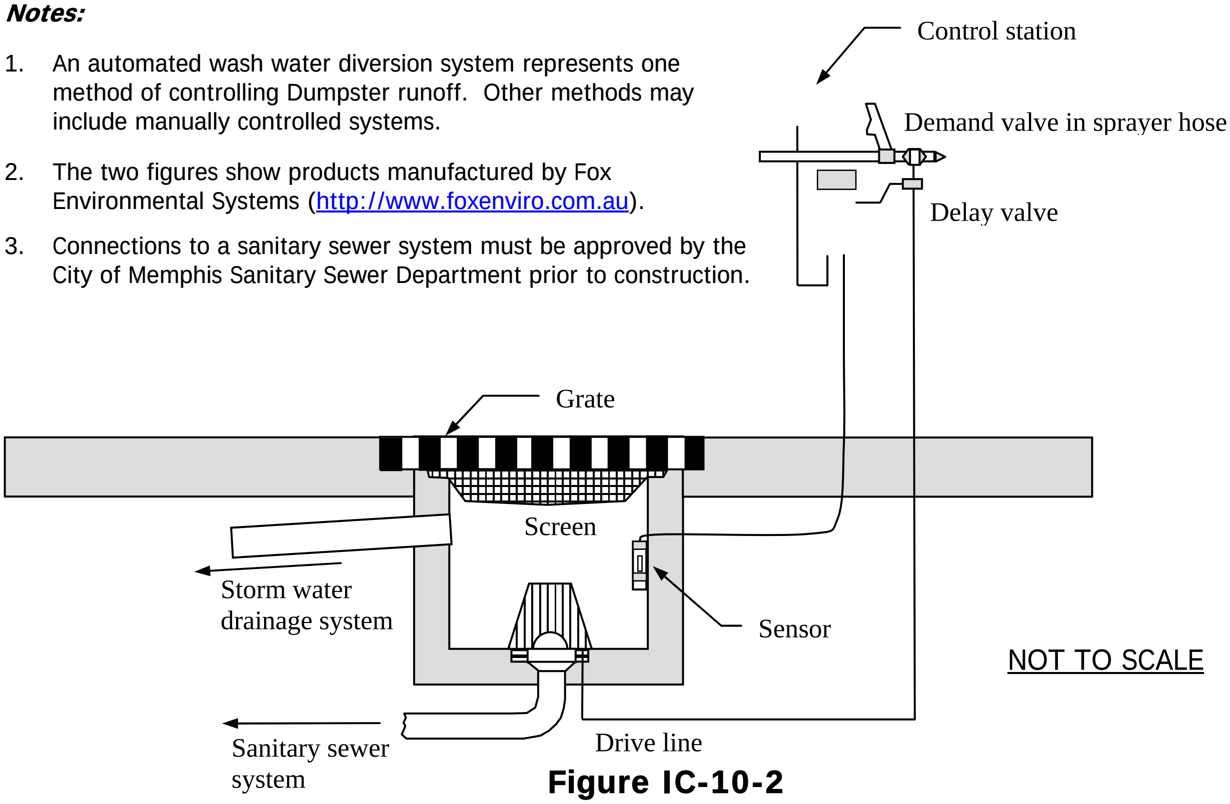
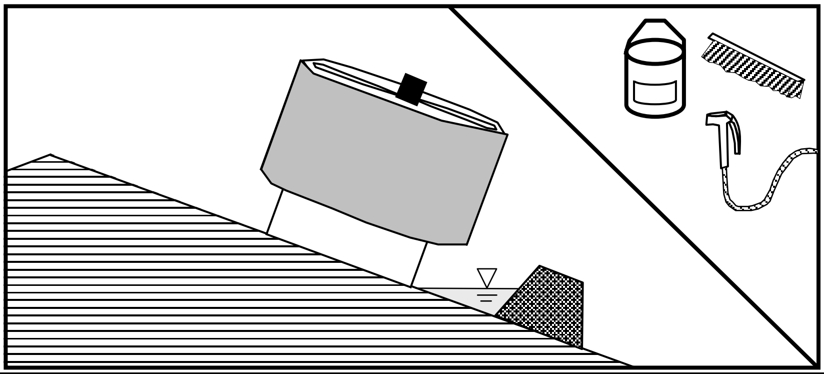


Figure IC-10-2
Automated Wash Water Diversion System

ACTIVITY: Kitchen Exhaust Cleaning

IC – 11



Targeted Constituents				
¸ Significant Benefit		Û Partial Benefit	¹ Low or Unknown Benefit	
¹ Sediment	¹ Heavy Metals	¹ Floatable Materials	Oxygen Demanding Substances	
Nutrients	¸ Toxic Materials	¸ Oil & Grease	Bacteria & Viruses	¹ Construction Wastes

Description

For restaurants and commercial kitchens, the cleaning of kitchen exhaust systems is required by law in order to avoid fire hazards from excessive grease buildup. Methods of cleaning are generally proscribed by National Fire Protection Association (NFPA) 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations. Requirements for inspection and cleaning include grease removal devices, exhaust systems, hoods, fans, and cooking equipment. Eliminate non-storm-water discharges by controlling all water, grease, solvents, cleaners, and other fluids generated in the cleaning process. Do not allow grease or solvents to contact roof surfaces, gutters, parking lots, or other areas that receive rainfall.

Approach

Exhaust systems generally consist of an exhaust hood, plenum, filters or baffles, exhaust stack, and a roof fan. Each exhaust system tends to be unique due to:

— different combinations of possible equipment
— restaurant layout and design
— building architecture and constraints

Hoods and filters are usually made of stainless steel, galvanized steel, or aluminum in order to facilitate regular cleaning. Stacks are usually made of fabricated black iron and are required to be leak proof so that cleaning with pressure washing equipment can take place. Common types of roof fans are upblast, squirrel cage, and supreme.

Disposal of any cleaning or wastewater discharges onto the ground, or any surface that washes off into the storm drainage system or natural streams, is a direct violation of the Memphis and Shelby County Storm Water Ordinances. Refer to IC-01, Non-Storm-Water Discharges to Storm Drains. Report illegal dumping to the storm drains or local waterways to the

Storm Water Hotlines at 576-6721 (City of Memphis) or 545-3870 (Shelby County).

Many restaurants and other smaller businesses may not know whether a particular drain leads to the storm drain system or the sanitary sewer system. Contact the property owner for plans indicating which pipes are connected to storm drains and which to the sanitary sewer. If plans are not available, contact the City of Memphis Sewer Department for assistance. A plumbing contractor can verify which pipes are connected to the sanitary sewer system. Procedures using smoke, dye tests, or air-monitoring equipment can also be used to identify sanitary sewer lines. All drains inside of a building or within a covered structure must be connected to the sanitary sewer. All drains outside of a building and exposed to rainfall should be connected to the storm drain system. This common-sense approach was not generally in effect for older buildings and neighborhoods, so it is important to verify that each pipe connects to the proper drain. Even newer buildings may not be configured in the correct way due to shortcuts taken by or assumptions on the part of a building contractor.

Methods

Typical Kitchen Exhaust Cleaning Procedures

Kitchen exhaust cleaning is a multistep operation designed to clean all of the system components to bare metal. This operation must be planned in order to clean each component thoroughly while protecting surrounding areas by working from the top down. Protect workers by disconnecting electricity to the exhaust cleaning system. A variety of cleaning equipment and supplies (degreasers, brushes, sponges, etc.), should be on hand. The following is a typical list of exhaust cleaning procedures for each hood:

Â Erect a waterproof tarp underneath the hood in order to collect wastewater and grease coming down the stack. The tarp must be securely fastened along all edges, in order to protect cooking equipment and surrounding areas. The tarp must be structurally supported or braced to handle the expected amounts of wastewater.

Â Remove filters and drain cups from the hood. Clean these components down to bare metal by soaking with chemical degreasers and then rinsing with high-pressure water. Try to remove any thick grease first, and dispose of grease properly.

Â Clean the roof exhaust fan inside and out, down to bare metal, using chemical degreasers and then rinse with high-pressure water. The exhaust fan may need to be partially disassembled in order to clean fully.

Â The exhaust stack is sprayed with chemical degreaser and then rinsed with high-pressure water. Remove exhaust duct access doors as necessary to clean and inspect the interior of the exhaust stack.

Â The plenum and interior of the exhaust hood are sprayed with chemical degreaser and then rinsed with high-pressure water.

Â Allow the hood/stack/fan system to fully drain and then dry by air. Remove tarp and dispose as solid waste. It is very difficult to clean and reuse the tarp, so disposal is recommended.

Â Dry the exhaust hood, and polish stainless steel surfaces as necessary. Replace filters and drain cups. Clean and polish wall surfaces in the immediate vicinity. Mop floors as needed.

There are several local companies that provide kitchen exhaust cleaning services; these companies must be familiar with NFPA 96 in order to properly inspect, clean, and reinstall kitchen exhaust systems. These companies have specialized equipment and the proper supplies to perform the work quickly and efficiently. In general, kitchen exhaust cleaning is performed late at night or during weekends to allow the maximum amount of time for cleaning and drying. Restaurant operators are responsible to hire only qualified contractors for kitchen exhaust cleaning.

Grease and Wastewater Recovery

Most kitchens and restaurants are required to have a grease trap as part of the sanitary drain systems in the cooking area. In addition, most kitchens and restaurants typically have an outdoor grease receptacle for the disposal and recycling of thick grease. Whenever thick grease is encountered, it should be scraped from the surface and then placed into the outdoor grease receptacle. This will increase the maintenance interval of a grease trap, and help to ensure the sanitary sewer systems will function adequately without adverse results.

During the entire process of kitchen exhaust cleaning, there is a substantial amount of wastewater generated. It is illegal to discharge this wastewater outdoors onto the ground or parking lot, into a ditch or storm drainage system, or into a natural stream. Refer to IC-01, Non-Storm-Water Discharges to Storm Drains. Illegal discharges can be reported anonymously to the Storm Water Hotlines at 576-6721 (City of Memphis) or 545-3870 (Shelby County).

Wastewater may either be disposed into the indoor sanitary sewer system, or removed for legal disposal by a wastewater disposal company. Any wastewater that contains grease is typically poured into a sink or floor drain that leads to a grease trap. The property owner should verify that all indoor floor drains lead into the sanitary sewer system. Otherwise, further modifications to the floor drains will be necessary.

Cleaning Methods for Exhaust Roof Fans

Exhaust fans typically are the hardest elements to clean. There are more surfaces for grease to accumulate on (fan blades, motor casings). Heavy accumulations of grease can put undue stress on fan motors, bearings, and drive belts (due to the excess weight). Exhaust fans must be cleaned thoroughly, both inside and outside, down to the bare metal surfaces.

Do not clean near catch basins, ditches, pipes, or any part of the storm water drainage system. Collect wastewater and rinse water by appropriate means for disposal into the interior sanitary drains. Exterior portions of the fan casing should be cleaned and rinsed by hand when necessary to avoid discharging wastewater onto the roof. However, a tarp or a child-sized swimming pool is also commonly used to contain wastewater and high-pressure water while cleaning the exterior surfaces.

Squirrel Cage Fan:

Squirrel cage fans usually have an integral water collection drain on the bottom, which simplifies the process of cleaning the interior surfaces. Collect wastewater into a watertight container, which can then be emptied into an interior sanitary drain leading into the grease trap. The exterior surfaces of squirrel cage fans may be cleaned by hand; there is generally a miniscule amount of grease on these surfaces.

Supreme Fan:

Supreme fans have an integral grease collection tray with a ball valve spout. This allows the interior cleaning wastewater to be collected into a watertight container, which can then be emptied into an interior sanitary drain leading into the grease trap. Wastewater from cleaning the underside of the fans will run down the stack. Supreme fans have the fan motor and blades mounted on a pivoting assembly that pops out of the fan housing. Ensure that all wastewater is collected when washing the fan blades and housing assembly.

Upblast Fan:

Upblast fans have an integral water collection spout on the bottom that simplifies the process of cleaning the interior surfaces. Collect wastewater into a watertight container, which can then be emptied into an interior sanitary drain leading into the grease trap. Wastewater from cleaning the underside will run directly down the stack. The fan assembly is usually cleaned in the normal position, and then tilted up for additional cleaning. Ensure that all wastewater is collected when washing the fan blades and housing assembly.

Roof Wastewater Collection Methods

Do not allow any roof wastewater or cleaning water into the municipal storm water drainage system, ditches, catch basins, natural creeks and streams, etc. Preferable methods for cleaning exhaust roof vents will not generate uncontrolled wastewater or rinse water on roofs. A watertight tarp can be securely fastened along all edges around an exhaust fan, with some sort of structural support or bracing to handle the expected water amounts. A child-sized swimming pool can be easily altered to perform as structural support for a watertight tarp.

As an alternate method, the roof itself can be used to store or contain wastewater. Flat roofs have drains that can be temporarily stopped up. Then the low point of the roof can be used as a collection point for grease and wastewater, which is then vacuumed and safely disposed. If needed, gutters or downspouts can be temporarily stopped and then used as a collection point. Wastewater must be collected into a suitable vacuum truck. The contaminated roof areas must be cleaned and rinsed a few times.

Maintenance

- Inspection of kitchen exhaust systems should occur weekly or as recommended by the equipment manufacturer. Cleaning and maintenance of kitchen exhaust systems should occur as soon as possible after a deficiency is noted.

- Keep adequate records of inspections and maintenance work at the restaurant or kitchen location. Records must be made available to City of Memphis and Shelby County inspectors upon request.

Limitations

- Some restaurants or kitchens may have space or access limitations that hamper efforts to inspect and clean kitchen exhaust systems. This may necessitate the removal of ovens, exhausts, or other types of kitchen equipment on a regular basis to adequately inspect kitchen exhaust systems.

Additional BMPs

These BMPs contain additional information related to kitchen exhaust cleaning:

IC-01	Non-Storm-Water Discharges to Storm Drains	IC-10	Dumpsters
IC-07	Food Service and Handling	AM-01	Employee Training
IC-08	Power or Pressure Washing		

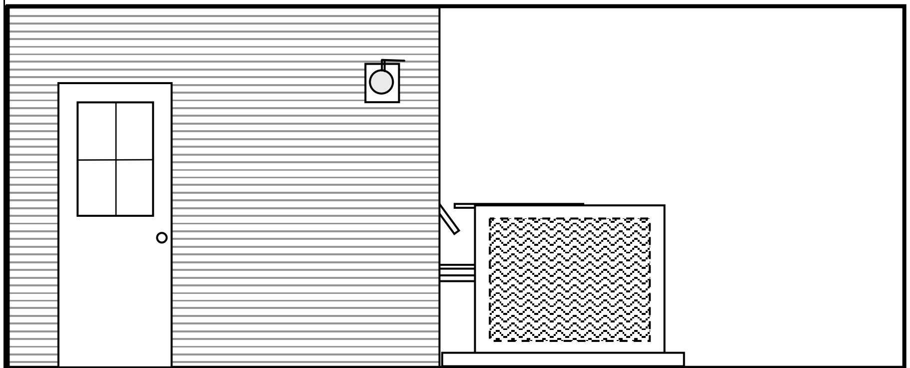
Summary

Due to the toxic nature of the cleaning chemicals involved, and the heavy amounts of grease and oil generated, kitchen exhaust cleaning has frequently caused severe pollution and degradation of natural creeks and streams, including noticeable fish kills. Many restaurants have been caught and fined heavily for this type of pollution.

References **31, 33, 34, 35, 99, 103, 138, 193** (see BMP Manual Chapter 10 for list)

National Fire Protection Association (NFPA) 96: Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations http://www.nfpa.org/

ACTIVITY: Air Conditioners and Refrigeration | IC – 12



Targeted Constituents

¸ Significant Benefit   Û Partial Benefit   ¹ Low or Unknown Benefit

¹ Sediment	¹ Heavy Metals	¹ Floatable Materials	Û Oxygen Demanding Substances	
¹ Nutrients	¸ Toxic Materials	¹ Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description

The purpose of this BMP is to reduce pollution impacts from cleaning and maintenance of air-conditioning and refrigeration units. It is allowable to discharge condensate water, which is essentially pure water from the atmosphere. It is illegal to discharge any water that contains chemicals, detergents, algae-killing agents, and other man-made substances onto the ground or onto any surface that drains to the city storm water drainage system, ditches, swales, curbs, natural creeks, and streams or wetlands. Even if the contaminated water does not directly reach the storm drainage system, the chemicals will wash into the storm water runoff during the next rainfall.

Approach

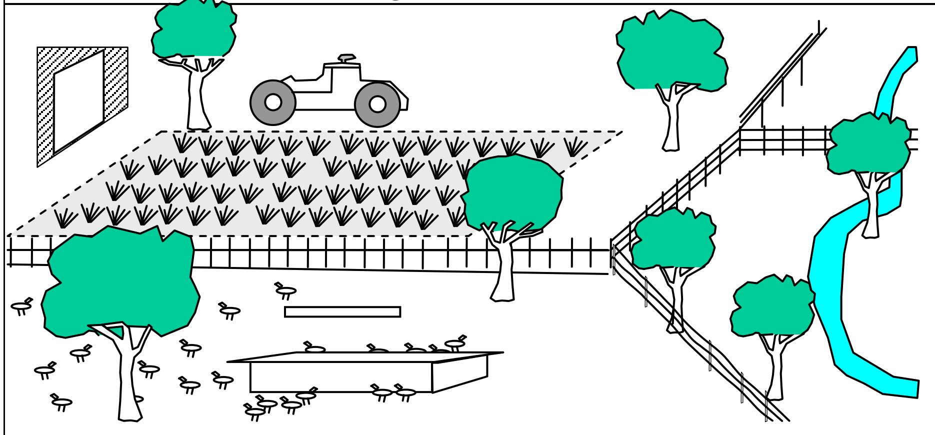
It is illegal to discharge any substance (liquid or solid) to the environment in any manner that could allow the substance to wash into the municipal storm water drainage system, ditches, swales, natural streams and creeks, wetlands, or sinkholes. This prohibition is mandated by federal and state regulations, and also included in the Memphis and Shelby County Storm Water Ordinances. Memphis and Shelby County are required to prohibit non-storm-water discharge as part of the National Pollutant Discharge Elimination System (NPDES) permits issued to the City of Memphis and Shelby County by the state of Tennessee.

See IC-01, Non-Storm-Water Discharges to Storm Drains, for a list of exempted discharges. Both air-conditioning condensate and refrigeration condensate are on the list of allowable discharges, provided that such water is distilled pure water taken from the atmosphere. However, any cleaning water or wash water can not be discharged to the ground, but must be captured for disposal in the sanitary sewer system.

When cleaning air-conditioner coils, capture wash water and dispose properly. Minimize the use of chemicals and cleaning agents by scrubbing to remove dirt and deposits. If power or pressure washing, then contain all generated wash water for recycling and proper disposal.

In addition to imposing possible fines and civil penalties, the Tennessee Department of Environment and Conservation (TDEC) investigates water quality complaints received from the general public. The local TDEC office regularly investigates known water quality issues on City of Memphis and Shelby County creeks and streams.

ACTIVITY: Farms and Agricultural Land	IC – 13



Targeted Constituents					
¸ Significant Benefit		Û Partial Benefit		¹ Low or Unknown Benefit	
¸ Sediment	¹ Heavy Metals	¹ Floatable Materials	Oxygen Demanding Substances		
¸ Nutrients	¸ Toxic Materials	¹ Oil & Grease	¸ Bacteria & Viruses	¹ Construction Wastes	

Description

Small farms, pastures, cropland, and other agricultural lands are potential sources of water quality degradation from a number of factors, particularly when located near a natural stream, storm drainage system, or other runoff conveyance. Common-sense approaches will minimize water quality impacts, improve neighborhood relationships, and satisfy legal obligations. Potential impacts include: soil erosion, overuse of chemicals such as pesticides and fertilizers, animal waste discharges, meat or dairy processing activities, etc.

Approach

Large and medium farms are governed by state rules and regulations from the Tennessee Department of Agriculture (TDA) and the Tennessee Department of Environment and Conservation (TDEC). In particular, TDA and TDEC focus on certain land uses defined as an Animal Feeding Operation (AFO) or a Concentrated Animal Feeding Operation (CAFO). See the TDEC permit Web site at http://www.state.tn.us/environment/permits/ and the TDA Web site at http://www.state.tn.us/agriculture/ for definitions and permit requirements.

Small farms and agricultural lands must also meet the basic state standards for not polluting waters of the state, creating a public nuisance, or harming the environment and wildlife. Common-sense solutions to protect storm water quality involve the efficient use of land, materials, and topography — the very things that farmers strive for. Good housekeeping procedures and storage methods will greatly reduce the potential for storm water pollution, leaks, and spills.

Due to federal mandates, Memphis and Shelby County Storm Water Ordinances prohibit discharge of soil, sediment, chemicals, debris, animal or human wastes (see IC-01, Non-Storm-Water Discharges to Storm Drains) into streets, ditches, storm drains, creeks, and streams. This prohibition includes chlorinated water, any soil or mulch, fertilizers, pesticides, nutrients such as fertilizer and lime, animal wastes, hay or straw clippings, meat or dairy processing wastes, etc. In addition to being toxic, these substances change the pH, oxygen, and turbidity of natural creeks and streams. Damage from toxic materials can take months or years to accumulate

Guidelines

Þ Create buffer zones near natural creeks, streams, wetlands, public waterways, and drainage ditches. A typical buffer zone width of 25 feet will allow grass, trees, and shrubs to protect waterways by filtering sediments, absorbing nutrients, and reducing toxic substances, and heavy metals.

Þ When using natural streams and creeks as a source of water for animals, limit the potential for animals to urinate or defecate directly into the water. Reduce potential for animals to cross the creek or waterway repeatedly, or to otherwise disturb the channel by causing erosion. Locate fences to protect waterways.

Þ Plan all activities and operations to minimize the potential for storm water contact, spills, leaks, and exposure to the weather. It may be helpful to create a property map that shows the location of all creeks, streams, wetlands, sinkholes, and drainage ditches in relation to pastures, crops, buildings, barns, and other structures. Limit the amount and types of activities that occur in floodplains or flooded areas.

Þ Store materials and supplies away from the weather, typically either inside a structure (shed, barn) or protected with tarps. Construct a small bermed or depression area on the downstream side to prevent offsite movement of loose bulk materials.

Þ Store animal wastes (manure) at locations away from creeks, drainage channels, ponds, sinkholes and other environmentally sensitive areas. Minimize potential for storm water impact if possible by storing under a tarp or roof (such as a barn).

Þ Do not use more water than the soils and crops can absorb. Excess water damages the plowed cropland by washing away the nutrients and soil. Lower the flow rate and increase watering time as necessary to avoid overland discharge.

Þ Use herbicides, pesticides, and fertilizers responsibly in accordance with manufacturer's instructions. Do not overapply these hazardous materials; this would be the equivalent of pouring toxic chemicals directly into the natural streams and creeks. Herbicides and pesticides should be applied after rainfall or watering occurs, and a dry period of a few days is expected.

Maintenance

- Þ Review farm operations regularly to ensure that storm water pollution is not occurring. The farm operator or landowner should occasionally inspect the property during large rainfall events to become aware of drainage problems.

- Þ Maintain records for hazardous materials and chemicals (such as quantity purchased, instructions, chemical name, etc). Properly control all materials using responsible farm management principles.

Related BMPs

These BMPs are also related to farm management and agricultural lands:

AM-01	Employee Training (with a table for waste disposal alternatives)
AM-13	Pesticides, Herbicides, and Fertilizer Use
ES-04	Gradient Terraces and Silt Trenches
ES-05	Surface Roughening
IC-01	Non-Storm-Water Discharges to Storm Drains
IC-02	Outdoor Loading and Unloading of Materials
ST-05	Filter Strips and Swales

References

31, 32 (see BMP Manual Chapter 10 for list)

TDA Web site — http://www.state.tn.us/agriculture — Forestry BMP rules, pesticides

TDEC Web site

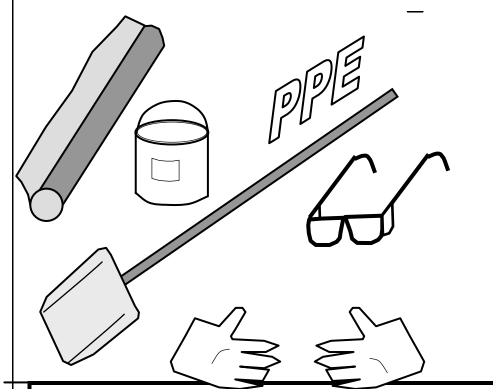
http://www.state.tn.us/environment/permits — CAFO general permit

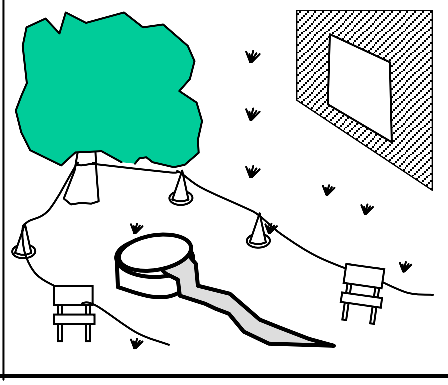
UT Agricultural Extension Service

http://www.utextension.utk.edu/

Farm management, pest management, environment, and natural resources

ACTIVITY: Response to Sanitary Sewer Overflows	IC – 14





Targeted Constituents

Significant Benefit		Partial Benefit	Low or Unknown Benefit	
¹ Sediment	¹ Heavy Metals	Û Floatable Materials	¸ Oxygen Demanding Substances	
¸ Nutrients	Û Toxic Materials	¹ Oil & Grease	¸ Bacteria & Viruses	¹ Construction Wastes

Description

This BMP is intended to describe the general procedures and precautions necessary when responding to sanitary sewer overflow (SSO) incidents. **<u>Citizens should report SSOs directly to the wastewater system operator for immediate response.</u>** Wastewater system employees receive training and equipment necessary to handle SSO incidents using procedures that meet state and local guidelines.

<u>Wastewater system operator</u>	**<u>Telephone # to report SSOs</u>**
City of Memphis Sanitary Sewer	**529-8025**
Shelby County Wastewater Management	**301-5801**

<u>Wastewater system employees will respond to reported SSO incidents</u> and follow procedures that meet state and local guidelines. These guidelines are intended as the minimum standards for SSO response by various wastewater system operators. Large industrial/commercial facilities may have the resources of responding to blocked sanitary laterals in a safe and effective manner.

Approach

The primary objective in SSO response shall be to protect human health, private and public property, and the environment. It is a known fact that sanitary sewage may contain viruses, bacteria, and other pathogens that are harmful to human and animal life. All practical steps must be taken to prevent the general public from having direct contact with areas contaminated by raw untreated sewage.

The wastewater system operator is responsible for posting signs and barricades as soon as possible to warn the general public about SSO occurrences. Restrict access to the contaminated areas. In addition, SSO responders should be aware of indirect exposures (through pets, birds, flies, mosquitoes, etc.) and take steps to prevent or reduce these exposures.

An SSO discharge is a direct violation of the National Pollutant Discharge Elimination System (NPDES) permits issued to each of the wastewater system operators. In addition, the SSO discharge also violates the NPDES municipal storm water permits issued to the City of Memphis and Shelby County by the Tennessee Department of Environment and Conservation (TDEC).

SSO Response Guidelines

<u>Personal Protective Equipment (PPE)</u>

Þ Wastewater system employees who respond to an SSO incident should wear appropriate personal protective equipment (PPE) to prevent any contact with raw sewage. PPE may include: rubber gloves, rubber boots, impermeable coveralls (usually Tyvex), and protective headwear with a splash shield.

Þ Leather gloves and leather boots are not adequate PPE for wastewater system employees. Leather is easily contaminated and cannot be cleaned; discard leather gloves and boots if they have been exposed to raw sewage.

Þ Maintain adequate PPE supplies for each responding crew. Replace PPE as necessary during cleanup operations to ensure employee protection. Place used PPE into sealed bags for decontamination or disposal at a later time.

Þ In addition to adequate PPE supplies, each responding crew should be equipped with tools (shovels, rakes, pumps, hoses), damming materials (plugs, blocks, plastic sheeting, straw bales, sandbags), testing equipment, and decontamination chemicals (typically lime).

Recommendations to Limit and Control Exposures

Þ Plan response activities and operations to prevent or minimize storm water contact. Identify the sources of raw sewage and probable causes. Determine the best manner to contain and reduce the area of SSO contamination. Field crew supervisors are expected to use their best judgment in controlling SSO discharges.

Þ Immediately protect nearby drainage structures (ditches, channels, curbs, drop inlets, culverts, natural streams and ponds, detention basins, etc.), from receiving raw sewage to the greatest extent possible. Available materials to contain SSOs include: pipe plugs, plastic or wood blocks, sandbags, straw bales, plastic sheeting, or dirt berms.

Þ In instances with large flows, the responding crew may immediately choose to create dirt berms to control the SSO discharge. Or it can even be beneficial to use an existing storm water detention basin to contain

SSO discharges by plugging the detention outlet structure. The goals are to: 1) reduce exposure to humans, 2) protect property and the environment, and 3) reduce the extent of contaminated areas which need to be cleaned.

Þ Eliminate the SSO if possible by:

— Directly removing blockages from the sanitary sewer line or manhole (if a blockage is clearly indicated).

— Pumping sewage into a sewage tank trunk until the overflow stops, for later disposal at another sanitary sewer manhole or at wastewater treatment plant.

— Pumping sewage downstream into the nearest downstream manhole at a location where the sanitary sewer line is properly functioning.

Cleanup and Decontamination

Þ After the SSO has been eliminated, then reclaim raw sewage from contaminated areas such as ground depressions, ditches, curb inlets, culverts, etc. Portable pumps and hoses can be used to collect raw sewage into sewage trucks. **Do not wash SSO discharges into the storm drainage system while cleaning SSO residues;** this is a violation of the City Storm Water and Street Ordinance and will be subject to penalties and other legal action.

Þ Remove **all** solid materials and residues that were discharged during an SSO. Solid materials include, but are not limited to: feces, toilet paper, personal hygiene products, napkins, food products, congealed grease or fat, soap residue, etc. Unfortunately, almost any type of material conceivable can be placed into the sanitary sewer system by the general public (limited only by size).

Þ Decontaminate areas with lime or other disinfectant as needed. Apply the correct amount of disinfectant. Do not allow disinfectant to enter ditches, storm drains, or natural streams. **Do not discharge lime into any flowing channels.**

Þ Important — Lime and other disinfectants are generally fatal to aquatic organisms, birds, pets, and other animals. Only use as much lime as needed. Prevent lime from entering ditches, storm drains, or flowing water. Field crews shall use their best judgment on the use and quantity of lime. Protection of human health is the highest priority.

Þ Contaminated areas with prolonged exposure to SSOs may need to be excavated, regraded, or replanted to fully repair SSO damage. Return site conditions so that human and animal contact with contaminated soils will not pose a health problem.

- Þ Remove signs and barricades only after the contaminated areas are safe again for human contact.

Maintenance

- Þ Wastewater system operators are required to maintain and repair sanitary sewer lines in a timely manner. SSO discharges are not allowable under NPDES permits, and must be prevented to the maximum extent possible.

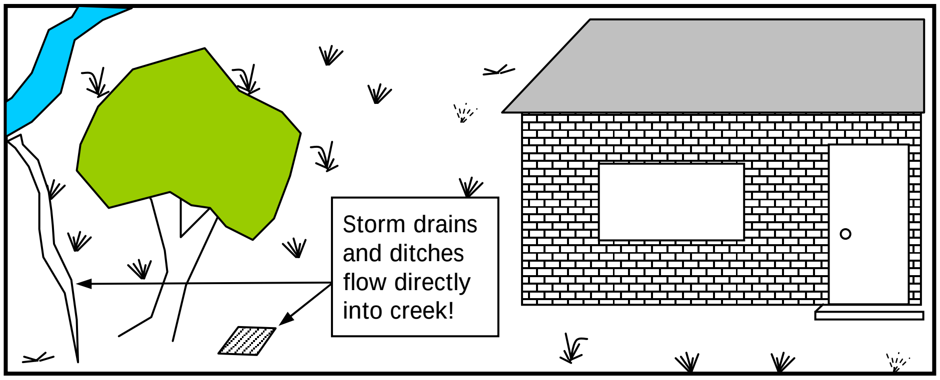
- Þ If the cause of an SSO discharge has compromised the ability of the sanitary sewer system to function, then the system should be repaired immediately to prevent a reoccurrence of the SSO.

References

170, 182, 195, 197 (see BMP Manual Chapter 10 for list)

Also, fecal coliform total maximum daily load (TMDL) reports (of which there are several written for streams Memphis and Shelby County), written by TDEC

ACTIVITY: Non-Storm-Water Discharges to Storm Drains — RH – 01



Targeted Constituents

¸ Significant Benefit   Û Partial Benefit   ¹ Low or Unknown Benefit

¸ Sediment	¸ Heavy Metals	¸ Floatable Materials	¸ Oxygen Demanding Substances	
¸ Nutrients	¸ Toxic Materials	¸ Oil & Grease	¸ Bacteria & Viruses	Û Construction Wastes

Description

Citizens, residents, and property owners in Memphis and Shelby County have the largest impact on the local streams and creeks. Most of the creeks, drainage channels, and storm water drains are located on private property. By eliminating pollution and protecting the quality of storm water runoff, our streams and creeks will again support fish and other wildlife. It is important to protect storm water quality since most city parks and recreation areas are located adjacent to streams and creeks.

Memphis and Shelby County are required by the Tennessee Department of Environment and Conservation (TDEC) to reduce various types of pollution. As part of the 1987 Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) was created with enforcement rights assigned to state governments. TDEC issued NPDES permits to Memphis and Shelby County that require storm water quality data to be reported annually to TDEC.

Objective

Citizens, residents, and property owners must be aware that almost all discharges (solid or liquid) to a storm drain system, ditch, swale, creek, stream or curb inlet, or any ground surface that drains to a storm drain system are illegal and expressly prohibited. Contact the Storm Water Hotlines at 576-6721 (City of Memphis) or 545-3870 (Shelby County) to report illegal discharges, dumping, or storm water pollution Related BMPs include:

AM-01, Employee Training
Table AM-01-01, Quick Reference for Disposal Alternatives
IC-01, Non-Storm-Water Discharges to Storm Drains

Approach

The principal goal of this BMP is to eliminate all substances (liquid or solid) that do not belong in storm water. The current Memphis and Shelby County Storm Water Ordinances, links to which are included at www.stormwatermatters.com, specifically describe the allowable discharges into storm water; all other discharges are prohibited. Severe penalties and fines can be assessed for each incident. The following non-storm-water discharges are allowable:

(1) Potable water
(2) Potable water line flushing
(3) Air-conditioning condensate
(4) Discharges from emergency firefighting activities and exercises (a storm water pollution prevention plan should be prepared to address discharges or flows from firefighting only where such discharges are identified as significant sources of pollutants to waters of the United States)
(5) Uncontaminated water from crawl space, pumps or footing drains
(6) Lawn watering
(7) Residential car and boat washing
(8) Dechlorinated swimming pool water
(9) Materials placed as part of an approved habitat restoration or bank stabilization project
(10) Rising ground waters, uncontaminated ground water infiltration, uncontaminated pumped ground water, uncontaminated springs, diverted stream flows; riparian habitats and wetlands
(11) Flows from riparian habitats and wetlands
(12) Common practices for water well disinfections
(13) Discharges within the constraints of a National Pollutant Discharge Elimination System (NPDES) permit from the Tennessee Department of Environment and Conservation (TDEC)
(14) Unless otherwise prohibited by this ordinance, any discharge that could be made directly to waters of the state without a federal or state permits being required
(15) Dye testing in compliance with section 30-28(b)
(16) Other types of discharges as determined by the manager

(Order No. 292, § 30-109, 12-6-04)

<u>The following non-storm-water discharges are explicitly prohibited by Memphis and Shelby County Storm Water Ordinances.</u> The list of prohibited discharges is not all-inclusive since any type of discharge not specifically exempted (see list of 16 items above) is prohibited. In other words, these are only the more commonly observed violations.

(1) Trash or debris
(2) Construction materials
(3) Petroleum products including but not limited to oil, gasoline, grease, fuel oil, or hydraulic fluids
(4) Antifreeze and other automotive products
(5) Metals in either particulate or dissolved form
(6) Flammable or explosive materials
(7) Radioactive material
(8) Batteries, including but not limited to, lead acid automobile batteries, alkaline batteries, lithium batteries, or mercury batteries
(9) Acids, alkalis, or bases
(10) Paints, stains, resins, lacquers, or varnishes
(11) Degreasers and/or solvents
(12) Drain cleaners

(13) Pesticides, herbicides, or fertilizers
(14) Steam cleaning wastes
(15) Soaps, detergents, or ammonia
(16) Swimming pool backwash including chlorinated swimming pool discharge
(17) Chlorine, bromine, and other disinfectants
(18) Heated water
(19) Animal waste from commercial animal or feeder lot operations
(20) Any industrial and sanitary wastewater, including leaking sewers or connections
(21) Recreational vehicle waste
(22) Animal carcasses
(23) Food wastes
(24) Medical wastes
(25) Collected lawn clippings, leaves, branches, bark, and other fibrous materials
(26) Collected silt, sediment, or gravel
(27) Dyes, except as stated in subsection (b)
(28) Chemicals, not normally found in uncontaminated water
(29) Any hazardous material or waste, not listed above
(30) Washing of fresh concrete for cleaning and/or finishing purposes or to expose aggregates
(31) Junk motor vehicles, as defined in subsection (c)
(32) Liquid from solid waste disposal containers

Penalties for minor discharges that have no significant adverse impact on the safety, health, welfare of the environment, or the functionality of the county's storm water collection system may be waived at the discretion of the manager.

- Dye testing is allowed but requires verbal notification to the manager a minimum of 24 hours prior to the date of the test. The City of Memphis and Shelby County governmental agencies are exempt from this requirement.

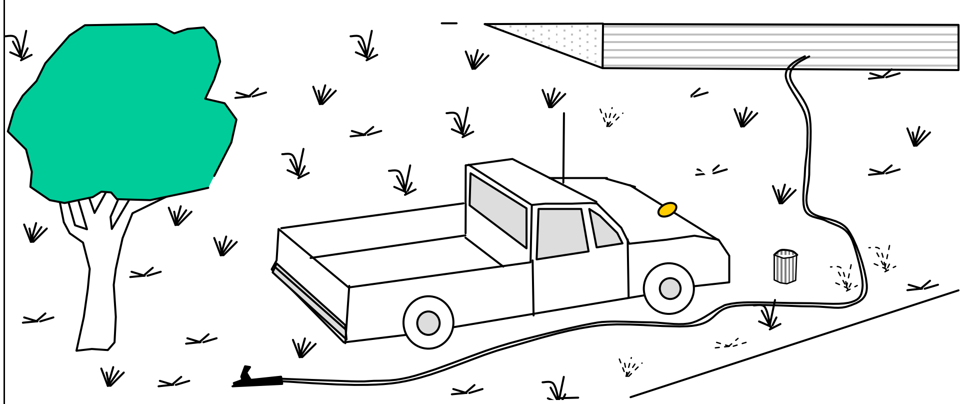
- Junk motor vehicle means any vehicle that shall include by way of example, but not be limited to, the following vehicle types: automobiles, construction equipment, motorcycles, and trucks, and that meets all of the following requirements:

  — Is three years old or older
  — Is extensively damaged, such damage including, but not limited to any of the following: a broken window or windshield or missing wheels, engine or transmission
  — Is apparently inoperable
  — Is without a valid current registration
  — Has a fair market value equivalent only to the value of the scrap in it

(Order No. 292, § 30-108, 12-6-04)

References **30, 31, 33, 34, 35, Memphis and Shelby County Storm Water Ordinances** (see BMP Manual Chapter 10 for list)

ACTIVITY: Vehicle Washing — RH – 02



Targeted Constituents				
¸ Significant Benefit		Û Partial Benefit	1 Low or Unknown Benefit	
Û Sediment	Û Heavy Metals	1 Floatable Materials	Û Oxygen Demanding Substances	
Û Nutrients	Û Toxic Materials	Û Oil & Grease	1 Bacteria & Viruses	1 Construction Wastes

Description

Reduce pollutants from cars, trucks, and other personal vehicles in order to protect natural streams and creeks. Pollutants, such as detergents and dirty wash water, must always be prevented from directly discharging to streams, creeks, ditches, and storm drains. In addition, pollutants should be prevented from running off the land and impervious surfaces due to precipitation and storm water.

Approach

Washing personal vehicles (cars, trucks, vans, motorcycles) has a very high potential for polluting streets, storm drains, streams, creeks, wetlands, and other natural water bodies. Vehicles accumulate the various products and emissions generated by gasoline and diesel fuel combustion (particularly in the engine area and underneath the frame).

- Vehicles contain large amounts of fluids that leak slowly from the engine, or may escape from a rupture, or spill during a vehicle collision. Fluids such as engine oil, transmission fluid, radiator coolant, battery acids, and brake fluid all have special properties due to their chemical formulation. All of these fluids are poisonous to plants, trees, insects, wildlife, fish, etc., and must be reduced as much as possible.

- Vehicles contain moving parts that wear down. Small pieces of the tires are continually being worn down and left on streets and roadways. Brakes and brake pads are designed purposely to erode and grind in a way to minimize vehicle maintenance. Small pieces of the brake pads (containing asbestos and metals) are being worn down continually and deposited on streets and roadways.

- <u>Detergents are harmful to fish and other aquatic life.</u> Many cleaning substances are toxic to aquatic life and result in fish kills. Reduce or eliminate the use of detergents and cleaners while washing vehicles. Wash vehicles on lawns or grassy areas to reduce direct discharge of wash water to curbs, inlets, ditches, and other waterways.

Prohibition to Discharge

Due to federal mandates, Memphis and Shelby County have adopted Storm Water Ordinances to prohibit the discharge of chemicals and man-made materials into creeks, streams, ditches, swales, pipes, storm drains, and parts of the city drainage system. See the BMP entitled RH-01, Non-Storm-Water Discharges to Storm Drains, for a complete list of allowable discharges; anything else is strictly prohibited. This prohibition includes all types of automotive fluids, whether discharged directly into a stream or storm drain, or discharged indirectly upon the ground surface. In addition to fines and legal action from the City of Memphis and Shelby County, the state government through the Tennessee Department of Environment and Conservation can also assess severe penalties for polluting waters of the state (defined as any blue-line stream on a U.S. Geological Survey quadrangle topographic map) or any storm drainage system that leads to waters of the state.

Vehicle Washing

It is legal to discharge water when washing individual cars on residential property. This is one of the allowable discharges listed in RH-01 (Non-Storm-Water Discharges to Storm Drains) and also in the City of Memphis and Shelby County Storm Water Ordinances. It is also legal to discharge water when holding a carwash event over a period of two days or less for the purpose of charity, nonprofit fund-raising, or similar noncommercial purpose. However, it is illegal to discharge wash water or rinse water that adversely affects the water quality of a creek or stream, even if otherwise allowable according to ordinance.

It is suggested that city residents minimize the amount of soap and detergents that are used in wash water. Extremely dirty or grimy vehicles should generally be cleaned using a commercial carwash, which is required to treat all wash water and rinse water to certain standards. Some detergents and soaps may actually harm automotive paint and wax finishes to the degree that many vehicle manufacturers recommend washing with water only. Commercial carwashes generally mix a waxing agent in the rinse water that is beneficial to some automotive paints.

A carwash or commercial vehicle washing facility is strictly prohibited from discharging water into streams, creeks, ditches, pipes, culverts, or storm drains. This includes, but is not limited to: automobile dealers, automotive repair shops, industrial or commercial plants with vehicle washing stations, construction sites, or any location that is not a personal residence.

Residents may want to wash vehicles on lawns or other pervious ground surfaces, or at least direct the discharge of wash water and rinse water into grassy areas. Avoid discharging large amounts of chlorinated city water directly to storm drains or streams. Reduce the amount of chlorinated water by turning off the hose when not needed. Relatively small amounts of chlorinated water can be toxic to the fish and other aquatic organisms, especially during dry weather.

Detergents affect the gill membranes of fish and adversely affect other aquatic life. Minimize the use of detergents, and dispose of soapy water indoors in a sink or drain. Even phosphate-free, biodegradable soaps have been shown to be toxic to fish before the soap degrades. Avoid the use of solvents and other toxic chemicals.

Do not wash engines, undercarriages, transmissions, or automotive parts near streams, creeks, storm drains, ditches, or impervious surfaces such as driveways and streets. Carefully control and dispose of engine wash water in a manner that does not pollute streams or the environment. Dirty engines and undercarriages should generally be cleaned at well-equipped commercial facilities to prevent pollution.

Related BMPs

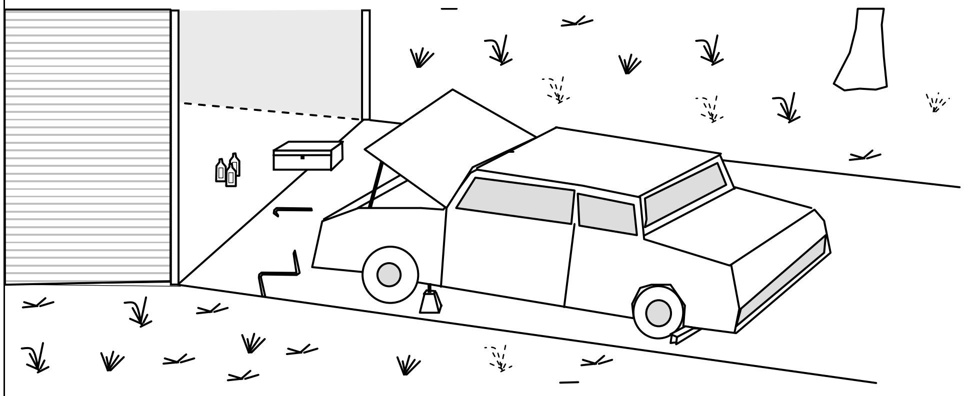
Consult the following list of related BMPs for disposal options and other guidance:

Table AM-01-1	Quick Reference for Disposal Alternatives
AM-14	Vehicle and Equipment Cleaning
RH-01	Non-Storm-Water Discharges to Storm Drains
RH-03	Vehicle Maintenance and Repairs

References

30, 31, 33, 34, 35, 98, 99, 103, 113, 138 (see BMP Manual Chapter 10 for list)

ACTIVITY: Vehicle Maintenance and Repairs	RH – 03



Targeted Constituents

¸ Significant Benefit   Û Partial Benefit   ¹ Low or Unknown Benefit

Û Sediment	¸ Heavy Metals	¹ Floatable Materials	Û Oxygen Demanding Substances	
¹ Nutrients	¸ Toxic Materials	¸ Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description

Prevent pollutants and automotive fluids from directly discharging to streams, creeks, ditches, and storm drains. In addition, pollutants should be prevented from accumulating on impervious surfaces in order to improve storm water quality and protect natural streams and creeks.

Approach

Personal vehicles (cars, trucks, vans, motorcycles) have a very high potential for polluting streets, grassy areas, streams, creeks, and the air that we breathe.

- Vehicles contain large amounts of fluids that could leak slowly from the engine or may escape from a ruptured hose. Fluids such as engine oil, transmission fluid, radiator coolant, battery acids, and brake fluid all have special properties due to their chemical formulation. All of these fluids are poisonous to plants, trees, insects, wildlife, fish, etc., and must be reduced or eliminated as much as possible. Repair automotive leaks immediately.

- Incomplete combustion of gasoline and diesel fuels is a major contributor to air pollution. There is a high level of concern in state and federal governments for air quality and ozone levels in Memphis. Please keep personal vehicles in good condition to reduce air pollution. The state of Tennessee currently does not require statewide vehicle inspections or emission testing; however, the City of Memphis does require this testing.

- Vehicles contain moving parts that wear down, such as tires and brake pads. Brakes and brake pads are designed purposely to erode and grind in a way to minimize vehicle maintenance. Small pieces of tires and brake pads (containing asbestos and metals) are continually being deposited on streets and roadways.

Prohibition to Discharge

Due to federal mandates, Memphis and Shelby County have adopted Storm Water Ordinances to prohibit discharge of chemicals and man-made materials into creeks, streams, ditches, swales, pipes, storm drains, and any surface that drains into these waterways. See BMP RH-01, Non-Storm-Water Discharges to Storm Drains, for a list of allowable discharges; anything else is strictly prohibited.

This prohibition includes all types of automotive fluids, whether discharged directly into a stream or storm drain, or discharged indirectly upon the ground so that the automotive fluid could wash away as storm water runoff at a later time. In addition to fines and legal action from Memphis and Shelby County, the state government Tennessee Department of Environment and Conservation (TDEC) can also assess severe penalties for polluting waters of the state (defined as any blue-line stream on a U.S. Geological Survey quadrangle topographic map) or any storm drainage system.

It is also illegal to discharge automotive fluids into a sinkhole, or to allow these fluids to soak into the ground. Sinkholes and known areas of groundwater recharge are also included as waters of the state, for which TDEC, the City of Memphis and Shelby County will assess penalties and take legal actions.

Disposal Options

Many automotive parts stores and repair shops will accept engine oil and other fluids for recycling. Ask about recycling when you purchase automotive parts and fluids. A comprehensive list of oil and fluids recycling locations is available through links at www.stormwatermatters.com. The recycling center and waste transfer station that accept used automotive fluids.

Vehicle Repairs

It is recommended that most city residents should take advantage of commercial repair shops and oil-change facilities. Home repair and maintenance may be performed if the home owner/resident has adequate knowledge and tools for the task, materials to control spills and leaks, and proper safeguards to properly protect natural streams, storm drains, drainage ditches, and the environment in general.

Purchase the correct automobile parts when making repairs or performing regular vehicle maintenance. Consult automotive repair manuals in order to perform the work quickly and efficiently. Use a funnel whenever pouring liquids such as motor oil, brake fluid, or coolant. Drain hoses prior to removing or adjusting them; in most cases the liquid can be reused. Drain pans and drop cloths are essential items when changing oil or other automotive fluids. Be sure to use some type of drain pan when unclipping hoses, unscrewing filters, or removing other parts. In general, use dry methods such as rags and absorbent material (kitty litter) to clean spills and leaks. Do not wash spills onto the ground or any surface that drains to the city storm water drainage system or to natural creeks and streams. Sweep or mop any spills or leaks promptly. Keep spill containment materials nearby.

Use nontoxic materials when possible. For instance, baking soda is used for cleaning battery terminals and clamps. Do not mix used motor oil with solvents. Do not mix chlorinated solvents with nonchlorinated solvents such as kerosene or mineral spirits.

Other Vehicle BMPs

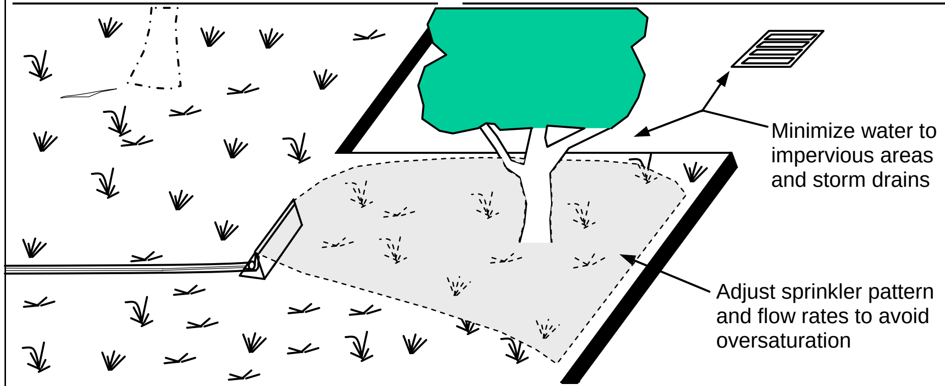
The following Activities & Methods BMPs are applicable to everyone who operates or maintains a vehicle, including as businesses, industries, home owners, automotive dealers, repair shops, garages, etc. The BMPs contain many specific requirements and guidelines for care and maintenance of vehicles.

Table AM-01-1	Quick Reference for Disposal Alternatives
AM-07	Spill Prevention and Control
AM-08	Waste Management and Recycling
AM-15	Vehicle and Equipment Fueling
AM-16	Vehicle and Equipment Maintenance and Repair

References

19, 20, 22, 30, 31, 33, 34, 35, 43, 98, 99, 100, 103, 108, 113, 127, 138
(see BMP Manual Chapter 10 for list)

ACTIVITY: Landscape Irrigation and Lawn Watering — RH – 04



Targeted Constituents				
¸ Significant Benefit		Û Partial Benefit	¹ Low or Unknown Benefit	
¹ Sediment	¹ Heavy Metals	¹ Floatable Materials	Û Oxygen Demanding Substances	
¸ Nutrients	¸ Toxic Materials	¹ Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description

Prevent or reduce the discharge of pollutants from sprinklers and landscaping water in order to protect natural streams and creeks. Runoff is reduced by decreasing the flow rate, by applying water in a more controlled manner, and by closely monitoring sprinklers.

Approach

During dry summer months in the Memphis area, it is not unusual to go a few weeks without rainfall. Many homes and businesses determine that watering lawns and other vegetation is a necessity. In addition to lawns and trees, water is needed for golf courses, flower and vegetable gardens, nurseries, and landscaped parking lot islands.

Pollution occurs when landscaping water produces runoff to the storm drainage system. Typical pollutants include herbicides, pesticides, fertilizers, and mulch. In addition, most watering is done with chlorinated utility water. Chlorinated water must not be discharged to creeks and streams because it kills aquatic life. Runoff from several overwatered lawns will kill fish and other aquatic organisms in a small creek. Overwatering is more likely to occur during the dry summer periods, which is when streams have lower flows and the chlorine dosages have more effect.

Due to federal mandates, Memphis and Shelby County adopted the Storm Water Ordinances to prohibit all discharges of chemicals, man-made materials, and soils (see RH-01, Non-Storm-Water Discharges to Storm Drains) into streets, ditches, storm drains, and natural streams. This prohibition includes chlorinated water, any soil or mulch, chemicals such as fertilizers and pesticides, and nutrients such as fertilizer and lime. In addition to being toxic, these substances also change the pH and turbidity of natural streams and creeks. Damage from toxic materials is not necessarily immediate but can take months or years to accumulate.

Guidelines

Þ Avoid discharging water onto impermeable surfaces such as paved driveways, roads, and parking lots. Direct water onto soil and lawns by using a correctly sized sprinkler with the right spray pattern. Sprinklers can be selected at a reasonable cost for round areas or long areas, with adjustable patterns, timers, and other settings.

- Þ Do not use more water than the plants and soil can absorb. Slowly watering plants at a rate that allows water to soak into the soil is much healthier for vegetation. Excess water damages the lawn or landscaped area by washing away the nutrients and soil. Lower the flow rate and increase watering time as necessary to avoid discharging water to the storm water drainage system.

- Þ Monitor watering activities and correct as necessary. Stop watering as soon as runoff leaves the landscaped area, which indicates saturated conditions. Adjust sprinklers to cover all areas evenly; use a variety of sprinkler patterns as needed.

- Þ Do not leave watering activities unattended. Unfortunately, many businesses feel that sprinklers are best operated overnight when the establishment is closed. Watering will be effective for a few hours, but the ground usually becomes saturated by nightfall. Afterwards, the sprinkler system is ineffective and almost all of the chlorinated water goes directly to the storm water drainage system.

- Þ Use herbicides, pesticides, and fertilizers responsibly in accordance with manufacturer's instructions. Do not overapply these hazardous materials; this would be the equivalent of pouring toxic chemicals directly into the natural streams and creeks. Herbicides and pesticides should be applied after rainfall or watering occurs, and a dry period of a few days is expected. Fertilizer and lime may be applied prior to light watering.

- Þ Construct a small berm, depression area, or curb on the lower side of landscaped areas. Minor grading modifications can also be performed to allow excess water to collect and soak into the soil instead of being wasted in the storm drains. Use native trees and shrubs when possible; native vegetation is usually more resistant to drought than ornamental trees.

- Þ If possible, avoid using chlorinated water for landscaping. Use rain barrels, cisterns, ponds, or other methods for capturing storm water. Or, allow chlorinated water to stand in an open container for a day or so, prior to being used for landscaping irrigation. Chlorine naturally escapes from chlorinated water as a gas at a rate that is subject to temperature, sunshine, and wind conditions. A simple swimming pool test kit can be used to detect chlorine. Once the dechlorination time has been established, further use of the chlorine test kit is usually not needed.

Maintenance

Monitor watering operations closely. Adjust watering rates and patterns to avoid runoff to storm drainage systems, curb inlets, ditches, natural creeks and streams, ponds, wetlands, etc. Repair damaged or incorrectly installed sprinklers. Repair leaking hoses and valves.

Limitations

- Þ Extra effort and attention is required to monitor landscape watering. Sprinklers and other equipment should have the correct size and configuration to accomplish the intended purpose without overwatering.

- Berms, curbs, or other grading modifications will require additional space for ponding water. Berms and grading modifications may affect the symmetry of landscape designs in very minor ways.

Related BMPs

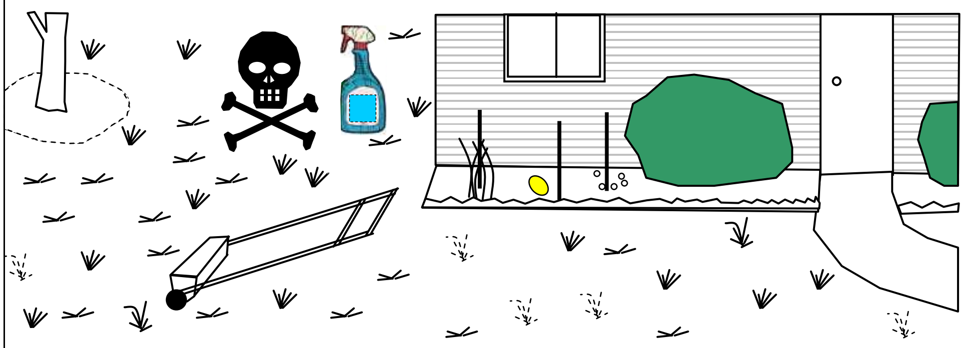
Other topics and aspects of landscape irrigation and lawn watering are included in these related BMPs:

AM-01	Employee Training — with a table for waste disposal alternatives
AM-13	Pesticides, Herbicides, and Fertilizer Use
ES-07	Mulch
ES-10	Trees, Shrubs, and Vines
RH-01	Non-Storm-Water Discharges to Storm Drains

References

32, 103 (see BMP Manual Chapter 10 for list)

ACTIVITY: Pesticides and Fertilizers — RH – 05



Targeted Constituents

¸ Significant Benefit   Û Partial Benefit   ¹ Low or Unknown Benefit

¹ Sediment	Û Heavy Metals	¹ Floatable Materials	¸ Oxygen Demanding Substances	
¸ Nutrients	¸ Toxic Materials	¹ Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description Use efficient and safe housekeeping practices (storage, use, and cleanup) when handling potentially harmful materials such as fertilizers, herbicides, and pesticides. Misuse and overuse leads to storm water pollution, poisons, and toxic substances in Memphis and Shelby County creeks and streams. Only use fertilizers and pesticides when necessary, and consider alternative methods and treatments if available.

Approach Fertilizer management involves control of the rate, timing, and method of application to minimize the chance of polluting surface water or groundwater. Pesticide and herbicide management involves eliminating excessive pesticide use, using proper application procedures, and considering alternatives to chemical control to reduce the amount of pesticides and herbicides in storm water runoff.

The use of fertilizers, herbicides, and pesticides contributes to pollution of storm water runoff. Residential users of these products tend to overapply by a factor of several times. Carefully read the instructions for application rates, recommended application equipment, and seasonal methods. See AM-13, Pesticides, Herbicides, and Fertilizer Use, for additional considerations and application instructions for various types of materials such as dusts, sprays, granular formulations, and fumigants.

In many cases, these products may not be essential for a productive lawn or garden. Selection of low-maintenance vegetation reduces the need for fertilizers, pesticides, and herbicides. University of Tennessee Agricultural Extension Service has many brochures and pamphlets concerning fertilizers and pesticides, including various environment-friendly alternatives. These pamphlets are available at the Agricenter or online at: http://www.utextension.utk.edu/publications/.

More information on pesticides is available from the U.S. Environmental Protection Agency Office of Prevention, Pesticides & Toxic Substances: http://www.epa.gov/opptsmnt/.

Fertilizers

Þ Do not apply fertilizer when immediate rainfall is expected. Apply fertilizer only when there is already adequate soil moisture and little likelihood of immediate heavy rainfall. After applying fertilizer, lightly sprinkle the lawn or garden. A soil test is recommended to determine the optimum lime and fertilizer application rates.

Pesticides and Herbicides

Þ Excessive application and misuse of pesticides and herbicides results in heavily polluted storm water runoff. Avoid using pesticides and herbicides when immediate rainfall is expected. Apply pesticides and herbicides in a narrow rather than wide band; do not broadcast them over the entire lawn area. Spot-spray infested areas. Never apply pesticides and herbicides near streams, creeks, ditches, storm drains, or on impervious surfaces.

Þ Examine all alternatives to pesticides and herbicides that, in the long term, may be much less costly than the use of a particular chemical. Use the least toxic chemical pesticide or herbicide that will accomplish the purpose. Pesticides and herbicides that degrade rapidly are less likely to become storm water runoff pollutants. Use pesticides and herbicides with low water solubility. Granular formulations are generally preferable to liquids because application losses are lower.

Þ Pesticides and herbicides should be sprayed only when wind speeds are less than 7 mph. Spray in the early morning or at dusk when wind speeds are usually lowest. Air temperature should range between 40 degrees to 80 degrees Fahrenheit.

Pesticide and Herbicide Types

Þ Dusts: This type is highly susceptible to wind drift, not only when being applied but also after reaching target. The application should be performed during the early morning or late evening hours when there is little or no air movement. The distance between the application equipment and the target should be minimized.

Þ Sprays: This type may be in the form of solutions, emulsions, or suspensions. Droplet size is an important factor in determining susceptibility to wind drift. Large droplets fall faster and are less likely to contaminate nontarget areas. Sprays should be applied during periods of low air movement. Ground sprays followed by soil incorporation are not likely to be sources of water pollution unless excessive erosion occurs.

Þ Granular formulations: This type is applied to either the ground surface or below the soil surface. Surface applications may or may not be followed by soil incorporation. Pollution of surface waters from granular formulations is unlikely unless heavy runoff or erosion occurs soon after treatment. However, groundwater pollution may result from excessive leaching due to rainfall after application, depending on the pesticide composition. Loss of granular formulations can be controlled for the most part with adequate soil conservation practices.

- Fumigants: This type must be kept in place for specific lengths of time in order to be effective. Containment methods include soil compaction, water seal, and sealing of the area with a plastic cover. Most fumigants act rapidly and degrade quickly. Consequently, water pollution is usually not a problem.

- Antimicrobial paints and other surface coatings: This type is designed to resist weathering and is therefore not a likely source of pollution. Empty containers should be disposed in accordance with rules for all pesticide containers. Use extreme care when sanding or scraping surfaces that have been previously treated with these substances. Treat sanded and scraped residue as hazardous waste.

- Preplant treatments: Seed, roots, tubers, etc., are frequently treated with pesticides prior to planting. Treatment is usually by dust, slurry, or liquids. Little pollution hazard exists from this application. Care must be taken, however, in disposing of residual treatment materials and with unused plants.

- Organic pesticides: A wide variety of organic pesticides, produced from plants, bacteria, and other naturally occurring substances, are available in quantities for both commercial and residential use. These substances usually present much less risk for contamination of groundwater and surface water, and fewer problems for disposal of leftover product or containers.

- Beneficial insects: This management method involves the use of insects in bulk or in amounts suitable for residential use. It can be used alone or in combination with other pesticides to eliminate or minimize the use of toxic substances.

Good Housekeeping and Safety

- Always use caution when handling any pesticide, herbicide, or fertilizer product. Many products contain toxic chemicals that cause severe injury or death. Keep pesticide or fertilizer products securely in containers protected from storm water and away from children, pets, and sources of heat, sparks, and flames. Store products in their original containers and keep clearly labeled. Do not store chemicals in food containers.

- Read and follow use instructions provided on packaging, and in material safety data sheets (MSDS) if available. Periodically review for handling pesticides, herbicides, or fertilizers. Work only in well-ventilated areas. Avoid contact with eyes and skin. Wear gloves and eye protection when using or handling hazardous substances. Do not wear contact lenses, which can absorb hazardous vapors.

Disposal Options

Consult Table AM-01-1 for a quick reference on disposal alternatives. Questions on household hazardous waste should be directed to the Shelby County Environmental Programs Coordinator at 379-4410.

In general, use the entire product before disposing of the container. However, do not overapply the product. Do not dispose of pesticide or fertilizer wastes in any of the following methods:

- Into trash or waste containers
- Into storm drains or into creeks
- Onto the ground
- By burning

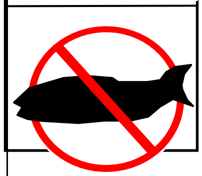
Related BMPs

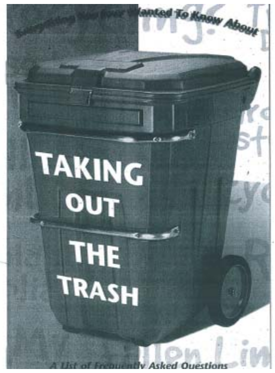
These related BMPs also provide guidance on the correct use and disposal of fertilizers and pesticides:

Table AM-01-01	Quick Reference for Disposal Alternatives
AM-08	Waste Management and Recycling
AM-13	Pesticides, Herbicides, and Fertilizer Use

References

18, 32, 33, 34, 35, 52, 53, 92, 93, 96, 97, 166 (see BMP Manual Chapter 10 for list)





Targeted Constituents

¸ Significant Benefit Û Partial Benefit ¹ Low or Unknown Benefit

¹ Sediment	¸ Heavy Metals	¹ Floatable Materials	Û Oxygen Demanding Substances	
¹ Nutrients	¸ Toxic Materials	¸ Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description

Prevent or reduce the discharge of pollutants to the storm water system or natural streams by effective management of waste materials. Primary approaches include educating of the public, proper material use, source reduction tracking waste generation and disposal, proper material storage, recycling, preventing storm water contact and runoff from waste management areas, and good waste disposal procedures.

Proper recycling is greatly encouraged by Memphis and Shelby County in order to reduce the amount of landfilled waste. Effective waste management and recycling is likely to create a significant reduction in the manner and volume of pollution that enters the city storm drainage system and natural channels.

Household hazardous waste must not be placed in the weekly curbside garbage containers or dumpsters. It is illegal to allow non-storm-water discharges to ditches, swales, curbs, storm drains, or natural creeks.

For a quick reference on disposal alternative for common household wastes, see Table AM-01-1, which is part of the Employee Training BMP fact sheet.

Consult the City of Memphis at 576-6508 or BFI at 794-3800 for the types of materials that are accepted at the Solid Waste Management Facility. In addition, contact the Shelby County Environmental Program Coordinator at 379-4410 for information about Household Hazardous Waste Collection.

Household Hazardous Wastes

A typical home contains many hazardous chemicals commonly used for cleaning, repairs, construction, automobile maintenance, lawn care, or hobbies. Often, household hazardous waste will accumulate on shelves in the garage or basement. The basic definition for a household hazardous substance is that it is toxic, poisonous, corrosive, chemically reactive, flammable, or combustible.

Some examples of household hazardous waste include:

- Adhesives
- Ammonia or bleach
- Anti-freeze
- Automotive fluids
- Batteries
- Cleaning fluids
- Detergents
- Disinfectants
- Herbicides
- Motor oil
- Oven cleaner
- Paint
- Paint thinner/remover
- Pesticides
- Solvents
- Toilet cleaner
- Wood stains and preservatives
- Fluorescent tubes and lights

Due to poisons and toxic substances, household hazardous waste should not be included in the ordinary weekly garbage collection that is collected curbside. Whenever possible, purchase nontoxic and biodegradable products. Or use natural cleaning solutions such as vinegar or lye soap. Always follow the directions on the product label, and clean up any spills immediately. In general, do not purchase more of a hazardous product than can be reasonably used.

Prohibition To Discharge

Due to federal mandates, Memphis and Shelby County have adopted a Storm Water and Street Ordinance to prohibit discharge of all chemicals and man-made materials into creeks, streams, ditches, swales, pipes, storm drains, and any surface that drains into these waterways. See BMP RH-01, Non-Storm-Water Discharges to Storm Drains, for a list of allowable discharges; anything else is strictly prohibited. This prohibition includes all types of fluids, whether discharged directly into a stream or storm drain, or discharged indirectly upon the ground. In addition to fines and legal action from the City of Memphis and Shelby County, the state government (Tennessee Department of Environment and Conservation) can also assess severe penalties for polluting waters of the state (defined as any blue-line stream on a U.S. Geological Survey quadrangle topographic map).

Solid Waste Disposal Guidelines

Residential waste disposal must follow these guidelines:

Þ No liquids may be placed in garbage carts.
Þ Ensure all wastes placed inside garbage carts are in closed plastic bags.
Þ Garbage carts must be routinely cleaned out.
Þ Yard wastes must be bagged. In no case may grass or leaves be blown or swept into the storm drainage system or into streets and roadways because such activity could cause flooding.

Recycling

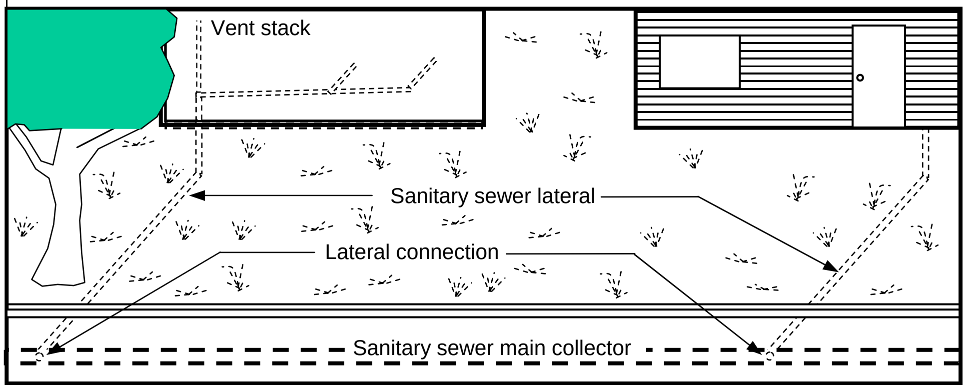
The City of Memphis and Shelby County promote recycling whenever possible and offer curbside recycling.

Related BMPs

These BMPs have additional information about waste disposal and alternatives:

Table AM-01-1	Quick Reference for Disposal Alternatives
AM-07	Spill Prevention and Control
AM-08	Waste Management and Recycling
RH-01	Non-Storm-Water Discharges to Storm Drains

ACTIVITY: Sanitary Sewer Laterals and Septic Tanks — RH – 07



Targeted Constituents				
¸ Significant Benefit		Û Partial Benefit	¹ Low or Unknown Benefit	
¹ Sediment	¹ Heavy Metals	¹ Floatable Materials	¸ Oxygen Demanding Substances	
¸ Nutrients	¹ Toxic Materials	¹ Oil & Grease	¸ Bacteria & Viruses	¹ Construction Wastes

Description

Prevent the discharge of pollutants from sanitary sewer laterals and from septic tank systems. Property owners are responsible for the inspection, maintenance, and repairs to the sanitary sewer laterals up to the connection with a sanitary sewer collector pipe. Property owners are responsible for maintenance and repairs to septic tank systems and associated drain fields.

Approach

The definition of sanitary and septic waste includes, but is not limited to, the following items:

- Human wastes
- Wastewater from toilets, sinks, dishwashers, washing machines, and other indoor plumbing fixtures
- Wastewater from kitchens and restaurants
- Wastewater from industries and commercial establishments

These types of wastes, as well as animal and pet wastes, carry harmful viruses and bacteria that spread disease. It is important to prevent direct and indirect human contact with these types of waste flows. Sanitary sewers are a vital part of American civilization and of the community health system but are seldom appreciated, noticed, or maintained.

Within Memphis and Shelby County, most waste flows are discharged into sanitary sewers that discharge to the City of Memphis waste water treatment plants.

All new development and redevelopment must be connected to a sanitary sewer system that fully treats the sewage in accordance with applicable federal and state standards for discharged effluent. Industrial plants, hospitals or nursing homes, and educational institutions may choose to construct and operate wastewater treatment plants on private property, if a National Pollutant Discharge Elimination System (NPDES) discharge permit has been obtained from Tennessee Department of Environment and Conservation (TDEC).

Sanitary Laterals

At a minimum, property owners should be aware of where sanitary sewer laterals are found on the property. Do not allow heavy vehicles or construction equipment to drive on top of sanitary sewer laterals. Do not plant large trees directly over or near sanitary sewer laterals. Large tree roots can infiltrate and eventually break a sanitary sewer lateral so that it will not function.

Inspection and Investigation

Þ The following guidelines are helpful for inspecting and maintaining sanitary sewer laterals. These guidelines will help the property owner to protect a valuable utility asset and will help to improve water quality in Memphis creeks and streams.

— Find location of sanitary sewer laterals on the property.
— Find location of sanitary sewer lateral connection to the main sewer.
— Determine approximate date of construction and materials used.
— Inspect lateral locations regularly for unusual odor or ground wetness.
— Inspect lateral locations regularly for subsidence or unusual soil color.

Þ A leaking sanitary sewer lateral may be contributing flow to a nearby storm drain, ditch, or creek. Inspect the nearest storm drain or ditch during dry weather to determine if there is a suspicious flow. Contact the Storm Water Hotlines at 576-6721 (City of Memphis) or 545-3870 (Shelby County) to report illicit discharges, spills, leaks, or suspicious sanitary sewer discharges that need to be investigated. Anonymous reports are also investigated.

Other Considerations

Þ All temporary and permanent connections to the municipal sanitary sewer system must be inspected and approved by the City of Memphis prior to installation. Contact the Memphis Sanitary Sewer Department at 576-4300 for construction procedures and testing requirements. Only use licensed plumbing contractors with adequate experience and equipment for each project.

Þ Older houses throughout Memphis and Shelby County may have cross connections where a sanitary sewer line discharges into a storm drain. There are many reasons that this may have occurred, including:

— A building contractor honestly may have misidentified the connection pipe.
— A building contractor may have taken a shortcut to save time and money.
— The storm drain contractor may have misidentified the sanitary sewer pipe.

Þ When found, cross connections must be replaced and repaired to function correctly. See IC-01, Non-Storm-Water Discharges to Storm Drains, for additional information on locating illicit discharges and cross connections. Smoke testing and dye testing are two common methods for locating leaks in the main sanitary sewer system.

Septic Tank Systems

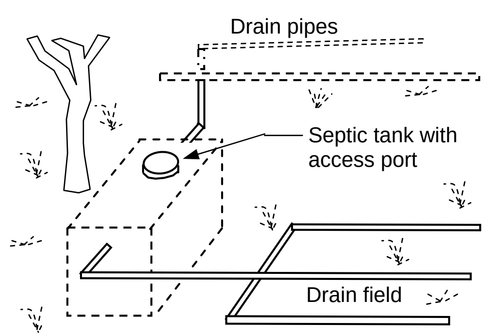
Þ Do not install an onsite disposal system (such as a septic tank) within the city limits. Septic tanks are not allowed in the City of Memphis and Shelby County, unless no municipal sanitary sewer connections are available and sufficient hardship exists to warrant a variance. Approval must be obtained from the Shelby County Health Department. A septic system must be designed by a professional engineer and located on a site development plan.

Þ Existing privately owned septic systems must be maintained in good working order. If a private septic system fails to function properly, then the owner may be required to hook into the municipal sanitary sewer system at his cost. Typically, a septic tank needs to be inspected every year and pumped out every three years.

Þ Septic systems are not designed to process large volumes of water in short time periods. Do not wash several loads of clothes consecutively and do not use excessive amounts of detergents that contain phosphorus. Do not pour household chemicals down the drain into a septic system; chemicals can kill the good microbes within the septic tank. Garbage disposals contribute to an overloading of solids in the septic tank, requiring more frequent cleanouts.

Þ Keep heavy equipment and vehicles away from septic tank and septic drain field. Do not compact soils in the septic field. Do not pave over the septic drain field. Adequate aeration and evaporation in drain field must occur for proper treatment.

Þ Inspect the septic tank and septic drain field regularly to verify that sanitary and septic waste is not being discharged inadvertently. Inspection is normally done during dry weather to determine whether a discharge occurs. See IC-01, Non-Storm-Water Discharges to Storm Drains, for methods to detect illicit discharges and leaks. Look for unusual odors, wet ground, discolored soil, subsidence, or unusual settlement.



Safety Concerns

Þ Be careful investigating sanitary sewer lines or other confined spaces where sewer gases may exist. Sanitary sewer gases can render a person unconscious before being detected by normal senses. There are many instances of people being killed by falling unconscious into an open man-hole due to sewer gases.

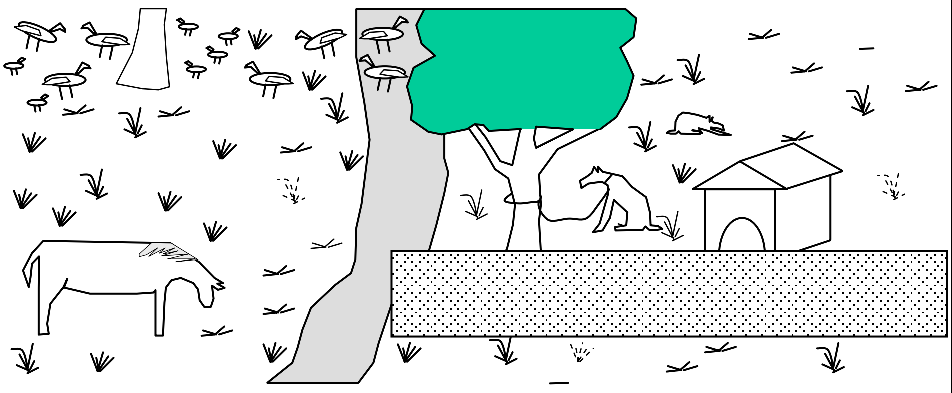
- Methane gas, along with other sewer gases, is very explosive. Keep sparks and open flames away from sewers, manholes, and septic tanks. Do not smoke near open manholes.

Related BMPs

AM-09	Sanitary and Septic Waste Management
IC-01	Non-Storm-Water Discharges to Storm Drains

References **137, 138** (see BMP Manual Chapter 10 for list)

ACTIVITY: Pet and Animal Wastes	RH – 08



Targeted Constituents				
¸ Significant Benefit		Û Partial Benefit	¹ Low or Unknown Benefit	
¹ Sediment	¹ Heavy Metals	¹ Floatable Materials	Û Oxygen Demanding Substances	
¸ Nutrients	¹ Toxic Materials	¹ Oil & Grease	¸ Bacteria & Viruses	¹ Construction Wastes

Description

Prevent animal and pet wastes in or near natural streams and creeks, storm drains, ditches, swales, or other types of storm water conveyance systems. This will reduce the amount of bacteria (particularly fecal coliform), which has been cited as the most serious contaminant for several creeks within the City of Memphis and Shelby County.

Approach

The Tennessee Department of Environment and Conversation (TDEC) has issued reports for several creeks within the City of Memphis and Shelby County. The reports state that the level of fecal coliform exceeds the computed Total Maximum Daily Loads (TMDLs) for the Wolf and Loosahatchie rivers and Nonconnah, Fletcher, Johns, Cypress, and Big creeks. Some example reports included for reference are:

Þ Total Maximum Daily Load (TMDL) Report for Fecal Coliform on Johns Creek, Cypress Creek South, Lower Nonconnah and Nonconnah Creek segments — (effective September 20, 2001)

Þ Total Maximum Daily Load (TMDL) Report for Fecal Coliform on Wolf River, Fletcher Creek, Cypress Creek — (effective June 30, 2003)

Þ Total Maximum Daily Load (TMDL) Report for Fecal Coliform on Cypress Creek and Big Creek — (effective September 12, 2003)

Sources of fecal coliform include animals (such as pets, cattle, wild birds) and humans (failing sewers, improper disposal of food products). This BMP addresses animal wastes (domestic and wild), which are a significant source of water pollution. Due to fecal coliform, some Memphis creeks are posted as unsafe for human contact. Animal waste may also contain other types of bacteria, viruses, and parasites.

When animal waste enters a natural creek, it uses the available dissolved oxygen to create ammonia. The combination of low oxygen, ammonia, and warm temperatures is detrimental to the fish and other aquatic life.

Animal waste contains nutrients that promote excessive weed and algae growth (eutrophication). Nutrients can make water cloudy and green, which further inhibits aquatic life and decreases the available dissolved oxygen.

Due to federal mandates, the City of Memphis and Shelby County adopted Storm Water Ordinances to prohibit and reduce pollution (see IC-01, Non-Storm-Water Discharges to Storm Drains, for a complete list) into streets, ditches, storm drains, and natural streams. This prohibition specifically includes animal wastes; see the following sections of the Storm Water and Street Ordinance for more details.

Guidelines

Pets

Pets can be a very significant source of fecal coliform. A 1982 study of urban watersheds in Baltimore, Maryland, found that dog feces were the single greatest contributor of fecal coliform and fecal strep bacteria (reference 190). A single gram of dog feces can contain 23 million fecal coliform bacteria (reference 199). Dogs can also be hosts for giardia and salmonella, two common types of harmful bacteria (reference 191).

Þ Provide a buffer zone and/or a fence to prevent animals from urinating or defecating into a creek, stream, or other storm water drainage feature. Do not keep pets immediately adjacent to ditches, swales, storm drains, pipes, or culverts.

Þ Clean up yards or fields that contain pet wastes on a regular basis. Animal waste can be sent to the sanitary landfill as part of the regular weekly garbage pickup. Burying animal waste away from ditches or storm water channels is also an acceptable option.

Þ Cat litter can be sent to the sanitary landfill as part of the regular weekly garbage pickup. Burying cat litter away from ditches or storm water channels is also an acceptable option, . Dumping used cat litter in piles on the ground surface is not an environmentally approved practice.

Þ When walking dogs, properly dispose of dog feces. Walk dogs in vegetated areas away from streams, creeks, ditches, and drainage channels. Disposal options are:

- Scoop up pet waste and flush down the toilet.
- Seal pet waste in a plastic bag and throw it in the garbage.
- Bury pet waste in the yard (at least 6 inches deep) so it decomposes.
- Add small quantities of pet waste to a compost pile; mix well. Make sure that pet waste is completely decomposed before using compost for gardens.

Þ It is <u>mandatory</u> for the owner or custodian of any pet to remove solid pet waste from all areas within the city (City Code of Ordinances, Section 5-63) and county (County Code of Ordinances, Section 3-40 [d] [2]).

Pastures/Farm Animals/Wildlife

- Provide a buffer zone and/or a fence to prevent livestock from urinating or defecating into a creek, stream, or other storm water drainage feature. Do not keep animals immediately adjacent to ditches, swales, storm drains, pipes, or culverts.

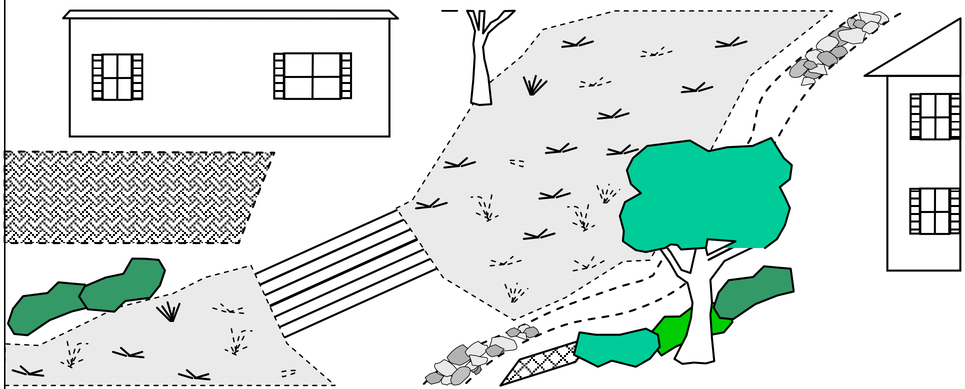
- If it is necessary for pasture animals to cross a stream or creek, limit the access as much as possible. Discourage livestock from standing in a stream or creek by limiting shade.

- Clean up pastures, fields, yards, and other open areas that contain animal wastes on a regular basis. Keep compost piles and manure piles as far away from ditches or storm water channels as possible. Burying animal waste is an acceptable alternative.

- Do not encourage ducks, geese, and other wild birds by feeding birds next to creeks, streams, and ponds. Duck and geese waste products are particularly harmful to water quality for creeks and streams. Ponds with regular populations of ducks and geese may need additional water quality treatment, such as sand filtration units.

References **32, 103, 190, 191, 199** (see BMP Manual Chapter 10 for list)
Final TMDL reports issued by TDEC http://www.epa.gov/owow/tmdl/

ACTIVITY: Slope and Stream Bank Stabilization — RH – 09



Targeted Constituents

¸ Significant Benefit   Û Partial Benefit   ¹ Low or Unknown Benefit

¸ Sediment	¹ Heavy Metals	Û Floatable Materials	¹ Oxygen Demanding Substances
¸ Nutrients	¹ Toxic Materials	¹ Oil & Grease	¹ Bacteria & Viruses; ¹ Construction Wastes

Description

Stabilize eroding slopes and stream banks in order to protect ditches, swales, storm drains, creeks, lakes and natural waterways. Slope stabilization improves the appearance of private property and will substantially reduce sedimentation and flood damage. Stream bank stabilization may require a permit from the Tennessee Department of Environment and Conservation (TDEC) prior to grading; see the TDEC Web site for more information. http://www.state.tn.us/environment/permits/

Approach

Home and private property owners can make a big difference in controlling erosion and sediment. The benefits of controlling erosion substantially outweigh the costs involved. Contrary to popular opinion, vegetation does not just grow by itself on disturbed areas and steep slopes. There is a large potential for eroding slopes wherever land is developed or landscaped in Memphis, due to hilly topography and native clay soils.

"Green" methods (with permanent vegetation) are the preferable means to fix steep slopes and erosion problems. Green methods help to capture rainfall, thus reducing the amount of runoff and flooding. Green methods are more attractive (and usually more durable) than structure stabilization methods such as gabion walls and riprap.

Overview of Slope Stabilization

First, determine the reason that a slope is unstable. If the slope tends to slide, collapse, or slough, the soil itself is unstable and typically needs a permanent solution. Possible remedies may include:

Þ Planting hardier and more durable types of vegetation (native trees and vines).

Þ Regrading the slope so that it is less steep.

Þ Constructing a retaining wall, crib wall, or other structural feature.

Þ Diverting surface water (and possibly groundwater) that tends to saturate soils and makes them heavier.

If a slope tends to erode or wash out in certain spots, the problem may be a combination of inadequate ground cover, poor drainage, no topsoil, wrong plants, etc. Possible remedies may include:

Þ Diverting surface water around the slope, if possible.

Þ Improving ground surface by adding topsoil, lime, fertilizer, mulch, or other soil amendments.

Þ Planting long grass, trees, shrubs, vines, or another type of ground cover. Select plants that meet sunlight, drainage, and maintenance requirements.

Green methods involving permanent vegetation are preferable to nongreen solutions. A common misconception is that gabions and riprap require less maintenance than green methods; this is not true. Gabions and riprap need to be inspected frequently for loose and misplaced stones, vegetation trimming and removal, settlement, etc. Green methods are more likely to be stable and self-maintaining. Specific aspects of slope stabilization are addressed in the following related BMPs:

Slope:	ES-04	Gradient Terraces and Silt Trenches
	ES-05	Surface Roughening
	ES-20	Bank Stabilization and Soil Bioengineering
	ES-23	Riprap (non-green solution)
	ES-28	Gabions (non-green solution)
Vegetation:	ES-06	Topsoil
	ES-07	Mulch
	ES-08	Seeding
	ES-09	Sodding
	ES-10	Trees, Shrubs, and Vines

Retaining walls, crib walls, and prefabricated structural walls must be designed by a professional engineer or other qualified expert for specific site conditions.

Overview of Stream Bank Stabilization

TDEC will require a property owner to obtain an Aquatic Resource Alteration Permit (ARAP) for any grading in or near waters of the state. Here are two quick definitions used to specify waters of the state:

- Memphis and Shelby County usually define this as a blue-line stream on a U.S. Geological Survey quadrangle map, or any point downstream from where a blue-line stream begins.

- TDEC typically defines a channel as carrying water for longer than one week after a heavy rainfall. The local TDEC office can send a field inspector to make difficult judgments when requested.

TDEC allows a property owner to clear downed trees and brush from a stream. The property owner should also unblock any culverts or pipes to prevent flooding. Live trees, shrubs, brush, and other vegetation (when adjacent to a channel) are usually necessary to anchor and protect the stream banks. An ARAP is needed for any grading work near a stream that places or removes soil. See the TDEC stream bank Web site for further information on permits, channelization, stream bank protection, and allowable activities.

It is important not to alter the hydraulic stream cross sections. An ARAP is needed to relocate a channel, change the slope, or to provide channel linings such as concrete or riprap. Changing the channel hydraulics at one location (flow width, flow depth, velocity, channel roughness) will affect the channel hydraulics elsewhere. Specific aspects of stream bank stabilization are addressed in these related BMPs:

Stream bank:	ES-20	Bank Stabilization and Soil Bioengineering
	ES-22	Channel Linings

References **141, 155, 162, 167, 179, 180, TDEC Web site** (see BMP Manual Chapter 10 for list)

ACTIVITY: Swimming Pools and Spas	RH – 10

Targeted Constituents				
¸ Significant Benefit		Û Partial Benefit	¹ Low or Unknown Benefit	
¹ Sediment	¹ Heavy Metals	¹ Floatable Materials	¸ Oxygen Demanding Substances	
¹ Nutrients	¸ Toxic Materials	¹ Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description

Chemical treatment of swimming pools and spas may prevent health concerns to bathers by killing organisms that live in the water. However, the chemicals that kill such organisms in pools and spas also kill aquatic life (fish, minnows, salamanders, crayfish) in creeks and streams that receive water with chemicals such as chlorine.

Approach

Since a variety of pool and spa treatment chemicals exists, it would be impossible to address proper disposal methods for every available chemical used in the treatment of pool and spa water. Due to federal mandates, Memphis and Shelby County adopted a Storm Water and Street Ordinance to prohibit discharge of non-storm-water materials (see RH-01, Non-Storm-Water Discharges to Storm Drains) such as chlorine, Baquacil, and other treatment chemicals into streets, ditches, storm drains, and natural streams.

The most common pool treatment is chlorine, which dissolves in water and is then very slowly released to the atmosphere as chlorine gas. This process is usually inhibited by the addition of other chemicals. Bromine is another type of pool chemical that is also commonly used. There are a variety of chemical products frequently used to reduce algae growth, adjust pH, remove hardness or metals, remove stains, etc. Memphis swimming pool and spa owners should use pool testing kits to monitor water conditions, and choose environmentally friendly products if available.

Swimming pool water will naturally release chlorine gas at a rate that is dependent upon water and air temperature, presence of chemical inhibitors, amount of sunlight, amount of wind, water depth, and circulation, etc. The process typically takes many days and requires that water should be periodically tested to monitor chlorine levels.

Reducing or Eliminating Discharges

Þ Before buying chemicals, select a method of pool treatment that has been successfully used in the Memphis area. Investigate and compare products to ensure that a proven method is selected. Select a method with the least toxic chemicals or chemicals that can be easily neutralized and removed from water.

Þ Retailers and manufacturers must make information readily available to customers, such as material safety data sheets (MSDS), with each chemical product to cover proper use of chemicals, safety issues, and safe disposal methods. All users of pool and spa chemicals should verify that the discharge and disposal process for any water treated with chemical products will be able to comply with federal and state regulations in addition to the manufacturer's recommendation.

Þ Do not overfill swimming pools and spas so that water is discharged with every splash and wave. Allow adequate freeboard for rainfall and storms. Splashes and waves should drain to a grassy area for ground infiltration.

Þ Most in-ground pool owners do not choose to drain the pool each year. Due to high groundwater in the Memphis area, it is often beneficial to leave an adequate weight of water for in-ground swimming pool or spa to prevent cracking or uplift.

Recommended Disposal Alternatives

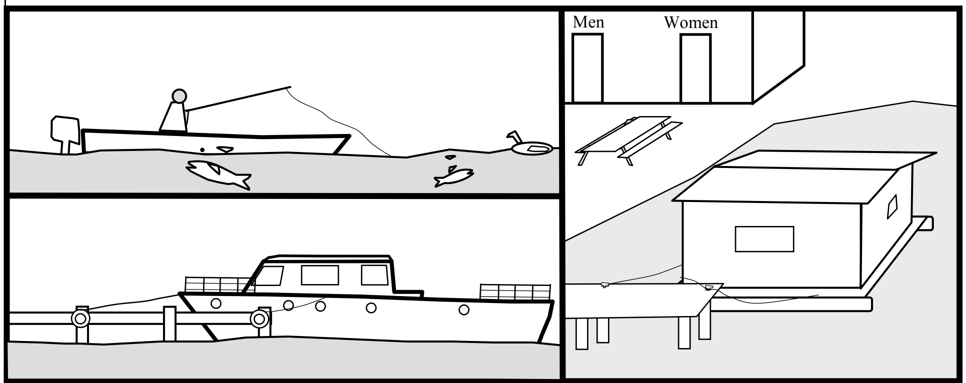
Þ Any swimming pool or spa water that has been treated by chlorine only and dechlorinated may then be discharged to grassy yards, streets, or the storm water system. Before discharging dechlorinated pool or spa water, check the water with a pool test kit to verify that it is completely dechlorinated. Dechlorinated discharges to streets and driveways should only occur in dry weather when it will not contribute to flooding for neighbors who live downstream. Do not discharge water during winter months for safety reasons if there is a potential for water freezing in the streets, curbs, and gutters.

Þ Any swimming pool or spa water that has been treated by chemicals other than chlorine is expressly prohibited from discharge to the storm drain system, even if the chemical has been neutralized. Disposal options include: 1) discharging to the sanitary sewer system, 2) drain pool and spa water at a very slow rate to grassy yards where the water will soak into the ground, or 3) construct an infiltration well or trench to allow water to soak into ground. A typical disposal method is to connect a hose from swimming pool to the sanitary sewer system. Connection to the sanitary sewer system must be approved by the City of Memphis prior to performing work. Do not discharge water onto or through neighbor's yard or property.

Þ Back wash water cannot be discharged directly to the storm water system unless it is completely dechlorinated and not treated with any other chemicals. Typical disposal method for back wash is to connect back wash hose from swimming pool or spa to the sanitary sewer system using a licensed plumbing contractor to install backflow prevention devices. Connections to sanitary system must be approved by the City of Memphis prior to installation. An alternate disposal method for back wash is to construct an infiltration well or trench as described in ST-03.

Limitations Disposal methods that comply with the Memphis and Shelby County Storm Water Ordinances may not necessarily comply with federal, state, and county regulations. Resolve compliance issues prior to discharging water from swimming pool or spa.

References **30, 31, 32, vendor information** (see BMP Manual Chapter 10 for list)



Targeted Constituents				
¸ Significant Benefit		Û Partial Benefit	¹ Low or Unknown Benefit	
¹ Sediment	Û Heavy Metals	¸ Floatable Materials	¸ Oxygen Demanding Substances	
¸ Nutrients	Û Toxic Materials	Û Oil & Grease	¸ Bacteria & Viruses	¹ Construction Wastes

Description

Prevent or reduce the discharge of pollutants to rivers, lakes, and streams by properly disposing of wastes, minimizing repairs and maintenance, cleaning up spills and wastes immediately, and improving boating equipment and methods. Protect our natural resources and environment by following guidelines from the National Clean Boating Campaign. Use common sense to protect the water quality of Memphis lakes and rivers.

Approach

Federal, state, and municipal regulations prohibit the discharge of any waste or litter into the storm water system. Therefore, polluters may be penalized or arrested by any government entity authorized to enforce federal, state, or municipal laws. **It is illegal to discharge raw sewage from a vessel within U.S. territorial waters.**

In addition to government agencies and authorities, fishing organizations and tournaments promote responsible boating and care for the environment. Public education is supported by the Tennessee Valley Authority (TVA) through participation in the National Clean Boating Campaign. Brochures and fact sheets for sewage pumpout, fueling, bilge water, litter, and boat maintenance are available at http://www.cleanboating.com/research/boatingpublic.html.

Marina owners and operators are encouraged to join TVA's Clean Marina Initiative by meeting the minimum standards of the Tennessee Valley Clean Marina Guidebook (reference 198); see http://www.tva.com/environment/water/boating.htm for this document. Marinas that are in compliance with TVA's voluntary program can display the Clean Marina logo and flag. Some marinas are eligible to receive public funds in order to construct pumpout stations for use by the general public.

Boating Activities

Boat Sewage and Pumpouts

Þ Properly dispose of domestic and sanitary wastewater by using holding tanks. Empty holding tanks at approved wastewater collection facilities at marinas and boat yards. Verify ballast water is clean before discharging to natural body of water. Remove or permanently lock Y-valve on holding tanks to prevent accidental discharge of untreated sewage to lakes, rivers, and streams. Comply with all laws regarding use and maintenance of a marine sanitation device (MSD). Guidelines and regulations are summarized on a Coast Guard Web site (http://www.uscg.mil/hq/g-m/mse/msd.htm).

- In general, the use of onshore restrooms is preferable to using restrooms on a boat. Minimize the use of onboard facilities by using onshore restrooms when docked. Make restroom stops every few hours as needed. Plan for restroom stops at marinas, fueling stations, waterfront restaurants, and public parks.

- Comply with all federal and state laws for MSD equipment. MSD equipment is regulated and certified by the U.S. Coast Guard to meet certain treatment standards. Type I and Type II MSD equipment is usually a combination of physical treatment (grinder) and chemical treatment (chlorinator) prior to discharge. Post operating instructions near the MSD, and keep MSD maintenance guide and user's manual on the boat.

MSD	Fecal Coliform Limits	Discharge Criteria
Type I	< 1,000 / 100 ml	No visible floating solids
Type II	< 200 / 100 ml	Suspended solids < 50 mg/l
Type III	----------------	No discharge (holding tank)

- Do not use boat toilets for disposal of fats, solvents, oil, emulsifiers, paint, poison, disposable diapers, or sanitary napkins. As a general rule, keep a supply of bags and containers ready for disposal of any conceivable item. Whenever possible, buy fast-dissolving marine toilet tissue for use in MSD equipment.

- Portable toilets shall not be discharged into U.S. territorial waters, which includes all lakes, rivers, and streams within Tennessee. Empty portable toilets at shoreside dump stations or at home.

- Use a pumpout station to empty holding tanks (and also MSD Type III equipment). Encourage marina owners to construct more pumpouts and dump stations by thanking marina owners and supporting their businesses.

Fuel and Oil

- Prevent fuel and oil from being discharged into the water or into the bilge by every means available. Use oil-absorbent pads and booms to contain any spilled fuel or oil. Boats with inboard engines should have oil absorption pads in bilge areas. The pads should be changed at least once a year or as needed. Do not pump bilge water if it is oily or has a sheen.

Þ Fuel, fluids, and oil should be kept in secure containers. Recycle used fuels in properly labeled containers. Inspect and repair engine valves, pipes, and hoses as necessary. Use drip pans when conducting maintenance and repair.

Þ Keep engine and other equipment in good operating condition. Inspect engine prior to each use. Follow manufacturer's recommendations for maintenance and tune-ups. Use drip pans and funnels when performing minor engine repairs.

Þ Avoid filling the fuel tank to the top. Watch and listen when filling the fuel tank. Use fuel stations with automatic shut-off nozzles whenever possible.

Þ Notify TDEC, the City of Memphis, and Shelby County in the event of major leaks and spills (as described in AM-07, Spill Prevention and Control). Use oil-absorbent pads and booms to contain the spill. Do not use any detergent, soap, cleaner, or emulsifier on a fuel spill, oil spill, or bilge water. These substances temporarily dissolve oil and grease, but do not actually remove the pollution from the water.

Litter and Fish Waste

Þ Do not discharge anything into the water, including excess food. Place all litter and waste into trash bags for disposal onshore. Retrieve any trash that falls overboard.

Þ In general, reduce the amount of unnecessary wrapping and packaging used on the boat. Reusable containers, cups, and dishes will reduce the amount of trash generated. Recycle whenever possible (aluminum cans, plastics, glass).

Þ Do not throw cigarettes (or other smoking materials) overboard. Use an ashtray when smoking. Do not spit chewing tobacco overboard.

Þ Do not discharge fish waste overboard. Place fish waste into trash bags for disposal onshore, or use a fish cleaning station onshore. Small amounts of fish parts may be used for bait or chum. Fish wastes should not be recycled in any dead-end lagoons or other poorly flushed areas. Restaurants are specifically prohibited from discharging fish wastes into the water; see IC-06, Over-Water Operations, for additional regulations for industrial and commercial facilities.

Þ People participating in fishing tournaments and other authorized events should follow guidelines presented by the sponsors. Follow all rules and regulations issued by the Tennessee Wildlife Resources Agency.

Boat Cleaning and Maintenance

- Þ Plan all cleaning and maintenance activities beforehand. Use the proper equipment to perform the activity efficiently and swiftly, while minimizing pollution. Use phosphate-free and biodegradable detergents for hull washing. Limit the amount of detergents used by first scrubbing and cleaning with water.

- Þ Perform all hull scraping, sanding, chemical stripping, and painting onshore. Place boat over a drop cloth and prevent the discharge of any chemicals or particles. Properly dispose of surface chips, used blasting sand, residual paints, and other materials. Use temporary storage containment that is not exposed to rain. Sweep dry docks each day or after maintenance is completed.

- Þ Limit over-water hull surface maintenance to minor sanding and minor painting using hand tools and a small can of paint or other surface agent. In general, conduct most boat repair and maintenance items by removing the boat from the water into an organized maintenance area.

- Þ Painting should be limited to spot work. In marinas, tenant maintenance over water should be such as to not require opening more than a pint-size paint can. Paint mixing should not occur on the dock. Use secondary containment on paint cans. Have available spill containment and cleanup materials. Use tarps, ground cloths, or plastic sheeting when sandblasting or painting boats on land. Spray applicators may be used when painting on land.

- Þ Immediately clean up spills on docks or boats using absorbent materials. Keep ample supply of spill cleanup materials on hand and conspicuously marked. Dispose of cleanup materials properly. Consult AM-07, Spill Prevention and Control, for emergency telephone numbers.

Marina Operations

- Þ Provide adequate waste containers, trash cans, and Dumpsters. Clean and maintain waste disposal areas in order to encourage patrons to not litter. Use responsible waste disposal contractors who are licensed to haul waste materials.

- Þ Educate visitors and employees on spill prevention and cleanup. Include appropriate language in tenant and user contracts that indicates the responsibility for guarding against spills, properly disposing waste materials, and limiting practices that may pollute storm water.

- Þ Clean catch basins and storm drains at regular intervals. Post signs to indicate proper use and disposal of residual paints, rags, used oil, and other engine fluids.

- Þ Marinas must provide wastewater disposal facilities onsite or close by. Wastewater facilities typically consist of either dockside lines or a pumpout station. Marinas should post signs at the entrance and through the facility indicating maintenance rules and reminders.

Limitations

- Þ Private tenants at marinas may resist restrictions on shipboard painting and maintenance. Existing contracts with tenants should be updated to require that tenants abide by new rules that benefit water quality.
- Þ Even small amounts of biodegradable cleaning agents have been found to be toxic to fish. Disposal of small amounts of cleaning agents should be done through the sanitary sewer system.

References

33, 95, 135, 192, 198 (see BMP Manual Chapter 10 for list)

U.S. Coast Guard http://www.uscg.mil/hq/g-m/mse/msd.htm

National Clean Boating Campaign
http://www.cleanboating.com/research/boatingpublic.html

National Clean Boating Campaign
http://cleanboating.org/bibliography/index.html

This BMP is adapted from a booklet (original date — September 1997) by:

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The primary purpose of this BMP is to inform the home owner, home buyer, and home builder about the usual causes for wet basements and crawl spaces, plus effective measures for preventing or correcting problems. This information can enable the public to build, select, or repair homes wisely. Although this BMP is not directly connected with water quality and storm water pollution, the matter of wet basements and crawl spaces is closely related to storm water design, landscaping, and minimizing contact with storm water

IMMEDIATE AND LONG-TERM PROBLEMS

Standing water or seepage inside residential crawl spaces and basements can cause frustrating problems for the home owner. These problems can be both immediate and long-term. For example, standing water and mud inside crawl spaces make it very difficult and messy to gain access under the house for inspecting, maintaining, and servicing electrical circuits, drains and water lines, heating and air conditioning, and other utilities. Wet basements and crawl spaces are sources of high humidity, which can produce surface condensation, mildew and fungi, musty odors, and an unhealthy environment. Such moisture can cause deterioration of floor joists, beams, subflooring, insulation, and electrical-mechanical systems. Prolonged water around the footer and foundation wall can soften the soil and weaken its bearing capacity, increasing the possibility of wall settlement and cracking. Serious seepage under the foundation footer may erode soil away and cause the wall to drop or crack. Excessive moisture can eventually penetrate the subflooring and buckle the flooring or cause warping, making doors and cabinets difficult to close or open. Since crawl space or basement dampness always moves toward the drier upstairs areas, higher humidity will result in costlier heating and air-conditioning bills. In the case of crawl spaces, if the underflooring insulation collects moisture, or sags from excessive wetness, the heating and air-conditioning costs are driven even higher.

Finally, wet basements and crawl spaces reduce the value of the house — at least by the amount that would be required to repair the damage and to eliminate the cause of the problem. Home owners in these situations should immediately seek professional assistance in assessing the source and extent of the problem and in finding a remedy.

CAUSE OF WET BASEMENTS AND CRAWL SPACES

Most wet basements or crawl spaces are caused by surface water that is not adequately drained away from the foundation wall. Sources of this water may include the following:

- Þ Roof water, if no guttering is present or if the guttering leaks and overflows due to leaves and obstructions. Concentrated roof water, when falling from a height of one or two stories, can cause erosion along the foundation wall and exacerbate the problem of storm water infiltration.

- Þ Roof water, if the downspouts are clogged or do not have sufficient means to drain water away from the foundation wall. Frequently, a downspout ends at the corner of the house without a splash pad (splash block) or shoe (sometimes called an elbow), leaving roof water to concentrate at that point and seep into the soil next to the foundation wall. A typical 2,000-square-foot roof can produce almost 1,250 gallons of water during just 1 inch of rainfall. If rainfall is steady and prolonged, roof water is even more likely to soak into the ground next to the foundation wall.

- Þ Excessive watering of flower beds and shrubbery around the foundation wall. Once the upper soil layer or mulch bed is filled with water, the excess water either runs off or seeps into the ground next to the wall. Prolonged watering can contribute large amounts of water to crawl spaces or basements.

- Þ Rainwater runoff from the adjacent lawn, walks, or driveway areas if the landscaping slopes to drain water toward the house instead of away. If surface runoff is directed toward foundation wall, water will pond and then soak into the soil, thus becoming a potential source of basement or crawl space water. Downspout splash pads are not very effective if the lawn drains back to the foundation wall.

Water or dampness problems in basements or crawl spaces are sometimes caused by other factors:

- Þ Subsurface or groundwater may be intercepted or dammed up by a basement or foundation wall. Houses that are built on a hillside are particularly vulnerable. Foundation walls act like dams to intercept and trap this subsurface water, causing pressure to build up on the outside of the wall, which forces water through joints and cracks in basement walls or as seepage under the footer.

- Þ Nearby springs may have been filled in or covered up by the developer. Unless the springs were properly drained away from the lot or subdivision, such water will eventually seep into the surrounding fill, become a pool of groundwater, and eventually force itself laterally and upwardly into basements and crawl spaces.

- Þ Nearby creeks may overflow during storm runoff and either directly flood basement or crawl space areas, or contribute to the groundwater, which may become sufficiently high to cause seepage into the basement or crawl space area. Home owners may not experience the effects of groundwater seepage or overflowing creeks for months or years after purchasing a house because of drought or infrequent out-of-bank flooding. However, when such conditions do occur, they may come suddenly without warning and cause serious problems after the warranty period has expired.

- Þ Improperly installed, clogged, collapsed, or leaky drains may not allow water to escape. Perimeter, footer, or foundation drains are installed around the exterior of a house below basement floor level to intercept groundwater build-up and seepage under the house. If drains are improperly installed or become clogged with silt or roots, they will not operate as intended. Sometimes an otherwise good perimeter drain gets covered up or crushed during the final backfilling or landscaping stages of construction, and the intercepted water will backup into a foundation wall and eventually seep into the basement or crawl space.

Þ Soil continuously draws water up from subsurface groundwater sources in a crawl space by capillary attraction. The finer the soil (e.g., clays), the more aggressive the capillary pumping action. As the water rises to the surface, it evaporates into the crawl space. This ground moisture is a significant source of dampness and humidity under a house, even without standing water. The presence of capillary water is often indicated by a whitish residue, left on the ground surface of the crawl spaces, resulting from evaporation of water containing minerals and salts. Lack of a moisture barrier, such as a plastic sheet, will allow capillary action and evaporation to contribute unlimited moisture to crawl space areas. Figure RH-12-1 illustrates how surface water and moisture can enter a crawl space area.

Þ Closed, inadequate, ineffective, or no crawl space venting around foundation walls will force the buildup of humidity in the space beneath a house. Given the combination of high humidity and low temperature, condensation can form on heating/AC ducts, joists, underflooring, and insulation. This environment, together with likely darkness, encourages mildew and other fungi to form.

Þ Damp or wet basements and crawl spaces may be caused by ruptured water or sanitary lines either just outside the wall or under the house. If a crawl space is unusually wet and muddy, inside leaks may be difficult to find and repair. Outside pipe leaks may be even more difficult to find, since water may appear several feet away from the actual leak. Old field drains under a house may also be a source of unwanted water.

PREVENTING WET BASEMENTS AND CRAWL SPACES

Many construction complaints about new homes arise from inadequate site drainage and water problems. Proper drainage of surface water is a primary element in preventing wet basements, damp crawl spaces, eroded banks, muddy yards, and possible failure of a foundation system. The City of Memphis and Shelby County requires that new construction or alteration of houses conform to the requirements of the Southern Building Code Congress International, Inc. (SBCCI). Generally, surface water drainage should be directed from all sides of the house and off the lot in a manner that will:

Þ Minimize possibility of dampness in basements and crawl spaces
Þ Prevent standing or ponding water on the site
Þ Prevent soil erosion
Þ Not adversely affect the supporting foundation soil behavior

Walks, driveways, retaining walls, and other landscape improvements should be constructed so as not to interfere with drainage. Walks should not be used as drainage channels. Site grading plans should specify minimum slopes from the house (usually 2 to 5%), depending on location, type of soils, frost depth, and soil moisture, to ensure water drainage for some specified distance (usually 6 to 25 feet) away from supporting foundations. In cases where minimum slopes or distances cannot be attained, paved gutters or other drainage structures acceptable to the building inspector may need to be installed. Maximum slopes are specified to prevent erosion or unstable banks around the house and yard.

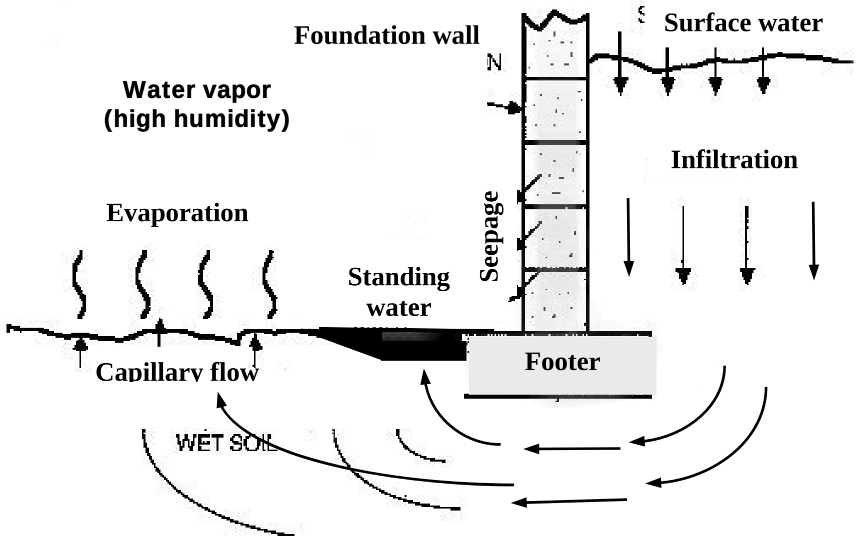


Figure RH-12-1
Typical Paths of Water and Moisture Entering Into a Crawl Space Area

Roof water should be directed to a downspout and away from the foundation wall toward a suitable ditch, swale, or drainage pipe to prevent ponding or backflow as shown in Figure RH-12-2. All drainage structures should be properly connected to adequate outlets that are protected, where necessary, by recorded permanent easement. House plans and landscaping should be developed to prevent "dead" drainage areas around the foundation wall—areas where rainfall has no place to flow away except by ponding and soaking into the soil near the foundation wall. Areas bounded by the front entrance/sidewalk/garage/driveway are especially vulnerable to trapped pockets of surface water.

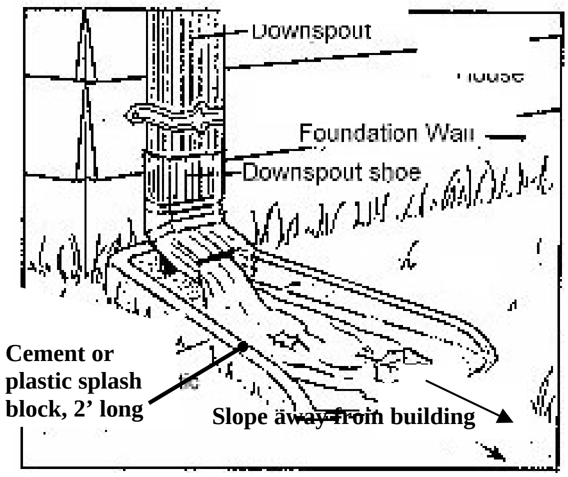


Figure RH-12-2
Correct Installation of Downspout Shoe and Splash Block at Foundation Wall.
(Note that the ground surface slopes away from house.)

Another vital step in preventing water in basements and crawl spaces is to intercept outside subsurface or groundwater with a perimeter drain at the footer base level around all sides of the house where the exterior ground surface is higher than the inside floor or crawl space level. While foundation drains are clearly necessary for houses with basements or potentially habitable living space below exterior ground surface, they may also be used in crawl spaces where water, soil, and/or earth floor elevation conditions warrant. The drains should discharge by gravity to a positive outfall such as an approved drainage ditch, swale, or storm system. In some cases, sump pits and pumping with automatic float actuation may be required.

Specifications for waterproofing and damp-proofing foundation walls are found in SBCCI. Building codes specify the materials, maximum vapor transmission rate, venting, etc., appropriate for construction. Excessive moisture vapor can be prevented from entering a crawl space area with the use of an effective and correctly installed vapor barrier (typically polyethylene sheeting) over the ground surface. Torn pieces, poor or non-overlapping joints, missing sections, or improperly sealed corners and edges at the walls, fireplaces, and interior piers must be avoided to produce an effective vapor barrier.

Crawl space areas should have adequate wall ventilation openings around the foundation walls to provide cross ventilation for preventing the buildup of water vapor inside the crawl space. Building codes specify minimum vent opening areas (usually 1 square foot of net opening for each 150 square feet of crawl space), opening location or arrangement, corrosion-resistant wire mesh screen, and any reduction in ventilation opening area allowance if an approved vapor barrier is used.

In older houses where any of the above moisture control methods are missing, measures should be taken to install appropriate drainage facilities, vapor barriers, or ventilation openings. Installing any of these elements after a house has been built will be more costly than while the house is constructed. A combination of remedial measures is often necessary. If the yard area slopes toward the house and surface water collects or ponds near the foundation wall, a V-ditch or swale should be constructed around the house to allow surface drainage from both the foundation wall and the other yard areas to an adequate ditch or storm drain. Such cases often exist where the front street is higher than the first floor of the house, or when the house is built on the side of a hill. Figure RH-12-3 illustrates how this problem can be solved.

If a flower bed or garden is next to the foundation wall, it may be a significant source of water for the basement or crawl space. Consider relocating the flower bed or shrubbery, or install heavy plastic sheets with drains beneath the flower bed. Then any water that soaks deeply into the soil is intercepted and carried safely away by gravity at least six to eight feet from the house to a gravel collection drain or swale.

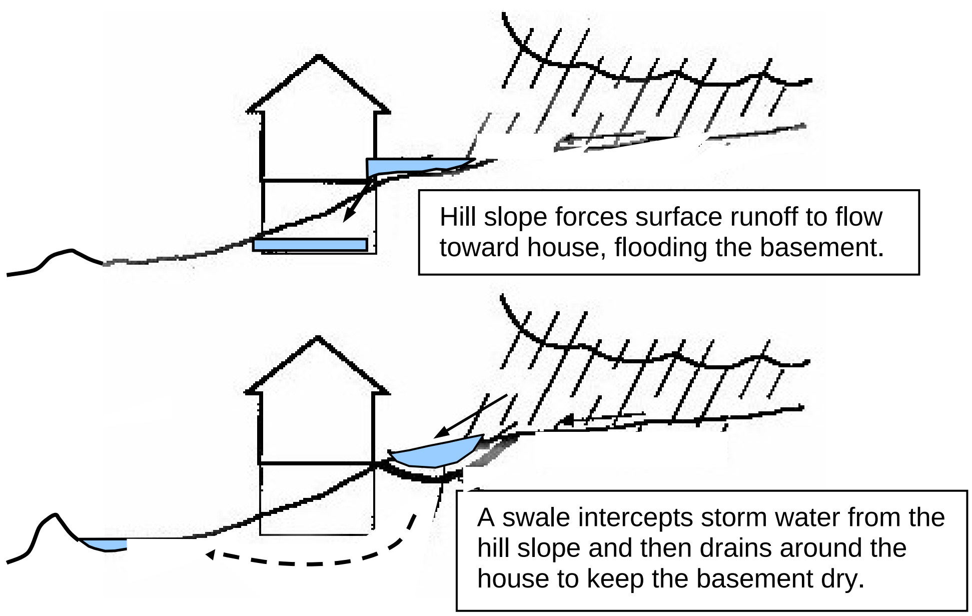


Figure RH-12-3
Correction of Typical Slope Drainage Problem Using Swale or Ditch

TIPS FOR HOME OWNERS AND HOME BUILDERS

To paraphrase and old axiom, "a teaspoon of prevention is worth a gallon of cure" certainly applies to new home builders — at least in avoiding water problems in basements or crawl spaces. Buyers of new or older houses should be cautious about drainage. The best time to sign a contract is on a rainy day!

Tips for buying or building a new house

The following tips are suggested to avoid water problems when building or buying a new house:

Þ Work with a professional engineer or architect to help locate the new house on the lot and at an elevation that minimizes the potential for surface or groundwater drainage problems. If a flowing stream or creek is nearby (especially if bordering the lot), check with local planning agency authorities or a hydrologic engineer for potential flooding, whether in a designated 500-year flood hazard zone or in an area that may be affected by nuisance flooding.

- Work with a reputable home builder that can supply reference names and projects for houses that the company has built. Visit these sites and check for patterns of any drainage problems. Contact the Better Business Bureau and other organizations to see if there are complaints and outstanding issues.

- It may be beneficial to hire an engineer or architect to check slopes, foundation wall waterproofing and damp proofing, underground drains, general surface and roof water drainage, and general quality of construction. If you suspect a potential problem, ask the local building inspector for advice.

- Check to make sure that the perimeter foundation drain, basement drain, or crawl space drain has an unobstructed outlet to a ditch or swale leading away from the house. Pay special attention around the outside and the basement or crawl space for: (1) backsloping lawns and landscaping toward foundation walls; (2) backsloping driveways toward garage, stoops, walks, or patios that force surface water toward the foundation wall; (3) very flat property; (4) standing water inside of crawl space next to foundation wall; (5) pattern of wet concrete blocks inside basement walls, particularly with whitish salt deposits on inside foundation walls as a result of leaching from moisture seepage and evaporation; (6) downspouts that drain to the foundation wall without any clear path for water to escape; and (7) depressions or settlement near the foundation. If necessary, use a level to check the slope direction.

- For specific construction or drainage questions, refer to applicable building codes, inspection/permit requirements, Memphis storm water ordinance, zoning ordinance, and local flood mapping documents. Some of these resources are available on the Internet at the City of Memphis and Shelby County Web sites. Above all, don't be timid about asking the questions to the realtor or builder. Document questions and concerns in writing.

Tips for buying an older home

The following recommendations are made to the prospective older home purchaser:

- Visit the house during or shortly after a prolonged or heavy storm. Check for water in the basement and crawl space, or hire a professional house inspector prior to purchase. Ask the realtor about any known water problems — inside or outside — by the previous owner. Check with the neighbors to see if the house has a history of drainage problems, wet basements, or damp crawl spaces. Don't necessarily accept a realtor's or builder's suggestion that water seepage into basement or crawl spaces is normal and should not be a concern.

- For houses with basements, carefully check for stain signs of standing water around the walls or seepage coming through the walls, especially along the walls having the highest outside ground level. Look for whitish salt deposits on inside foundation walls left from moisture seepage and evaporation. For houses with crawl spaces, use a flashlight and check for current or previous water ponding, mud, mildew, condensation on various surfaces, or sagging or wet insulation.

- Check the basement and crawl space for musty odors and signs of mildew, condensation on surfaces, and unusually heavy rust deposits. Try to determine the source of the moisture — foundation wall seepage; capillary moisture from the crawl space ground; water or sanitary pipe leakage; poor crawl space ventilation; or combination of problems. Check the inside corners for cracks and separation of blocks at the joints from foundation settlement.

Tips for home owners who currently have water problems

- Check to see if the house is in warranty—if so, discuss the problem with the builder and ask him to correct it. If the builder refuses, contact an attorney for advice. If the warranty period has expired, have an expert in drainage engineering determine the cause of the problem, whether or not the problem is serious, and what can be done to correct it.

- Check to see if all surface and subsurface drains are functioning. Use a hose to see if roof and gutter water is being directed away from the foundation wall. Refrain from heavy watering of flower beds and shrubbery next to the house. Observe the path of all surface drainage around the house during prolonged or heavy rainfall. Watch for ponding near the walls. Check to see if the foundation drain is operating by looking for evidence of seepage from the ends.

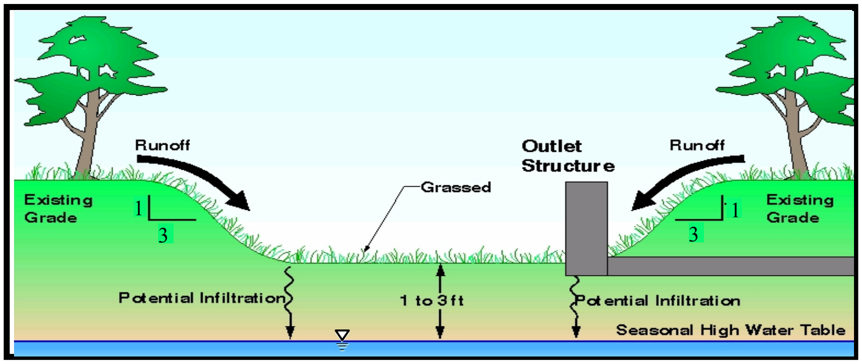
The following three Web sites are indicative of the amount of information available on the Internet. *Investigate* all promises and statements made by any company or service prior to entering into an agreement.

Wet basements	http://www.allaroundthehouse.com/lib.abc.na25.htm
Wet basements	http://www.accurateinspection.com/wet_basements.htm
Vapor barriers	http://www.eren.doe.gov/consumerinfo/refbriefs/bd4.html

Some problems may be solved simply by repairing an obvious gutter or downspout leak, while other problems may have causes that are difficult to identify and very expensive to fix. Severe crawl space water problems may cost several thousand dollars to remedy. Always use a competent professional to help you find and eliminate the source of the problem. Don't settle on quick and cheap fixes that merely deal with the symptoms of the problems.

Above all, remember that in most home purchases it is . . . LET THE BUYER BEWARE.

ACTIVITY: Dry Detention Basin	ST – 01



Targeted Constituents

¸ Significant Benefit | Û Partial Benefit | ¹ Low or Unknown Benefit

¸ Sediment	Û Heavy Metals	Û Floatable Materials	Û Oxygen Demanding Substances	
Û Nutrients	Û Toxic Materials	Û Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description

A dry detention basin is the most common method for satisfying storm water detention and storm water quality requirements. It is applicable to small and large developments, can be easily designed and constructed, and, with adequate inspection and maintenance, is long lasting and durable. This practice will provide a significant reduction in sediment, as well as a partial reduction in nutrients, toxic materials, heavy metals, floatable materials, oxygen demanding substances, and oil and grease.

A dry detention basin is intended to be dry between storm events, but may not necessarily have a chance to drain completely prior to the next storm event. The detention basin begins to fill as storm water runoff enters the facility. The first flush volume is captured in order to ensure water quality. One or more outlet structures then release the storm water runoff slowly to reduce peak discharge rates and to provide time for sediments to settle. Protect area streams and lakes by preventing litter and debris from leaving the detention basin. Some soluble pollutants are captured by a combination of vegetation and soils.

Selection Criteria

Þ The primary objective is to reduce the peak flow discharge and slow the storm water runoff response for a particular property or development, thus reducing flooding downstream. Procedures for preparing calculations are outlined in Volume 2, Chapter 2, Hydrology, of the Storm Water Management Manual (SWMM) and include the correct use of Natural Resources Conservation Service (NRCS) Technical Release 55 for determining the required detention storage. An example detention problem is worked with complex spreadsheets and HEC-1/HEC-HMS runs in Volume 2, Chapter 8, Detention, of the SWMM.

Þ The secondary objective is to remove suspended sediment, trash and debris, oil, grease, and other pollutants to protect the water quality of Memphis and Shelby County streams and channels. Although dry detention basins are usually not as effective at removing soluble pollutants as wet detention basins and wetlands, dry detention basins are usually easier and less expensive to construct, inspect, and maintain. Dry detention basins can be used wherever a lack of sufficient supply water would prevent the use of wet detention basins or wetlands.

- Dry detention basins can also supply multiple benefits for passive recreation during dry periods (recreational trails, ball fields, picnicking). Portions of a dry detention basin that are not wetted frequently can be attractively landscaped or used for other purposes. See Figure ST-09-1 for the typical placement of various storm water treatment BMPs near streams and natural areas.

Design Approach

- As the primary objective, dry detention basins must be designed to have adequate detention storage and outlet structures. See Volume 2, Chapter 8, Detention, of the SWMM for a discussion of detention design methods and formulas that are acceptable. Memphis and Shelby County require volume control of the two-year and five-year NRCS Type II rainfall storm design events. In addition, peak control of the 10-year NRCS Type II rainfall is required. The outlet structure must be made from durable concrete or masonry construction, and typically the outlet structure has multiple weirs and/or orifices to release the design storms at predevelopment rates.

- As the secondary objective, water quality is obtained through detaining the volume of the two-year and five-year rainfall events. The initial wave of storm water runoff is more likely to contain aerially deposited sediments, particulates from vehicles (such as incomplete combustion, dust from brake linings, and tire particles), leaves, trash, cigarette butts, etc. In addition, vegetative cover that lines detention basins will serve as a biofilter for first flush pollutants.

- Additional measures may be required to improve storm water quality, depending upon the nature of the land use and expected pollutants. Pretreatment of storm water runoff with a media filtration inlet or oil-water separator may be necessary. A trash rack for capturing floating debris is generally considered to be standard equipment for a storm water treatment BMP.

- Storm water runoff that falls onto pavement and rooftops should be detained and treated in a manner that will reduce thermal impacts to streams. This may include locating a detention basin away from sunlight by using trees or buildings as shade.

Location & Layout

Basic elements of a dry detention basin are illustrated in Figure ST-01-1. The recommended design includes the use of a sediment forebay to reduce sediment loading, particularly if the detention basin is modified to also function as a temporary sediment basin during the construction phase. The use of an upper stage (for storage of infrequent storms) is optional; there are both benefits and drawbacks. A shallow detention basin with a large surface area will usually perform better than a deeper detention basin with the same volume. However, shallow storage areas increase the overall surface area needed for detention.

Design flow paths to minimize potential short-circuiting by locating the inlets as far away from the outlet structure as possible. The length-to-width ratio of a basin should be at least 2:1 (and preferably 3:1). Baffles or backslope drains may be used to prevent short-circuiting. If topography or aesthetics require the pond to have an irregular shape, increase pond area and volume to compensate for dead spaces. It is important to reduce the velocity of incoming storm water using riprap or other energy dissipaters.

Although dry detention basins are generally less expensive to construct and maintain than wet detention basins, they provide lower water quality benefits. The primary disadvantage of a dry detention basin is the required amount of surface area, which can be reduced somewhat by using concrete retaining walls on one or more sides. In general, concrete retaining walls should not face southward in order to reduce the potential for heating on hot summer days.

Interaction with site utilities must be considered during preliminary design. Typical utilities include electrical, telephone, cable television, water, sewer, natural gas, petroleum, etc. These utilities may or may not be in a dedicated utility easement, so it is always necessary to conduct a careful site survey. Detention basins (including embankments) are not allowed over utility lines.

Detention basin access must be considered during preliminary design in order to allow for construction and maintenance. Detention basins that are not frequently inspected and maintained often become more of a nuisance than a beneficial part of a storm water management program. In particular, provide access for inspection and maintenance to the sediment forebay and to the outlet control structure. It may also be desirable to encourage or discourage public access to the detention basin (by using site grading, signs, fences, or gates). Additional safety elements include trash racks, grating over pipes and culverts, gentle side slopes whenever possible, increased visibility and/or lighting in residential areas, etc.

Small detention basins serving individual properties do not offer as much recreational benefit as community or regional detention basins do. Regional facilities can often be landscaped to offer recreational and aesthetic benefits. Jogging and walking trails, picnic areas, and ball fields are some of the typical uses. For example, portions of a flood-control facility can be used for exercise areas, soccer fields, or football fields. Wildlife benefits can also be provided in the form of islands, buffer areas, or preservation zones. Figure ST-09-1 shows an example of a multiuse regional facility.

Volume and Size

The volume of a dry detention basin consists of two elements: the live pool (the upper portion of the basin representing detention capability) and the first flush volume (the lower portion of the basin representing storm water quality treatment). These two elements should be sized according to detention computations in Volume 2, Chapter 8, Detention of the SWWM, and also the procedures from NRCS Technical Release 55 (reference 175). Verify that the preliminary estimate of volume and size works by routing the storm water hydrographs.

As a warning to those who design detention basins, it should be recognized that future storm water regulations are likely to be more stringent than the current regulations. Such measures are mostly driven by national and state laws and regulations, which will require municipalities and county governments to accomplish additional pollution reduction with a proportional effort for water quality monitoring and enforcement. Figure 4-2 in Chapter 4 of the BMP Manual shows the measured pollution removal values for dry detention basins near metropolitan Washington, D.C. It is anticipated that this type of information will become more commonplace and more useful in the near future.

Grading

Side slopes shall generally be 3:1 (H:V) or flatter to allow for traversable access to the bottom of the detention basin. This also encourages a strong growth of vegetation on the side slopes and helps to prevent soil erosion. Steep slopes, particularly on embankments or other fill soils, will contribute to soil erosion, and thereby reduce or negate the effectiveness of a dry detention basin with respect to water quality. Vegetate the side slopes and basin bottom to the maximum extent practical. If side erosion is particularly severe, consider the use of soil stabilization or armoring techniques. Do not locate detention basins immediately above or below a steep slope or grade, because impounded water may create slope stability problems.

Minimum width for top of embankment is 5 feet. Allow for 10% settlement of embankment, unless the embankment is thoroughly compacted with vibratory equipment or sheepsfoot rollers. The top of embankment (after expected settlement) shall generally be at least 2 feet above the top of outlet structure and at least 1 foot above the peak 100-year water surface elevation.

Compaction in the immediate area of the emergency spillway is necessary.

In instances where storm water runoff does not flow directly down a slope, the side slope of a detention basin can be as steep as 2:1 (H:V) with proper erosion controls, geotextiles, and quick establishment of vegetation. Retaining walls may be used on one or more sides of a detention basin if properly designed. Analysis of a retaining wall should include effects of saturated soil behind the retaining wall, in addition to the usual design considerations of vehicle and structural loadings above the retaining wall.

The use of a backslope drain can be very beneficial in preventing erosion at detention basins. See Figure ST-01-5 for a typical detail. The backslope drain is also useful for increasing lengths of flow paths to prevent short circuiting of the detention basin. Intercepted storm water can be routed around the detention basin to enter at the most hydraulically distant point from the outlet structure.

Outlet Structure

Memphis and Shelby County require that a detention basin outlet structure be constructed from concrete, masonry block, or other durable materials. Metal corrugated metal pipe (CMP) risers used as outlet structures have problems with crushing, flotation, and durability. A concrete outlet structure is preferable to a masonry block structure because it is sturdier and more durable. Provisions should be made for sufficient reinforcement and anchoring.

The specific flow-controlling elements of an outlet structure may include one or more of the following: circular orifice, noncircular orifice, rectangular weir, trapezoidal weir, triangular weir, V-notch weir, culvert entrance control or riser overflow opening. These types of controls are described at length in Volume 2, Chapter 8, Detention, of the SWMM.

Figures ST-01-2 and ST-01-3 illustrate possible designs for the outlet structure. These details are only two possible ways to accomplish storm water detention and storm water quality control. The first flush volume is typically drained during a minimum time of 24 hours by using an orifice with a designed size. Maximum drain time should be less than 72 hours to allow for sufficient volume recovery prior to the next period of rainfall. The first flush volume can be filtered through sand by using an underdrain system (shown in Figure ST-01-2) or by an aboveground filter box with sand or aggregate (shown in Figure ST-01-3). Figure ST-01-4 shows an alternative outlet structure with a water quality manhole. Provide an emergency spillway in order to route large storms through the facility without overtopping.

Common Problems

Þ Inadequate storage is the most frequent problem that occurs in the design review before construction, as well as for the as-built review after construction. This can occur for several reasons:

— The design engineer did not allow enough room to construct the detention basin (most often due to insufficient design detail such as slope transitions, setbacks, parking lot widths, inaccurate contours, utilities not shown).

— The engineer who performs the storm water computations is not the same person as the design engineer who does site layout and grading. The required detention storage volume and outlet structure details need to be communicated clearly to the design engineer for inclusion on the plans.

- — The construction contractor does not excavate deeply enough or does not build berms of sufficient height to hold the required detention volume. This may occur due to rock formations or groundwater encountered.

- — The construction contractor changes the basin configuration during construction without being aware of the required volume.

- — Approval from the city or county was not obtained for a design change.

Þ It is highly recommended that the design engineer be involved in the construction and inspection of the detention basin. Special attention should be given to the detention basin volume, elevations of each outlet, side slopes, size and shape of various weirs or orifices, and installation of cutoff collars in embankments.

Þ Proper hydraulic design of the outlet is critical to achieving good performance for both storm water detention and storm water quality of the dry detention basin. The two most common problems for detention basin outlets are:

- — The discharge capacity of the outlet structures is too great. This causes excessive basin outflows, and results in fast drawdown times and inadequate filling of the detention basin volume. Both storm water detention and storm water quality will suffer.

- — The outlet structure clogs because it is not adequately protected against trash and debris. The use of innovative trash racks is recommended. A typical trash rack is often created using welded rebar with 2” openings sufficient to stop most beverage cans, food containers from restaurants, tree limbs, etc. A trash rack sized with 1” to 1.5” openings is preferable because it can also catch leaves and small sticks.

Maintenance

- Þ Inspect the dry detention basin regularly (several times a year) and particularly after heavy rainfall events. Record all observations and measurements taken. Perform any maintenance and repair erosion promptly. Remove debris and trash after storm events. Check outlet structure regularly for clogging.

- Þ Remove sediment when accumulation becomes noticeable (1" to 2" over a wide area) or if resuspension is observed or probable. Sediment may be permitted to accumulate if the detention basin volume has been overdesigned with adequate controls to prevent further sediment movement. If a sand underdrain is used, look for reduced infiltration or ponded water; sand layer replacement may be needed.

- Þ Maintain a thick and healthy stand of vegetation (usually grass). Mow or trim at regular intervals to encourage thick growth. Remove leaves, grass clippings, or sticks from the detention basin regularly to prevent storm water pollution. Remove trees or nuisance vegetation as necessary to ensure structural integrity of the basin.

- Þ If both the operational and aesthetic characteristics of a dry detention basin are not properly maintained, then it becomes an eyesore and has a negative environmental impact. Vegetation needs to be trimmed or harvested. Ensure that repairs are made to walkways, picnic tables, signs, and public recreation equipment as needed.

Sediment Removal

A primary function of storm water treatment BMPs is to provide details on collecting and removing sediment. The sediment accumulation rate is dependent on a number of factors including watershed size, facility size, construction upstream, nearby industrial or commercial activities, etc. Sediment should be identified before removal and disposal is performed. Special attention or sampling should be given to sediment accumulated from industrial or manufacturing facilities, heavy commercial sites, fueling centers or automotive maintenance areas, parking areas, or other areas where pollutants are suspected. Treat sediment as potentially hazardous until proven otherwise.

Some sediment may contain contaminants for which the Tennessee Department of Environment and Conservation (TDEC) requires special disposal procedures. Consult TDEC — Division of Water Pollution Control (368-7939) if there is any uncertainty about what the sediment contains or if it is known to contain contaminants. Clean sediment may be used as fill material, hole filling, or land spreading. It is important that this material not be placed in a way that will promote or allow resuspension in storm water runoff. Some demolition or sanitary landfill operators will allow the sediment to be disposed at their facility for use as cover. This generally requires that the sediment be tested to ensure that it is innocuous.

Limitations

- Þ A dry detention basin will require frequent inspection and maintenance. Trash, debris, leaves, and other large items should be removed from the detention basin following each rainfall event. If upstream erosion is not properly controlled, dry detention basins can be maintenance intensive with respect to sediment removal, nuisance odors, insects, and mosquitoes, etc.

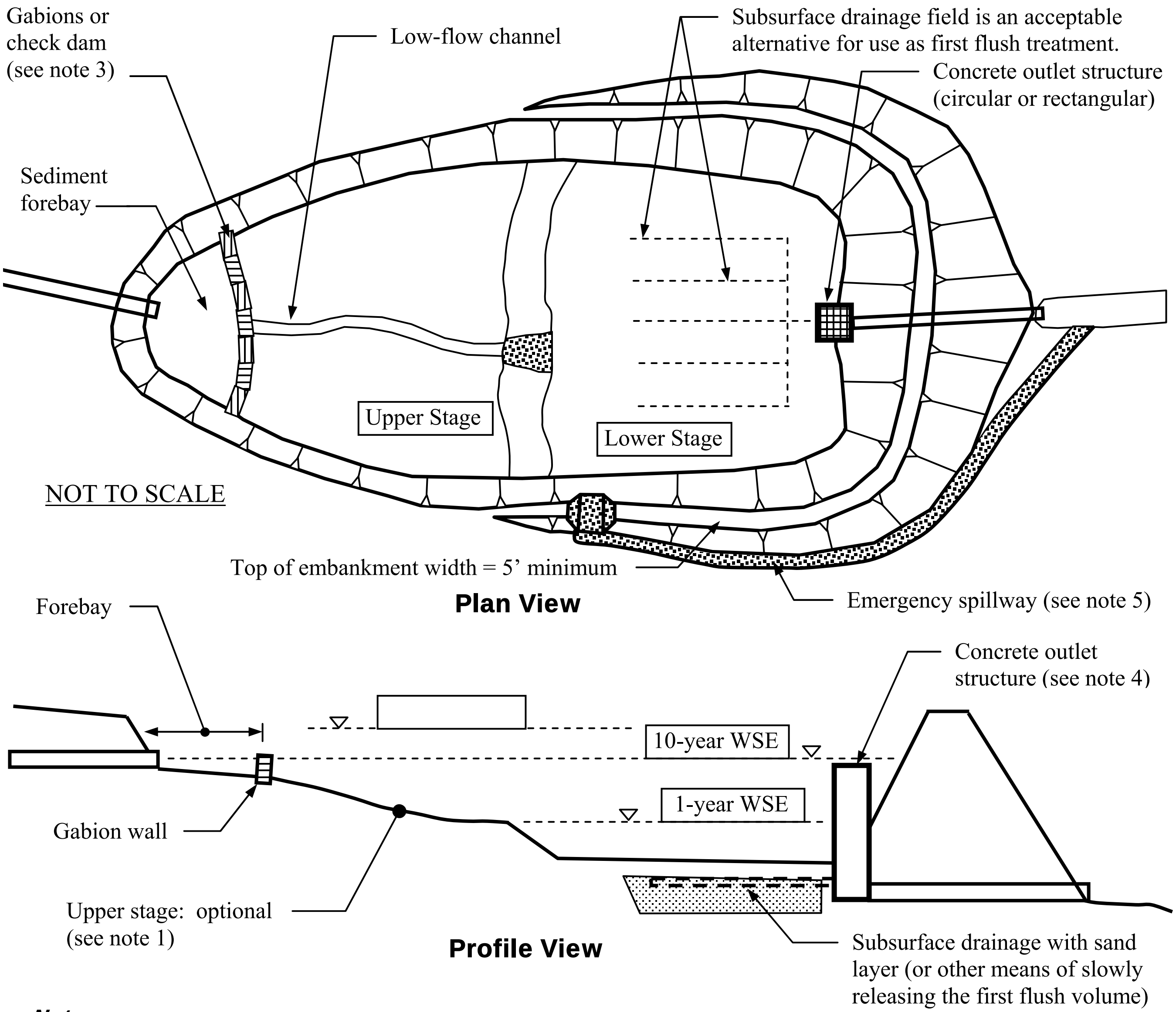
- Þ A dry detention basin may not have sufficient vegetation on the slopes and bottom to prevent erosion and pollutant resuspension. Vegetation must be maintained and cut at adequate intervals. Remove grass clippings from detention basin immediately after cutting, using rakes or other hand equipment.

- Þ A dry detention basin that impounds more than 30 acre-feet of volume (and minimum 6 feet high) or that is higher than 20 feet (and minimum 15 acre-feet of volume) is subject to the Tennessee Safe Dams Act of 1973 and as amended by law. The Safe Dams Act is administered by the TDEC Division of Water Supply; further information on design standards, regulations and permit applications is available at the TDEC Web site:

  http://www.state.tn.us/environment/permits/safedam.php

- Þ Dry detention basins require a relatively large surface area (1% to 3% of the contributing drainage area) in order to provide sufficient pond volume for detention and water quality. Dry detention basins require a differential elevation between inlets and outlets, for which extremely flat areas may not be suitable.

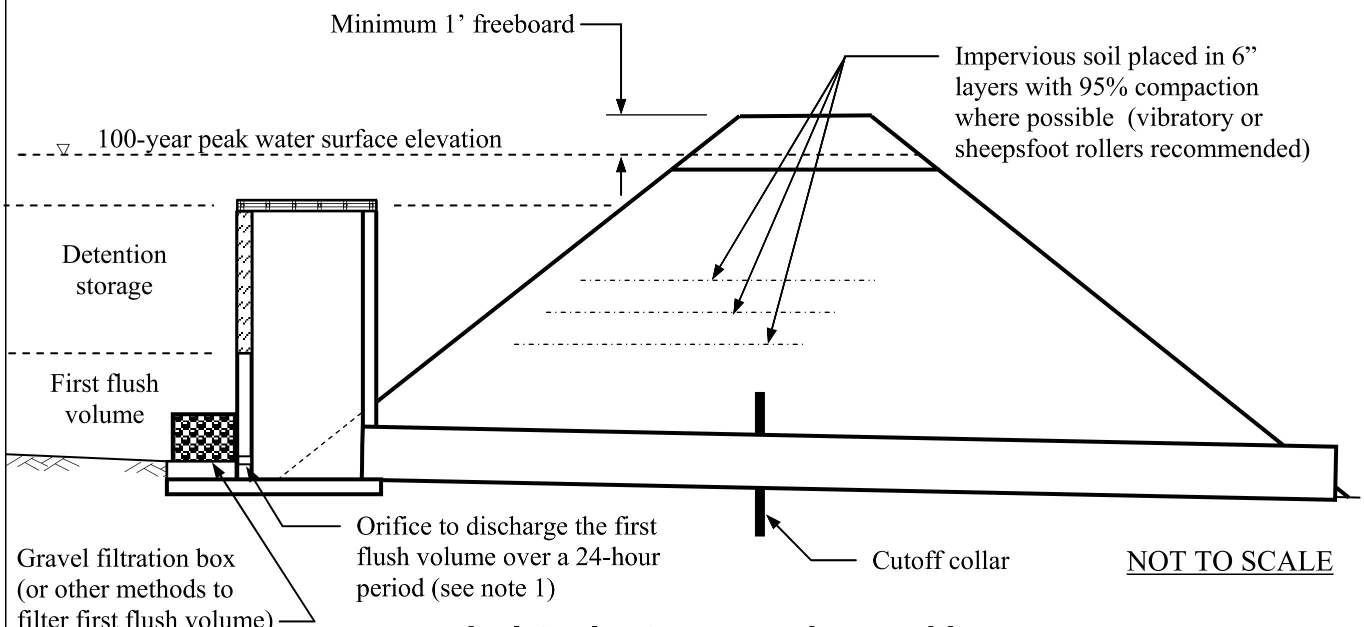
References **9, 28, 31, 33, 48, 50, 58, 73, 76, 77, 78, 81, 83, 88, 140, 145, 153, 166, 175, 180, 182** (see BMP Manual Chapter 10 for list)



Notes:

1. This example of a typical dry detention basin layout shows an upper stage which is used for storm water detention on infrequent storms. An upper stage can also be located on the side of a dry detention basin, eliminating the need for a low-flow channel.
2. The lower stage is typically sized to handle the first flush volume or the one-year design storm, whichever is greater.
3. A forebay can be constructed from gabions, rock check dams, or a separate berm with culvert. A forebay can facilitate the capture and cleanup of coarse sediments, debris, and trash.
4. The outlet structure typically has orifices or weirs at computed elevations that will release the predevelopment volume of the two-year and five-year storms and the 10-year storm at the specified predevelopment peak flow rates.
5. The emergency spillway is generally constructed on natural ground or excavated areas (rather than fill soils) to reduce the potential for erosion and washout.

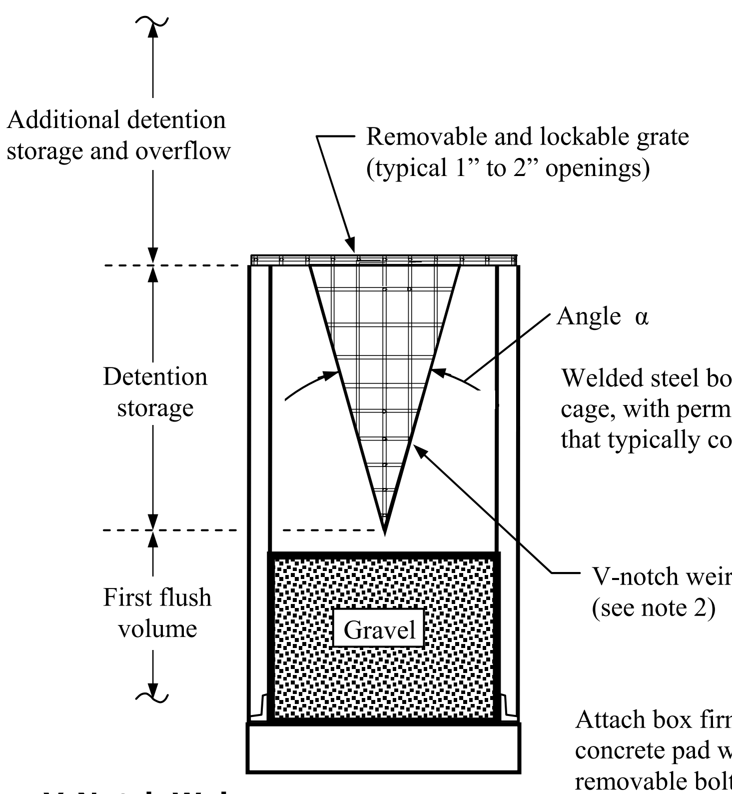
Figure ST-01-1
Typical Dry Detention Basin Layout



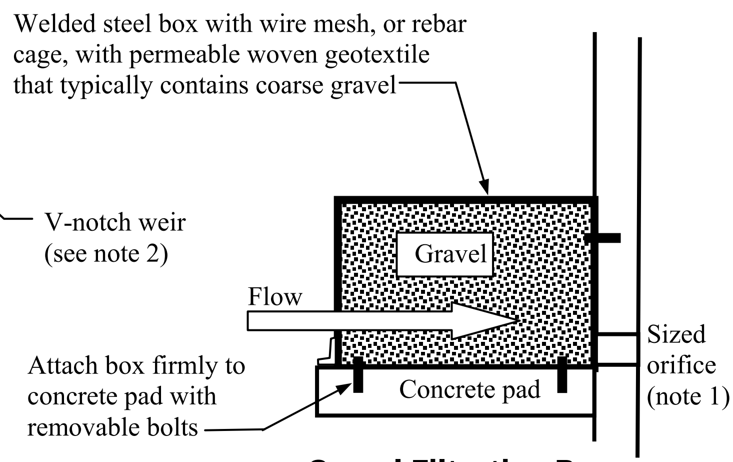
Typical Outlet Structure (V-Notch)

Notes:

1. The orifice is sized to release the first flush volume over a period from 24 to 72 hours. Protect the orifice from clogging by a sand filtration box, gravel filtration box, or with a trash rack.
2. This example of a typical outlet structure shows a V-notch weir, which should be sized to release the volume of the two-year and five-year storms and the 10-year storm peak flows at the predevelopment rates.



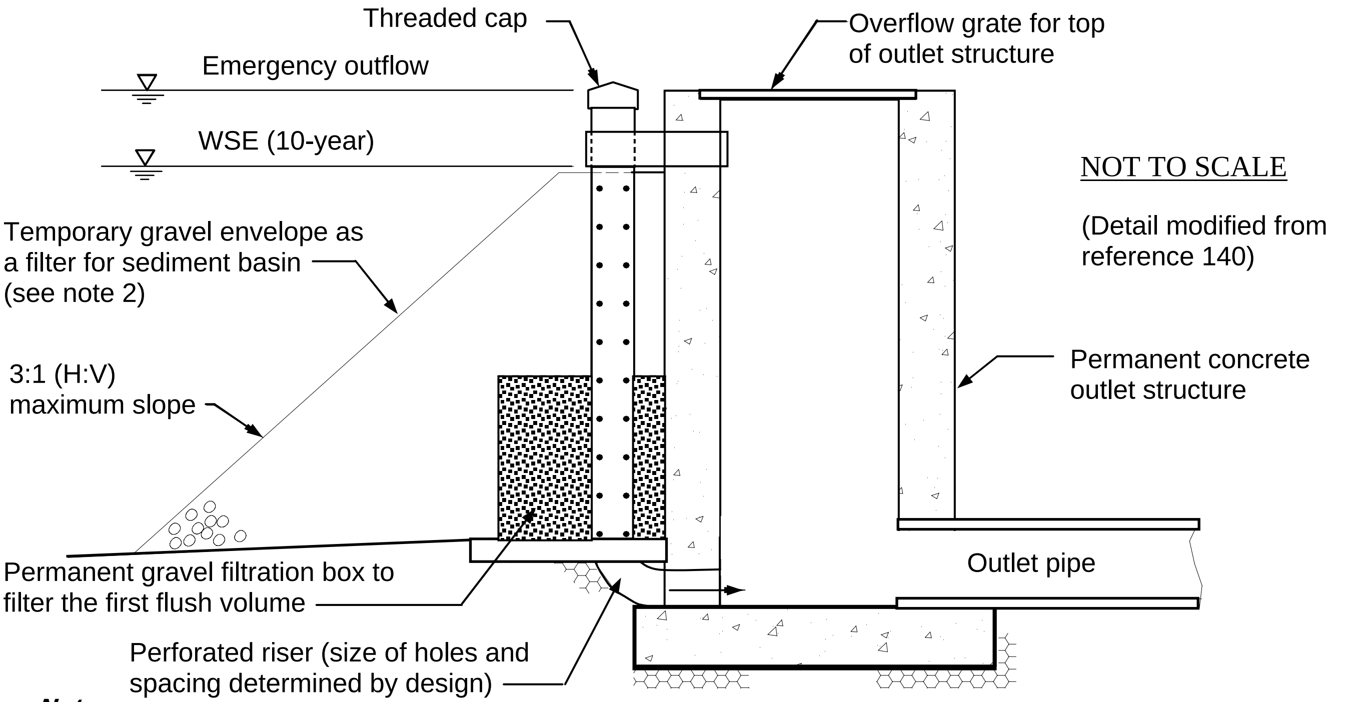
V-Notch Weir
(to control outflows)



Gravel Filtration Box
(first flush release)

Figure ST-01-2
Typical Outlet Structure

(shown with a V-notch weir and gravel filtration box)



Notes:

2. This type of outlet structure may be used as a permanent outlet structure for a dry detention basin. Maintain the gravel filtration box in unclogged condition within an enclosure in front of outlet structure to protect the perforated riser.

OR

1. This type of outlet structure may be used as a temporary modification to a dry detention basin (so that it may also function as a sediment basin). A temporary plastic riser is securely fastened using bolts, screws, or threaded connectors. Use gravel to help protect the temporary riser.

Figure ST-01-3
Outlet Structure — Alternative A
(also shown as a temporary sediment basin during construction)

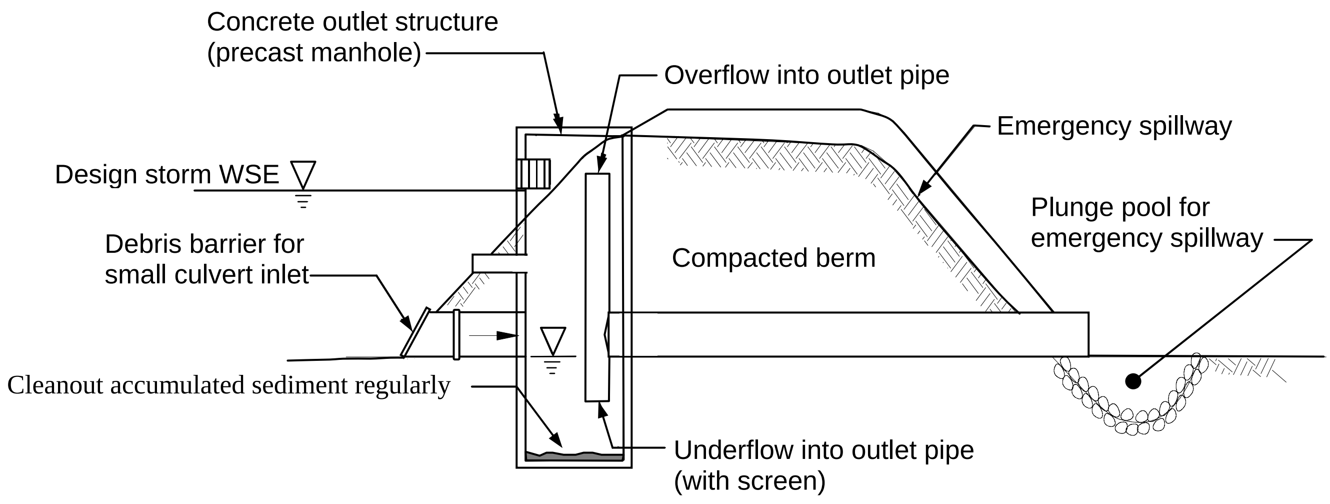


Figure ST-01-4
Outlet Structure — Alternative B
(includes water quality manhole with underflow)

A backslope drain has two purposes:

1. Safely convey storm water to the bottom of a detention basin slope.
2. Increase flow paths by channeling storm water into the detention basin far away from outlet structure.

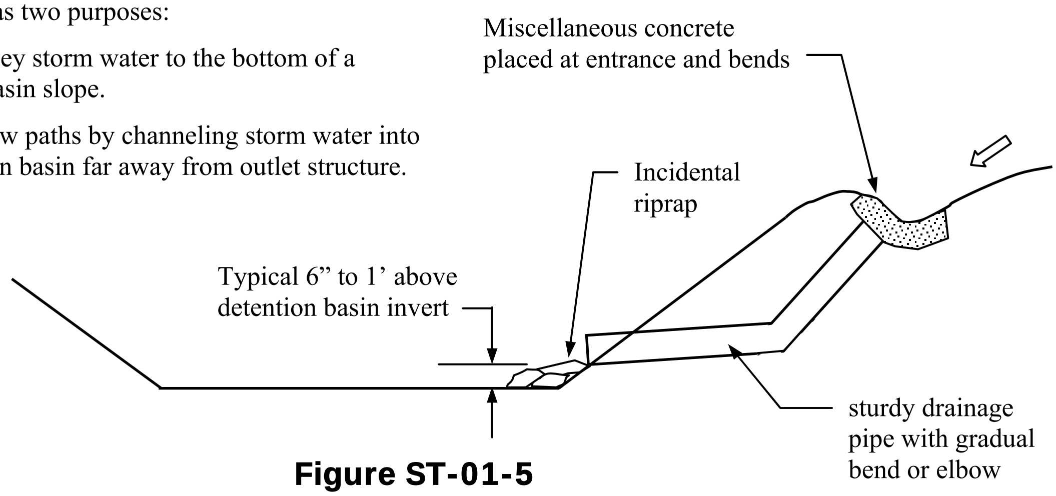


Figure ST-01-5
Typical Detail — Backslope Drain

Required Data for Detention Basin Design:

1. A map showing the predevelopment and post development tributary areas with computed area in acres.
2. Soil map (with legend and supporting data) to show the Hydrologic Soil Group for soils in drainage areas.
3. Land uses labeled and curve numbers computed for each tributary area.
4. Delineation of the longest flow path and Tc computations for each tributary area.
5. Predevelopment & post development hydrographs (NRCS Type II distribution for 24-hour storms).
6. Preliminary estimate for needed detention storage volume and for the first flush volume.
7. Storage vs. elevation—curve or rating table. Computed at regular intervals (not just interpolated).
8. Outflow vs. elevation—curve or rating table. Computed at regular intervals (not just interpolated).
9. Routed post development hydrographs for the volume of the two-year and five-year storms and the 10-year storm, showing no increase in peak outflows.
10. First flush orifice is sized to release the first flush volume over a minimum period of 24 hours.

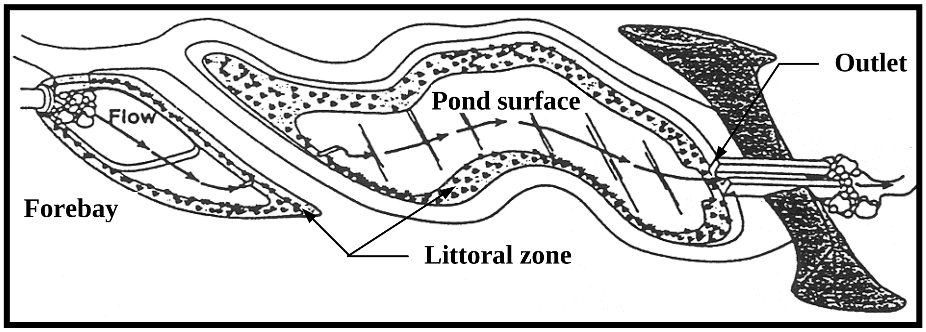
Physical Layout for Detention Basin:

1. Side slopes that are 3:1 (H:V) or flatter, with BMPs to assist in fully establishing vegetation and preventing erosion —OR— Side slopes that are not steeper than 2:1 (H:V) with traversable access and additional BMP controls for fully establishing vegetation.
2. Minimum bottom slope of 2% (minimum 1% with paved invert). Not marshy, drains well.
3. Minimum 2:1 length to width ratio for basin. Maximize distance between inlets and the outlet structure.
4. Provide minimum freeboard of 12 inches between top of berm and the largest routed storm hydrograph.

Outlet Structure:

1. Concrete, block, or precast outlet structure (typical 6” wall thickness), with a concrete outlet pipe.
2. Minimum diameter of outlet structure is 36” to allow for access within the outlet structure.
3. Orifices and weirs are neatly formed/drilled to correct size. Durable metal weir plates are also acceptable.
4. Provide steps at 18” intervals if outlet structure is more than 3 feet high.
5. Provide lockable grates or other measures to prevent neighborhood children from playing in basin.
6. Provide gravel filtration box (or other durable low-maintenance device) for the first flush orifice.
7. Consider building a trash rack if debris and litter are likely to occur.

ACTIVITY: Wet Detention Basin	ST – 02



Targeted Constituents				
¸ Significant Benefit		Û Partial Benefit	¹ Low or Unknown Benefit	
¸ Sediment	¸ Heavy Metals	¸ Floatable Materials	Û Oxygen Demanding Substances	
¸ Nutrients	¸ Toxic Materials	Û Oil & Grease	Û Bacteria & Viruses	¹ Construction Wastes

Description

A wet detention basin is a very desirable method to satisfy both storm water detention and storm water quality requirements. It is applicable to most locations for which the contributing drainage area can support a permanent pool of water. A wet detention basin can be enhanced with other storm water treatment BMPs such as a pretreatment sediment forebay, baffle box, or storm water quality inlet.

This practice will provide a significant reduction in sediment and most types of pollutants. A wet detention basin is generally more effective than a dry detention basin at allowing sediments and other pollutants to completely settle out.

Selection Criteria

Þ The primary objective is to reduce the peak flow discharge and slow the storm water runoff response for a particular property or development, thus reducing flooding downstream. Procedures for preparing calculations are outlined in Volume 2, Chapter 8, Detention, of the Storm Water Management Manual (SWMM) including the correct use of Natural Resources Conservation Services (NRCS) Technical Release 55 (TR 55) for determining the required detention storage. Some example problems are included in Volume 2, Chapter 8 of the SWMM using complex spreadsheet analyses HEC-1 and HEC-HMS.

Þ The secondary objective is to remove suspended sediments, trash and debris, oil, grease, and other pollutants to protect the water quality of Memphis-area streams and channels. Wet detention basins not only allow physical settling of sediments and pollutants, but will also permit a limited amount of chemical mixing and interaction of dissolved nutrients and metals. Biological uptake will also occur to some degree within a wet detention basin. Dissolved contaminants are removed by a combination of physical adsorption to bottom sediments and suspended fine sediments, natural chemical flocculation, and uptake by aquatic plants.

- Wet detention basins are ideal for large regional detention facilities; larger drainage areas are likely to have a minimum base flow entering the system. Wet detention basins should be used if it is imperative to achieve high levels of particulate and dissolved contaminant removal.

- Wet detention basins also can supply multiple benefits for passive recreation during dry periods (recreational trails, ball fields, picnicking, bird-watching, wildlife habitat). Portions of a wet detention basin that are not wetted frequently can be attractively landscaped or used for other purposes. See Figure ST-09-1 for typical placement of various storm water treatment BMPs.

Design Criteria

A permanent detention basin design must be stamped by a professional engineer licensed in the state of Tennessee. The professional engineer must be qualified by education and experience to perform the necessary hydrologic and hydraulic calculations. A wet detention basin must be located and designed so that failure of the structure will not result in danger to human life, damage to personal property, inundation of public streets or highways, interruption of public services or utilities, or inconvenience to the general public.

- As the primary objective, dry detention basins must be designed to have adequate detention storage and outlet structures. See Volume 2, Chapter 8, Detention, of the SWMM for a discussion of detention design methods and formulas that are acceptable. Memphis and Shelby County require detention for two-year and five-year NRCS Type II rainfall storm design events. In addition, peak control of the 10-year NRCS Type II rainfall is required. The outlet structure must be made from durable concrete or masonry construction, and typically the outlet structure has multiple weirs and/or orifices to release the design storms at predevelopment rates.

- As the secondary objective, water quality is obtained through detaining the volume of the two-year and five-year rainfall events. The initial wave of storm water runoff is more likely to contain aerially deposited sediments, particulates from vehicles (such as incomplete combustion, dust from brake linings, tire particles), leaves, trash, cigarette butts, etc. In addition, vegetative lower lining detention basins will serve as a biofilter for first flush pollutants. The permanent pool storage volume should be designed with vegetation around the water surface and with riprap or nonerosive materials near inlet and outlet structures. Sediment and particulates continue to settle in the permanent pool storage volume for a few days after a rainfall event.

- Additional measures may be required to improve storm water quality, depending upon the nature of the land use and expected pollutants. Pretreatment of storm water runoff with a media filtration inlet or oil-water separator may be necessary. A trash rack for capturing floating debris is generally considered to be standard equipment for a storm water treatment

BMP. Storm water runoff that falls onto pavement and rooftops should be detained and treated in a manner that will reduce thermal impacts to streams, such as locating a detention basin away from sunlight by using trees or buildings as shade.

Design Approach

The major features of a wet detention basin are shown in Figure ST-02-1. It is essentially a small pond or lake with rooted wetland vegetation along the perimeter. The storage volume can be divided into two portions: 1) live detention storage and 2) permanent pool storage.

The live detention storage (above the lowest opening in the outlet structure) provides peak flood control, erosion control, and additional treatment benefits. The recommended design includes a sediment forebay (or even multiple forebays) wherever the storm water runoff enters the wet detention basin. Live detention storage can also include areas that are not frequently inundated; these areas may have multiple recreational uses as shown in Figure ST-09-1. The storage volumes necessary to limit peak flow discharges from a wet detention basin to predevelopment peak flows are computed using NRCS TR 55 methods as shown in Volume 2, Chapter 8, Detention, of the SWMM. Live detention storage volume is computed using the same methods for both dry detention basins and wet detention basins.

The permanent pool storage volume (below the lowest opening in the outlet structure) provides a quiescent volume for settling of particulate contaminants and the uptake of dissolved contaminants by aquatic plants between storms. Wetland vegetation (in the littoral zone) will improve removal of dissolved contaminants, reduce the formation of algae, stabilize the shoreline and reduce waves, provide dissolved oxygen and habitats for aquatic organisms, and create attractive landscaping. The permanent pool storage volume is computed to determine a minimum residence hydraulic time, which is the average time that a drop of water is expected to remain in the wet detention basin.

Location & Layout

Basic elements of a wet detention basin are illustrated in Figures ST-02-1 and ST-02-2. The recommended design includes the use of a sediment forebay or other storm water treatment BMPs to reduce sediment and pollutant loading. Principal elements in assessing the potential for a wet detention basin are the existing and proposed site conditions for soils, topography, and vegetation, and the amount of available base flow.

Design flow paths to minimize potential short-circuiting by locating the inlets as far away from the outlet structure as possible. The length-to-width ratio of a basin should be at least 2:1 (and preferably 3:1). If topography or aesthetics require the basin to have an irregular shape, increase the basin area and volume to compensate for dead spaces. Reduce velocity of incoming storm water with riprap or energy dissipaters.

Interaction with site utilities must be considered during preliminary design. Typical utilities include electrical, telephone, cable TV, water, sewer, natural gas, petroleum, etc. These utilities may or may not be in a dedicated utility easement, so it is always necessary to conduct a careful site survey. Detention basins (including embankments) are not allowed over utility lines.

Detention basin access must be considered during preliminary design in order to allow for construction and maintenance. Detention basins that are not frequently inspected and maintained often become more of a nuisance than a beneficial part of a storm water management program. In particular, provide access for inspection and maintenance to the sediment forebay and to the outlet control structure. It may also be desirable to encourage or discourage public access to the detention basin (by using site grading, signs, fences, or gates). Additional safety elements include trash racks, grating over pipes and culverts, gentle side slopes whenever possible, increased visibility and/or lighting in residential areas, etc.

Small detention basins serving individual properties do not offer as many recreational benefits as community or regional detention basins would. Regional facilities can often be landscaped to offer recreational and aesthetic benefits. Jogging and walking trails, picnic areas, ball fields, and canoeing or boating are some of the typical uses. For example, portions of the facility for flood control of major design storms can be used for exercise areas, soccer fields, or football fields. Wildlife benefits can also be provided in the form of islands, buffer areas, or preservation zones. Figure ST-09-1 shows an example of a multiuse regional facility.

Volume and Size

The volume of a wet detention basin consists of two elements: the live detention storage (the upper portion of the basin representing detention capability) and the permanent pool storage volume (the lower portion of the basin representing storm water quality treatment). The live detention storage (which also includes the first flush volume) should be sized according to Volume 2, Chapter 8, Detention, of the SWMM, and also the procedures from NRCS TR 55 (reference 175). Detention computations should generally be checked and verified by performing routing computations.

The minimum permanent pool storage volume should have a hydraulic residence time of 14 days, based on average rainfall during the wettest month of the year. In general, a longer hydraulic residence time is desirable because it allows biological and chemical assimilation of nutrients and pollutants to continue for a longer time. In addition, since sediment removal and maintenance of a wet detention basin is very difficult and costly, additional sediment storage should be designed as part of the permanent pool volume.

Size the permanent pool volume of a wet detention basin using the following formula:

$$V_{pp} = A_T \ R$$

V_{pp} = permanent pool volume (acre-ft)
A_T = total tributary area (acres)
R = average 14-day rainfall (feet)

The average 14-day rainfall is computed using March as the wettest month of the year.

Grading

The maximum slope above the permanent pool storage volume shall generally be 4:1 (H:V) or flatter. This encourages a strong growth of vegetation on the side slopes and helps to prevent soil erosion. Steep slopes, particularly on embankments or other fill soils, contribute to soil erosion and thereby reduce or negate the effectiveness of a wet detention basin with respect to water quality. Vegetate the side slopes and basin bottom to the maximum extent practical. If side erosion is particularly severe, consider the use of soil stabilization or armoring techniques. Do not locate detention basins immediately above or below a steep slope or grade, because impounded water may create slope stability problems.

The littoral zone is an area of the detention basin that supports rooted wetland vegetation. The littoral zone should be 1 to 2 feet below the normal water level, with a gentle slope of 6:1 (H:V) or flatter. Typically the littoral zone is 10 feet wide. The remainder of the permanent pool storage volume may have slopes as steep as 2:1 (H:V); this portion of the wet detention basin is generally protected against rainfall, water velocities, and wave action so that erosion does not occur.

The minimum width for top of embankment is 5 feet. Allow for 10% settlement of embankment, unless the embankment is thoroughly compacted with vibratory equipment or sheepsfoot rollers. The top of embankment (after expected settlement) shall generally be at least 2 feet above the top of outlet structure and at least 1 foot above the peak 10-year water surface elevation. Compaction in the immediate area of the emergency spillway can be difficult, but is necessary.

Retaining walls may be used on one or more sides of a detention basin if properly designed. Analysis of a retaining wall should include effects of saturated soil behind the retaining wall, in addition to the usual design considerations of vehicle and structural loadings above the retaining wall. In general, concrete retaining walls should not face southward in order to reduce the potential for heating on hot summer days. Using a backslope drain (see Figure ST-01-5 for a detail) can increase the flow path lengths to prevent short circuiting of the detention basin.

Outlet Structure

Memphis and Shelby County require that a detention basin outlet structure must be constructed from concrete, masonry block, or other durable materials. The city and county do not allow metal CMP risers to be used as an outlet structure due to problems with crushing, flotation, and durability. A concrete outlet structure is preferable to a masonry block structure because it is sturdier and more durable. Provisions should be made for sufficient reinforcement and anchoring.

The specific flow-controlling elements of an outlet structure may include one or more of the following: a circular orifice, a noncircular orifice, a rectangular weir, a trapezoidal weir, a triangular weir, a V-notch weir, culvert entrance control, or a riser overflow opening. The V-notch weir is an efficient combination of low maintenance requirements and a wide range of flow discharges. These types of controls for outlet structures are described at length Volume 2, Chapter 8 of the SWMM.

Figures ST-02-3 and ST-02-4 illustrate possible designs for the outlet structure. These details are only two possible ways to accomplish storm water detention and storm water quality control. The first flush volume is typically drained during a minimum time of 24 hours by using an orifice or orifices with a designed size. Maximum drain time should be less than 72 hours to allow for sufficient volume recovery prior to the next period of rainfall. Figure ST-02-5 shows an alternative outlet structure with a water quality manhole.

Other Design Elements

Þ A sediment forebay — to facilitate the cleanout of sediment, trash, debris, leaves, etc. The sediment forebay typically contains 5% to 10% of the total volume for a wet detention basin. It should be located at a point where velocities have dissipated, to allow large sediments and debris to settle out. A forebay can be separated from the remainder of a detention basin by several means: a lateral sill with rooted wetland vegetation, rock-filled gabion, rock retaining wall, or rock check dam placed laterally across the basin. The sediment forebay should be easily accessible so that it can be inspected and maintained.

Þ Public safety should be considered, particularly in residential areas. Avoid steep slopes and dropoffs; consider routes for escaping the detention basin if a person accidentally falls in. Provide fencing and signs in areas where children may potentially play, or in areas that have deeper water. Limit access to the outlet structure.

Þ Mosquitoes can be reduced by installing a steeper shelf transition at the water surface to reduce areas with water depths less than 12 inches. Small rock walls, gabions, or other structures may help to create this shelf transition. Habitats for the introduction of gambusia (mosquito fish) are also beneficial if the design also includes maintaining water levels for fish survival during the dry season. Water levels also need to be maintained during winter months for fish to survive the cold weather.

Þ Antiseep collars (around the outlet pipe) and cutoff clay layers (within the embankment) are usually necessary to reduce seepage. An antiseep collar should extend at least one pipe diameter from the culvert in all directions, with compacted clay backfill, using small mechanical tampers.

Þ Include trash racks or other debris barriers with a maximum opening size of 2” (and preferably 1”) on all outlet structures, except for any emergency spillway structures that are designed for a 25-year storm or greater return period. Trash racks that are placed at an angle to the direction of flow are somewhat less vulnerable to clogging.

- Provide means for vehicle access to the wet detention basin. Detention basins must be located in a maintenance easement so that city personnel have the right to inspect the facility. Maintenance easements that are not adjacent to a city right-of-way must also have an access easement, which allows for vehicle access without large trees or excessive vehicle grades.

- Include a skimmer, oil-water separator, or other type of storm water runoff pretreatment for detention basins with greater than 50 percent impervious surface or a potential for oil and grease contamination (such as vehicle fueling and maintenance facilities, in addition to large parking areas).

- An antivortex device for the outlet structure may be potentially needed for very large detention basins in areas where public access is not limited. The antivortex device may be a combination of vanes above the outlet structure or guide walls around the outlet structure that lessen the chance of humans drowning or reduce the potential for erosion and structural undercutting.

- Provide rooted vegetation at the pond perimeter to serve several functions. Rooted vegetation enhances the removal of dissolved pollutants and reduces the formation of floating algae. It provides some habitat for insects, aquatic life, and wetland wildlife. The littoral zone for rooted vegetation should be about 10 feet wide with a water depth of 1 to 2 feet. Vegetation in general slows flow velocities and increases settling.

- If placement of wetland vegetation along the perimeter is not feasible, consider the use of nonrooted wetland species (i.e., floating plants). Nonrooted vegetation is actually more effective than rooted vegetation in removing dissolved nutrients and metals. Nonrooted vegetation can be placed within floating containers to facilitate periodic removal and cleaning. Another alternative is a rock filter or bed to support nonrooted vegetation (similar to design of wastewater oxidation ponds).

Maintenance

- Inspect the wet detention basin regularly (several times a year) and particularly after heavy rainfall events. Record all observations and measurements taken. Perform any maintenance and repairs promptly. Remove debris and trash after storm events. Check outlet structure regularly for clogging.

- Remove sediment from forebay regularly to prevent resuspension or movement. The wet detention basin should be dredged or excavated when 10% of permanent pool storage volume has been lost. Sediment removal in a wet detention basin is a major effort requiring dewatering, difficult equipment access, wet soils, and some loss of wildlife and vegetation. Sediment may be permitted to accumulate if the detention basin volume has been overdesigned with adequate controls.

- Maintain a thick and healthy stand of vegetation. Mow or trim at regular intervals to encourage thick growth. Remove leaves, grass clippings, or sticks from the wet detention basin to prevent storm water pollution. Remove trees or nuisance vegetation as necessary in order to protect embankments. Repair banks and eroded areas.

- Reduce mosquitoes as necessary. Trim vegetation or alter water surface perimeter to reduce ponded depths that are less than 12 inches. Design of the wet detention basin may include a steeper depth transition to reduce shallow water depths less than 12 inches. Gambusia (mosquito fish) can also be placed in larger ponds if water levels are maintained to insure their survival during the dry season.

- A fountain may be desirable to increase the amount of dissolved oxygen in the water. Depths greater than 12 feet may develop anaerobic conditions, which is not desirable.

- If both the operational and aesthetic characteristics of a wet detention basin are not properly maintained, it will become an eyesore and a negative environmental impact. Vegetation needs to be trimmed or harvested. Ensure that repairs are made to walkways, picnic tables, signs, and public recreation equipment as needed.

Sediment Removal

A primary function of storm water treatment BMPs is to provide information on collecting and removing sediment. The sediment accumulation rate is dependent on a number of factors including watershed size, facility sizing, construction upstream, nearby industrial or commercial activities, etc. Sediments should be identified before sediment removal and disposal is performed. Special attention or sampling should be given to sediments accumulated from industrial or manufacturing facilities, heavy commercial sites, fueling centers or automotive maintenance areas, parking areas, or other areas where pollutants are suspected. Treat sediment as potentially hazardous soil until proven otherwise.

Some sediment may contain contaminants for which TDEC requires special disposal procedures. Consult TDEC–Division of Water Pollution Control (368-7939) if there is any uncertainty about what the sediment contains or if it is known to contain contaminants. Clean sediment may be used as fill material, hole filling, or land spreading. It is important that this material not be placed in a way that will promote or allow resuspension in storm water runoff. Some demolition or sanitary landfill operators will allow the sediment to be disposed at their facility for use as cover. This generally requires that the sediment be tested to ensure that it is innocuous.

Limitations

- A wet detention basin will require frequent inspection and maintenance. Trash, debris, leaves, and other large items should be removed from the detention basin following each rainfall event. If upstream erosion is not properly controlled, wet detention basins can be maintenance intensive with respect to sediment removal, nuisance odors, insects, and mosquitoes, etc.

Þ A wet detention basin may not have sufficient vegetation on the slopes and bottom to prevent erosion and pollutant resuspension. Vegetation must be maintained and cut at adequate intervals.

Þ A wet detention basin that impounds more than 30 acre-feet of volume (and minimum 6 feet high) or that is higher than 20 feet (and minimum 15 acre-feet of volume) is subject to the Tennessee Safe Dams Act of 1973 and as amended by law. The Safe Dams Act is administered by the TDEC Division of Water Supply; further information on design standards, regulations and permit applications is available at the TDEC Web site:

http://www.state.tn.us/environment/permits/safedam.php

Þ Wet detention basins may not be feasible in very dense urban areas. Do not locate detention basins on steep unstable slopes. Impervious soils such as clay are desirable to maintain water levels during the summer or other dry periods.

References **28, 31, 32, 33, 37, 45, 46, 64, 68, 72, 73, 76, 77, 84, 86, 88, 106, 133, 140, 142, 143, 147, 153, 154, 166, 175, 180** (see BMP Manual Chapter 10 for list)

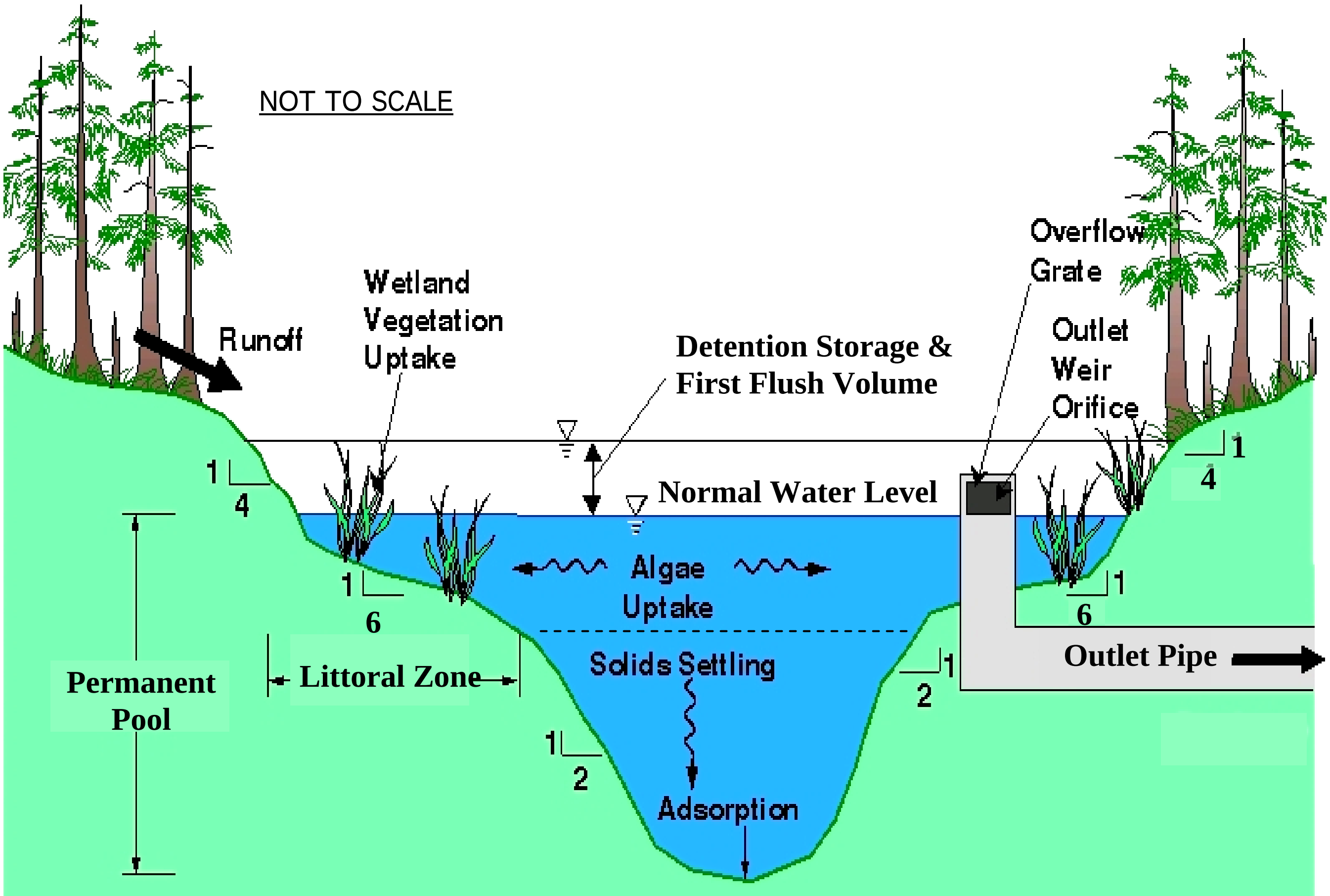
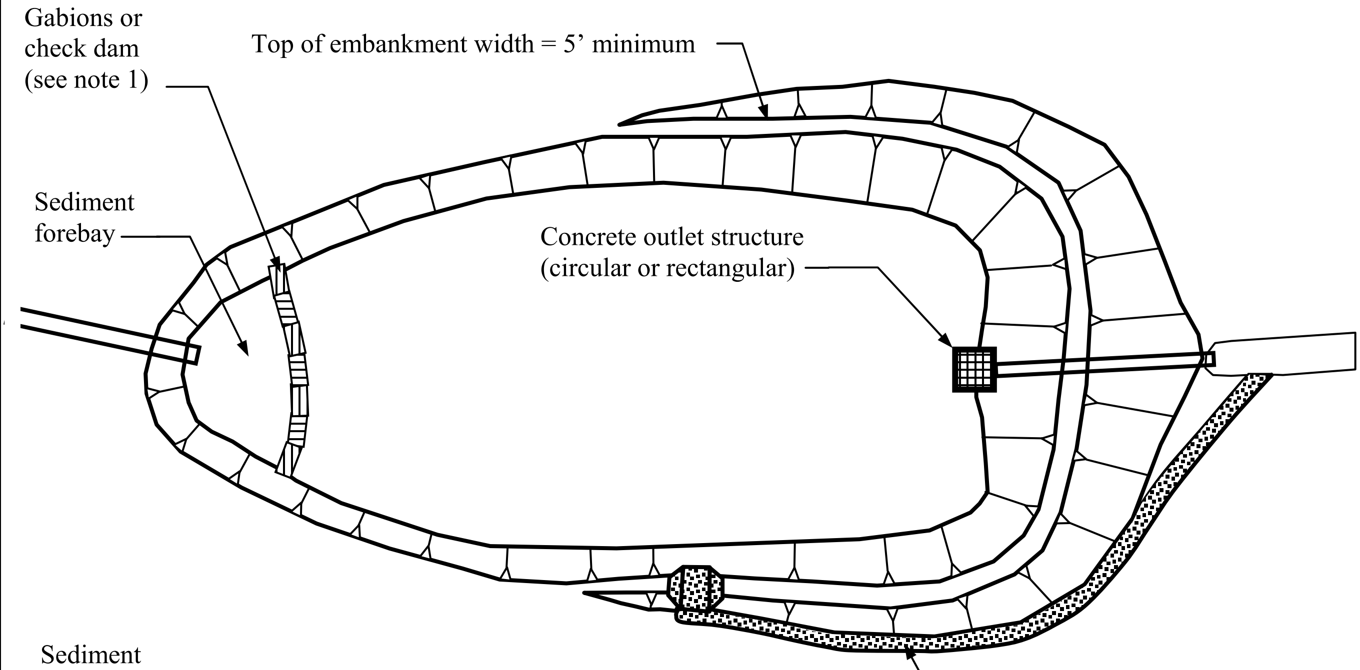
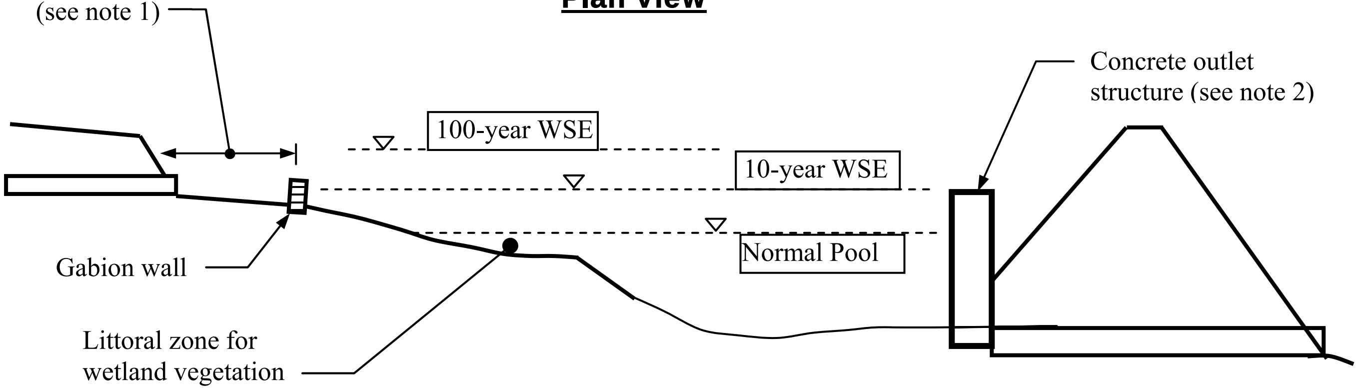


Figure ST-02-1
Schematic of Wet Detention Basin



Plan View



Profile View

Notes:

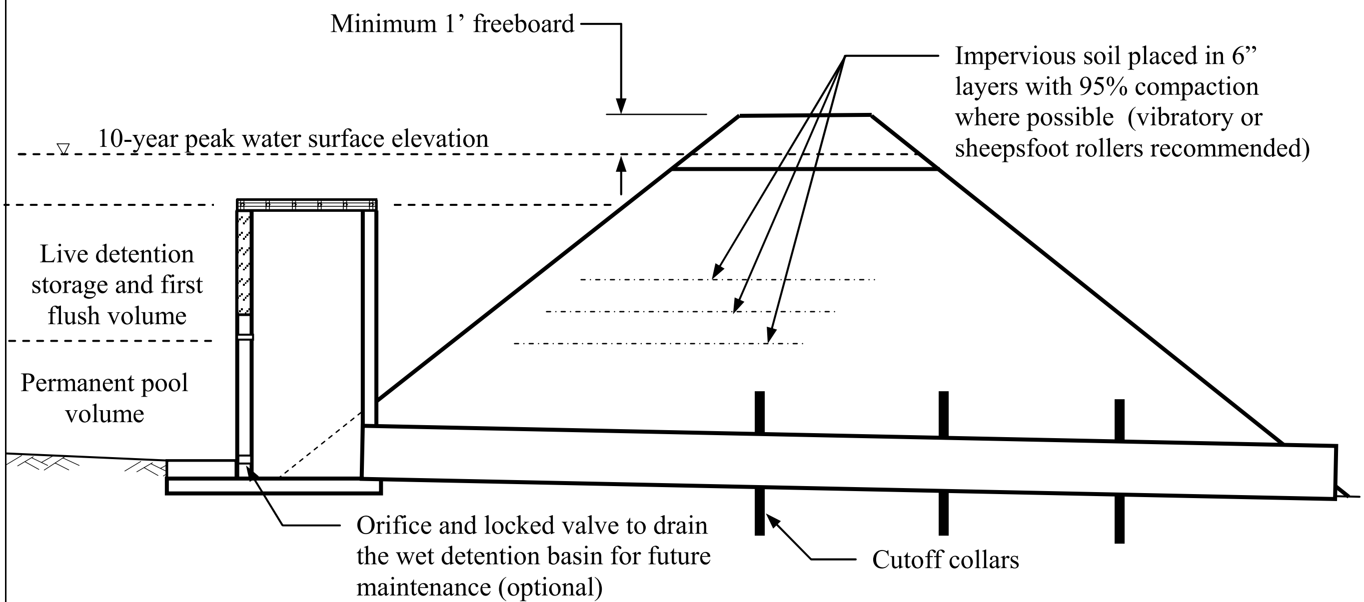
NOT TO SCALE

1. A sediment forebay can be constructed from gabions, rock check dams, or a separate berm with culvert. A sediment forebay can facilitate the capture and cleanup of coarse sediments, debris, and trash.

4. The outlet structure typically has orifices or weirs at computed elevations that will release the volume of the two-year, five-year, and 10-year storms at the specified predevelopment peak flow rates.

5. The emergency spillway is generally constructed on natural ground or excavated areas (rather than fill soils) to reduce the potential for erosion and washout.

Figure ST-02-2
Typical Wet Detention Basin Layout



Typical Outlet Structure (V-Notch)

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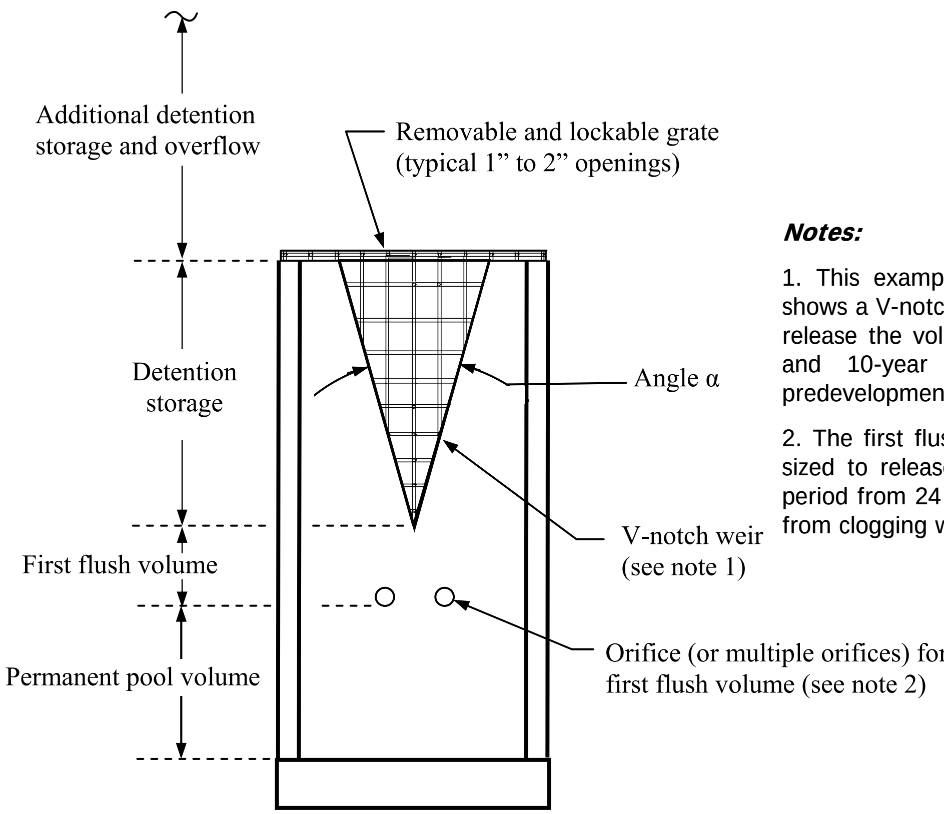


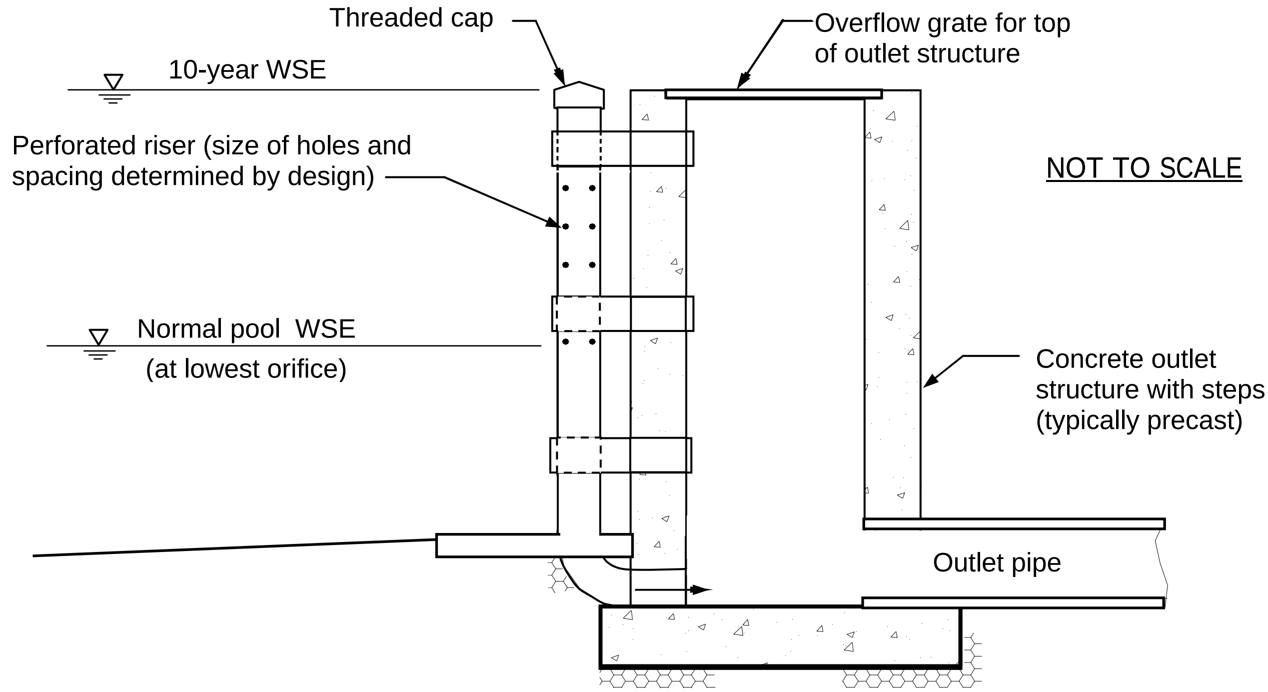
Notes:

1. This example of a typical outlet structure shows a V-notch weir, which should be sized to release the volume of the two-year, five-year, and 10-year storms peak flows at the predevelopment rates.

2. The first flush volume orifice or orifices are sized to release the first flush volume over a period from 24 to 72 hours. Protect the orifice from clogging with a trash rack.

Figure ST-02-3
Typical Outlet Structure

(shown with a V-notch weir)



Note:

This type of outlet structure may be used if there is adequate protection and structural support for the perforated riser.

Figure ST-02-4
Outlet Structure — Alternative A

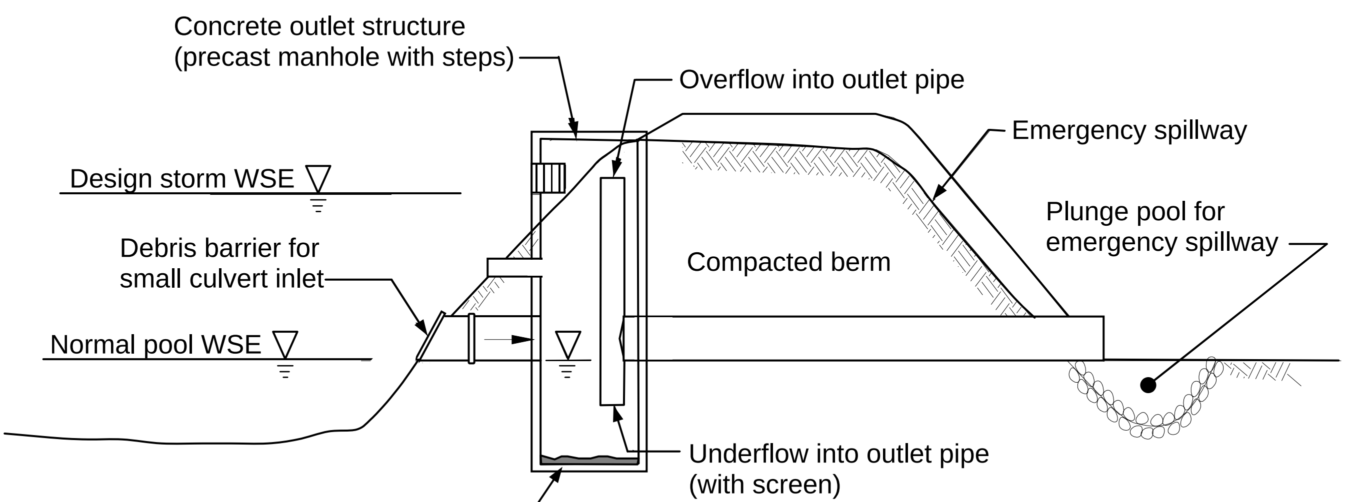
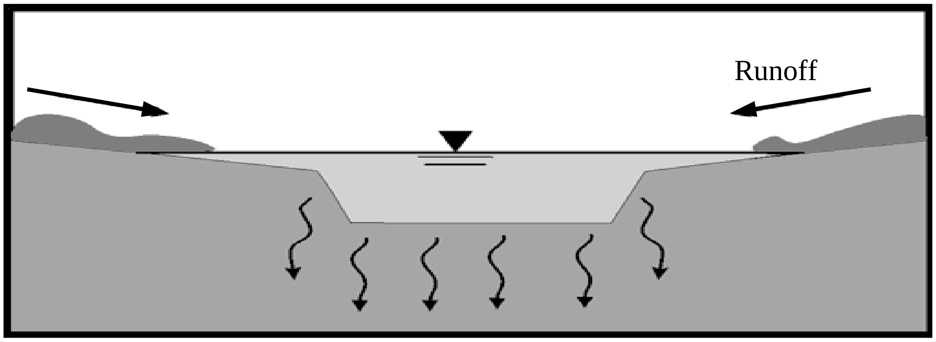


Figure ST-02-5
Outlet Structure — Alternative B
(includes water quality manhole with underflow)

ACTIVITY: Infiltration Systems and Methods	ST – 03



Targeted Constituents				
¸ Significant Benefit		Û Partial Benefit	¹ Low or Unknown Benefit	
¸ Sediment	Û Heavy Metals	Û Floatable Materials	Û Oxygen Demanding Substances	
Û Nutrients	Û Toxic Materials	Û Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description

This BMP covers various methods, loosely grouped as infiltration systems, in which storm water runoff is infiltrated into the ground rather than discharged to a surface channel. These systems include infiltration basins; infiltration trenches, drywells, and vaults; and porous pavement. Infiltration rates in most of the Memphis area are typically poor due to clay soils. Some areas in eastern Shelby County that are currently undeveloped are located on large sand lenses that may allow for use of infiltration systems and methods.

Suitable Applications

Þ Infiltration basins and infiltration trenches may be used for storm water quality and storm water detention at small project sites only if soil, geologic, and groundwater conditions are suitable. Soils must have adequate infiltration rates as measured or tested in the field. No unfavorable geologic conditions shall be present that would indicate sinkholes or underground passageways.

Þ Drywells and vaults are suitable for draining small impervious surfaces, such as parking lots or residential rooftops, for which the adjacent pervious area has soils with adequate infiltration rates.

Þ Porous pavements make a generally impervious surface into a semi-pervious surface and do not usually function as a true infiltration system. There is a basic conflict for nonsandy soils to both support vehicle loads and allow water to infiltrate. Porous pavements should be restricted to light traffic conditions, such as residential driveways and overflow parking lots, without heavy truck use.

Þ Natural sinkholes (or other evidences of karst topography and drainage) are not considered to be infiltration systems for use in treating storm water quality or in providing storm water detention. In general, storm water drainage may continue to flow to a natural sinkhole at a rate that is representative of natural undeveloped conditions. No unusual or unfavorable geologic conditions shall be present near the sinkhole that indicates subsidence, piping, increased limestone dissolution, potential collapse, or other safety concerns.

Approach

Infiltration can be a very desirable method of storm water treatment for land uses that do not heavily pollute storm water runoff. For instance, established residential areas typically have less pollution than industrial and commercial areas. The primary physical conditions necessary for infiltration are: 1) permeable soils that have not been compacted or graded, and 2) low groundwater tables. Storm water runoff from parking lots or buildings should be pretreated with a water quality inlet, oil-water separator, grass swale, or other type of storm water treatment BMPs. The measures listed in this BMP can be informally grouped into two categories:

- Larger amounts of storm water runoff from a project site that are ponded and then forced to infiltrate (e.g., infiltration basin or infiltration trench).

- Smaller amounts of storm water runoff from selected impervious areas that are given an opportunity to infiltrate (e.g., drywell, dry vault, or porous pavement).

It is very important to protect the natural infiltration rate of suitable soils by only using lightweight equipment and construction procedures that minimize or eliminate compaction. In addition, prevent erosion and sediment transport from occurring upstream of an infiltration basin or other infiltration system. Inspect frequently for clogged soils and for ineffective infiltration rates. Improperly functioning infiltration systems must be replaced by other storm water treatment BMPs that are capable of providing water quality treatment.

Maintenance can be difficult and costly for infiltration systems, with a potential for high maintenance costs due to clogging. Maintenance costs and site access should be carefully considered prior to design. Pretreatment of storm water runoff may reduce maintenance costs by capturing coarse sediments and floatable materials in a smaller structure that can be more easily cleaned. All infiltration systems should be inspected several times the first year and at least twice a year thereafter. Maintain records of inspections and maintenance performed.

Overview of Infiltration Theory

The recommended minimum infiltration rate is at least 0.5 inches per hour, but may depend on type of infiltration system and the desired water quality treatment involved. Drawdown should occur within 72 hours using a safety factor of 2.0 to account for wet-weather water table conditions. An infiltration basin or trench must have at least 3 feet of separation from seasonal high groundwater. Coarse soils are not as effective in filtering groundwater; therefore, provide at least 6 to 8 feet separation from seasonal high groundwater for sand and gravel soils.

The overall degree of water quality treatment achieved by infiltration is a function of the amount of storm water that is captured and infiltrated over time. Minimum infiltration storage is generally required to be the first flush volume (the first 0.5" of storm water runoff from the entire contributing area). Consideration may be given to the following formula for 85% volume capture for the average rainfall event volume, with a minimum drain time of 12 hours, if there are extenuating circumstances such as impervious runoff from an adjoining property. Longer drain times require a larger capture volume.

$$V = (B)\ (C)\ (A)\ (P_m / 12)$$

V	=	storm water runoff capture volume (acre-feet)
B	=	regression constant from least-square analysis = 1.312 (for 85% runoff volume capture ratio with a 12-hour drain time)
C	=	watershed runoff coefficient (dimensionless)
A	=	watershed area (acres)
P_m	=	mean storm precipitation volume

Typical infiltration rates are shown in Table ST-03-1. The U.S. Department of Agriculture (USDA) soil texture classification is based upon the following definitions:

	Approximate size	**Rough description**
Gravel	> 2 millimeters (mm)	> No. 8 sieve or so
Sand	0.05 mm to 2 mm	> No. 200 sieve
Silt	0.002 mm to 0.05 mm	Little plasticity or cohesion
Clay	< 0.002 mm	Can be rolled and compressed

For preliminary design, infiltration rates may be estimated using a published soil survey. However, final design must include soil gradation testing and measurement of unsaturated vertical infiltration rates in the field by the double-ring infiltrometer test. This test is not appropriate for clay soils or other soils that clearly appear to be unsuitable for infiltration methods. The allowable infiltration rate is 0.5 inches per hour, although an infiltration rate of 1 inch per hour is highly recommended. Table ST-03-1 shows that soils with a hydrologic soil group of C or D will not have sufficient infiltration rates.

Another well-known method of categorizing soils and evaluating soil properties is by the Unified Soil Classification System (USCS). The following soil groups are generally acceptable as good soils for infiltration:

SW	Well-graded sands and gravelly sands, little or no fines
SP	Poorly graded sands and gravelly sands, little or no fines
SM	Silty sands, sand-silt mixtures

Table ST-03-1
Typical infiltration Rates from USDA Soil Texture

	USDA Soil Texture	Typical Water Capacity (inches per inch of soil)	Typical Infiltration Rate (inches per hour)	Hydrologic Soil Group
*	Sand	0.35	8.27	A
*	Loamy sand	0.31	2.41	A
*	Sandy loam	0.25	1.02	B
*	Loam	0.19	0.52	B
	Silt loam	0.17	0.27	C
	Sandy clay loam	0.14	0.17	C
	Clay loam	0.14	0.09	D
	Silty clay loam	0.11	0.06	D
	Sandy clay	0.09	0.05	D
	Silty clay	0.09	0.04	D
	Clay	0.08	0.02	D

* — Suitable for infiltration with typical 6' to 8' separation from seasonal high groundwater
** — Suitable for infiltration with at least 3' separation from seasonal high groundwater

Design Guidelines

Infiltration Basin

Infiltration basins may be used for storm water quality and storm water detention at small project sites only if soil, geologic, and groundwater conditions are suitable. Soils must have adequate infiltration rates as measured or tested in the field. No unfavorable geologic conditions shall be present that would indicate sinkholes or underground passageways. Unless adequate engineering documentation is submitted, an infiltration basin must be located at least 100 feet away from any drinking water well, septic tank, or drainfield. It is also recommended that an infiltration basin should not be located near building foundations, buildings with basements, major roadways, wetlands, streams, or potentially unstable slopes and hillsides.

In general, infiltration basins are not effective in the Memphis area due to clay soils and shallow bedrock conditions. Smaller infiltration systems (trenches or drywells) may be applicable if local soil conditions allow. Avoid steep slopes or other geologic conditions that could potentially be made unstable by infiltrating water into the ground.

Figure ST-03-1 shows a typical infiltration basin. Pretreatment is highly recommended for areas with fine-grained soils, dust, sediment, debris, or other materials with the potential to clog the soils of an infiltration basin. Design an emergency overflow or a bypass for larger storms (using overland relief swales or possibly even street drainage in the case of 100-year floods).

The criteria in Table ST-03-2 (taken from reference 32) can be used to make comparative evaluations if there is more than one potential site for an infiltration system. A score of 20 or below is definitely unsuitable for use as an infiltration basin. A score of 30 or more indicates an adequate site for an infiltration basin.

Table ST-03-2
Comparative Evaluations of Potential Infiltration Sites

A. Ratio of tributary-connected impervious area (A_{IMP}) and the infiltration area (A_{INF}):

- × $A_{INF} > 2\ A_{IMP}$ 20 points
- × $A_{IMP} < A_{INF} < 2\ A_{IMP}$ 10 points
- × $0.5\ A_{IMP} < A_{INF} < A_{IMP}$ Π 5 points

B. Nature of surface soil layer:

- × Coarse soils with low ratio of organic material Π 7 points
- × Normal humus soil 5 points
- × Fine-grained soils (silt or clay) 0 points

C. Underlying soil layer:

- × If the underlying soils are coarser than surface soil, assign the same number of points as for the surface soil layer assigned under item A above.
- × If the underlying soils are finer grained than the surface soils, then use:
  - — Gravel, sand, or coarse glacial till Π 7 points
  - — Silty sand or loam Π 5 points
  - — Fine-grained soils (silt or clay) Π 0 points

D. Slope of the infiltration surface:

- × Slope < 7% Π 5 points
- × 7% < slope < 20% Π 3 points
- × Slope > 20% Π 0 points

E. Vegetation cover:

- × Healthy natural vegetation cover 5 points
- × Lawn is well established 3 points
- × Lawn is new 0 points
- × No vegetation, bare ground 5 points

F. Degree of traffic on infiltration surface:

- × Little or no foot traffic 5 points
- × Average foot traffic (park, lawn) 3 points
- × Much foot traffic (playing fields) 0 points

The infiltration basin volume should be sized to handle at least 85% of the average annual runoff, using the formula for volume capture (as discussed previously). The maximum allowable depth should be calculated using a safety factor of 2.0 to represent the uncertainty of infiltration due to construction methods and potential clogging:

Maximum ponding depth = (24 hours) x (infiltration rate)/(factor of safety)

Minimum surface area = (required volume)/(maximum ponding depth)

An infiltration basin should be excavated by a backhoe or excavator with adequate reach to operate from outside the basin. Side slopes should typically have 5:1 side slopes or flatter in order to minimize soil erosion. The bottom slopes should be as flat as possible. Sodding may help to quickly establish dense grass on the slopes, low-flow channels, basin entrance, and emergency spillway. Do not plant trees or woody vegetation within the infiltration basin.

An observation and sampling well (typically a perforated polyvinyl chloride (PVC) pipe riser, 6” diameter, threaded cap) should be installed to allow for periodic monitoring and testing. Installation of a PVC riser may occur during the initial geotechnical investigation and then be modified during the construction of the infiltration basin. Prevent surface water runoff from using the riser to gain direct access to the groundwater table, particularly in areas with high pollution potential such as industrial facilities, parking lots, roadways (due to truck spills or deicing salts), major utility lines, etc.

For infiltration basins treating less than a few acres of pavement, pretreatment can usually be accomplished with a catch basin and a submerged outlet. The diameter and depth of the sump in the catch basin should be at least four times the diameter of the outlet pipe to the infiltration system (reference 66). Grass swales can also be used, although they may not be feasible in industrial sites, which tend to be fully utilized.

Inspect and repair infiltration basins at least twice a year. Remove sediment and debris as necessary. Do not allow heavy equipment or vehicles within the infiltration basin by using physical restrictions such as a fence or gate. Do not allow heavy foot traffic (as would be typical for a soccer or football field) within the infiltration basin area. Maintenance must also include regular mowing and removal of trees.

Infiltration Trench

An infiltration trench essentially has the same design characteristics as an infiltration basin, except that part of the storm water runoff storage is located within a gravel trench. The volume available for water storage is found by multiplying the total gravel volume by the porosity (η). Typical details for an infiltration trench are shown in Figure ST-03-2 (for surface drainage) and Figure ST-03-3 (for rooftop drainage). The bottom of the infiltration trench should be located at least 3 feet above the seasonal high groundwater table. There are provisions for emergency overflow in both details.

At a minimum, the infiltration trench should have adequate volume to treat the first flush (which is the first 0.5” of storm water runoff from the entire contributing area). Infiltration trenches may be used around the perimeter of parking lots, between subdivision lots, or along medians or roadside swales. An infiltration trench does not have organic soil layers or surface vegetation to trap some types of pollutants. A trench may be ineffective for soluble pollutants such as hydrocarbons, nitrates, salts, or organic compounds.

An infiltration trench should have an observation and sampling port, to assist in cleanout and to check water quality and groundwater levels. Geotextile fabric should be selected on the basis of durability, with an adequate opening size to resist clogging. Use clean washed aggregate (little or no fines). Do not compact the trench bottom or the aggregate; protect the area from heavy equipment and traffic by physical means.

Maintenance considerations should include the possibility of replacing an infiltration trench every 5 years, as the gravel and geotextile fabric will eventually become clogged and cease to function. Clogging may also occur at the bottom of the trench, along the gravel/soil interface. Clogging will occur even faster if there are fine silts, oil and grease, fertilizers, and other materials present in storm water runoff. Do not allow trees or other woody vegetation to become rooted along an infiltration trench. Inspect operation and recovery of infiltration trench at least a few times a year.

Drywell or Dry Vault

A drywell or dry vault can be used to infiltrate storm water runoff from small areas of impervious runoff, such as roofs or parking lots. The designer should be very careful to avoid adverse impacts to foundations, basements, unstable slopes, hillsides, septic tanks, or utility lines, etc. A small pretreatment chamber with a screen is recommended in many instances to handle leaves (roofs) or trash and sediment (parking lots).

A typical drywell adjacent to a house foundation is shown in Figure ST-03-4 (without a pretreatment chamber). A dry vault (larger than a drywell) can be constructed using masonry blocks and a poured concrete lid to hold a larger volume of storm water runoff. Inspect the drywell or dry vault on a regular basis. Maintenance plans should include provisions to repair or replace this type of structure after five years or so.

Porous Pavement

Porous pavements are not actually considered as a true infiltration system unless there is a mechanism for ensuring that captured water is vertically transmitted through the soil into groundwater. Otherwise, porous pavements shall generally be analyzed as a gravel surface (road or parking lot) with normal runoff coefficients used for the Rational formula or for National Resources Conservation Service methods of drainage design.

Porous pavement is usually a modular pavement grid, although pour-in-place concrete can be made into porous pavement also. See Figure ST-03-5 for a few types of porous pavement (taken from reference 45) for which grass is allowed to grow between the grids. A less durable variation can be made with bricks, placed on sand bedding, and filled in with soil, with approximately 50% brick surface. Porous pavements should be restricted to light traffic conditions without heavy trucks. Porous pavements are particularly recommended for residential driveways or overflow parking lots.

Porous pavements are likely to absorb large amounts of pollutants from automobiles, such as heavy metals and petroleum products. Porous pavements should be cleaned regularly using methods that will not dislodge the grass, sand, or soil from between the concrete grids. Collect wash water and dispose properly to avoid washing pollutants downstream.

Maintenance

- Inspect and observe the infiltration system several times during the first year, particularly after heavy rainfall events. Use observation wells and cleanout ports to monitor water levels and drawdown times. Record all observations and measurements taken. Perform any maintenance and repairs promptly.

- Inspect the infiltration system annually thereafter, and after extreme rainfall events. If storm water does not infiltrate within 72 hours after a storm, it is generally time to clean, repair, or replace the facility. Remove debris and sediment at least annually to avoid high concentrations of pollutants and loss of infiltration capacity.

- The primary objective of maintenance and inspection activities is to ensure that the infiltration facility continues to perform as designed. Regular inspection can substantially lengthen the required time interval between major rehabilitations.

- Prevent compaction of the infiltration surfaces by physical controls such as gates or fences. Maintain dense grass vegetation for infiltration basins. Use rotary tillers on infiltration surfaces when needed to restore infiltration capacity and to control weed growth.

Sediment Removal

A primary function of storm water treatment BMPs is to collect and remove sediments. The sediment accumulation rate is dependent upon a number of factors including watershed size, facility sizing, construction upstream, and nearby industrial or commercial activities, etc. Sediments should be identified before sediment removal and disposal is performed. Special attention or sampling should be given to sediments accumulated from industrial or manufacturing facilities, heavy commercial sites, fueling centers or automotive maintenance areas, parking areas, or other areas where pollutants are suspected. Treat sediment as potentially hazardous soil until proven otherwise.

Some sediment may contain contaminants for which the Tennessee Department of Environment and Conservation (TDEC) requires special disposal procedures.

Consult TDEC — Division of Water Pollution Control (368-7939) if there is any uncertainty about what the sediment contains or if it is known to contain contaminants. Clean sediment may be used as fill material, hole filling, or land spreading. It is important that this material not be placed in a way that will promote or allow resuspension in storm water runoff. Some demolition or sanitary landfill operators will allow the sediment to be disposed at their facility for use as cover. This generally requires that the sediment be tested to ensure that it is innocuous.

Limitations

The four major concerns with infiltration systems are clogging, potential impact on other structures and properties, accumulation of heavy metals, and the potential for groundwater contamination.

- Clogging and high maintenance costs are very likely to occur in fine soils that are marginally allowable for infiltration rates. Erosion control is extremely important to prevent clogging; infiltration systems fail if they receive high sediment loads. Perform regular maintenance and inspections to minimize the potential for clogging and loss of infiltration capacity. Pretreatment is highly recommended for storm water runoff from many land uses, prior to discharging to an infiltration system. Erosion of the side slopes is a major factor in clogged infiltration basins.

- Infiltration systems are not appropriate for areas with high groundwater tables, steep slopes, lots of underground infrastructure, and nearby buildings.

- Heavy metals are likely to settle in any of the storm water treatment BMPs, but particularly for infiltration systems (which have the lowest velocity). High levels of heavy metals have been observed in other states where adequate maintenance was not performed. Toxic levels are not likely to be exceeded, but the sediments will need to be handled as hazardous waste after a few years of neglect.

- There is a higher risk of groundwater contamination in very coarse soils (references 2 and 79). It is highly recommended that a monitoring and inspection program should be used to verify that no contamination occurs. Infiltration systems may not be appropriate where there is significant potential for hazardous chemical spills.

References

2, 3, 28, 31, 32, 33, 42, 44, 45, 49, 51, 56, 62, 66, 69, 71, 77, 79, 88, 101, 104, 109, 121, 130, 163, 166 (see BMP Manual Chapter 10 for list)

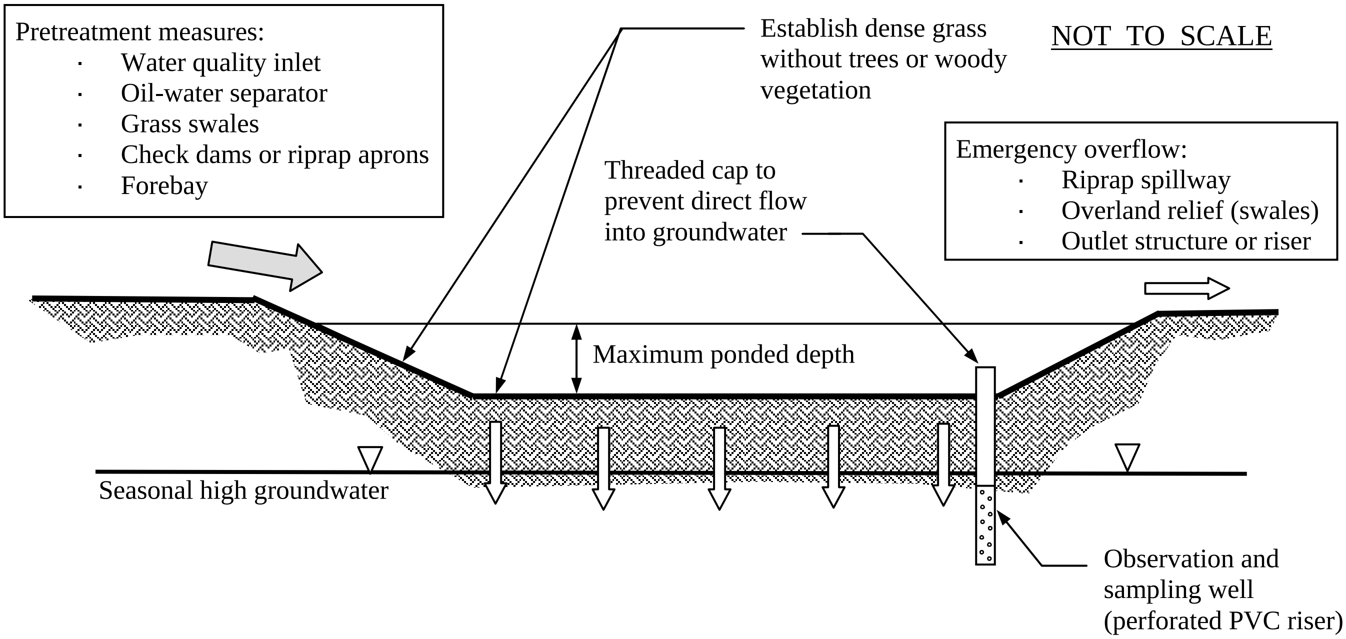


Figure ST-03-1
Typical Infiltration Basin

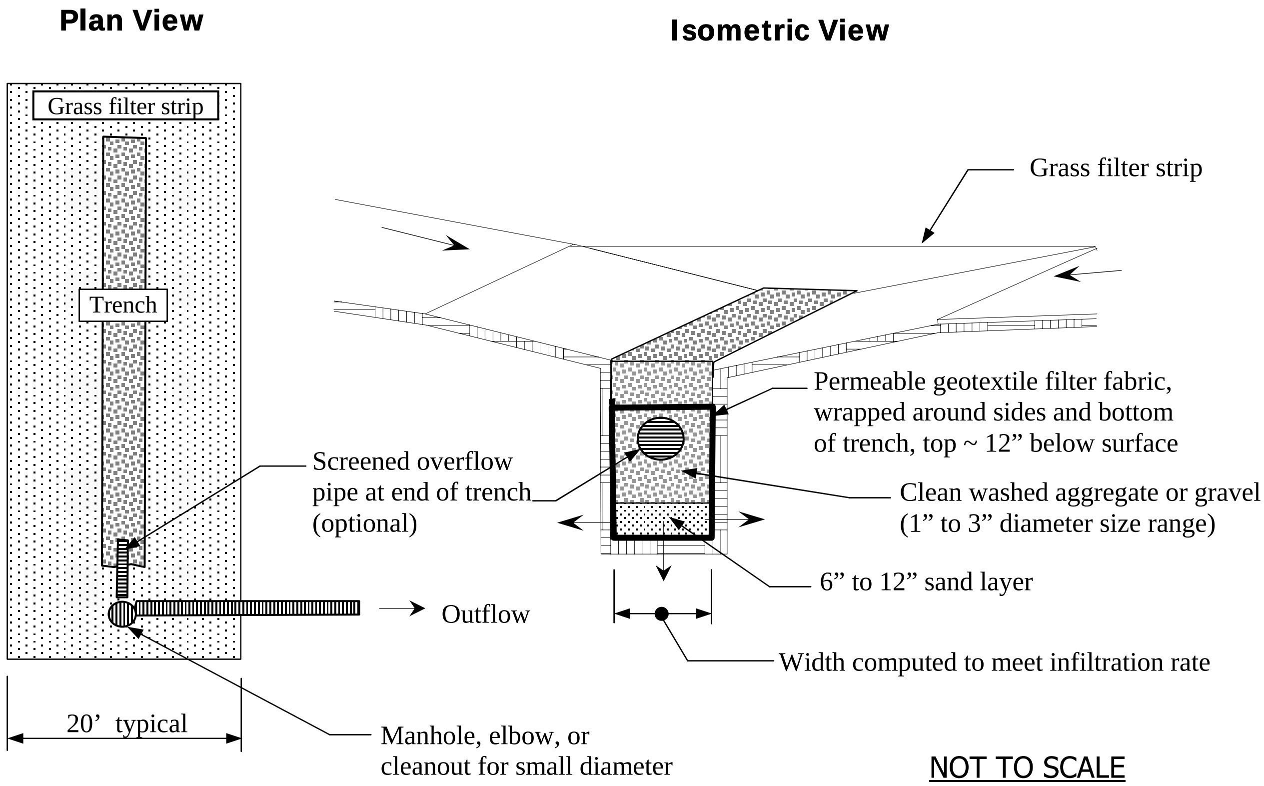


Figure ST-03-2
Typical Infiltration Trench (with Surface Drainage)

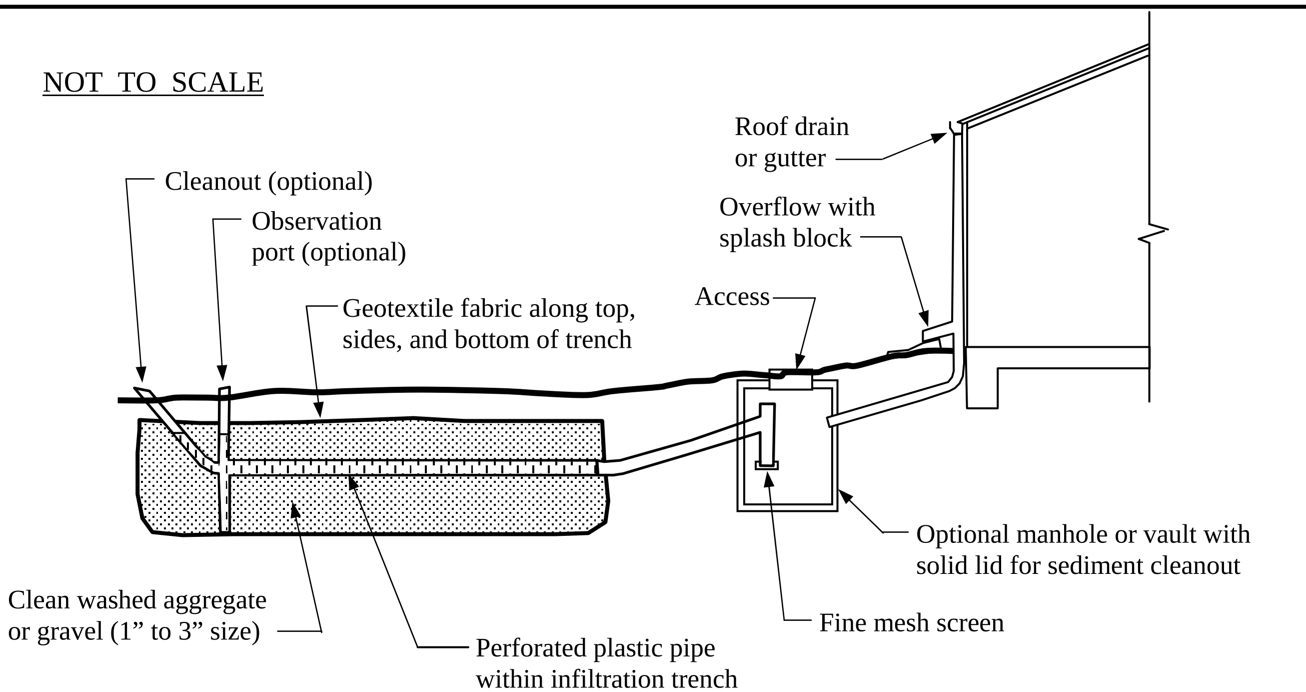


Figure ST-03-3
Typical Infiltration Trench (with Rooftop Drainage)

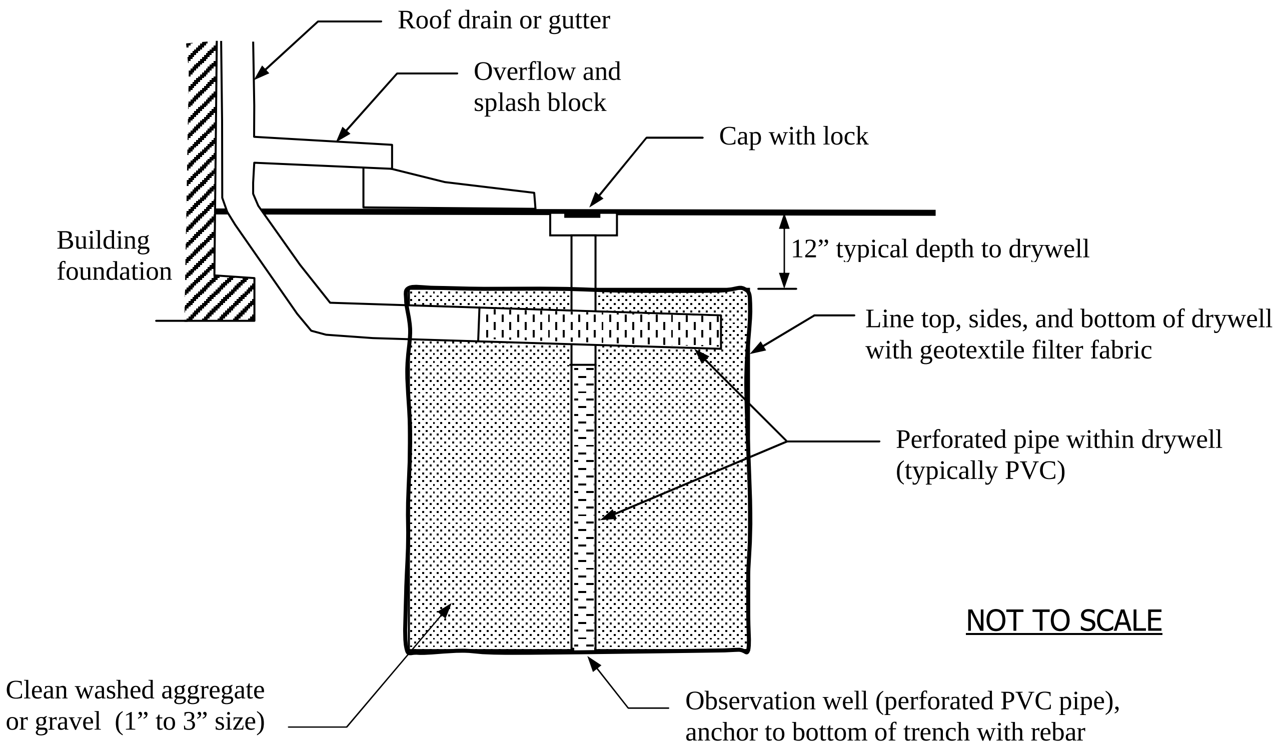


Figure ST-03-4
Typical Drywell (with Rooftop Drainage)

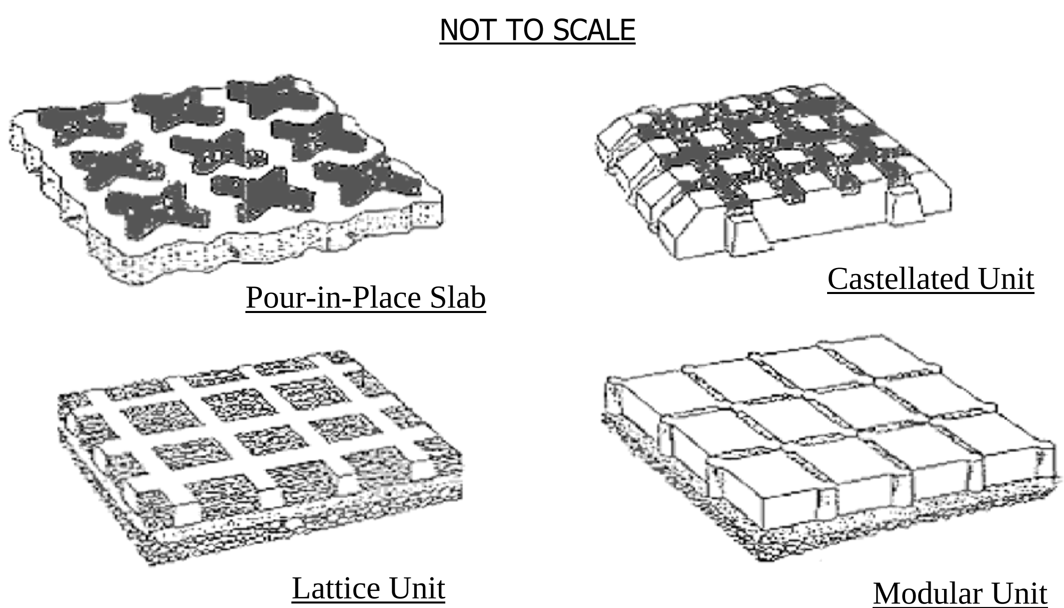
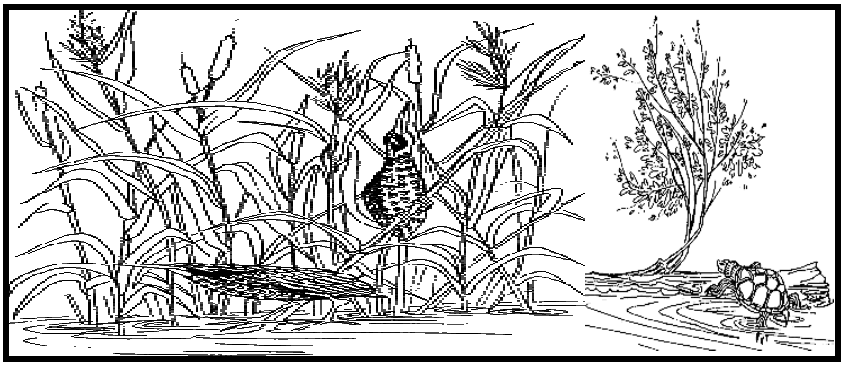


Figure ST-03-5
Examples of Porous Pavement

ACTIVITY: Constructed Wetlands	ST – 04



Targeted Constituents

¸ Significant Benefit Û Partial Benefit ¹ Low or Unknown Benefit

Û Sediment	Û Heavy Metals	Û Floatable Materials	Û Oxygen Demanding Substances	
Û Nutrients	Û Toxic Materials	Û Oil & Grease	Û Bacteria & Viruses	¹ Construction Wastes

Description

Constructed wetlands may be used as a method of storm water treatment if designed and applied correctly, and are highly desirable as wildlife habitats. Wetlands can be very efficient in removing pollutants under some conditions; however, they should be used in conjunction with another BMP until firmly established and pollutant efficiency is verified. This practice is likely to provide significant reductions in most targeted constituents, but may not be as reliable as other types of storm water treatment.

Suitable Applications

Þ Small outfalls for which adequate water and soil conditions will allow the establishment and permanent growth of wetland vegetation.

Þ Large industrial and commercial project sites with ample space, for which adequate water and soil conditions will allow the establishment and permanent growth of wetland vegetation.

Þ Near greenways, parks, landscaping, recreational areas, or other aesthetic locations.

Approach

The regulatory definition of a wetland is an area that is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions, such as a swamp, marsh, bog, or vernal spring.

Natural wetlands are protected and permitted by the Tennessee Department of Conservation (TDEC) in conjunction with the U.S. Army Corps of Engineers. Wetlands can be identified through the presence of certain plants, soil types, insects, etc., in addition to the presence of water or poor drainage. Wetlands may be seasonal, so that it can be very difficult to recognize a wetland during the summer months. Do not disturb natural wetlands without express written permission from TDEC and the U.S. Army Corps of Engineers. Visit the TDEC Web site for more details on how to obtain an Aquatic Resource Alteration Permit:
http://www.state.tn.us/environment/permits/

In contrast, constructed wetlands are built specifically for treating storm water runoff, and are not created as mitigation for the loss of natural wetlands. Consequently, constructed wetlands do not necessarily have to meet the stricter standards necessary to replace natural wetlands. Constructed wetlands use larger areas than other types of storm water treatment BMPs. For small sites with advantageous water and soil conditions, concrete retaining walls can be used for one or more sides to save space.

The term "constructed wetland" may also refer to a method of treating small amounts of wastewater and sanitary sewage, typically from a single residence or a small group of residences. Within the context of the BMP Manual, the term "constructed wetland" refers to the treatment of storm water runoff only. Collection and treatment of wastewater and sanitary sewage is provided by the City of Memphis.

Constructed wetlands remove dissolved phosphorous, nitrogen, and other nutrients both directly (for aquatic plants) and through the soil (for rooted plants). In addition, wetland vegetation will uptake heavy metals, toxic materials, and other pollutants. Over long periods of time, bioaccumulation of metals such as lead or zinc have been observed in both fish and wildlife in some instances. Sediments should be removed regularly from the wetland forebay, and the presence of heavy metals should be monitored. It is conjectured that the wetland soils may need to be replaced every five to 10 years in order to improve uptake of heavy metals and phosphorous. Cleaning the forebay and replacing bottom soils is probably adequate for collecting and removing heavy metals.

A constructed wetland with additional capacity for extended detention is very similar to a wet detention basin, except that constructed wetlands have different types of vegetation. Guidelines in this BMP apply to the portion of constructed wetlands below the normal pool elevation. See ST-02, Wet Detention Basin, for typical berms, outlet structures, and grading details which are generally applicable to constructed wetlands also. An advantage of a constructed wetland, in addition to aesthetics and wildlife, is that a wetland has smaller required treatment volumes (which may be negotiable) than does a wet detention basin.

Basic Design Guidelines

The detailed design of a constructed wetland should generally be accomplished by a team that includes a hydrologist or engineer for hydrologic/hydraulic/water balance analyses and a wetland ecology specialist for selecting vegetation and habitat parameters. However, the following basic guidelines will assist in making preliminary plans and layouts for a constructed wetland.

Size

The overall goal for constructed wetlands is to capture over 90% of the annual storm water runoff volume for urban areas, using a design storm of 1.0 inch rainfall. For storms that are smaller than 1.0 inch of rainfall, the normal pool elevation will not be completely replaced by newer storm water during the storm event. This means that in most instances, the average water residence time within the wetland is longer than the average time between storm events, greatly enhancing pollutant removal efficiency of the constructed wetland. The recommended treatment volume and the recommended surface area to be used for the normal pool elevation is:

$$V_T = C\,(1.0 / 12)\,(43{,}560)\,(A_D)$$
$$A_S = 0.02\ A_D$$

V_T = Treatment volume (cubic feet)
C = Rational runoff coefficient (dimensionless)
A_D = Contributing drainage area (acres)
A_S = Surface area of constructed wetland (acres)

Using recommended values for V_T and A_S above, the average depth of wetland (D) expressed in feet is:

$$D = 5.21\ C$$

Table ST-04-1
Size Criteria for Storm Water Wetlands

Surface area = percentage of area at normal water pool Elevation (without storm water surge)

Depth range = depth from normal water pool elevation

Volume = percentage of total volume below normal water pool elevation

** The surface area of high marsh should be maximized whenever possible (depending upon the types of vegetation or fish that are selected).

A. Shallow Marsh	**Surface Area**	**Depth Range**	**Approx. Volumes**
Forebay	5 %	18″ to 72″	10 %
High marsh	** 45 %	0″ to 6″	25 %
Low marsh	40 %	6″ to 18″	45 %
Deep water	5 %	12″ to 48″	10 %
Micropool	5 %	18″ to 72″	10 %
B. Deep Marsh	**Surface Area**	**Depth Range**	**Approx. Volumes**
Forebay	5 %	18″ to 72″	5 %
High marsh	** 25 %	0″ to 6″	10 %
Low marsh	25 %	6″ to 18″	15 %
Deep water	40 %	12″ to 48″	60 %
Micropool	5 %	18″ to 72″	10 %

Layout

Table ST-04-1 shows a basic allocation of different zones within a constructed wetland. The five zones are also shown in Figure ST-04-1. Zone percentages for two basic types of wetland (designated as Shallow Marsh and Deep Marsh) can be adjusted to match the target volumes and to support various types of desired vegetation. The zone designated as high marsh (0" to 6" deep) is highly desirable; it generally contains thicker vegetation than low marsh zones. Ecological complexity is promoted by varying water depth through the vegetated area rather than keeping the depth uniform.

The length-to-width ratio of the constructed wetland should generally be at least 2:1, although a 1:1 ratio is usually acceptable with baffles, islands, internal berms, or other flow barriers. Dry-weather flow paths should meander back and forth throughout the wetland, as shown in Figures ST-04-1 and ST-04-2, to maximize contact time with soils and vegetation. Distribute flows equally throughout the wetland and avoid dead spaces. Prevent flow shortcuts by anticipating possible locations; erosion control matting and other geotextile applications may be useful to "armor" shortcut locations.

Islands reduce the total treatment volume (below the normal pool elevation) by a small, usually negligible, amount. Overgrowth of vegetation may actually cause a more significant reduction in storage volume and can be a factor in whether to harvest vegetation within a constructed wetland. It is important to provide plenty of shade to the wetland during the summer months, since shallow depths will generally allow the water to get warm and thus degrade the downstream environment for many cold-water fish and other organisms.

It is beneficial to incorporate cascades into the wetland layout, possibly by having more than one water surface elevation. Or a cascade can be placed on one fork of a flow path and not on another. A cascade provides aeration and increases oxygen levels in the water. Oxygen is needed for the digestion of organic nutrients and particles in the water. Cascades are aesthetically pleasing and can be fashioned in many ways.

Other layout considerations include maximum side slopes of 4:1 (H:V) and preferably side slopes that are 10:1 (H:V) or flatter. On very small facilities, retaining walls may be used to conserve space. There must be provisions for vehicle access to the forebay (which requires periodic cleaning) and to the micropool (which may require maintenance and water level adjustments). Provide adequate freeboard (typically 1 foot) to prevent ponding storm water or flood damage on adjacent properties.

The forebay may be partially replaced by a baffle box, storm water quality inlets (media filtration or oil-water separators) or other means to remove floatable debris and coarse sediments. If a detention basin is constructed upstream from the wetland, then the forebay may be eliminated altogether.

Water Balance

The water balance for the constructed wetland must be examined using typical values (maximum, average, minimum) for rainfall, temperature, humidity, water table, evaporation rate, and infiltration rate. The 30-year averages, published by the National Oceanic and Atmospheric Administration, are broken down for each month of the year and represent a good starting point for water balance calculations. Evaporation rates may depend on the amount of sunlight or shade, prevailing wind directions, types of windbreaks (fences can be very beneficial), and other factors. Infiltration rates can be reduced or eliminated by using a geosynthetic liner, clay, or concrete. Infiltration rates can be significant in karst areas, sinkholes, fractured bedrock, sands, or gravels.

In particular, the water balance must be computed for dry-weather scenarios such as late summer and early fall. A groundwater baseflow or stream baseflow is very favorable but may not be present during extended periods of dry weather. Drinking water or treated process water can be added during dry weather, provided that water is dechlorinated prior to use within the wetland.

Soils

The soil must be suitable for wetland vegetation. Hydric soils (soils that are normally saturated) are preferable and can be identified by wetland experts using color and texture. If necessary, organic soils must be imported to the site and placed in areas up to 24 inches deep. The soil must have an affinity for phosphorus, for which minerals containing aluminum and iron ions are typically desirable. Do not use soils that contain large concentrations of phosphorus or heavy metals, as these soils may cause concentrations of contaminants to increase in the overlying water.

Minimize water loss by preventing infiltration through the wetland bottom. Depending on the type of soil, this can be accomplished by compaction, incorporating clay into the soil, or an artificial geosynthetic liner (at least 30 mil thickness, ultraviolet resistant, durable throughout extreme temperatures). Using gravel as the substrate may be a suitable approach in small facilities. Because gravel is lacking in nutrients, emergent species will have to take nutrients directly from the water (references 85 and 117). However, harvesting may be more practical if plants can be easily removed from gravel.

Vegetation

The overall design of vegetation for a constructed wetland should be performed by a qualified wetland ecologist with adequate experience and training. The wetland ecologist should also be involved during construction and installation in order to achieve best results. Basic types of wetland vegetation (also called hydrophytic vegetation or hydrophytes) can be classified as floating, emergent, and submergent. Wetland vegetation species should be selected based upon stress tolerance and hardiness to seasonal variations in water availability. During periods of dry weather, there must be sufficient water to avoid complete desiccation of plant roots.

Placing rooted wetland species from nursery stock throughout the wetland can be expensive when compared to a wet detention basin. However, relying on native volunteer plants to establish themselves would delay complete coverage for several years. Delayed coverage may allow the invasion of undesirable species or dominance by one or two species (such as cattails) which tend to flourish in disturbed conditions. Vegetation can also be established by taking donor soils from existing wetlands, but the soils must be transported and handled carefully. The best times to establish vegetation are typically spring and fall.

Common wetland plants include: arrowhead, bulrush, canarygrass, cattails, duckweed, ferns, marshgrass, pond lilies, pondweed, rushes, sedges, skunk cabbage, and woolgrass. Common wetland trees include: alder, ash, cottonwood, dogwood, and some maples. Trees should not have acidic leaves (such as oak trees) or undesirable fruit or nuts. Decaying leaves and stems provide food for many types of insects and other invertebrates, which in turn become food for fish, reptiles, amphibians, and mammals. Trees provide habitats for many birds and animals. Trees also tend to discourage migrating birds (geese and ducks), which severely degrade water quality.

It can be expected that soil adsorption will continue at a slower pace during the winter. For instance, the minimum temperature for cattails, sedges, and bulrushes to function effectively is 50°, 57°, and 60° Fahrenheit, respectively. It has been observed during fall and winter months that pollutants may actually be released at a greater rate than being absorbed. The net effect over a 12-month period may be that a constructed wetland is no more effective than a wet pond, particularly with regard to the removal of dissolved phosphorus and metals.

Phosphorous removal has been observed for wastewater applications (rather than storm water treatment) to occur during the first two or three years, but then declines thereafter and may actually become negative. This effect is thought to be the result of plants reaching maximum density, for which some researchers recommend that mature plant material should be harvested and removed from the wetlands. The uptake of heavy metals is not affected by plant density and maturity, and nitrogen removal does not degrade over time either, because it is a bacteriological process. The nitrogen removal process is very temperature dependent and, therefore, much slower in winter.

Annual harvesting of rooted vegetation may or may not be practical or effective at reducing seasonal losses of nutrients and prolonging the life of the constructed wetland facility (reference 128). The benefits of harvesting may depend upon the wetland species (reference 112). Placing rooted vegetation in gravel beds rather than soil may make harvesting practical. If harvesting is to be done, it should occur twice per season: 1) in the early summer when nutrient content in the plant material is at its peak, and 2) in the early fall as the growing season comes to a close.

Vegetation is planted only after the constructed wetland has been completely created, and then carefully surveyed and regraded. Flood for at least two weeks to ensure wet soils. Drain water from the constructed wetland 2 to 3 days prior to planting. Plant vegetation at staked locations that correspond to the proper normal pool depths. Allow water to reflood the wetland within 24 hours after planting.

Wildlife

It is beneficial to provide wildlife habitats within and around a constructed wetland. Fences can protect a wetland from human impacts, prevent access by domestic animals such as dogs and cats, and protect children. A particular concern about constructed wetlands is that mosquitoes will breed and thrive. Many types of birds and bats are very useful in reducing mosquitoes. Fish can help to control mosquitoes if a deep pool area is included for fish to reside during dry weather. Typical measures include:

- Mix of deciduous/evergreen trees
- Exposed trunks, snags, or logs
- Islands within constructed wetland
- Shrubs, vines, and hedges
- Brush piles
- Birdhouses, bathhouses, birdfeeders

Maintenance

Þ Inspect wetlands at least twice a year and after each extreme storm event. Remove trash and foreign debris. Remove nuisance vegetation and animals if present. Repair or replace areas of erosion or damage. Check sediment deposits and remove, if necessary. Clean deposits from the forebay when a loss of capacity is significant, probably every 3 to 5 years depending on the land use, or if concentrations of heavy metals or other pollutants in sediments are reaching a level of concern, typically every five to 10 years.

Þ In general, a constructed wetland should be preceded by other types of storm water treatment BMPs to remove oil, grease, toxic sediments, heavy metals, and coarse sediment. Inspect upstream controls at least twice a year and after each extreme storm event. Perform required maintenance and repairs, particularly for oil-water separators and for media filtration inlets.

Þ Removal of sediment depends on the accumulation rate and available storage, in addition to other factors such as watershed size, facility sizing, construction upstream, industrial or commercial activities upstream, etc. The types of sediment should be identified before removal and disposal. Special attention or sampling should be given to sediments accumulated from industrial, manufacturing or heavy commercial sites, fueling centers or automotive maintenance areas, parking areas, or other areas where pollutants are suspected. Treat sediment as potentially hazardous soil until proven otherwise.

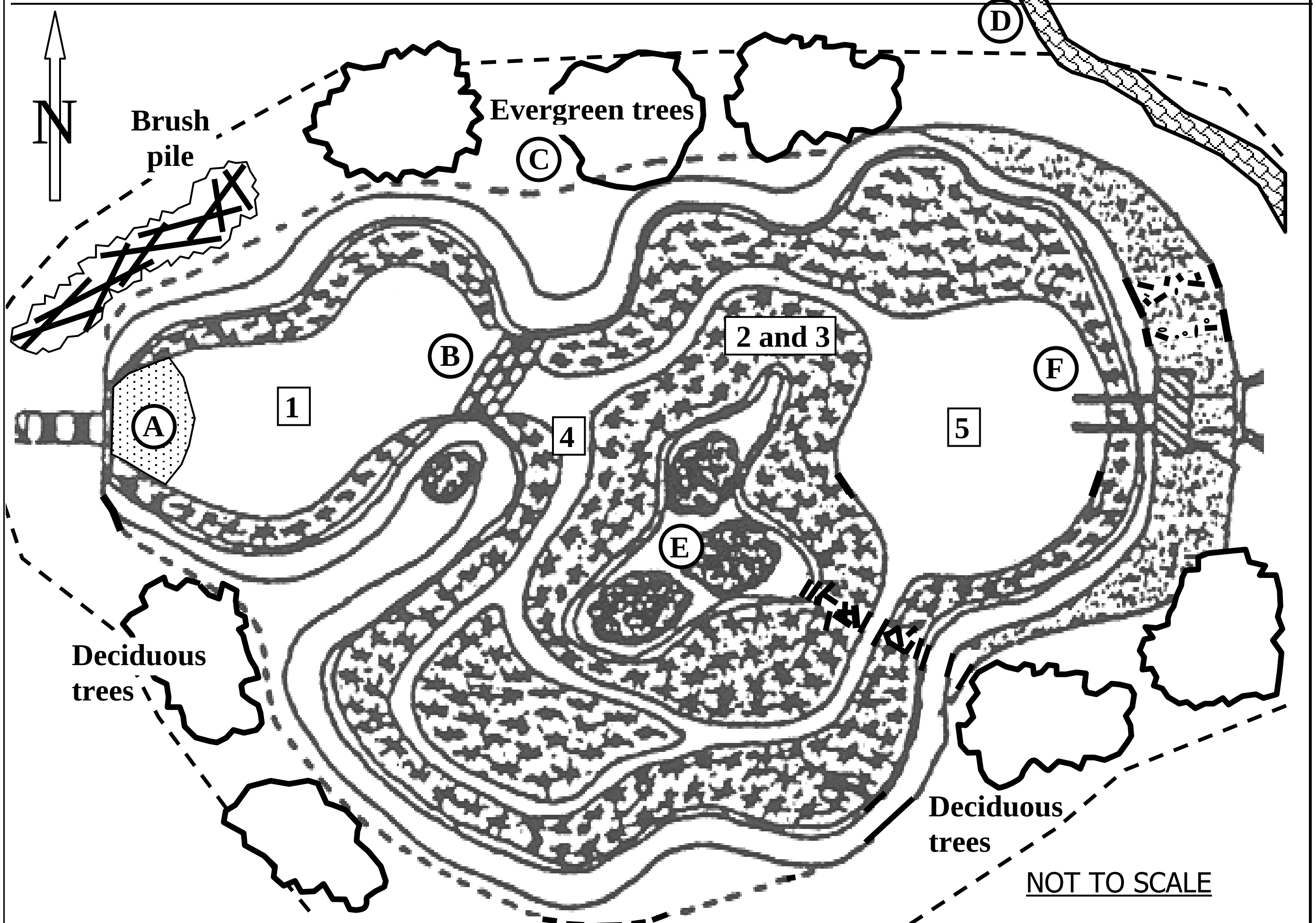
Limitations

There are many limitations to the task of establishing a self-functioning ecological system such as a constructed wetland. A few limitations are listed here:

— Must have the correct soil types and the appropriate vegetation.

— Requires adequate surface area and volumes to function effectively.
— Difficult to construct and requires careful attention to detail.
— Must have adequate flow to maintain water level.
— Requires constant monitoring to remove nuisance vegetation and animals.
— Burrowing animals can damage geosynthetic liners and increase infiltration.
— Concern for mosquitoes, snakes, spiders, and other undesirable wildlife.

References **1, 28, 31, 39, 45, 55, 61, 65, 70, 75, 77, 85, 87, 88, 107, 111, 112, 117, 128, 144, 166, 185** (see BMP Manual Chapter 10 for list)



Notes:

A. Culvert outlet velocity should be minimized using efficient design or some type of outlet protection (ES-25).

B. A gabion wall or riprap berm will provide some filtering capability for removing trash, floating debris, and coarse sediment. This will reduce maintenance upon vegetated portions of wetland.

C. Provide a buffer zone (typically 20′ to 25′) around the wetland using native trees, shrubs, and grasses. Evergreen trees (also brush piles or fences) on north side will protect against winter weather. Deciduous trees on south side will provide shade in summer and sunlight in winter.

D. Post signs and place garbage cans as needed along nearby trails, sidewalks, or greenways.

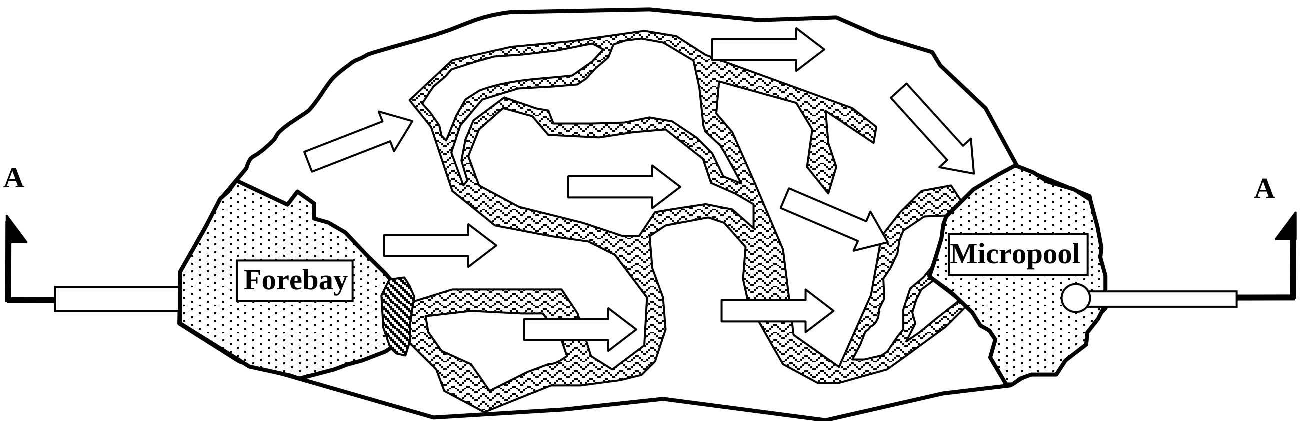
E. An island in the center of the wetland can provide a safe haven for wildlife or birds. The island will also prevent shortcutting of flows.

F. Provide adjustable weirs, gate valves, or other means of controlling water surface elevation for long-term operations and maintenance.

Principal zones of a wetland:

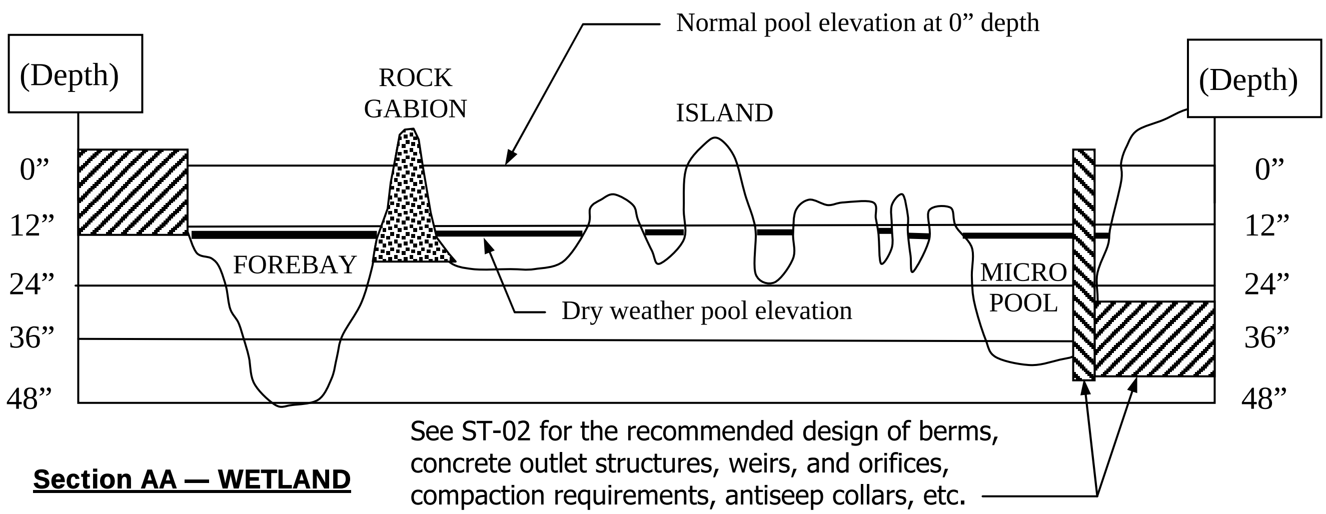
1. Forebay
2. High marsh
3. Low marsh
4. Deep water
5. Micropool

Figure ST-04-1
Typical Wetlands Layout



Flow Patterns - WETLAND

NOT TO SCALE



Section AA — WETLAND

Figure ST-04-2
Typical Flow Patterns

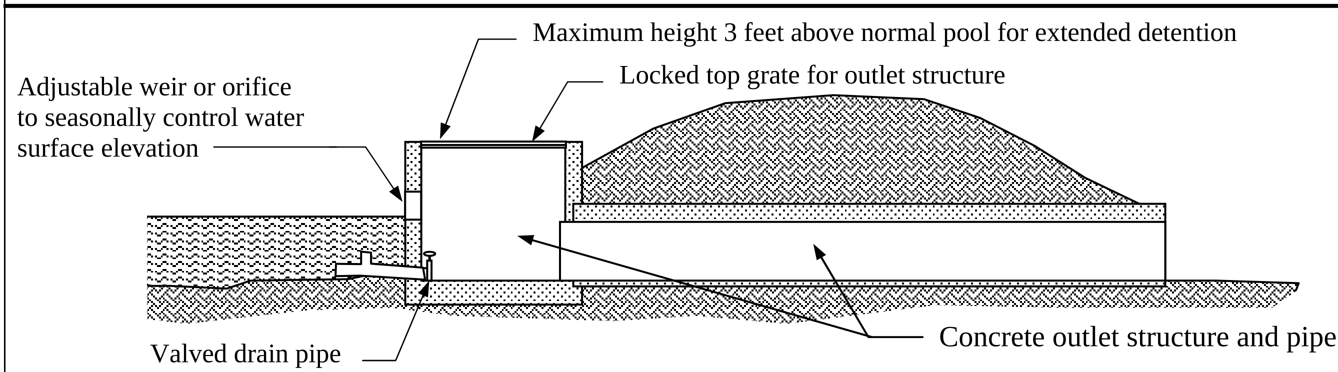
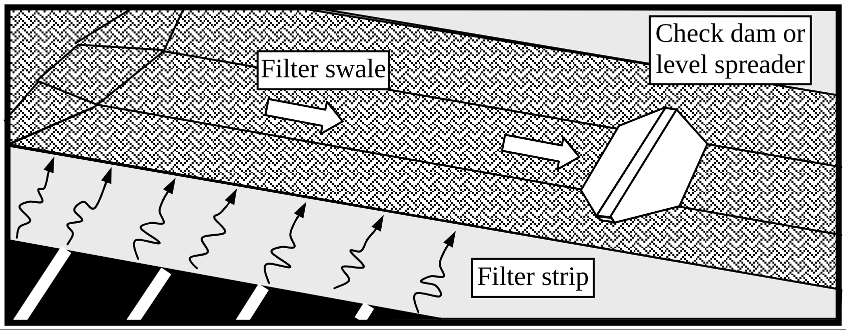


Figure ST-04-3
Typical Outlet Structure

NOT TO SCALE

ACTIVITY: Filter Strips and Swales

ST – 05



Targeted Constituents

¸ Significant Benefit   Û Partial Benefit   ¹ Low or Unknown Benefit

Û Sediment	Û Heavy Metals	¹ Floatable Materials	Û Oxygen Demanding Substances	
Û Nutrients	Û Toxic Materials	Û Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description

Filter strips and swales are capable of removing some sediments and pollutants from storm water runoff if correctly designed and constructed. Low velocities, combined with healthy stands of grass vegetation, allow particles to settle out from storm water runoff. Filter strips can be composed of grass or forest buffer zones, provided that efforts are made to ensure sheet flow to the buffer zone. Generally, a maintained grass filter strip is used to treat sheet flow, and a maintained grass filter swale is used to treat channel flow. This practice will provide a partial reduction in most types of pollutants.

Suitable Applications

Þ Filter strips and swales are often used in conjunction with other storm water management practices to treat runoff from paved streets and parking lots.

Þ Filter strips and swales can also be used to reduce the amount of directly connected impervious area (DCIA) that drains into the storm drainage system, thus reducing peak flows. In addition to pavement areas, this typically can be used for rooftops.

Approach

A filter strip is a relatively flat area of healthy grass vegetation adjacent to or downstream from an impervious surface that may contain pollutants. Alternatively, a wildgrass or forest buffer zone may function as a filter strip. A filter strip is usually intended for sheet flow from parking lots or streets, unless a level spreader (see ES-26) is used to convert concentrated channel flow into sheet flow. A filter swale is a vegetated channel that is wide and flat, used to slow runoff velocities from impervious surfaces that may contain pollutants. A filter swale is wider than necessary to convey the design storm; it is designed to have much lower velocities than a normal channel or ditch but still drain adequately.

Filter strips and swales perform well for small light-intensity rainfalls, but typically have no effect on the large design rainfalls used for storm water detention. Since most precipitation occurs during light-intensity rainfalls, filter strips and swales are a major component in improving water quality. Detention basins and constructed wetlands provide water quality treatment both during and between storms for the large design rainfalls. Filter strips and swales should generally be used in combination with other storm water treatment BMPs whenever possible.

See Figure ST-05-2 for examples of how filter strips and swales can be used in parking lots and residential properties. Since thick and healthy grass vegetation is a part of every landscaped property, filter strips and swales are easy to incorporate into most BMP strategies. Filter strips and swales have removed as much as 80% of total suspended sediments and 50% of soluble zinc in the metropolitan Washington, D.C., area where properly constructed, but have not shown any removal for dissolved phosphorous or copper (reference 77). Other studies have also shown little or no removal for heavy metals, and also generally poor performance due to incorrect construction. California guidelines include a typical size for filter strips equal to 1,000 square feet per impervious acre, with a minimum width of 10 feet (reference 32).

The upper layout (Figure 2A—parking lot) shows sheet flow entering a wide swale rather than a gutter or curb inlet. Design considerations include width of swale, the anticipated overhang of vehicles, whether to use wheel stops, and spacing of grate inlets. In general, the grate inlets should flow to a detention basin or other storm water treatment BMP prior to being discharged to a storm drainage system or natural stream.

The lower layout (Figure 2B—residential property) shows the impervious area from rooftops and driveways. Rooftop drainage typically reaches ground level via gutters and downspouts, and it is understood that this storm water should be conveyed at least 5 to 10 feet from the building to avoid wet basements or saturated foundations. However, downspouts should be turned into sheet flow through filter strips whenever possible.

Filter strips and swales may also be used as a temporary erosion control strategy, in conjunction with other erosion control measures. Filter strips and swales are used downstream from erosion control measures that remove most coarse sediment and silts from the storm water. Also, sod (if properly pegged and stabilized) may be used as part of temporary inlet protection in conjunction with silt fence or straw bale barriers.

Sod Placement

Sodded grass (see ES-09) is preferable to seeded grass vegetation (see ES-08), but either method may be used to establish grass filter strips and swales. Sod has the advantages of immediate erosion control and storm water treatment, healthier stands of vegetation, aesthetics, less maintenance and less inspection, and increased property values. Refer to Figure ST-05-3 for a relative comparison of various types of turfgrass; information is also available from the Shelby County Extension Service Web site and office at the Agricenter.

Sod guidelines are explained more fully in ES-09. Protect sod with tarps or other covers during delivery so that it does not dry out between harvesting and placement. Prepare subgrade by removing all weeds and debris, then add fertilizer, lime, and water as needed. Place sod in staggered fashion so that there are no long seams. After placing sod, lightly roll to eliminate air pockets and ensure close contact with the soil. After rolling, the sodded areas should be watered so that the soil is moistened to a minimum depth of 4 inches. Sod should not be planted during very hot or wet weather. Do not place sod on slopes that are greater than 3:1 (H:V) if they are to be mowed.

Filter Strips

A minimum width of 10 feet is recommended for vegetated filter strips at a slope of 1%. Widths of 20 to 30 feet are highly recommended, particularly if the slope is more than 1%. The length of a filter strip is typically the entire length of the adjacent parking lot, street, or building. The use of sod is very beneficial in establishing a filter strip, particularly for small widths such as 10 feet. Limit the width of pavement that drains to a filter strip; typical values should be 50 to 100 feet whenever possible.

Curbs and curb cuts will concentrate flows, so that generally curbs and gutters are not desirable for paved areas with filter strips. Avoid concentrating storm water runoff on pavements by ensuring that the pavement slopes and vegetated surface slopes are level or change very gradually. In busy parking lots, even vehicle wheels or parking curb stops may channelize flow in some instances and can only be overcome by a level spreader. Channelization will reduce the effective treatment area of the filter strip and may erode grass because of excessive velocities. A level spreader, check dam, or energy dissipater may assist in returning channelized flow back into sheet flow, if designed and constructed properly.

Protect grass filter strips from vehicle traffic; this is typically done with wheel stops made of precast concrete, iron, or landscaping timbers. Even heavy foot traffic can compact the topsoil and trample the grass, affecting performance of a filter strip. Design and analyze probable areas of foot traffic, and provide paths and sidewalks that are compatible with the need for grass filter strips. If irregular or uneven areas appear while the vegetation is being established, repair and restore to a smooth and even appearance to prevent concentrating storm water sheet flows.

Filter Swales

Filter swales are generally grass-lined channels that are wider than necessary for conveyance. Other materials may be incorporated into grass-lined channels, such as a gabion wall along one side of the channel or a concrete swale crossing, provided that overall flow velocities are below 1 foot per second. Typical slopes are generally 1 percent to ensure positive drainage. The average flow depth should not be more than 1 inch, and the maximum flow depth at any point should not be more than 3 inches.

Filter swales are often constructed around parking lots and commercial centers as recessed planters for landscaping. Filter swales in these areas may also incorporate inlets raised 4 to 6 inches above the swale, which may function as first-flush retention volume for pretreatment if infiltration rates are sufficient (typically 0.2 inches per hour observed field rate). Raised inlets should be constructed in a way that appears different and purposeful, so that the flooded median will not appear to be a case of bad drainage design. For instance, the inlets in Figure ST-05-2 may be raised if there is sufficient storage in the median areas to prevent flooding the parking lot. A raised inlet may also be indicated by wetland-type vegetation such as bulrushes, cattails, or sedges.

Filter swales may have level spreaders at the beginning of the swale (see ES-26) or landscape timbers spaced at regular intervals throughout the swale. Landscape timbers can be used to reduce the channel slope and increase residence time within the filter swale. Landscape timbers can also be used as bookends to enclose a "gravel filter," typically 5 to 10 feet long, in the end reach of a swale to trap sediment and pollutants.

The typical channel shape for a filter swale is trapezoidal or parabolic, with side slopes as flat as possible. The swale velocity and flow depth should be determined using Manning's equation and the design parameters included in ES-22, Channel Linings. Typically the velocity is checked for the mowed condition, while the flow depth and capacity are checked for the unmowed condition. Manning's roughness coefficient n depends heavily on the height of grass, so that the mowed and unmowed conditions will yield significantly different velocities and flow depths.

Pollutant Removal Efficiency

Grass swales and ditches should generally be designed for a minimum 10-year storm in order to verify adequate capacity. However, the average mean rainfall is generally used to analyze the total suspended sediment (TSS) removal efficiency, which is shown in Figure ST-05-1 and comes from reference 40. Compute the average flow depth: divide the cross-sectional flow area by the top width of the water surface. The following three heavy metals can also be estimated based upon the TSS removal efficiency:

Copper (Cu)	—	60 percent of TSS removal efficiency
Lead (Pb)	—	90 percent of TSS removal efficiency
Zinc (Zn)	—	50 percent of TSS removal efficiency

In addition, removal efficiencies for grass filter strips and grass buffers can be estimated using Figure ST-05-1. Compute travel time using typical National Resources Conservation Service methods such as the kinematic equation for time of concentration. Then enter the graph with an assumed depth of 0.02 feet (or about 0.25 inches). The effectiveness of a grass filter strip depends heavily upon sheet flow being maintained across the grass surface. This is accomplished by level spreaders and by careful maintenance of the grass surface.

Check dams generally increase the travel time within a swale and remove trash/debris.

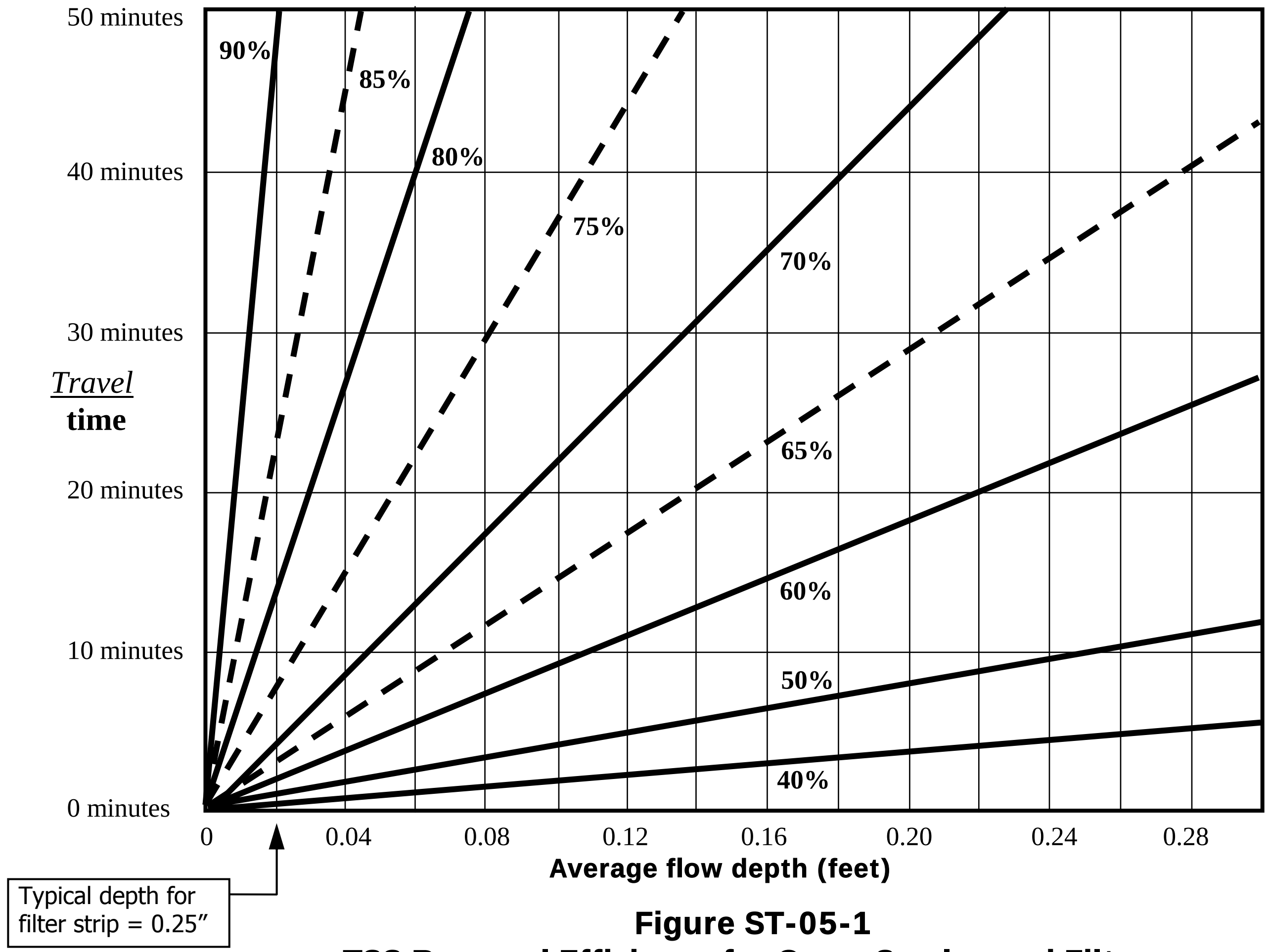


Figure ST-05-1
TSS Removal Efficiency for Grass Swales and Filters

Maintenance

- Filter strips and swales should be inspected regularly during the establishment of vegetation. Repair or replace any damage to the sod, vegetation, or evenness of grade as needed. Look for signs of erosion, distressed vegetation, or channelization of sheet flow.
- In general, grass vegetation should not be mowed shorter than 3 inches. Maximum recommended length of grass is 6 to 8 inches. Allowing the grass to grow taller may cause it to thin and become less effective. The clippings should be bagged and removed. Mowing grass regularly promotes growth and pollutant uptake.
- Keep all level spreaders or check dams even and free of debris. Remove sediment by hand with a flat-bottomed shovel during dry periods, leaving as much of the vegetation in place as possible. Reseed or plug any damaged turf or vegetation.

Sediment Removal

- Þ The sediment accumulation rate is dependent upon a number of factors such as land use, watershed size, types of industry, nearby construction, etc. The sediment composition should be identified before being removed and disposed.

- Þ Some sediment may contain contaminants for which the Tennessee Department of Environment and Conservation (TDEC) requires special disposal procedures. Consult TDEC—Division of Water Pollution Control (368-7939) if there is any uncertainty about what the sediment contains or if it is known to contain contaminants. Generally, special attention or sampling should be given to sediments accumulated in facilities serving industrial, manufacturing or heavy commercial sites, fueling centers or automotive maintenance areas, large parking areas, or other areas where pollutants are suspected to accumulate.

- Þ Clean sediment can be used as fill material, hole filling, or land spreading. It is important that this material not be placed in a way that will promote or allow resuspension in storm runoff.

Limitations

- Þ Grass filter strips can only treat sheet flow. Curb cuts have the effect of channelizing sheet flow and are not useful in establishing grass filter strips as a storm water treatment BMP.

- Þ Grass filter strips and swales are effective only on gentle slopes, typically less than 1 or 2 percent. Steeper slopes generally will not receive credit as being a storm water treatment BMP. Site topography may not allow the use of grass filter strips or swales. Grass swales typically must be very long to accomplish storm water flow reduction and storm water quality equal to a detention basin.

- Þ Grass filter strips and swales are useful primarily for small areas only, typically 1 acre or less. Larger project sites or properties can also make effective use of filter strips and swales for smaller sub-basins.

- Þ Proper maintenance is required to maintain the health and density of grass vegetation, such as irrigation during summer droughts and adding small amounts of fertilizer or lime as needed.

References

15, 16, 17, 28, 31, 32, 33, 40, 59, 60, 66, 77, 88, 91, 102, 116, 118, 144, 146 (see BMP Manual Chapter 10 for list)

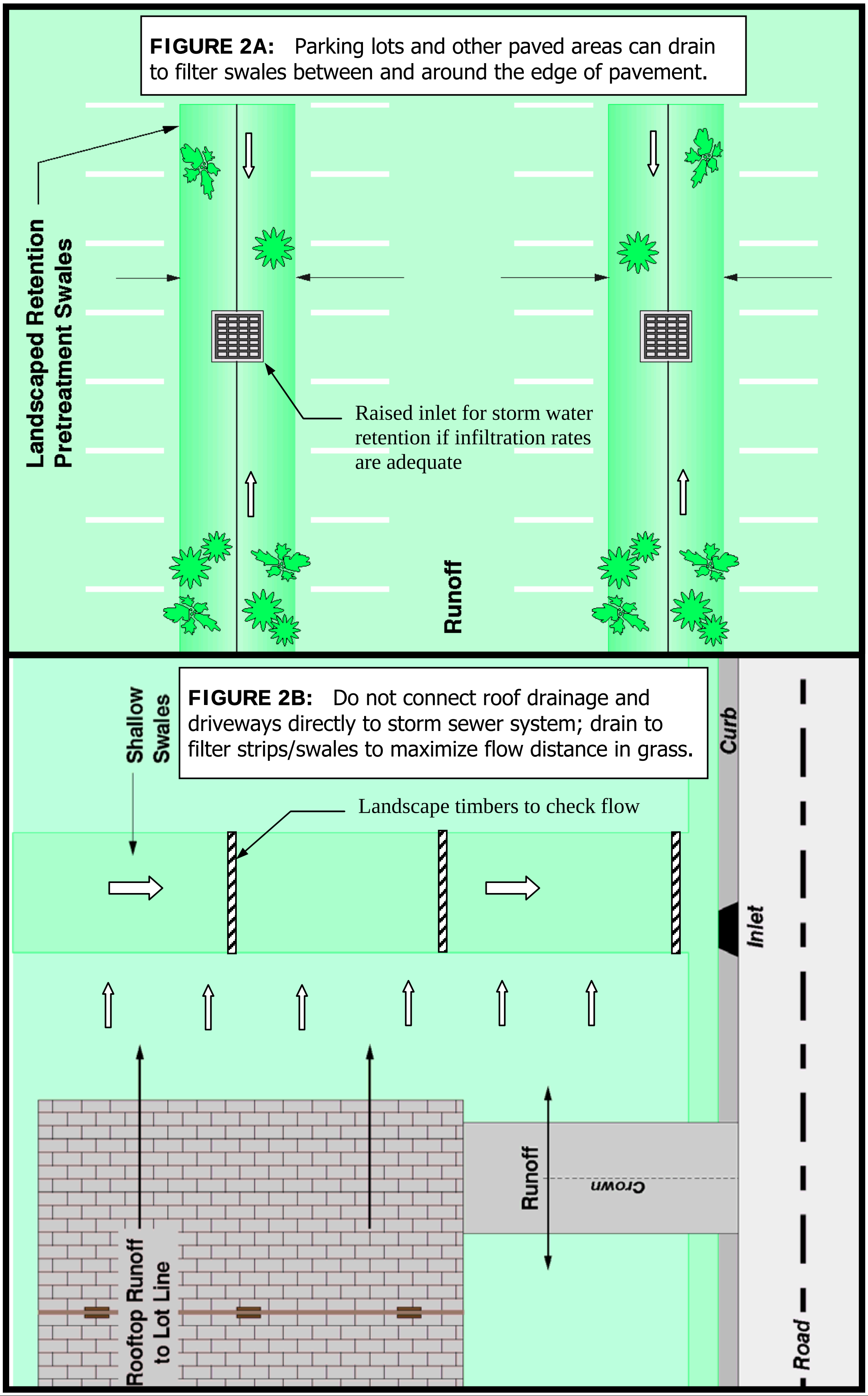


Figure ST-05-2
Examples of Filter Strips and Swales

COLD TOLERANCE (winter color persistance)

High
- Creeping bentgrass
- Kentucky bluegrass
- Red fescue *
- Colonial bentgrass
- Highland bentgrass
- Perennial ryegrass *
- Tall fescue *
- Weeping alkaligrass
- Dichondra
- Zoysiagrass *
- Common bermudagrass *
- Hybrid bermudagrass *
- Kikuyugrass
- Seashore paspalum
- St. Augustinegrass

Low

HEAT TOLERANCE

High
- Zoysiagrass *
- Hybrid bermudagrass *
- Common bermudagrass *
- Seashore paspalum
- St. Augustinegrass
- Kikuyugrass
- Tall fescue *
- Dichondra
- Creeping bentgrass
- Kentucky bluegrass
- Highland bentgrass
- Perennial ryegrass
- Colonial bentgrass
- Weeping alkaligrass
- Red fescue *

Low

MOWING HEIGHT ADAPTATION

High cut
- Tall fescue *
- Red fescue *
- Kentucky bluegrass
- Perennial ryegrass *
- Weeping alkaligrass
- St. Augustinegrass
- Common bermudagrass *
- Dichondra
- Kikuyugrass
- Colonial bentgrass
- Highland bentgrass
- Zoysiagrass *
- Seashore paspalum
- Hybrid bermudagrass
- Creeping bentgrass

Low Cut

DROUGHT TOLERANCE

High
- Hybrid bermudagrass *
- Zoysiagrass *
- Common bermudagrass *
- Seashore paspalum
- St. Augustinegrass
- Kikuyugrass
- Tall fescue *
- Red fescue *
- Kentucky bluegrass
- Perennial ryegrass *
- Highland bentgrass
- Creeping bentgrass
- Colonial bentgrass
- Weeping alkaligrass
- Dichondra

Low

MAINTENANCE COST AND EFFORT

High
- Creeping bentgrass
- Dichondra
- Hybrid bermudagrass *
- Kentucky bluegrass
- Colonial bentgrass
- Seashore paspalum
- Perennial ryegrass
- St. Augustinegrass
- Highland bentgrass
- Zoysiagrass *
- Tall fescue *
- Common bern ıgrass *
- Kikuyugrass

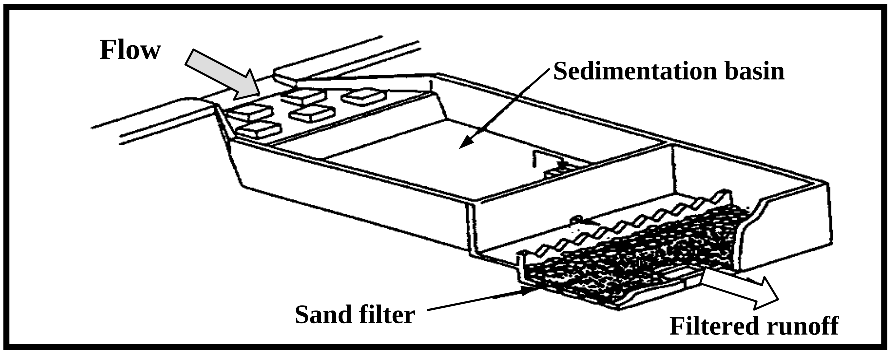
Low

Taken from reference 16 (1984)

* Locally Applicable

Figure ST-05-3
Characteristics of Various Types of Grass

ACTIVITY: Water Quality Inlets and Media Filtration Inlets	ST – 06



Targeted Constituents

¸ Significant Benefit   Û Partial Benefit   ¹ Low or Unknown Benefit

¸ Sediment	Û Heavy Metals	Û Floatable Materials	Û Oxygen Demanding Substances	
Û Nutrients	Û Toxic Materials	Û Oil & Grease	Û Bacteria & Viruses	¹ Construction Wastes

Description

This storm water treatment BMP addresses a variety of water quality inlets, consisting of modified catch basins and media filtration inlets, with oil-water separators being specifically addressed in ST-07.

Modified catch basins contain an oversized sump and some type of inflow and outflow control to remove coarse sediments and floatable materials. Modified catch basins are effective as a pretreatment measure for other BMPs, but are not sufficient to provide storm water treatment as a stand-alone measure.

Media filtration inlets use materials such as sand, peat, screens, or cloth to filter storm water runoff. Sand filtration inlets can be constructed in a variety of layouts using precast vaults. Media filtration systems are available commercially with a wide range of materials and methods for easy installation and operation. Media filtration inlets will create a partial reduction in most pollutants if they are inspected, cleaned, and maintained on a regular basis. A layer of organic material (such as peat moss) or potentially some types of clay can increase the removal of metallic ions and organic pollutants from storm water runoff.

Suitable Applications

Þ Modified catch basins (with enhanced capability to capture coarse sediments and floating debris) and media filtration inlets may be used on commercial and industrial properties that have parking lots and vehicle traffic. This type of land use is likely to receive salts and sands for removing ice and snow, trash from vehicles, leaking oil and grease, and leaves and dirt from landscaping.

Þ Water quality inlets may be used for most impervious properties with parking lots and vehicles traffic. They are also highly recommended for commercial and industrial sites that generate fine particles, sediment, tailings, sawdust, or other pollutants for which a media filtration inlet would be effective.

Approach

The various types of water quality inlets should be selected according to targeted constituents, site area constraints, cost and frequency of maintenance, and inspection requirements. Media filtration inlets can essentially be designed to filter any particle size and particle type imaginable at low to moderate flow rates. Many filtration systems are readily available from commercial vendors in a variety of sizes, layouts, and targeted pollutants. Water quality inlets can be designed for new property uses or can often be retrofitted onto existing storm water drainage systems. Water quality inlets must be constructed with watertight joints and seals to be effective.

A very important decision to be evaluated is the ability to bypass or convey large storm events that have the potential to damage the BMP system or resuspend collected pollutants. Figure ST-06-1 shows one method for allowing high-flow storm water to bypass the BMP system; there are many other types of flow-splitting structures that allow the BMP system to function “offline” rather than “online.” It is recommended that water quality inlets and media filtration inlets should treat the 1-year design storm. Other storms that are mentioned in the vendor catalogs are also the 6-month design storm (80% of the 1-year storm) and the 3-month design storm (62% of the 1-year storm).

A very important consideration is the allocation of long-term resources for inspection, maintenance, and repair. Water quality inlets should only be constructed if: 1) there is a maintenance plan to regularly inspect and maintain inlets on a long-term basis, and 2) there is an agreement or fiscal guarantee that the required maintenance resources will be available throughout the operation life of the water quality inlets. Without regular inspection and maintenance, a water quality inlet will fail and generally create a worse pollution problem than having no inlet at all.

Some advantages of water quality inlets are:

Â Do not require a supply of water (such as wet detention basins or wetlands).

Â Can be placed underground as part of the storm drainage system.

Â Suitable for smaller catchments including parking lots and roadways.

Â Many types of filters are suitable for larger drainage areas up to 5 or 10 acres.

Â Sand or cartridged media filters may be particularly suitable for industrial sites because they can be located underground and industrial facilities generally have the resources to routinely inspect and maintain the systems.

This BMP fact sheet discusses the general uses of modified catch basins and media filtration inlets. The practices presented in ST-07, Oil-Water Separator, should also be reviewed when oil and grease are likely to be present in storm water runoff.

A typical modified catch basin, as shown in Figure ST-06-2, will capture coarse sediments and floating debris. A modified catch basin could have many possible variations that will essentially perform the same function. The modified catch basin must have removable elements to allow inspection and cleaning of all pipes.

A sand filter is probably the most common type of media filtration system used.

Figure ST-06-3 shows a surface sand filter system, which is easier to inspect and usually less costly than an underground sand filter system. The detail shown can be sized to handle several acres. Filter cartridges or other media may also be acceptable alternatives to using sand if maintenance and operation considerations are addressed.

Figure ST-06-4 shows a manufactured BMP media filtration system called StormFilter, manufactured by Contech Stormwater Solutions. It is similar to the sand filter vault (shown in Figure ST-06-6), except that it uses media cartridges instead of sand. The internal valving, hardware, and cartridges are installed into a precast concrete vault. Media cartridges are especially useful for industrial sites where specific types of particles can be targeted. Media cartridges can be designed to target specific pollutants such as sediments, oil and grease, organics, heavy metals, and soluble nutrients. StormFilter requires 2.3 feet of head differential across the unit to work properly. Contech also makes a high-flow bypass system called StormGate. Contact the manufacturer for design and installation details and pricing at http://www.contechstormwater.com/

Two different types of underground sand filter layouts are also shown in the figures as details. Underground filtration systems are more difficult to inspect and maintain. On the other hand, underground filtration systems are protected from weather and other hazards, and they do not take up valuable real estate. Underground systems may exhibit odor problems during the summer because of a lack of bacterial degradation of accumulated organic matter and a lack of aeration within the wet pool.

The Delaware sand filter (Figure ST-06-5) is suitable for overland sheet flow from paved areas such as commercial properties or industrial sites. Originally designed by Earl Shaver for the state of Delaware, it has two parallel concrete trenches or vaults. The first concrete trench serves as a sedimentation basin and storage facility, to evenly distribute water across the sand filter in the second concrete trench. A clearwell is located at the end, with room for an overflow weir and underdrain system to outlet.

The underground sand filter (Figure ST-06-6) handles concentrated flow after it has already been collected within a storm drainage system. The front end of the system helps to trap sediment and floatable materials prior to entering the sand filter. The underground sand filter should contain an overflow bypass within the vault, or alternatively a flow-splitter prior to the system.

Figure ST-06-7 shows a grate inlet filter insert that uses trays to improve storm water quality. Figure ST-06-8 shows a grate inlet filter insert that uses sorbent material to capture oil and grease. Some special types of sorbent material are durable and strong enough to remain in a filter tray for months, with exceptional capacity for absorbing oils and grease. Figure ST-06-9 shows two types of catch basin modifications that will produce clog-resistant media filtration inlets. In general, catch basin filter inserts should only be used wherever maintenance staff is available to check the filters frequently and where local flooding will not occur if the filters should clog. Some companies manufacture the insert frame (stainless steel or fiberglass), which can generally be fabricated in any size to match an existing or proposed inlet. The filter medium typically consists of a blown polypropylene filter with a Dacron outer scrim, which is designed to handle oils, grease, polychlorinated biphenyls, and sediment. Contact manufacturers for design and installation details and pricing of grate inlet inserts at:

http://www.aquashieldinc.com
http://www.suntreetech.com
http://www.abtechindustries.com

Two media filtration inlet manufacturers are included in this BMP. Manufactured systems should be selected on the basis of good design, suitability for desired pollution control goals, durability of materials, ease of installation, and reliability. The products listed here are not intended as a specific endorsement or recommendation. It is incumbent upon the property owner and developer to carefully investigate the suitability and overall trustworthiness of each manufacturer and/or subcontractor.

Media filtration systems are most effective under smaller flow volumes such as the first flush volume (which is required to be treated according to the Memphis Storm Water and Street Ordinance). Media filtration systems are generally not effective under conditions of heavy rainfall or floods. Furthermore, some systems can be damaged or the pollutants could be resuspended if operating under high-flow or flooding conditions. To prevent overloading filtration systems, there should be a mechanism to bypass or divert large flows. Commercially available systems may have a high-flow bypass built into the equipment.

Design Variables

There are no design requirements for a modified catch basin, other than the minimum dimensions shown in Figure ST-06-2. Extra attention may be required for multiple inlet pipes or special flow conditions, possibly requiring a larger size for a catch basin.

When using commercial products such as water quality inlets (media filtration inlets or oil-water separators), the manufacturer's recommendations should be considered in the product sizing and applicability. Verify that adequate storm water treatment is provided and that high-flow bypass methods do not hinder the system from adequately treating the first flush volume. The first flush volume is described in the Memphis Storm Water and Street Ordinance as 0.5” of storm water runoff times the contributing drainage area.

A major drawback for a media filtration inlet is the need for elevation differences in the storm drainage system. A media filtration typically needs at least 5 feet of head loss available across the system, in order to accommodate live pool storage and sand filter thickness. <u>Water quality inlets and media filtration inlets must be constructed with watertight joints and seals to be effective.</u>

Filtration Volume

The volume of the live pool for a sand filtration or other media filtration system shall usually be the first flush volume, which is intended to be slowly released through the filtration device after being treated. The live pool may include any storage capacity of incoming pipes and catch basins that is clearly not part of the dead pool volume. The dead pool volume is the portion of the filtration system that always has water (such as underground sand filters). Some examples of live pool volumes are shown in Figures ST-06-3, ST-06-5, and ST-06-6. Larger filtration volumes are typically much easier to accommodate within an open system such as the surface sand filter.

Filtration Surface Area

The following equation is commonly used (references 9 and 180) to determine the surface area of a sand filter:

$$A_S = 3630\, A_D\, D_{FF}\, D_S \,/\, (\, K\, T_D\, (\, D_S + D_W\,)\,)$$

A_S = surface area of sand filter (square feet)
3630 = conversion factor from acre-inches to cubic feet
A_D = area draining to facility (acres)
D_{FF} = first flush depth (inches) — 0.5” for the City of Memphis
D_S = depth of sand filter (feet) — 1.5’ to 2.0’ recommended sand depth
D_W = average water depth over sand filter (feet) — usually one-half the difference between top of sand and maximum water surface elevation
K = sand filter permeability (feet/hour) — recommended 2.0 feet/hour
T_D = drawdown time (hours) — 24 hours for the City of Memphis

This equation is appropriate for sand filters with typical gradation from 0.02 to 0.04 inches diameter. Sand meeting standards of clean concrete sand (American Society for Testing and Materials C 33) or fine aggregate for concrete (Tennessee Department of Transportation Section 903.01 in reference 172) will satisfy gradation requirements. The filter area must be increased if a smaller size sand is used. Alternatively, measured values of sand filter permeability may be used to compute surface area with an appropriate safety factor (2.0 to 3.0) for clogging and compaction.

Additional design criteria for the surface sand filter (Figure ST-06-3) include:

Â Size the control orifice or perforated riser pipe to allow for a 24-hour drawdown time, in conjunction with allowable sand filtration loading rate.

Â Provide an energy dissipater prior to the sedimentation basin to reduce turbulence. Consider using some type of flow-splitter immediately upstream of a surface sand filter.

Â Typical length-to-width ratio of the sedimentation basin should be at least 3:1 (L:W) to prevent possible shortcutting. Allow for a minimum freeboard of 6”. Provide easy vehicle access to basin for maintenance and cleaning.

Additional design criteria for the Delaware sand filter (Figure ST-06-5) and the underground sand filter (Figure ST-06-6) include:

Â The live pool volume typically is the most stringent requirement to meet. An adjacent vault may be needed to provide additional live pool volume. Ensure that storm water runoff flow entering the sand filter is distributed evenly.

Â Structural design should be performed by a professional engineer in areas where traffic loading is a concern. Otherwise, prevent vehicles from driving onto any type of underground structure while ensuring nearby access.

Â Provide baffled walls to reduce entrance velocities. The front portion of the structure should contain a dead storage pool to retain floatable materials and sediment. For ease of inspection and maintenance, limit the depth of the dead pool volume to less than 4 feet.

Â Provide adequate access for inspection, cleaning, and maintenance activities for each chamber. Removable access covers are recommended for chambers that do not have adequate standing room. Provide steps or rungs as needed.

Â Use geotextile fabric on top of the sand layer to prevent displacement. Use geotextile fabric beneath the sand layer to prevent loss of material through the gravel underdrain layer. Typical underdrain pipe is 4” diameter schedule 40 polyvinyl chloride pipe, with 3/8” perforations around the pipe diameter at 6” spacing. Place underdrains at 5’ lateral spacing with a 1% to 2% positive grade.

A pretreatment sedimentation basin is essential to avoid rapid clogging of the filter medium. Since peat seems to be very effective at removing dissolved contaminates such as heavy metals, there has been research into using peat/ sand mixtures (references 47 and 119) that are subject to clogging problems. Research has also indicated that compost made from leaves is very effective at removing dissolved phosphorus and metals as well as oil and grease (reference 110). Field research at Austin, Texas, (reference 10) indicates that the surface sand filter has a removal efficiency of total suspended solids that is similar to wet and dry detention basins: about 70 to 90%. Removal rates for heavy metals, oil, and grease vary from 20% to 80%, depending on the application.

Consult references 10, 105, and 120 for additional design and maintenance criteria. Inspection and maintenance frequency will also greatly affect pollutant removal rates.

Catch Basin Inserts

Catch basin inserts are ideal for industrial sites as they fit into existing catch basins, and therefore may avoid the need for an "end-of-pipe" facility. Typical catch basin inserts are shown in Figures ST-06-7 and ST-06-8, consisting of a series of trays or sorbent roles/tubes. The top trays are designed to capture coarse sediments, and lower trays may capture finer sediments or specific pollutants. Inserts made from fiberglass insulation materials can achieve up to 90% removal for heavy metals, oils, and grease (reference 74). Since catch basin inserts require frequent inspection and maintenance, they should only be used where a full-time maintenance person is located on the site (typically at large commercial or industrial facilities). A typical insert design may have a high-flow bypass and should be hydraulically designed to allow storm water runoff into the drain system without danger of local flooding.

Maintenance

- Inspect modified catch basins and media filtration systems on a regular basis, typically every month and after heavy rainfalls. Record observations in an inspection log and take pictures as necessary to document conditions. Make immediate repairs as needed. Clean or replace filtration media as needed to prevent clogging.

- Perform cleanout on a regular basis using confined-space procedures and equipment as required by Occupational Health and Safety regulations, such as nonsparking electrical equipment, oxygen meter, flammable gas meter, etc. Remove trash, debris, sediments or clogged media as needed, and then dispose of them properly. Sediments or clogged media may contain heavy metals or other toxic substances and should be handled as hazardous waste. Removal of sediment or clogged media depends on the accumulation rate, available storage, watershed size, nearby construction, industrial or commercial activities upstream, etc. Sediment or clogged media should be tested for identification of pollutants prior to disposal.

- Some sediment may contain contaminants for which the Tennessee Department of Environment and Conservation (TDEC) requires special disposal procedures. Consult TDEC — Division of Water Pollution Control (368-7939) if uncertain about what the sediment contains or if it is known to contain contaminants. Generally, give special attention or sampling to sediment accumulated in industrial or manufacturing facilities, fueling centers or automotive maintenance areas, large parking areas, or other areas where pollutants are suspected to accumulate.

- Þ It is generally more cost efficient to clean the filtration media. For sand filters, cleaning or replacement of the top few inches may restore the permeability rate. Failure to clean the filter surface regularly may result in the need to replace the entire media because of penetration of fines into the filter.

Limitations

- Þ Media filtration systems and modified catch basins will require more frequent inspection and maintenance than most other storm water treatment BMPs. Filtration media will need to be cleaned and/or replaced frequently. There is very high potential for severe clogging or reduced pollutant removal efficiency in filtration systems, particularly if there are unstabilized soil surfaces upstream. Do not operate filtration systems until upstream erosion areas are controlled.

- Þ Media filtration systems cause a large head loss that may require special consideration in the hydraulic design of the overall storm water collection system. Systems may typically require vertical filtration through at least 18 inches of sand and 6 inches of underdrain material, for an absolute minimum head loss of 2.5 feet.

References

9, 10, 31, 33, 34, 35, 38, 47, 74, 77, 105, 110, 119, 120, 172, 180, vendor information (see BMP Manual Chapter 10 for list)

A high-flow bypass structure may also be constructed in a rectangular structure or an open channel using diversion weirs.

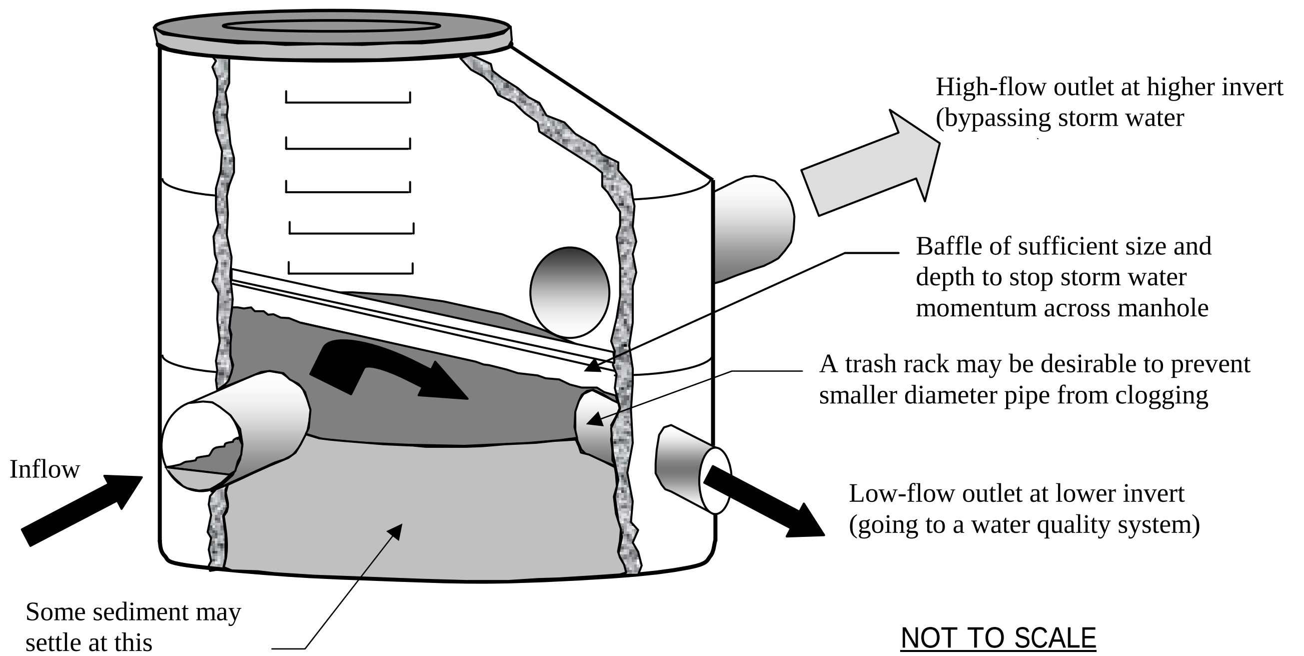


Figure ST-06-1
Typical Storm Water High-Flow Bypass Manhole

Notes:

1. Securely attach pipe elbow, tee, or cross to the manhole or structure to resist expected flow velocities and forces. Bolts or other removable fasteners should preferably be used. Cross braces or other supports may be necessary.
2. A modified catch basin is a good practice for areas with potential sediment loads, and as a pretreatment unit for most other storm water treatment BMPs.

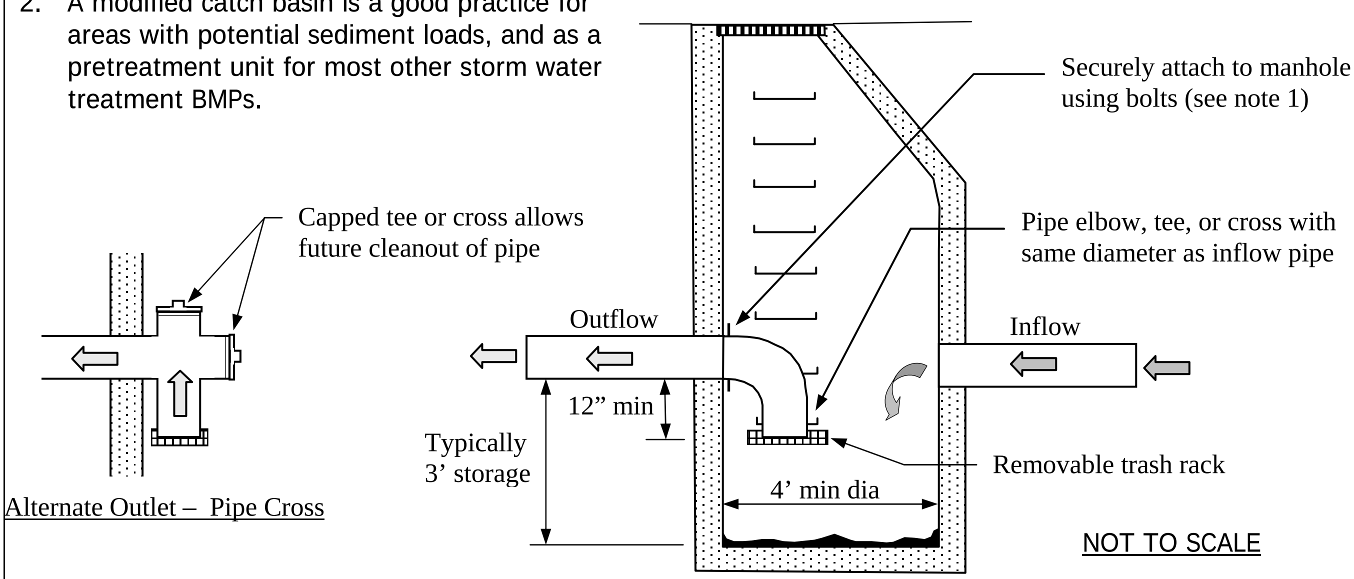


Figure ST-06-2
Modified Catch Basin

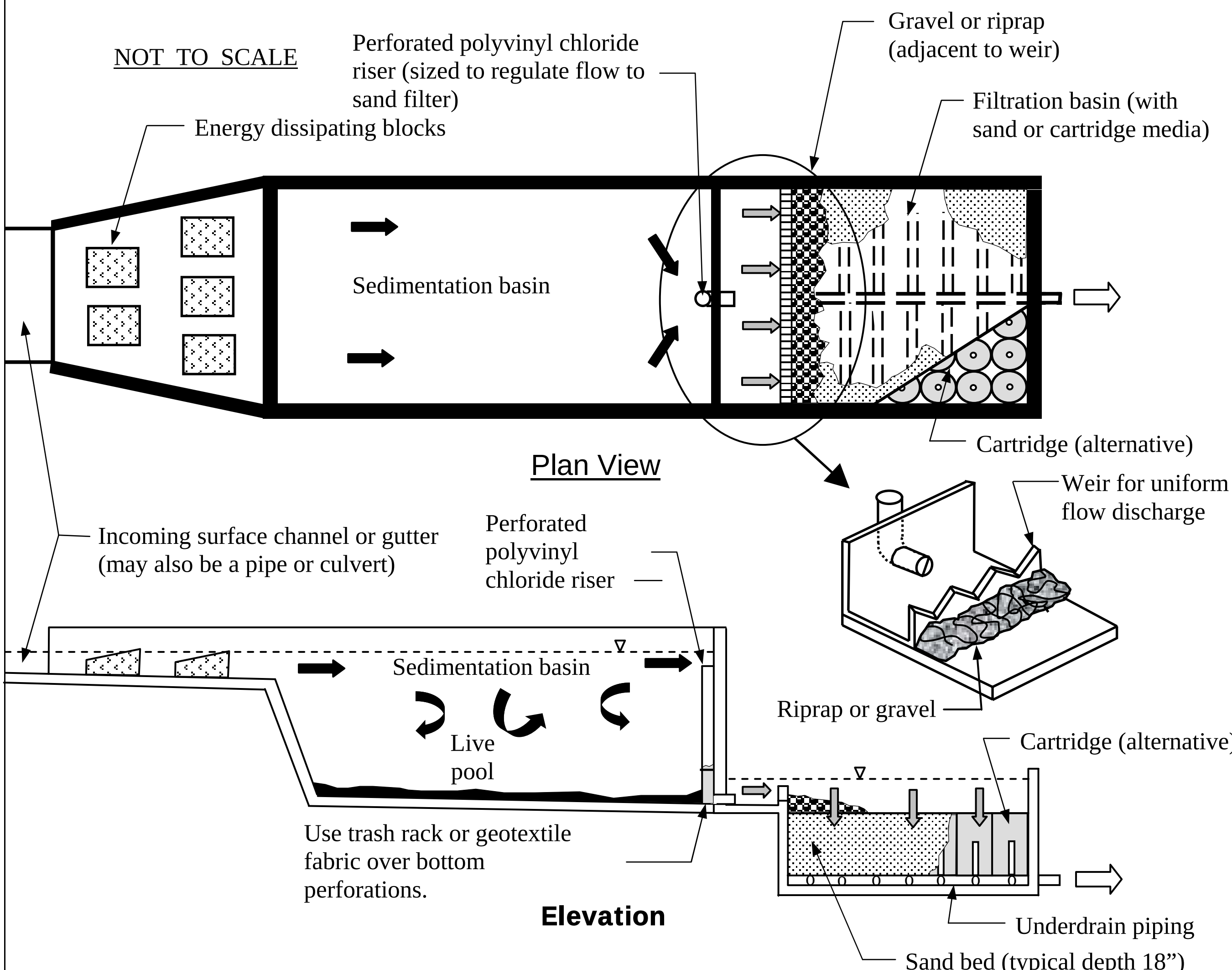
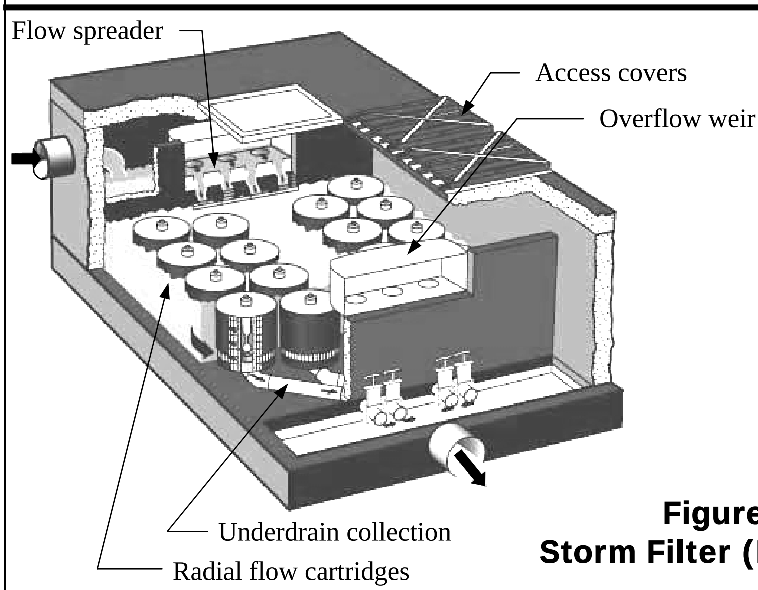


Figure ST-06-3
Surface Sand Filter



Notes:

1. Storm Filter is manufactured by Contech Storm Water Solutions. The end product consists of a precast vault (sized by Contech and produced by a precast vendor) and the necessary valving and hardware. Contech also makes a high-flow bypass system called Storm Gate. See http://www.contechstormwater.com/ for details.
2. Media cartridges can be designed to target specific pollutants such as sediments, oil and grease, organics, heavy metals, and soluble nutrients. The Storm Filter requires 2.3 feet of head differential across unit.

Figure ST-06-4
Storm Filter (Media Cartridge)

NOT TO SCALE

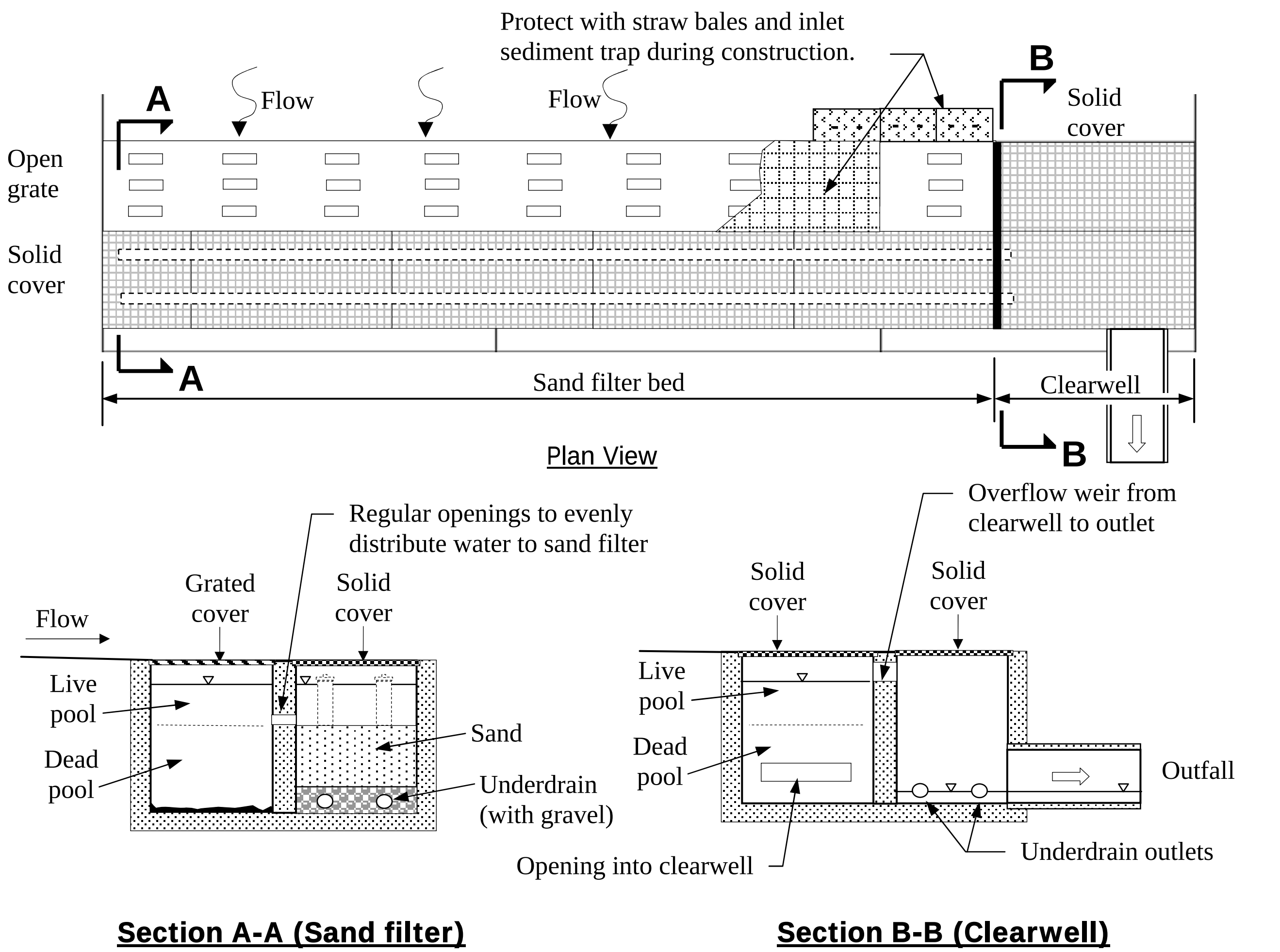


Figure ST-06-5
Delaware Sand Filter

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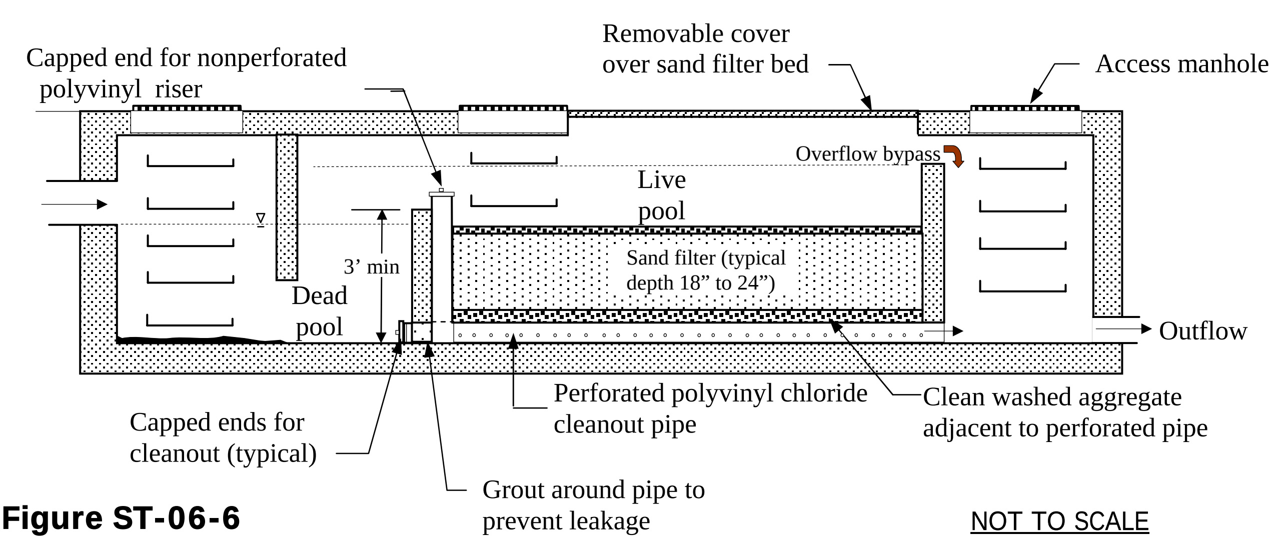

Figure ST-06-6
Underground Sand Filter

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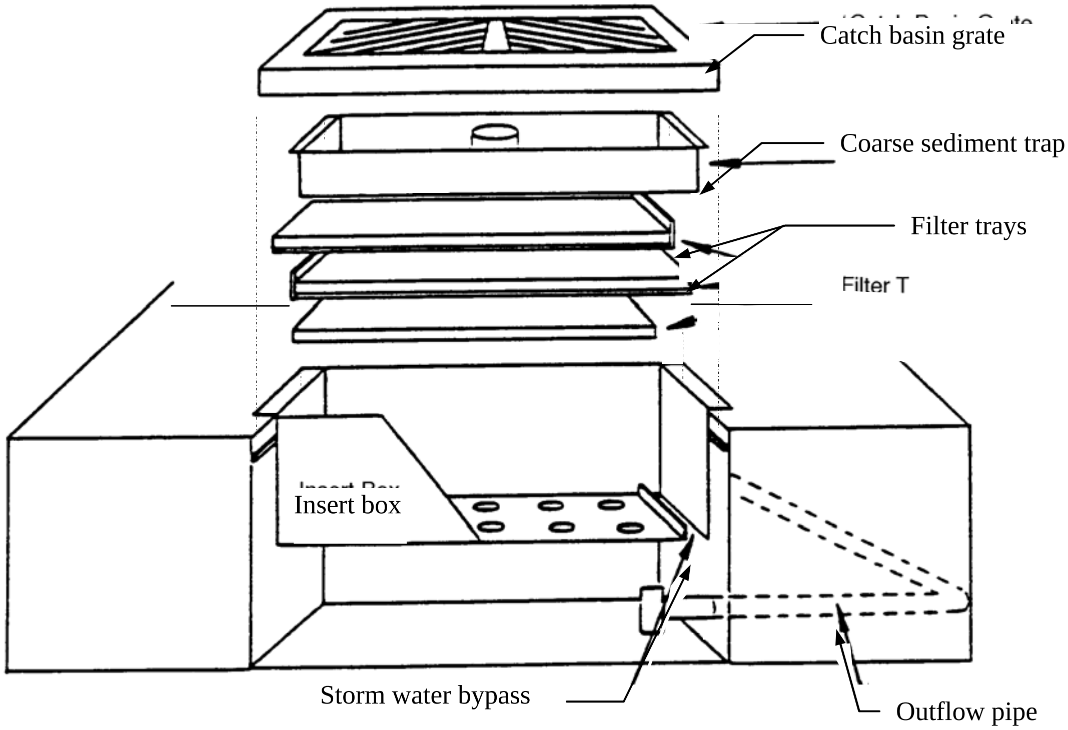

NOT TO SCALE

Figure ST-06-7
Typical Grate Inlet Filter (with Filter Trays)

Typical manufacturers of grate inlet inserts –

http://www.aquashieldinc.com

http://www.suntreetech.com.

http://www.abtechindustries.com

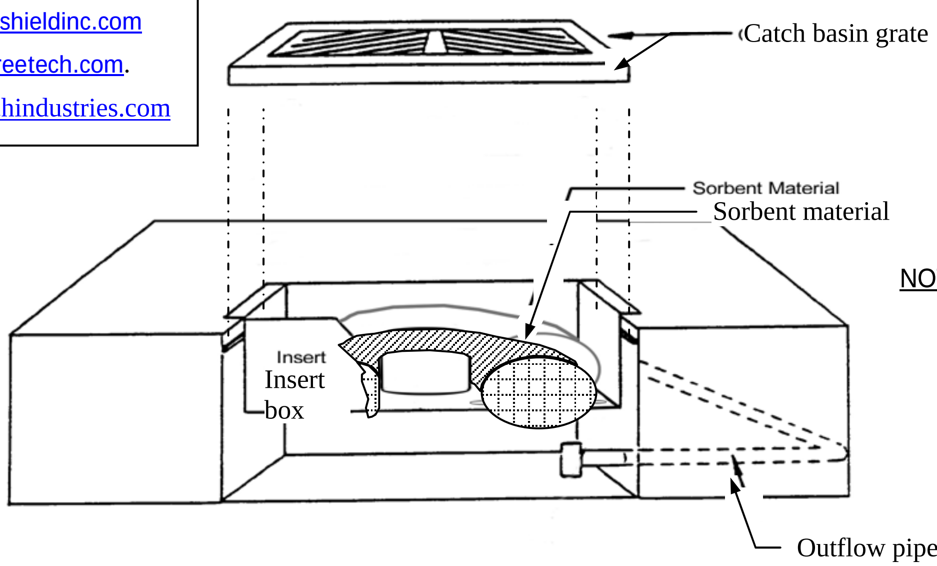

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Figure ST-06-8
Typical Grate Inlet Filter (with Sorbent Material)

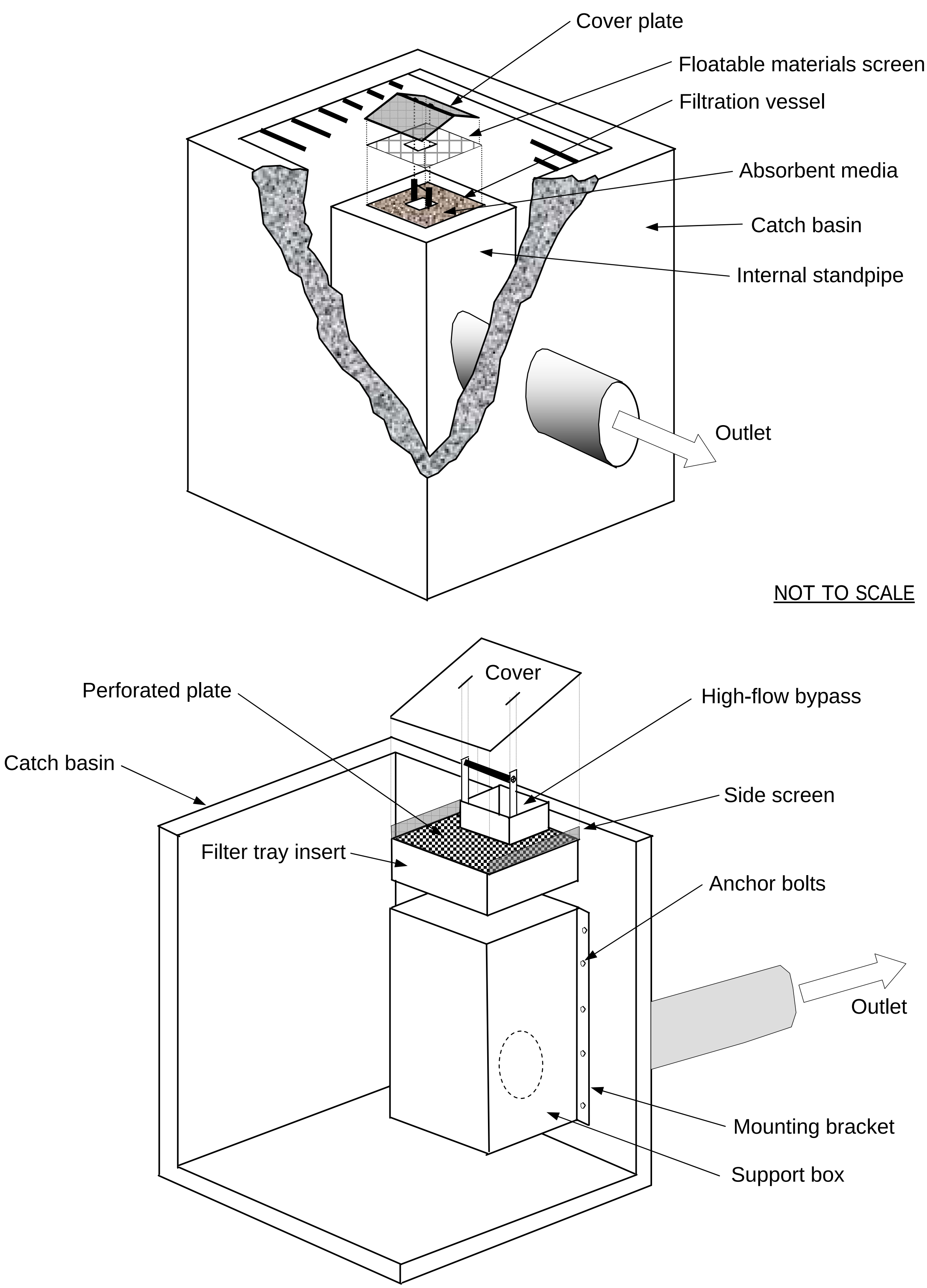
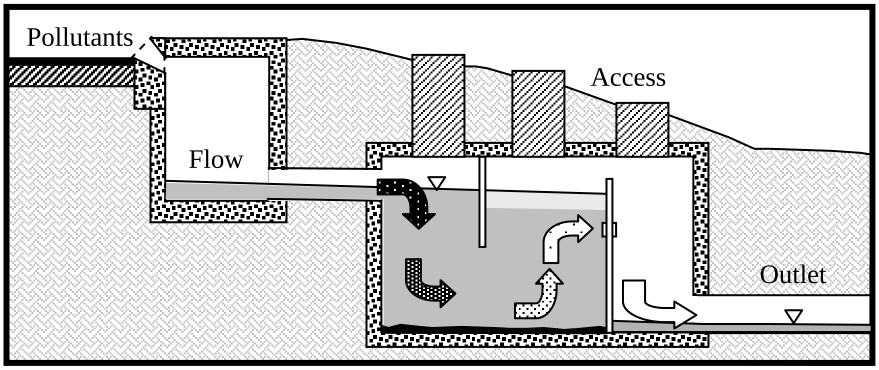


Figure ST-06-9
Clog-Resistant Media Filtration Inlets

ACTIVITY: Oil-Water Separator	ST – 07



Targeted Constituents				
¸ Significant Benefit		Û Partial Benefit		¹ Low or Unknown Benefit
¸ Sediment	¸ Heavy Metals	¸ Floatable Materials	Û Oxygen Demanding Substances	
¹ Nutrients	Û Toxic Materials	¸ Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description

Oil-water separators are designed to specifically remove floating oil, gasoline, light petroleum compounds, and grease. However, most separators will generally remove floatable debris and coarse sediment in order to reduce maintenance and cleaning requirements. There are two main methods of intercepting oil: a conventional gravity separator and a coalescing plate interceptor (CPI). This practice will significantly reduce coarse sediment, floatable materials, oil and grease, and heavy metals that are typically associated with vehicle operations and automotive exhausts.

Suitable Applications

Þ Parking lots, streets, driveways, truck loading areas
Þ Runways, marinas, loading wharves
Þ Gasoline stations, refueling areas
Þ Automotive repair facilities, oil-change businesses, fleet maintenance yards
Þ Recycling or salvage yards that accept automotive equipment
Þ Commercial vehicle washing facilities

Discussion

Oil-water separators (also called oil-grit separators because most designs generally remove coarse sediment) are intended to remove floating gasoline, oil, grease, light petroleum products, and other floating liquids from storm water runoff. See ST-06, Water Quality Inlets and Media Filtration Inlets, for similar structures that also have some capabilities for removing oil and grease. Various systems discussed in this BMP should be evaluated for targeted constituents, site area constraints, cost, frequency of maintenance, reliability, and inspection requirements. <u>Oil-water separators must be constructed with watertight joints and seals to be effective.</u>

There are two basic types of oil-water separators (conventional and CPI), as displayed in Figure ST-07-1. Conventional separators rely upon gravity, physical characteristics of oil and sediments, and good design parameters to achieve pollutant removal. CPI separators contain closely spaced plates that greatly enhance the removal efficiency for oils and grease. In addition, a variety of systems is commercially available in a range of layouts for which vendors have design data and procedures.

Oil-water separators are commonly used for industrial applications, which have a constant flow of known quantity. Separators are very efficient in these types of applications. However, it is much more difficult to remove smaller concentrations (such as 10 parts per million) from storm water runoff that has a much broader range of flows.

Due to many unknown variables concerning oil and grease pollutants, theoretical equations for oil separation are not usually applicable for storm water runoff. There is a variety of empirical guidelines when evaluating manufactured oil-water separators. The most important selection criteria are the long-term maintenance and operation costs, regular inspections, and cleanout procedures. The oil-water separator system should only be constructed if: 1) there is a maintenance plan to regularly inspect and maintain the oil-water separator on a long-term basis, and 2) there is an agreement or fiscal guarantee that the required maintenance resources will be available for the life of the system. Without regular inspection and maintenance, an oil-water separator will fail and generally create a worse pollution problem.

Another very important decision is whether to bypass large storm events around the oil-water separator without damaging the system, exceeding design flow capacity, or resuspending collected pollutants. For larger storm events, storm water runoff will become turbulent and remix the oil droplets. Large flows can also scour sediments that have been deposited on the bottom of an oil-water separator over the course of several months. Essentially, pollutant removal is only ensured when the oil-water separator is cleaned out regularly and the sediments are properly analyzed and disposed.

Storm water runoff is only detained briefly within oil-water separators because of size constraints for an engineered structure. Therefore, it is important that all factors leading up to the separator and also downstream from the separator are favorable for its effective operation. An oil-water separator is frequently used as the upstream measure in a series of storm water treatment BMPs, ahead of a detention basin or constructed wetland. Advantages of an oil-water separator may include:

— Efficient use of valuable space (since it is usually located underground)
— Does not require as much vertical drop as some other types of BMPs
— Easily accessible and easy to clean with proper equipment
— Reliable if carefully designed (including upstream and downstream reaches)

Typical Design Parameters

A scientific basis for sizing oil-water separators relies upon the rising velocity of oil droplets and the rate of runoff through the system. However (other than storm water from oil refineries), there is generally no relevant method for describing the characteristics of petroleum products in urban storm water. It is known that conventional oil-water separators are probably not efficient for removing oil droplets with diameters smaller than 150 microns. For instance, Figure ST-07-2 shows a size distribution for which a CPI oil-water separator would be more effective.

Therefore, design is performed on the basis of engineering judgment and guidelines. Design procedures for commercially available oil-water separators are usually given by simplified tables or graphs based on field testing and observed pollutant removal rates. It is desirable to maintain reasonable dimensions by bypassing larger flows in excess of the 1-year storm rainfall rates (preferably by placing the separator "offline" rather than "online"). An offline separator can be an existing or proposed manhole with a baffle or other control (shown in Figure ST-07-3). Bypass mechanisms must minimize potential for captured pollutants from being washed out or resuspended by large flows.

Some petroleum products may become attached to coarse sediments that are easily removed in the first chamber. A significant percentage of petroleum products also become attached to fine suspended solids and therefore are not removed by settling or flotation. Consequently, the performance of oil-water separators can be difficult to estimate prior to installation and monitoring.

Theoretical Oil Separation

The theoretical sizing of a conventional oil-water separator could be performed using Stokes Law for the computation of rise velocity of oil droplets. The rise velocity is:

V_p = $(1.79 \times 10^{-8} \ (S_w - S_p)\ (D_P^2)\ ) / N$
V_p = upward rise velocity of petroleum droplet (in feet per second)
S_p = specific gravity of the petroleum droplet (typically 0.85 to 0.95)
S_w = specific gravity of water (0.998 to 1.000)
D_P = diameter of petroleum droplet to be removed (in microns)
N = absolute viscosity of water (in poises)

The expected temperature is generally chosen for cold winter months. Typical values for the specific gravity and absolute viscosity of water at various temperatures are:

32° F	S_w = 0.999	N = 0.01794
40° F	S_w = 1.000	N = 0.01546
50° F	S_w = 0.999	N = 0.01310
60° F	S_w = 0.999	N = 0.01129
70° F	S_w = 0.998	N = 0.00982

For example, consider the effluent goal as 10 parts per million (ppm) and the design influent concentration is estimated to be 50 ppm (or equivalent to 50 milligrams per liter) so that a removal efficiency of 80% is the desired target. From Figure ST-07-2, this is achieved by removing all droplets with diameters 90 microns or larger. Assume an oil droplet specific gravity of 0.90. With water temperature of 32° F, the upward rise velocity is 0.00080 feet per second (or 1 foot in 21 minutes). With a water temperature of 60° F, the upward rise velocity is 0.00127 feet per second (1 foot in 13 minutes).

There are many difficulties in attempting to use this equation in a design situation. It is impossible to estimate density or size distribution of petroleum products accumulating on streets and parking lots. Initially, unleaded gasoline has a specific gravity of 0.80, kerosene has a specific gravity of 0.81 to 0.84, diesel fuel has a specific gravity of 0.83 to 0.85, and No. 2 home heating fuel has a typical gravity of 0.86. However, lighter portions of these products evaporate quickly. It is not certain whether smaller oil droplets (less than 150 microns) will rise in water unless formed into larger oil droplets by coalescing; otherwise, they are more likely to be emulsified into the storm water.

Sizing guidelines for a conventional oil-water separator are derived from references 6 and 31 using a design flow rate, Q.

$$D = (Q / RV_H)^{0.5} \qquad V_H = 15\ (V_P) \quad \text{or} \quad V_H = 0.05 \text{ feet/second}$$

$$W = R\ D$$

$$L = (V_H\ D) / V_P$$

D = depth of unit (feet), generally between 3 and 8 feet
W = width of unit (feet), usually twice the depth
L = length of unit (feet), usually fifteen times the depth
Q = design flow rate (cfs)
R = width to depth ratio, generally a value of 2 is recommended
V_H = allowable horizontal velocity (maximum 0.05 fps)
V_P = upward rise velocity of petroleum droplet (fps)

Adjust the total depth D by adding 1 foot of freeboard. Other design parameters are that top baffles should extend downward by 0.85 D and bottom baffles should extend upward by 0.15 D. Locate the distribution baffle at a distance of 0.10 L from the inlet end of unit. If depth exceeds 8 feet, then design parallel units to receive proportional flow or use a smaller sub-basin. Some sort of physical mechanism should be installed to allow flow bypasses for storms in excess of the design flow. Most impervious sub-basins have a rational runoff coefficient of at least 0.90 and a time of concentration in the neighborhood of five minutes. The following example shows an impervious parking lot containing 1 acre and a treated intensity of 1 inch per hour. Using computed V_P from previous page, the allowable horizontal velocity V_H is:

V_H = 15 x 0.0008 = 0.012 feet per second (less than 0.05 feet per second)
Q = CIA = (0.95) (1) (1) = 0.95 cfs

D = $(Q / RV_H)^{0.5} = (1.52 / (2 \times 0.012))^{0.5}$ = 6.3 feet
W = 2 x 6.3 feet = 12.6 feet
L = 15 x 6.3 feet = 95 feet

Conventional Oil-Water Separator

The very large size chamber (6′ x 13′ x 95′) computed above represents the fact that oil and water do not separate easily. By careful design of upstream and downstream reaches, it is possible to reduce turbulent flows, drop heights, mixing or swirling storm water runoff, and excessive velocities. It is highly recommended that maximum sub-basin size for an oil-water separator should be no larger than 1 acre; this will keep units to manageable sizes and allow for accurate monitoring of storm water quality.

Figure ST-07-4 (based upon Maryland standards and taken from reference 154) shows a typical design for a conventional oil-water separator, with slightly different features than those shown in Figure ST-07-1 (based upon California standards). The basic flow layout of Figure ST-07-4 provides: 1) uniform tranquil flow, 2) a trash rack or other narrow opening to prevent trash and debris from flowing through, 3) a chamber for settling sediments and solids, 4) a chamber to capture floating oil and grease, and 5) access for each chamber, preferably with steps and large openings. The first two chambers for Figure ST-07-4 should provide at least 400 cubic feet of permanent pool storage per acre. Both chambers must be cleaned regularly to remove floating oils and grease from the top and sediments from the bottom. Perform maintenance by using a conventional vacuum truck for both chambers, being careful not to discharge any pollutants to the storm water outfall.

Manufactured Oil-Water Separators

A few manufacturers of oil-water separators are included in this BMP. Manufactured separators should be selected on the basis of good design, suitability for desired pollution control goals, durable materials, ease of installation, and reliability. The product list is not intended to be inclusive, nor is it intended to be an endorsement for each listed product. It is merely a list of separator manufacturers that are known to work in the Tennessee area.

Manufacturers generally provide design methods, installation guidelines, and proof of effectiveness for each application where used. These structures tend to include innovative methods of providing high-flow bypass. However, it is incumbent upon the landowner to carefully investigate the suitability and overall trustworthiness of each manufacturer and/or subcontractor. <u>Oil-water separators must be constructed with watertight joints and seals to be effective.</u>

Examples of oil-water separators illustrated in this BMP include:

Figure ST-07-1 Highland Tank (CPI unit) www.highlandtank.com

Figure ST-07-5 Contech Stormwater Solutions www.vortechnics.com

Figure ST-07-6 CDS Technologies www.cdstech.com

Figure ST-07-7 Stormceptor Corporation www.stormceptor.com

Figure ST-07-8 Downstream Defender

Figure ST-07-9 BaySaver, Inc. www.baysaver.com

Other manufacturers may also include:

Aquashield, Inc. Aqua-Swirl Concentrator www.aquashieldinc.com

Environment 21, LLC V2B1 www.env21.com

Each manufacturer may specify its design based upon an average design storm in order to achieve the recommended pollutant efficiency. The 1-year design storm intensity may be computed from the peak incremental rainfall distribution from the Natural Resources Conservation Service Type II storm, for which 0.276 of total rainfall occurs in the most intense 15-minute period sometime during the twelfth hour. So then the 15-minute time of concentration is 0.276 x 2.5" / (0.25 hours) = 2.76 inches per hour. It is recommended that the oil-water separator should capture and treat the 1-year design storm. Other storms that are mentioned in the vendor catalogs are also the 6-month design storm (80% of the 1-year storm) and the 3-month design storm (62% of the 1-year storm).

Coalescing Plate Interceptor

The CPI separator requires considerably less space than a conventional separator to obtain the same effluent quality. The angle of the plates to the horizontal ranges from 0° (horizontal) to 60°, with a typical plate spacing of 1 inch. Storm water will either flow across or down through the plates. A CPI oil-water separator is able to process smaller oil droplets by collecting them on polyurethane plates or other materials. It is recommended that the design engineer consult vendors for a plate package that will meet site and flow criteria. Manufacturers typically identify the capacity of various standard units. The basic equation for design of coalescent plates is:

$A_P = Q / (E\ V_p \cos(H))$

A_P = total surface area of coalescing plates (square feet)

Q = design flow (cfs)

E = efficiency of coalescent plates (typically 0.35 to 0.95)

V_P = upward rise velocity of oil droplet (fps), typically use 0.0010 fps
H = angle of coalescing plates measured from horizontal (degrees)

The angle of coalescing plates to the horizontal may range from 0° to 60°. However, at an angle of 0°, the plates would be horizontal and subject to having sediment settle on them. At an angle of 45° to 60°, sediment would be able to slide off and collect at the bottom. The spacing between plates is usually about 1 inch. Select a likely length and width of coalescing plate, and then compute the number of plates needed, N.

$N = A_P / W_P L_P$
N = number of plates required
W_P = width of plate
L_P = length of plate

Check geometry and necessary volume to contain the coalescing plates. Allow 1 foot below the plates for sediment storage. Add 6 to 12 inches above plates for oil to accumulate, and then allow an additional 1 foot above that for freeboard. Include a forebay to collect floatable debris and evenly distribute flow if more than one plate unit is needed. Larger units have a device to remove and store oil from the water surface, such as a skimmer or vacuum. Plates are easily damaged when removed for cleaning. Install plates at an angle of 45° to 60° so that most sediments slide off. Placing plates closer together reduces the total volume, but may instead allow debris such as twigs, plastics, or paper to clog plates. Use a trash rack or screen to reduce clogging.

Maintenance

Follow vendor recommendations for manufactured oil-water separators. The following general instructions may be used in the absence of conflicting data or guidelines.

Þ Oil-water separators should be inspected on a regular basis (such as every three months) to ensure that accumulated oil, grease, sediment, trash, and floating debris do not disturb the proper functioning of the system. Record observations in an inspection log and take pictures as necessary to document conditions. Make immediate repairs as needed, and make arrangements for cleanout if needed. Consider using a licensed commercial subcontractor, who may have special equipment and abilities to perform periodic cleanout on oil-water separators.

Þ Perform cleanout on regular basis using confined-space procedures and equipment as required by Occupational Safety and Health Administration regulations, such as nonsparking electrical equipment, oxygen meter, flammable gas meter, etc. Remove trash and debris and dispose properly. Remove floating oil, grease, and petroleum substances using special vacuum hoses; treat as hazardous waste. Sediments may also contain heavy metals or other toxic substances and should be handled as hazardous waste. Removal of sediment depends on accumulation rate, available storage, watershed size, nearby construction, industrial or commercial activities upstream, etc. The sediment composition should be identified by testing prior to disposal.

Þ Some sediment may contain contaminants for which the Tennessee Department of Environment and Conservation (TDEC) requires special disposal procedures. Consult TDEC — Division of Water Pollution Control (368-7939) if uncertain about what the sediment contains or if it is known to contain contaminants. Generally, give special attention or sampling to sediment accumulated in industrial or manufacturing facilities, fueling centers or automotive maintenance areas, large parking areas, or other areas where pollutants are suspected to accumulate.

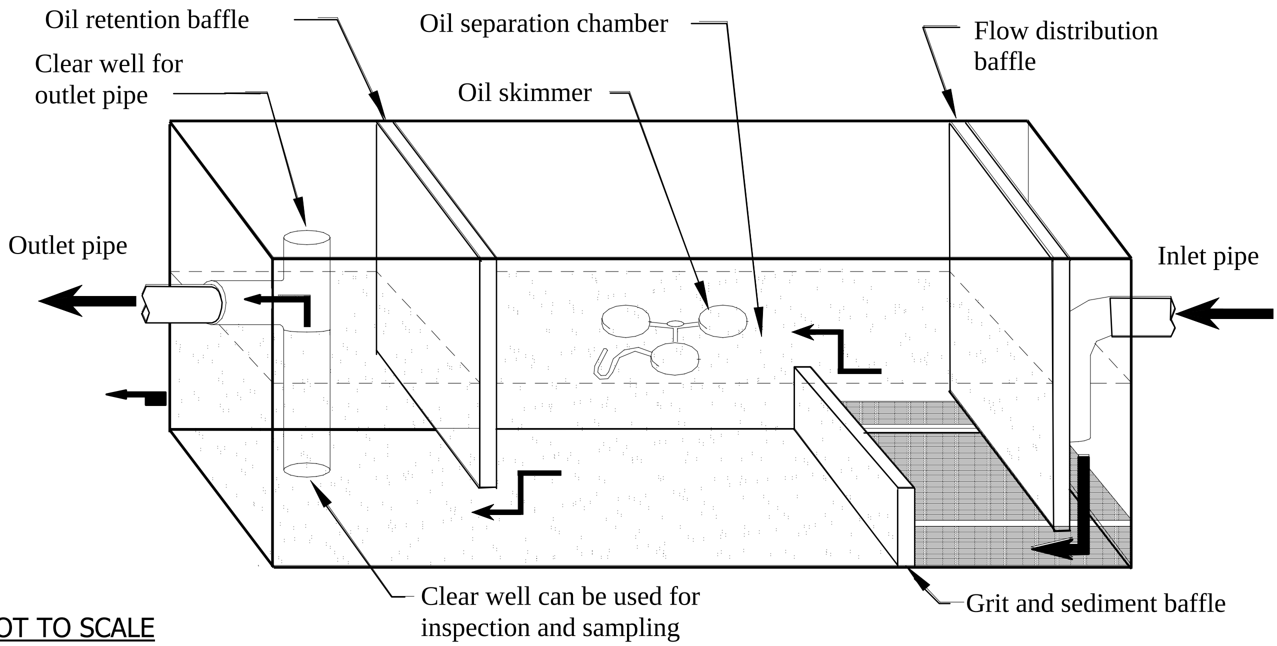
Limitations

Þ There is usually uncertainty about what types of oil or petroleum products may be encountered. A significant percentage of petroleum products are attached to fine suspended solids and therefore are not easily removed by settling.

Þ The design loading rate for oil-water separators is low; therefore, they can only be cost-effectively sized to detain and treat nuisance and low storm flows and particularly first flush volumes. It is usually not economical or feasible to size an oil-water separator to treat a design storm with a return period longer than 1 year. Oil-water separators require frequent periodic maintenance for the life of the structure. Maintenance can be minimized (and performance can be increased) by careful planning and design, particularly upstream and downstream from separator.

References

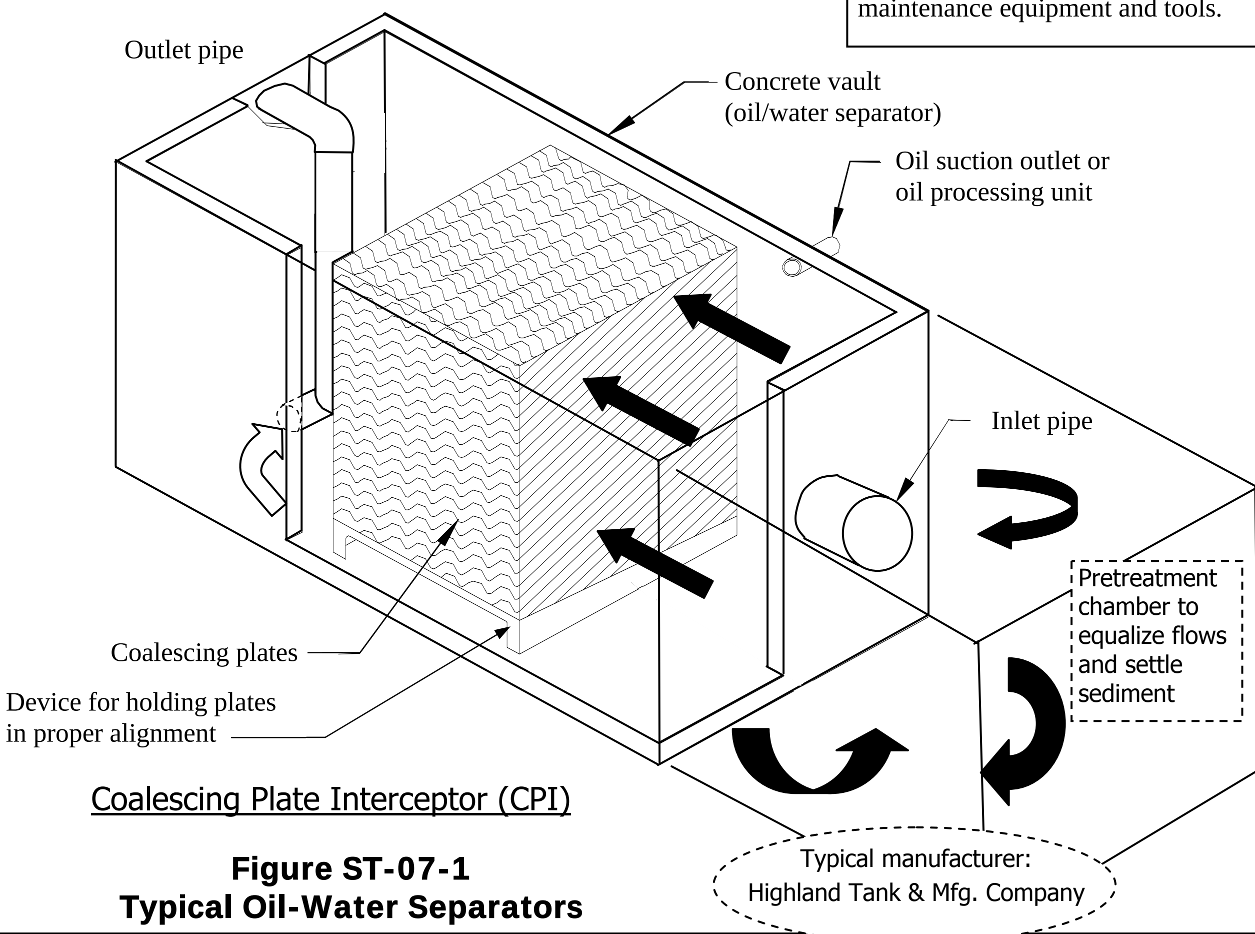
6, 12, 31, 33, 67, 77, 107, 154, 166, 179, vendor information (see BMP Manual Chapter 10 for list of references)



NOT TO SCALE

Conventional Oil / Water Separator

Provide access hatches or manhole covers for each compartment of an oil-water separator. Size openings to adequately convey all expected maintenance equipment and tools.



Coalescing Plate Interceptor (CPI)

Figure ST-07-1
Typical Oil-Water Separators

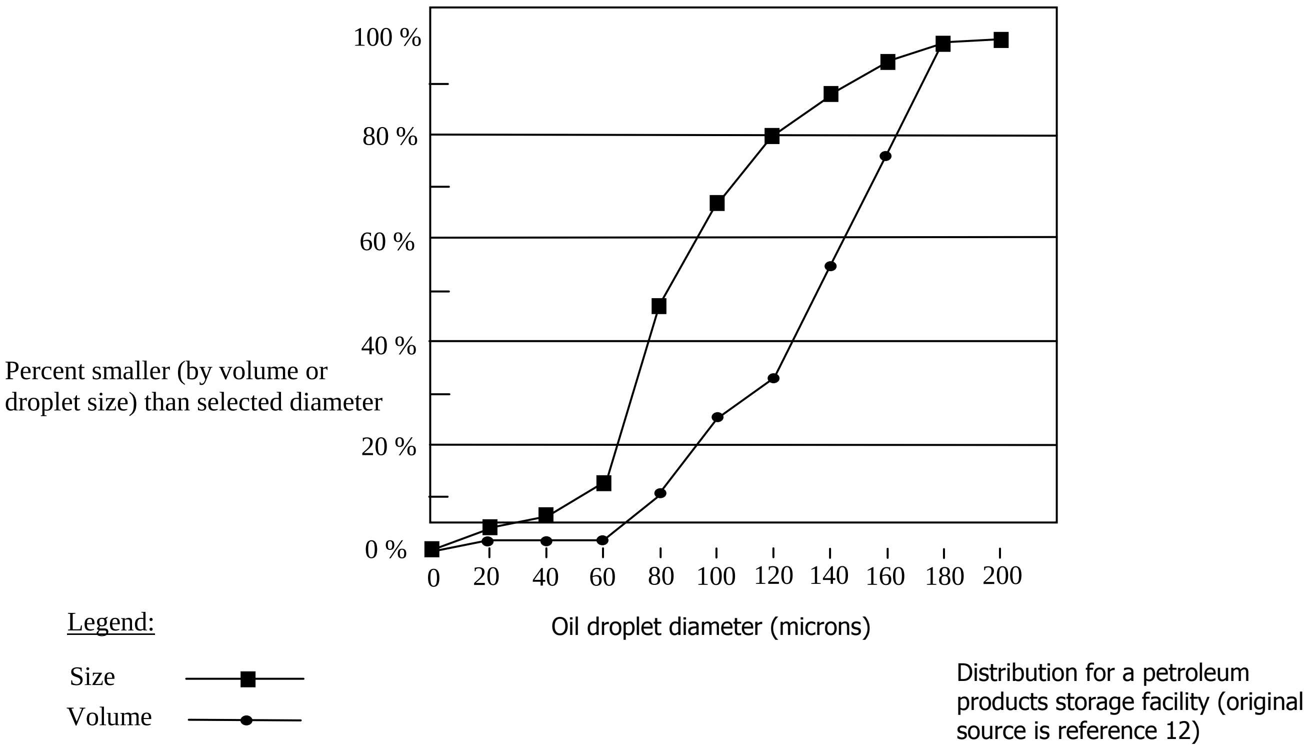


Figure ST-07-2
Typical Size and Volume Distribution of Oil Droplets

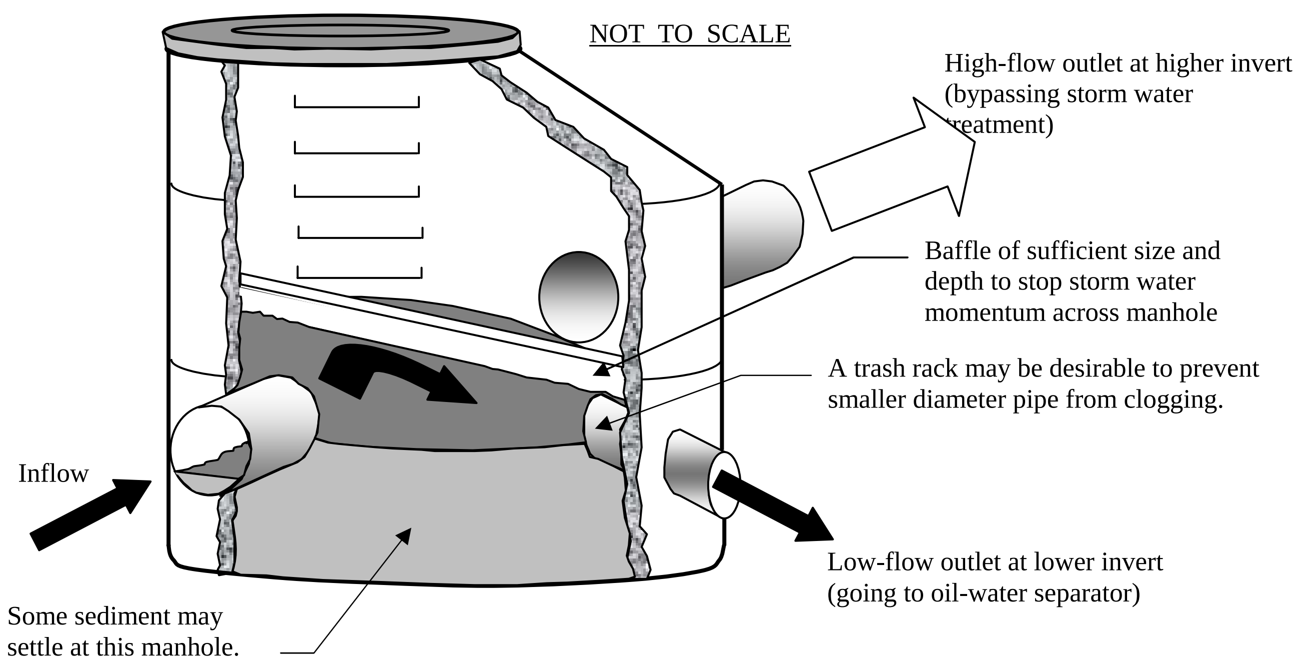
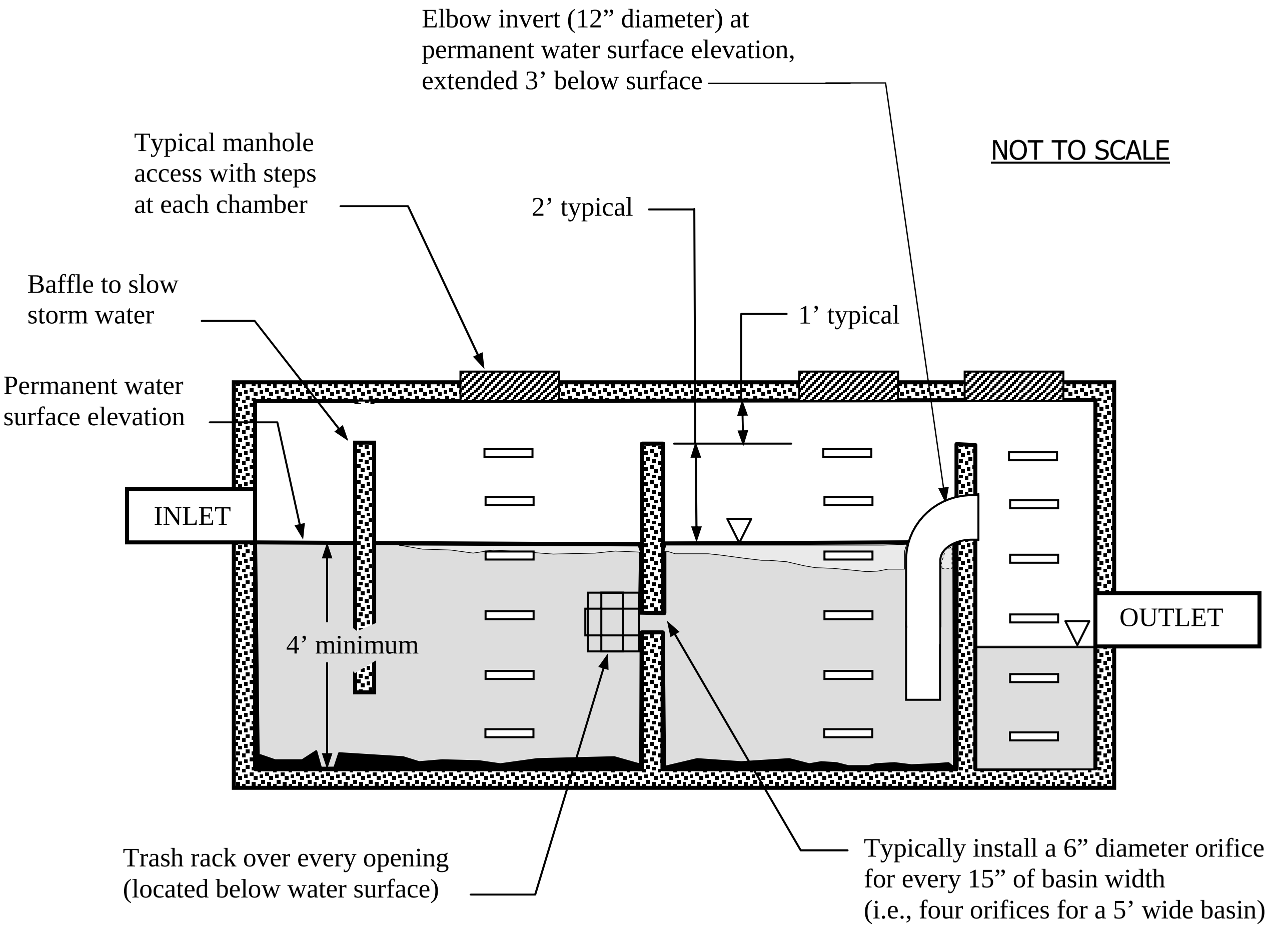


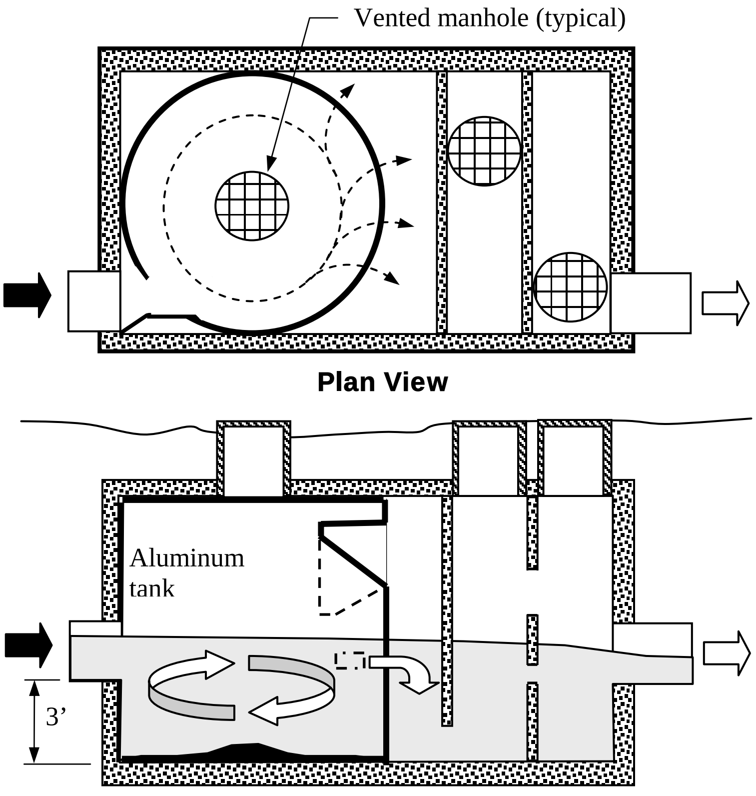
Figure ST-07-3
Typical Storm Water High-Flow Bypass Manhole



Notes:

1. Provide low velocities entering the oil-water separator and minimize opportunities for turbulence and mixing. Prevent backwater conditions downstream from the oil-water separator.
2. Minimum permanent pool storage shall be 400 cubic feet per acre of contributing drainage area.
3. Place 6" diameter orifices and 12" diameter pipe elbows across the internal walls to distribute flow evenly across the separator. Reduce or eliminate dead spots (or ineffective flow areas) in order to increase pollutant removal.
4. Label manhole lids so that the structure is easily identified as an oil-water separator. It may be necessary to control the type of truck traffic that is allowed to travel or park over a large oil-water separator.

Figure ST-07-4
Conventional Oil-Water Separator

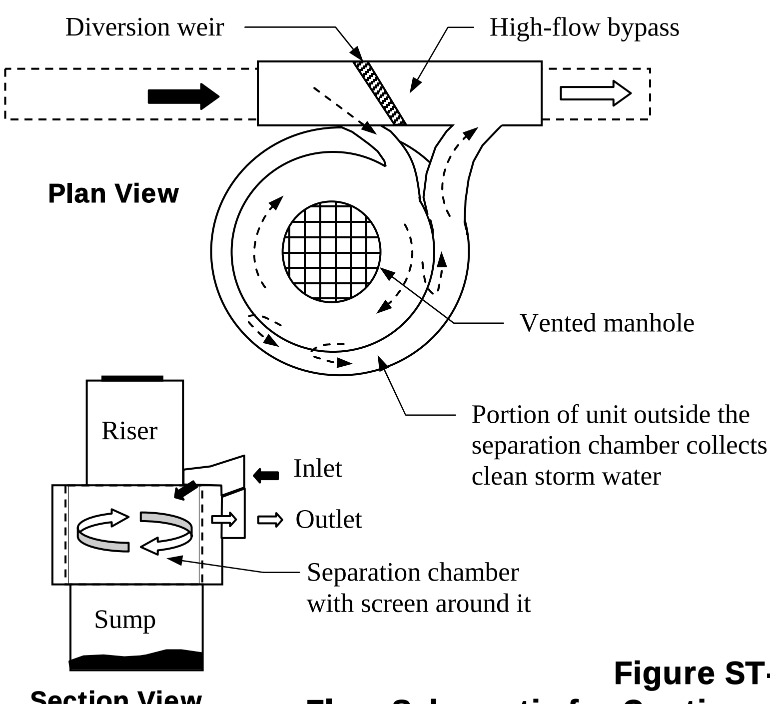


Notes:

1. This figure represents the Vortechs storm water treatment system, which uses swirl action to settle grit and sediments.
2. Vortechs specifies a ¼" thick aluminum tank for the swirl chamber and 6" thick concrete walls for vault.
3. Inside width = tank diameter Inside length = diameter + 5' or so Inside height = 6' to 9'
4. Inlet pipe and outlet pipe may be located on side of structure. A side inlet is optimal for swirling action.
5. Use vented and labeled manhole lids so that the structure is easily identified as an oil/water separator. Vortechs recommends minimum structural design for H-20 vehicle loading.

NOT TO SCALE

Figure ST-07-5
Typical Detail for Swirl Oil-Water Separators

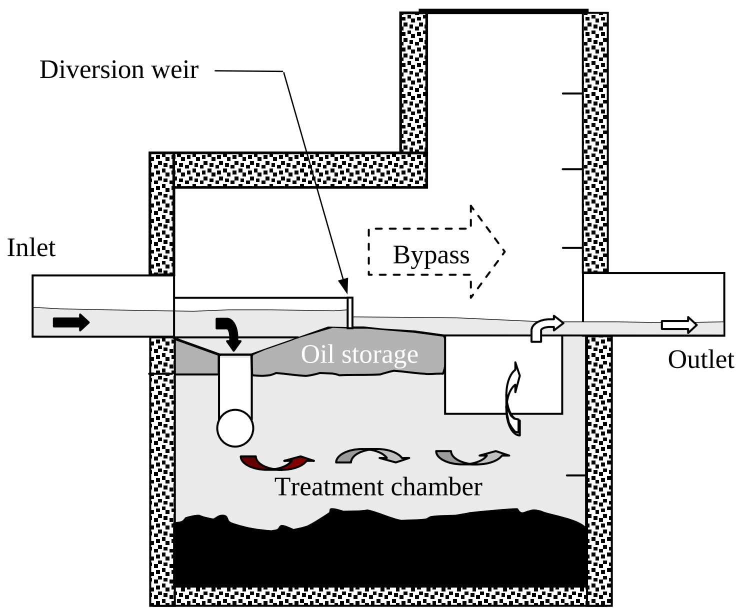


Notes:

1. This figure represents the continuous deflection storm water treatment as manufactured by CDS Technologies. Units can also be retrofitted onto existing storm drains.
2. Units are manufactured from either fiberglass or precast concrete.
3. Manufacturer recommends the use of sorbent material within CDS separation chamber to improve capture of oil and grease. Usage rate is typically several pounds of sorbent per acre per year.

NOT TO SCALE

Figure ST-07-6
Flow Schematic for Continuous Deflection Separators



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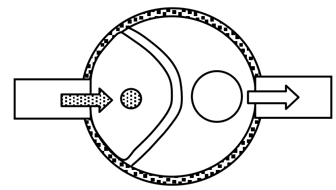
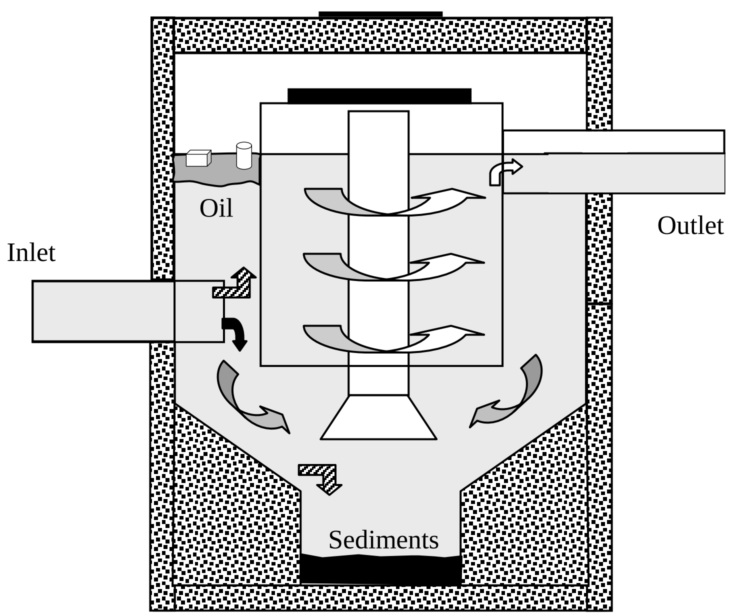


Notes:

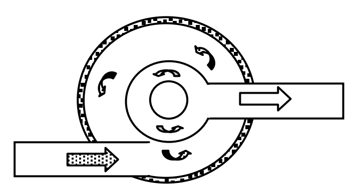
1. This figure represents a single-unit system designed to process storm water runoff on-line, as manufactured by Stormceptor Corporation.
2. Unit consists of an insert placed into a standard concrete manhole. Basic size is 72" diameter, with larger sections used for the treatment chamber as needed.

Figure ST-07-7
Oil-Water Separator (Stormceptor)



Notes:

1. This figure shows a single unit to treat storm water runoff, manufactured by H.I.L. Technologies, Inc.
2. Unit consists of polyethylene components supported by a stainless steel frame, inserted into a standard concrete manhole. Concrete manhole sizes vary from 4' to 10'.

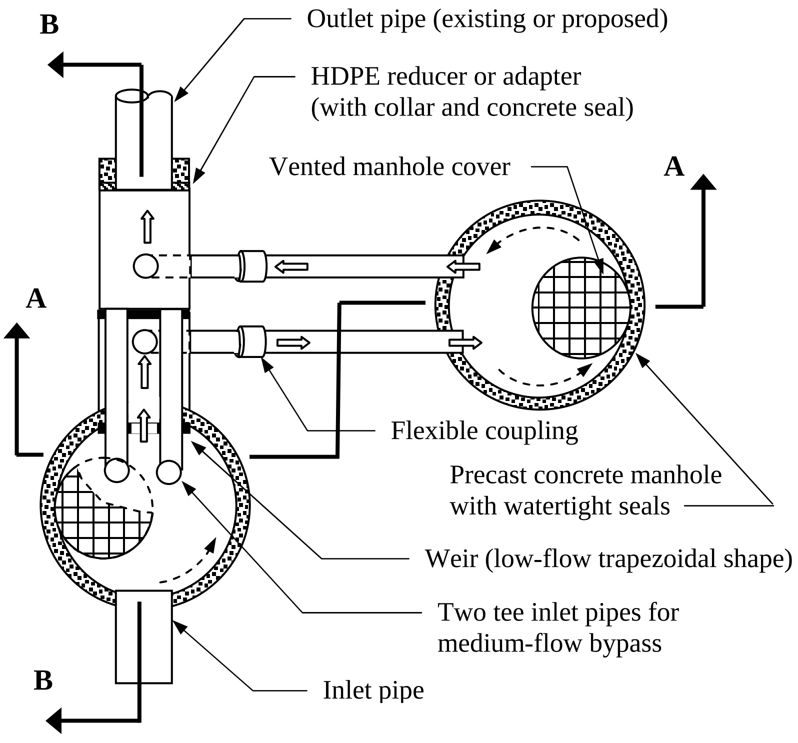


NOT TO SCALE

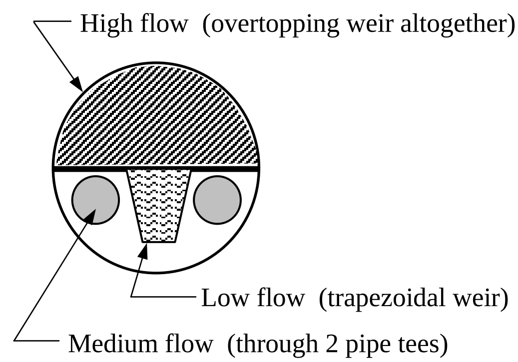
Figure ST-07-8
Oil-Water Separator (Downstream Defender)

Notes:

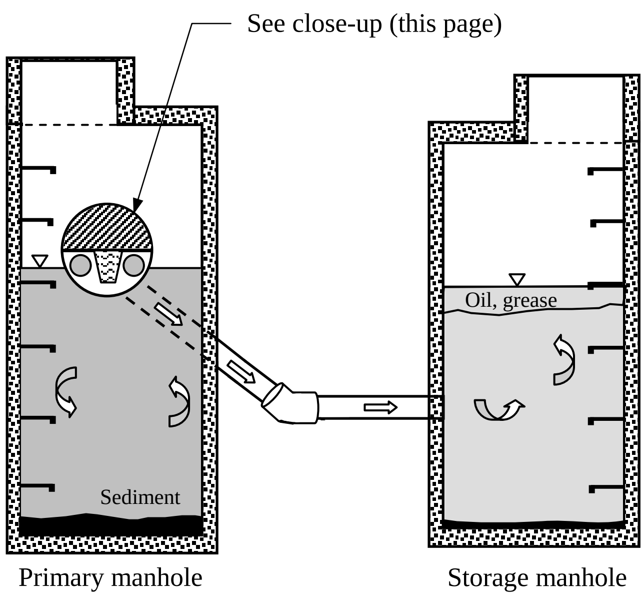
1. This figure represents the BaySaver separation system, an offline unit that divides flows into low, medium, and high regimes.
2. The unit can be retrofitted onto existing storm drain system or installed as part of a new storm drain system, using two standard precast concrete manholes.



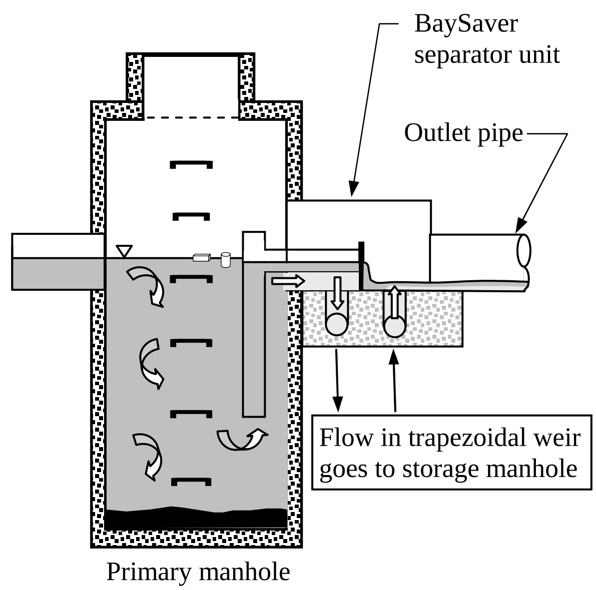
Plan View (with low flow)



<u>Close-up of Section A-A (flow control)</u>



Section A-A (with low flow)

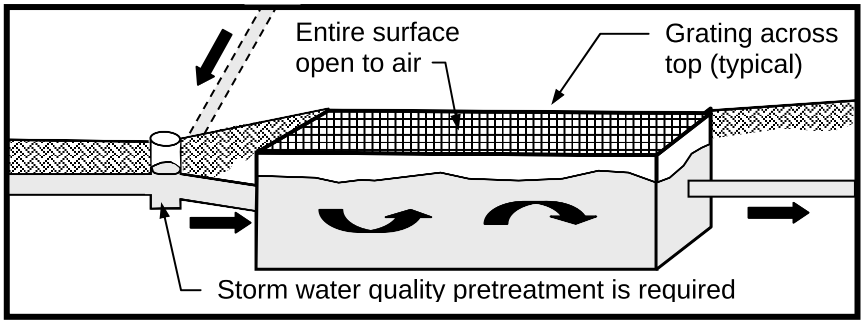


Section B-B (with medium flow)

<u>NOT TO SCALE</u>

Figure ST-07-9
Flow Schematic for Dual Tank System

ACTIVITY: Underground Detention	ST – 08



Targeted Constituents				
¸ Significant Benefit		Û Partial Benefit	¹ Low or Unknown Benefit	
Û Sediment	¹ Heavy Metals	Û Floatable Materials	¹ Oxygen Demanding Substances	
¹ Nutrients	¹ Toxic Materials	¹ Oil & Grease	¹ Bacteria & Viruses	¹ Construction Wastes

Description Underground detention is the use of large underground structures to provide necessary volumes for attenuating storm water peak flows. Underground detention is sometimes desired in areas where the cost of land is high enough to justify the additional construction, maintenance, and operating costs. Underground detention structures generally provide little or no storm water quality benefits. Potential applications could include very large development projects (such as regional shopping malls) for which the cost of providing underground detention structures would not be prohibitive.

Approach **Memphis and Shelby County have a policy against underground detention structures due to many observed problems in local applications and the potential for future problems.** Underground detention structures are very strongly discouraged for several reasons:

Â The cost of building underground structures is usually prohibitive when compared to dry detention basins, and this may cause some developers and contractors to illegally reduce detention volume or alter construction details in an effort to contain costs.

Â It is very difficult to inspect underground structures, particularly if entering the structure qualifies as confined space entry (which is controlled by Occupational Health and Safety Administration [OSHA] safety regulations). Cleanout and maintenance costs will need to be provided for and budgeted indefinitely.

Â Underground structures may not receive enough air and proper ventilation to avoid anaerobic conditions and dangerous flow conditions.

Â Storm water runoff quality is not substantially improved or enhanced by underground detention. Underground structures do not allow grass or other vegetation to absorb nutrients, minerals, or pollutants from storm water runoff. Underground structures do not take advantage of natural storm water infiltration into the ground surface.

Therefore in most instances, underground detention facilities are not allowed.

The city or county engineer could potentially allow such a facility if designed and constructed in accordance with good engineering practices by reliable and proven contractors of local reputation. The following minimum requirements must be followed in the potential design and construction of an underground detention facility:

1. The entire area of the underground detention structure must be open to the air surface directly above, either with no cover or by installing continuous grates across the top. This allows for inspection and maintenance of the entire facility with sunlight to provide the primary means of illumination. The facility will consider public safety and access (locks, fences, curbs) and is often designed to withstand truck loading such as HS-15 or HS-20. Access to the system shall be provided via a City of Memphis standard manhole, at a maximum spacing of 200 feet, on the upstream and downstream end of the system and at any changes in direction or grade.

2. The underground detention structure must be constructed of durable materials with a typical 100-year lifetime. Detention storage volume shall not include the porous space within a stone or gravel bed (commonly done in many states for a series of pipes or pipe arches under parking lots).

3. The underground detention structure shall be designed to have positive drainage into the receiving channel, assuming that there is a 10-year flood in the receiving channel. This ensures that the designed volume is used for onsite detention rather than containing offsite floodwaters.

4. The underground detention structure shall not receive surface runoff directly from parking lots through the top opening. Surface runoff shall be directed to a BMP that improves storm water quality, such as an oil-water separator or grass filter strips. The underground structure will usually have a curb or other barrier around the top to prevent this. In addition, trash and debris must be prevented from clogging inlets to the structure.

5. Design measures must be taken to trap and store sediments in locations where cleanout and maintenance can be easily performed. This generally requires that some type of water quality inlet or other storm water treatment BMP must be installed upstream from the underground detention facility.

6. Good design practices also require that structural measures shall be in place to prevent blockages. Floatable waste materials shall be collected

by trash racks for periodic removal. The underground detention structure shall have a positive means of being dewatered for inspection and maintenance purposes. The outlet structure shall include a trash screen or trash rack with a minimum bar spacing (center to center) equal to one-half the minimum dimension of the outlet control, unless the outlet control is 12 inches or greater in diameter. The trash screen shall be designed to allow removal for easy cleaning. The outlet structure shall include manhole and an inlet grade or other means of access to permit inspection, cleaning, and other maintenance. In the event that the orifice or other control device becomes clogged, the outlet structure shall provide for bypass flow, without overflow entering a public right of way.

7. A postconstruction runoff control plan, including inspection schedules and guidelines, must be submitted and approved. Evidence of responsibility and financial budgeting must be presented, in addition to the usual bonds and agreements necessary for all detention structures.

8. The pipes shall be a minimum of 24 inches in diameter. Arch or elliptical pipe is acceptable with the same minimum and maximum "equivalent" cross-sectional area.

9. The system shall not be part of the conveyance system for adjacent properties, except in cases where small portions of the adjacent property enters the site as sheet flow. The system shall not be in-line with any portion of the public drainage system.

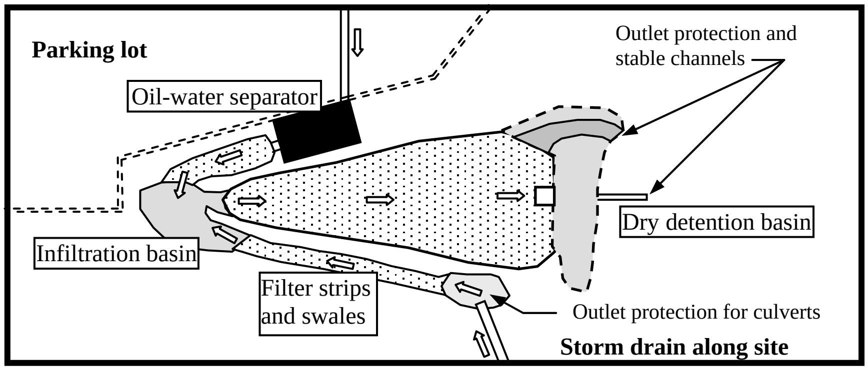
10. The system shall be in an easily accessible location. No permanent structure shall be constructed over the detention basin. And the plat shall specifically allow entrance by the city and/or county.

11. The owner or his representative shall inspect the system at least annually, and any deficiencies noted in the inspection shall be repaired within 60 days of the date of the inspection. A report detailing the findings of the inspection shall be submitted to Memphis or Shelby County within 30 days of the anniversary date of the acceptance of the project. The owner and his representatives should be aware that inspection of an underground detention system is considered a confined space entry and take all necessary precautions in accordance with OSHA regulations. Exemptions to this policy require the prior, site-specific approval of the city or county engineer.

The above requirements do not allow for the use of large-diameter pipes in a gravel layer or envelope. Arch culverts filled with stone and gravel, or even masonry block structures, were frequently used to provide storm water detention/infiltration underneath parking lots. Underground detention structures were promoted a few decades ago as a common means of detention in many areas of the country, particularly under parking lots. Most states and cities now discourage underground detention.

References **103, 153, 154, 180, vendor data** (see BMP Manual Chapter 10 for list)

ACTIVITY: Multiple Systems | ST – 09



Targeted Constituents				
¸ Significant Benefit		Û Partial Benefit	¹ Low or Unknown Benefit	
Û Sediment	Û Heavy Metals	Û Floatable Materials	Û Oxygen Demanding Substances	
Û Nutrients	Û Toxic Materials	Û Oil & Grease	Û Bacteria & Viruses	Û Construction Wastes

Description

It is often beneficial to use multiple storm water treatment BMPs, either in series or in parallel. Possible reasons may include:

Â Proximity to environmentally sensitive areas

Â Enhanced reliability or improved performance

Â Large expected pollutant loading

Â Two (or more) radically different types of land uses or expected pollutant categories

Â Optimal use of land area and resources to best improve storm water quality

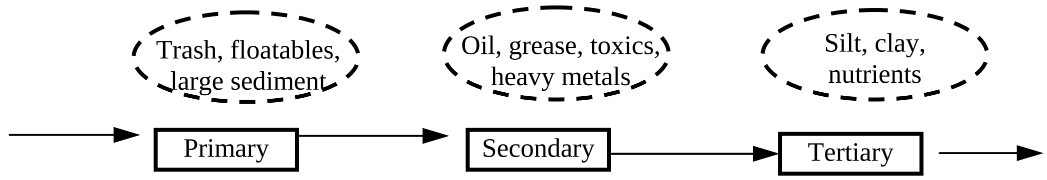
This practice may potentially provide significant reductions in pollutants for which the primary treatment BMP does not target, depending on the combinations involved.

Approach

Storm water treatment BMPs may be placed either in series or in parallel. In essence, parallel storm water treatment BMPs, have different sub-basins and act independently of each other. Storm water treatment BMPs in series may be labeled as primary, secondary, or tertiary to reflect the order in which they occur.

Storm water treatment BMPs in series should be placed in order to remove pollutants that may interfere with the functioning of a downstream BMP. For instance, large volumes of sediment should be removed from storm water prior to entering an oil-water separator. An oil-water separator may be necessary upstream from wetlands in order to control storm water runoff from parking lots.

Figure ST-09-1 shows a typical arrangement for placing storm water treatment BMPs with compatible land uses, typically along the edge of a property or project site. Aesthetics for these permanent structures help to maintain property values (residential), provide an attractive landscape for customers



and employees (industrial, commercial), and improve the overall quality of the environment and recreational facilities.

Typical Storm Water Treatment BMPs — In Series

Applications

The following combinations of multiple storm water treatment BMPs are briefly discussed using the following terms to denote the order of treatment: (1) primary or upstream, (2) secondary, and (3) tertiary or downstream. This list is intended to be suggestive and should be adapted for specific sites based upon land use, land surfaces, slopes and grades, available space, pollution potential, etc.

A

(1) Baffle box, manhole, gate, or weir (with high-flow bypass)
(2) Oil-water separator, filter swale, media filtration, water quality manhole/insert, wetlands

This is preferred for all storm water quality systems to ensure that flows in excess of the design flow do not damage the treatment system or resuspend the previously collected pollutants. A baffle box or manhole should ideally capture trash and large sediment particles to assist operations of the downstream BMP.

B

(1) Wet detention basin or dry detention basin
(2) Media filtration or oil-water separator
(3) Wetlands

It is desirable to protect wetlands (either natural or constructed) from excessive flow volumes and from pollutants that typically run off from parking lots, streets and highways, industrial or commercial properties, etc. Media filters will clog less frequently. Reduced maintenance costs for an oil-water separator.

C

(1) Filter strips and swales, forebay, baffle box, or manhole
(2) Wet detention basin or dry detention basin

Treatment measures in front of a detention basin will collect floatable debris and coarse sediment (to reduce frequency and difficulty of detention basin cleanout).

D

(1) Oil-water separator, media filtration
(2) Wetlands, filter strips, swales, infiltration trench or basin

Pretreatment of storm water runoff is desirable for sensitive vegetation systems wherever storm water runoff comes from streets and highways, parking lots, industrial or commercial properties, etc.

Overall pollutant removal goals are discussed in Chapter 4 of the BMP Manual. The primary measurable pollutant is total suspended sediments (TSS), and the desirable goal is to achieve 75% removal based on the equivalent definition of the first flush treatment. Most other pollutants will be removed proportionately to the TSS removal rate.

Maintenance Maintenance for a system of multiple storm water treatment BMPs should be conducted on a regular basis. Examine the system as a whole and note findings for future use. Coordinate cleanouts and repairs to occur during dry weather. In general, the upstream BMP is more likely to need maintenance and repair, since it is selected to reduce the loading and potential damage to the downstream BMP.

Limitations Available space may be limited for some storm water treatment BMPs. Configuration may be difficult to accomplish. Storm water detention is required by Memphis and Shelby County for most construction and redevelopment project sites, so that the largest portion of space is defined by hydrological requirements that are non-negotiable.

References **31** (see BMP Manual Chapter 10 for list)

Notes:

1. This figure illustrates how storm water treatment BMPs may be incorporated into recreational areas, parking areas, landscaping, and outlying property areas near buffer zones and setbacks.
2. Reduce outlet velocities on all culverts and storm drains. Provide outlet protection where necessary.
3. Media filtration, storm water quality inlets, and oil-water separators are highly desirable to reduce oils, grease, heavy metals, and other pollutants associated with automobiles.
4. The wet detention basin shown has an aesthetically pleasing fountain, which also provides aeration for fish and aquatic life.

ST-01	Dry Detention Basin
ST-02	Wet Detention Basin
ST-03	Infiltration Systems and Methods
ST-04	Constructed Wetlands
ST-05	Filter Strips and Swales
ST-06	Water Quality Inlets and Media Filtration Systems
ST-07	Oil-Water Separator
ST-08	Underground Detention

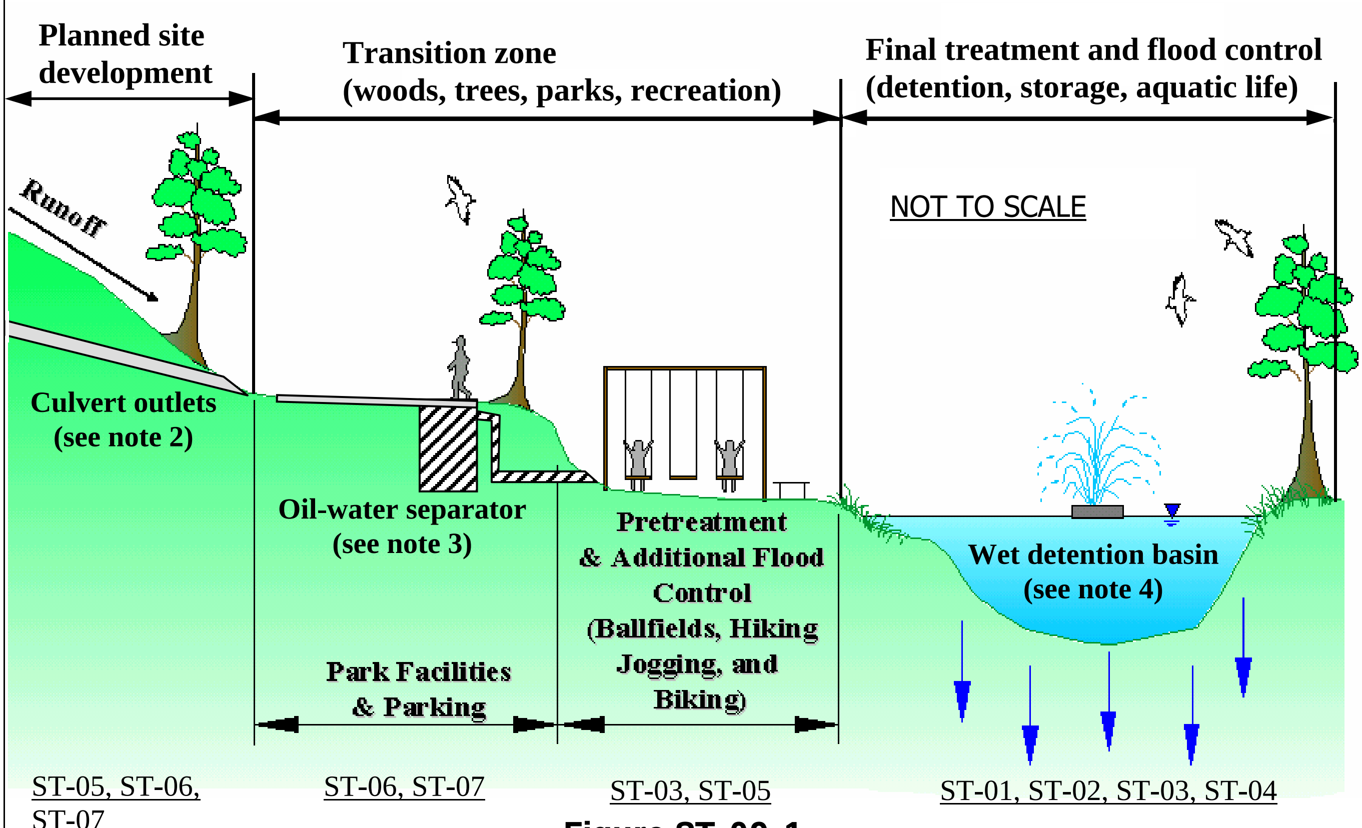


Figure ST-09-1
Multiple Systems for Storm Water Treatment BMPs