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SECTION 1. STORMWATER MANAGEMENT REQUIREMENTS

1.1 Purpose

The Clean Water Act (CWA) was passed in 1972 to help protect and restore the waters in our Nation's streams, rivers, and lakes. In the early 1990s, Phase I of the National Pollutant Discharge Elimination System (NPDES), under authority of the CWA, was passed to regulate stormwater management in large urban areas. Phase II regulations were developed and passed near the turn of the century requiring medium size cities meeting a certain population density and other criteria to develop stormwater initiatives to address pollution associated with urban runoff. In March of 2003, the City of Glasgow, and numerous other "Phase II Cities and Counties" submitted permit applications to the Kentucky Division of Water outlining a 5 year plan for addressing the Phase II requirements.

The thought behind the Phase II program is that urban runoff is a chief cause of stream impairment, and that urban runoff can be managed in large part by effectively addressing a few key areas; educating and involving the public on the impacts of urban runoff and how the public can help, managing the storm sewer infrastructure and addressing illicit discharges (discharge of pollution / polluted runoff), implementation of local regulatory authority, development of best management practices (BMPs) for construction and post-construction, and environmentally sensitive and responsible municipal operations. This BMP manual was developed to support Phase II efforts in addressing Construction Site Runoff and Post Construction Runoff as required by the Phase II permit for Glasgow and numerous other Phase II communities. Additionally, a number of the BMPs address municipal operations, and residential issues and can be used for sharing information with the public.

The KY Division of Water issued the statewide construction stormwater general permit, KYR10, in August 2009 that will be in effect until July 31, 2014. This permit regulates stormwater discharges from construction sites that disturb an acre or more or less than an acre if part of a larger common plan of development. The City's stormwater management program incorporates the requirements of KYR10.

This manual presents a brief introduction to stormwater Best Management Practices (BMPs). The following types of BMPs are addressed: Site Planning and Design Practices (SPD); Erosion Prevention Practices (EPP); Sediment Management Practices (SMP); Good Housekeeping Practices (GHP); BMPs for Residential and Homeowners (RHP), Stormwater Pollution Prevention Practices (SPP) , and Stormwater Pollution Treatment Practices (PTP).

The manual describes how BMPs can be selected, and contains a series of fact sheets for each type of BMP to be used in the area. The intent of the Stormwater Best Management Practices Manual is to provide guidance on BMP selection, design, and implementation to plan submitters, reviewers, construction site operators, and site inspectors. There are also guidance materials for activities at commercial and industrial facilities.

The fact sheets are categorized, focused, and concise so that they may be used as quick references for design, inspection, and maintenance guidance. In this way, the fact sheets are designed to be stand-alone documents that may be distributed to facilitate discussion about design and/or implementation of the management practice. Many of the practices are considered structural practices in that they involve construction. However, several of the BMPs cover non-structural practices where normal activities are performed in a different manner with stormwater quality in mind. An example site design is used throughout the PTP fact sheets to demonstrate their design.

1.2 Goals of the Program

In support of the information provided in City Code Section 21-2 goals of the post-construction runoff management program are:

1. Improve the Quality of Glasgow and Barren County's water resources by:
    - Implementing of minimum control measure
    - Providing education to citizens
2. Provide protection of the short-term and long-term public health, safety, and general welfare by:
    - Providing for regulation and management of Glasgow's stormwater system, including public and private facilities in Glasgow service area.
    - Protecting, and preserving stormwater quality and fish and wildlife habitat within Glasgow.
    - Protecting those downstream from stormwater quality impairment.
3. Comply with state and federal stormwater regulations developed pursuant to the Clean Water Act Amendments of 1987 and subsequent amendments.
    - Managing the quality of stormwater discharged to the MS4 by controlling the contribution of pollutants associated with development and redevelopment activity.
    - Controlling stormwater pollution caused by the suspension and transport of soils and other sediments.

- Facilitating the use of the public and private stormwater management systems that will not result in excessive maintenance costs.
- Encouraging the use of natural and aesthetically-pleasing designs that optimize the preservation of natural areas.
- Guiding the construction of stormwater management facilities by developing comprehensive master plans and guidance that address stormwater quantity and quality.

4. Sustain Development of the area in an environmentally conscience manner by:
   - Development of regulation protecting the environment.
   - Providing training and guidance material to the development community.
   - Enforcement of regulations.

5. Preserve Natural features in the Glasgow and Barren County area by:
   - Using environmentally friendly practices.
   - Providing buffering around natural features.
   - Encouraging the preservation of floodplains, floodways and open spaces to protect and benefit the community's quality of life and natural resources.

1.3 How to Use This Manual

This manual is laid out in sections to aid the designer and site manager in finding pertinent information. Section 1 contains requirements, policies, and procedures. Section 2 contains construction site management techniques and tools. Section 3 contains fact sheets, such as the one below, on different BMPs that can be used on construction sites to manage stormwater and reduce pollutant discharges from construction sites and developed properties. The appendices contain design information, examples, inspection report forms, and BMP operation and maintenance guidance for your use.

1

Glasgow, Kentucky
Stormwater Best Management Practices (BMPs)Sediment Management Practices (SMPs)

Activity: Check Dams 2

3

SMP-01

4

PLANNING CONSIDERATIONS:

Design Life:

Acreage Needed:

Minimal

6

7

CD

Target Pollutants 8

Significant ·	Partial ¹	Low or Unknown ¸

Sediment · Heavy Metals ¸ Nutrients ¸ Oxygen Demanding Substances ¸ Toxic Materials ¸

Description

This section provides a general overview of the BMP activity and introduces common niches where it can be applied.

Suitable Applications

Suitable applications direct the user to the general design limitations and site compatibility for the BMP. This section targets situations where the BMP will be most effective, and points out situations where the BMP should not be implemented.

Approach

This section contains a suggested plan of action for implementing the BMP. It includes planning considerations respective to the type of materials, construction planning, and suggests BMPs to install in series in order to maximize benefits.

Installation Procedures

This section provides guidance for consideration in the design specific to constructing the BMP and often references the BMP drawing.

Maintenance

Although maintenance is often needed after a significant rain event, this section gives detailed guidance to users for the frequency of maintenance specific to each BMP design. Here, the user can find recommended maintenance techniques, frequency of in-active inspection checks, and key areas to maintain in order to maximize the design life of the BMP.

Legend

1. Logo of City or Agency
2. BMP Activity Title
3. BMP Activity Number
4. Planning Considerations:
   - Design Life – a quantitative measurement of the BMP's effective life given that proper maintenance procedures are followed
   - Estimated Unit Cost – general costs are categorized by Low, Medium, High
   - Monthly Maintenance – approximate frequency of maintenance
5. Typical Photo – photos are included as examples only, and are not meant for use in structural design
6. Suggested BMP symbol to place on ESPC drawings or design plans
7. Suggested BMP planning symbol to place on conceptual drawings or illustrations
8. Target Pollutants Table – likely pollutants to be removed by BMP practice

Section 2
Construction Site Stormwater Management Requirements

2.1 Coordinating with other agencies

Many agencies may need input on development plans. The following table outlines the type of activity that may require approval or information from other agencies. A permit or application cannot be approved until documentation from those agencies has been received.

Table 2.1-1 Other Agency Contact Information

Activity that may require information from another agency	Permit or approval	Contact
Disturbing an acre or more or disturbing less than one acre but part of a larger common development disturbing one acre or more.	KPDES General Permit	Section Supervisor Inventory and Data Management Section KPDES Branch, Kentucky Division of Water 14 Reilly Road, Frankfort Office Park Frankfort, Kentucky 40601
Improving the throat of a sinkhole	Class V Injection Well	EPA Region 4 US EPA Ground Water/Drinking Water Branch 61 Forsyth St. Atlanta, GA 30308-8960 (404)562-9307
Working in a stream or river	404 Permit	U.S. Army Cops of Engineers 3701 Bell Road Nashville, Tennessee 37214 Phone (615) 369-7500 Fax (615) 369-7501
Stream crossings and riparian area development	401/Water quality certification	Water Quality Certification Section 14 Reilly Road Frankfort, KY 40601 Phone: 502-564-3410 Fax: 502-564-0111 Email: jenni.garland@ky.gov
Development in a floodplain or flood prone area	LOMR, CLOMR, Elevation Certificate, No-Rise Certification	City-County Planning Commission of Barren County 1141 State Street, Glasgow, KY 42101 270-842-1953

2.2 Regulations

This section describes the regulations supporting the City's stormwater management program. It establishes the baseline requirements. More information about the policies and procedures in support of these regulations can be found in Section 3 and the appendices.

2.2.1 Waterway Buffers

Areas of new development and redevelopment require a 25- to 50-foot undisturbed no-build buffer zone from top of bank on both sides for the entire length of streams that are identified in the most recent USGS Quadrangle maps within the City of Glasgow. Buffer zones are vegetated areas, including trees and shrubs which exist or are established to protect a stream system, lake, or reservoir area. These buffers also apply to other sensitive areas such as springs, wetlands and sinkholes as follows:

KYR10 requires buffer zones as described below:

> For discharges to waters categorized as High Quality Waters or Impaired Waters (Non-construction related impairment) permittees are required maintain at a minimum a 25-foot buffer zone between any disturbance and all edges of the receiving water as means of providing adequate protection to receiving waters. For discharges to waters categorized as Impaired Waters (Sediment impaired, but no TMDL), permittees are required to maintain a minimum 50-footwide buffer zone between any disturbance and all edges of the receiving water as means of providing adequate protection to receiving waters. If the buffer zone between any disturbance and the edge of the receiving water on all edges of the water body cannot be maintained, an adequately protective alternate practice may be employed. The SWPPP shall explain any alternate practices and how these practices are adequately protective. Such cases include but are not limited to stream crossings and dredge and fill areas. In these cases the permittee shall minimize disturbances in the buffer zones by using hand held or other low-impact equipment.

2.2.2 Erosion Prevention and Sediment Control Requirements

The City of Glasgow, KY requires an Erosion Prevention and Sediment Control (EPSC) Plan for most types of construction. When preparing the EPSC Plan, the design engineer and/or developer should determine the best practices to protect the environment from the potential impacts from construction sites by selecting source control and sediment containment practices. Proper site planning and BMP selection are critical to the success of the erosion prevention and sediment control plan. The appendices contain plan submittal forms and checklists for your use.

Site characteristics such as soil types, topography, and on-site or nearby natural resources, and construction methods should be thoroughly reviewed when selecting BMPs to implement throughout the life of the project. The designer should plan for how the site will change throughout the project so that BMPs can be repaired, modified or replaced.

For more information regarding the required elements of an EPSC Plan, refer to Appendix C – EPSC Plans.

EPSC plans must incorporate the following concepts:

Minimize Disturbed Areas - Phasing

Construction planning and sequencing are the least expensive methods to reduce and control erosion and sediment. The following points should be considered to minimize disturbed areas:

- Do not disturb areas of the construction site and keep existing vegetation for as long as possible. Delay disturbing areas of the site until necessary for construction activities.
- Carefully schedule and phase construction. Avoid grading during wet months (December through May).

- Plan and implement permanent structures throughout the earlier phases of the project. This will maximize the BMP's effectiveness.
- Avoid delays and work expeditiously on any part of the site. Install landscaping and stabilize upon the completion of any sequence and prior to moving on to the next phase.

Focus on Erosion Control

- Erosion control is THE most effective practice used on a construction site. Temporary covers (mulch, temporary grains, plastic) are cost effective and should be used on any area of the construction site that has a high potential for discharging sediment off-site.
- Use temporary cover measures (seed or mulch) whenever construction ceases for 14 days.
- Phase site grading to limit the amount and time of an area is exposed. Exposed areas should be stabilized immediately following the completion of grading in that area.
- Any exposed soil is subject to erosion, even by a single rain drop. Designers and contractors should make every effort to stabilize the following highly susceptible areas at a construction site throughout construction:
  - Slopes
  - Highly erosive soils
  - Construction entrances and exits
  - Stream channels
  - Soil stockpiles

Manage Sediment

- Where erosion controls are impractical due to construction activities, sediment controls must be installed. Sediment controls are much less effective and have higher maintenance requirements than erosion control practices.
- The designer should consider sediment controls for the initial clearing and grubbing phase. Typically, these controls are perimeter controls, as follows:

Area of Concern	Site Perimeter Control
Disturbed areas or slopes that drain toward adjacent properties	Continuous berms, silt fences, sandbags
Stabilizing area after grading has been completed	Mulching, seeding, planting, emulsifiers, or a combination of two or more
Off site flows that enter the constructions site	Continuous berms, earth dikes, drainage swales and lined ditches
Concentrated flows that leave the construction site	Outlet control measures that will dissipate velocities
Construction traffic exiting onto a public right of way or other property	Construction exit to reduce mud tracking

Additional controls within the interior of construction site should supplement perimeter controls once rough grading is complete.

Internal Erosion and Drainage Design

Once the perimeter controls have been designed, the issue of internal erosion and drainage controls must be addressed for each phase or stage of construction. Internal practices are required early in the project until permanent practices can be implemented.

Some of the internal erosion and drainage design practices to be used include:

- Check dams, geotextile mats, and under extreme circumstances concrete channel lining.

- Terracing at regular intervals.
- Slope benches or ditches.
- Surface roughening or temporary seeding.
- Temporary sediment traps and basins.

Maintenance and Inspection of Measures

Constant inspection and maintenance of the BMPs is critical for successful prevention of erosion and sediment transport. Maintaining a daily or weekly checklist of practices to inspect for deficiencies is critical. All areas of the active construction site must be inspected at last once every 7 calendar days, and these inspections must be documented in an inspection report. When maintenance needs are identified in an inspection, they must be addressed before the next rain event or as soon as practicable.

A simple way to ensure that all practices are compliant is for the EPSC Certified Contractor to arrange a pre-construction meeting with the City of Glasgow's Stormwater program. This meeting should take place after the Notice to Proceed, but prior to the mobilization of equipment.

All construction site BMPs require ongoing maintenance. At a minimum, sediment should be removed from the sediment storage area when the storage area is a third full. However, the contractor should demonstrate sound judgment and maintain the structures more frequently if necessary.

An inspection and maintenance strategy should include the following:

- ü Verify that sediment-laden stormwater flows to temporary sediment traps, basins or other sediment control devices.
- ü Runoff from undisturbed areas should be directed around disturbed areas and not directed into sediment control devices.
- ü Protect all existing or newly installed storm drainage structures from sediment clogging by providing inlet protection for area drains and curb inlets. Stormwater inlet protection can utilize sand bags, sediment traps, or other similar devices.
- ü Excavate permanent stormwater 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.
- ü Inspect temporary sediment barriers such as silt fences, rock filters, and continuous berms after every 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.
- ü Internal outlets must also be protected to reduce scour from high velocity flows leaving pipes or other drainage facilities.
- ü Protect sinkholes, drywells, yard inlets and other internal drainage features from sediment with inlet protection.

2.2.3 NPDES Phase II EPSC Requirements

New requirements for small municipalities, NPDES Phase II stormwater requirements, became effective on March 10, 2003. In these requirements, certain municipalities and agencies that are owners or operators of their stormwater systems were required to apply for coverage under the Phase II permitting program enforced by the State. The City of Glasgow is an NPDES Phase II regulated municipality and has coverage under the NPDES Phase II general stormwater permit, KYG20.

One of the requirements of the Phase II program is to develop a construction site runoff control program for new developments and redevelopments affecting one acre or more. The City's Stormwater Ordinance was developed in an effort to comply with this requirement. It parallels KDOW's stormwater general permit for construction activities, called KYR10, as well as the requirements within KYG20.

2.2.4 Complying with KYR10 Requirements and the City of Glasgow's Stormwater Requirements

The City's EPSC program mirrors KYR10. Whenever a construction site disturbs 1 acre or more, coverage under KYR10 is required, and the City will not issue a grading permit until a Notice of Coverage for the site in question has been submitted to the City. A summary of KYR10 requirements is in Table 2.2-1.

Table 2.2-1 Summary of Major KYR10 Components

Land disturbing activities affecting 1 acre or more are required to obtain coverage under KYR10. For common plans of development, contiguous construction activities that cumulatively equal one or more acres of disturbance must have coverage. Non-contiguous activities (activities that are separated by 0.25 miles or more) that disturb one or more acres are considered separate activities. An applicant is required to submit a Notice of Intent for Stormwater Construction Activities (NOI-SWCA) for coverage under KYR10 and wait for a Notice of Coverage prior to beginning construction. The KPDES permit also requires permittees to develop and maintain stormwater pollution prevention plans (SWPPPs) for each permitted site. These plans do not have to be submitted with the NOI-SWCA. However, they must be made available to State and City inspectors during site inspections or as otherwise requested. EPSC measures must be designed, installed and maintained to effectively minimize discharges up to and including the 2-yr, 24-hr storm event. EPSC maintenance must be completed before the next storm event. Inspections must be performed by knowledgeable and qualified inspectors, either At least once every seven (7) calendar days **OR** At least every fourteen (14) calendar days and within 24 hours after any storm event of 0.5 inch or greater. All inspections must be documented and inspection reports kept with the SWPPP. Areas where construction has temporarily or permanently ceased must be stabilized within fourteen (14) days of the cessation of construction activities. EPSC measures must be implemented on disturbed critical areas within 24 hrs after completion of grading/disturbance. A 25-foot buffer zone must be maintained between construction activities and the edge of high quality and impaired streams. For sediment impaired streams, a minimum 50 foot buffer must be maintained.

The following sections provide detailed information regarding The City of Glasgow's stormwater management program. These sections describe how the City's stormwater program meets the requirements of KYR10 and the City's Municipal Separate Stormwater System (MS4) Phase II permit, KYG20.

2.2.5 EPSC Plan Requirements

Different levels of EPSC plans are required for different types of developments. Simple Plot Plans, for example, that do not include sinkholes or other sensitive features can address EPSC by completing the form found in Appendix C, Standard EPSC Plan for Plot Plan. Larger, more complex sites, such as non-residential buildings and subdivisions, are required to submit detailed EPSC plans.

The level of detail shown on the drawings depends on the size and complexity of the project. For single lots, a sketch may be all that is required to show the inspector. However for larger developments, such as a shopping center or industrial park, a plan sheet (or several) at an appropriate scale shall be submitted to the City for review.

This is a list of required notes that must be added to every EPSC plan, large and small.

- As a minimum, all erosion prevention and sediment control practices will be constructed and maintained according to the standards located in the City of Glasgow's BMP Manual, Stormwater Ordinances, and as required by state and federal laws.
- A copy of the approved Erosion Prevention and Sediment Control Plan shall be maintained at the project site at all times or shall be made available to the City upon request within one working day.
- Prior to commencing land-disturbing activities in any area not on the approved erosion prevention and sediment control plan, the contractor shall submit a supplementary erosion control plan to the City of Glasgow for review and approval.
- All erosion prevention 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.
- During dewatering operations water must be pumped through an appropriate filtering device. The City of Glasgow may suspend dewatering operations if pollution is observed.
- The contractor shall inspect all erosion and sediment control devices at least once a week. The contractor shall perform any repairs or maintenance prior to the next storm event or as soon as practicable in order to ensure effective erosion and sediment control.
- The contractor shall maintain a record of all inspections and maintenance activities. This record shall be made available to the City of Glasgow upon request.

2.2.6 Plot plans

Plot plans are required with improvements meeting the following criteria:

a) Permanent structure greater than 750 square feet; and,
b) Increased impervious less than 3400 square feet; and,
c) Critical Slope not exceeded. Average drive slope does not exceed a twelve percent (12%) up slope or five percent (5%) down slope within 10 feet of back of sidewalk; or the average drive slope does not exceed a ten percent (10%) up slope or twelve percent (12%) down slope within 15 feet of back of curb or edge of pavement when no sidewalk is present or required.
d) Site is not in a critical flood area.

Items required to be submitted to the City with the plot plan are included in Appendix C. The required EPSC notes in Section 2.2.5 above also apply to EPSC plans for plot plans. For these sites, a standard EPSC plan form must be completed and submitted as part of the building or paving permit application. However, if features such as sinkholes, drainage inlets, or streams are located within the lot or permit area boundary, additional information may be required. A detailed EPSC plan completed by a design professional may be required that shows how that feature will be protected.

Once the permit has been issued, the completed standard EPSC plan form becomes part of the permit and the permittee is required to comply with the plan.

2.2.7 Grading and Drainage Plans

Grading and drainage plans (GDPs) are required for improvements meeting the following criteria:

a) An increase in impervious area greater than 3400 square feet and site disturbance less than one acre and which is not part of a Stormwater Master Plan (SWMP); or,
b) Construction is greater than 750 square feet and is less than 3400 square feet increase in impervious areas and lot slope exceeds critical slope limit; or,
c) Construction is greater than 750 square feet and is less than a 3400 square feet increase in impervious areas, slope does not exceed limits and site is located in a critical flood area and is part of a master SWMP.

d) Items required to be submitted to the City with the grading and drainage plan are in Appendix C. As part of the GDP submittal, an Erosion Prevention and Sediment Control (EPSC) Plan will also be required: EPSC plans must be signed and stamped by a licensed professional.

1. The EPSC plan shall include the following:

a) A natural resources map identifying
- soil types,
- forest cover,
- topography (1' contours), existing and proposed grades
- receiving stream and other natural features of concern on the property or immediately adjacent to the property
- location of sinkholes and drywells within the property or immediately adjacent to the property

This map should be to scale equivalent to balance of submittal.

b) A construction schedule for the development site, including stripping and clearing, rough grading, construction of utilities, infrastructure, final grading and landscaping. Sequencing shall identify the expected date on which clearing will begin, the estimated duration of exposure of cleared areas, areas of clearing, installation of temporary EPSC measures and establishment of permanent vegetation.

a) All EPSC measures necessary shall be shown on the plan by location and referred to by a legend for all phases of construction. Depending upon the complexity of the project, the drafting of intermediate plans may be required for the close of winter season. Multiple EPSC plan sheets may be necessary to best convey requirements for each phase. Supporting calculations for the measures must be provided.

b) Seeding mixtures and rates, types of sod, method of seedbed preparation, expected seeding dates, type and rate of lime and fertilizer application, and type and quantity of mulching for both temporary and permanent vegetative control measures.

c) Provisions for maintenance of control facilities, including easements and estimates of the cost of maintenance.

2. Modifications to the plan shall be processed and accepted or denied in the same manner as the review and issuance of the original permit application and may be authorized by the City of Glasgow by written authorization to the permittee, and shall include:

a) Major amendments of the EPSC plan require an engineer's signature and shall be submitted to the City of Glasgow for acceptance prior to completion.

b) Field modifications of a minor nature shall require an engineer's signature and shall be noted and dated on the EPSC record drawings and available for review and acceptance by the City of Glasgow within 14 calendar days after changes have been made in the field.

EPSC plans must be reviewed and approved prior to any land disturbing activity on the site.

The plan submittal checklist found in Appendix C contains a detailed list of the items that must be included with a grading and drainage plan AND detailed EPSC plans.

2.3 Inspections by an EPSC Certified Contractor

An EPSC certified contractor shall be responsible for overseeing the implementation and maintenance of all aspects of the plan and performing inspections. Whenever an Erosion Control Plan is required, a certified contractor must be identified in the permit application package. The following information must be submitted with the application:

- ü Certified Contractor's name, company name, address, phone number, and certification number.
- ü A statement signed by the contractor certifying that he/she will be the person responsible for the installation, inspection and maintenance of EPSC measures at the site and will be the point of contact for the City regarding EPSC questions or concerns for the permitted site.

On projects where numerous grading or site contractors are likely to be working, a representative of the contractor responsible for overseeing the initial grading and installation of initial EPSC practices must be identified as the Certified Contractor when the Stormwater Pollution Prevention Plan is submitted to the City for review and approval. However, prior to obtaining any permits, the applicant must identify any new Certified Contractor for the individual lot **or** certify that the overall Stormwater Pollution Prevention Plan (which includes the EPSC Plan) for the development will be followed and that the Certified Contractor for the overall development will also serve as the Certified Contractor for the individual lot.

Certified Contractors are responsible for the following within the City of Glasgow's jurisdiction:

1. Understand when an Erosion Prevention and Sediment Control Plan is required by the City and inform developers prior to beginning land-disturbing activities of the requirement for a plan.
2. Install or oversee the installation of erosion prevention practices (EPP), sediment management practices (SMP) and good housekeeping practices (GHP) before land disturbing activities begin.
3. Inspect EPP, SMP and GHP controls every 7 calendar days. Document the findings of the site inspections, inform the developer of the findings, and maintain inspection documentation for the permitted site.
4. Maintain EPP, SMP and GHP controls for the duration of the construction activities. Maintenance of controls must be conducted in accordance with the requirements identified in the City's Best Management Practices Manual.
5. Act as the site contact for the City regarding the EPSC plan, relaying information to the permit holder from the City.
6. Inform the City in writing of Certified Contractor substitutions, deletions and/or additions. These forms can be found in Appendix E.

The City of Glasgow or its designated agent shall make inspections as deemed necessary to ensure the EPSC measures are being properly implemented and maintained during construction. If minimum requirements for the EPSC are not met, the permittee shall be notified and enforcement actions shall be taken.

2.4 Stormwater Management Plan

The City of Glasgow is a permitted Phase 2 NPDES Municipal Separate Stormwater System (MS4) owner and is required to maintain coverage under the KPDES MS4 General Permit, KYG20. KYG20 requires all new development and redevelopment sites that disturb one acre or more (or less than an acre if part of a larger common plan of development) to develop and implement stormwater quality management plans. KYG20 provides minimal guidance to MS4s for developing stormwater quality treatment control programs. Instead, KDOW and EPA desire municipalities to develop programs that best suit each locale. The following criteria were established as minimum requirements in KYG20, issued in 2010:

- The City must develop a locally derived water-quality treatment standard that requires new development projects to implement controls to manage runoff through water-quality control structures. The standard shall be based, at a minimum, on an analysis of precipitation records to determine the equivalent surface depth of runoff produced from an 80th percentile precipitation event

- The City must develop procedures for the site-plan review and approval process and a required re-approval process when changes to stormwater management measures are required.
- The City must develop procedures for a post-construction process to demonstrate and document that post-construction stormwater measures have been installed per design specifications, which includes enforceable procedures for bringing noncompliant projects into compliance.
- The City must develop a long term maintenance program for new development and redevelopment to ensure structural controls are maintained and functioning perpetually.

KYG20 is primarily focused on stormwater quality. The City's stormwater management program is comprehensive and includes stormwater quantity management as well. The SWQMP encompasses both stormwater quality and quantity management goals. The following sections describe the City of Glasgow's approach to the stormwater quality and quantity management program.

2.4.1 Stormwater Quality Management Plan Submittal Requirements

A SWQMP is required with improvements that meet the following criteria:

a) Disturb greater than one acre; and,
b) Create 10,000 square feet of impervious area; and,
c) Project is not part of a master SWQMP or the project changes the scope of a previous SWQMP.

2.4.2 Stormwater Quality Program Rationale

In developing the post construction stormwater quality program, the City considered numerous factors related to the environment and the type of development common to Glasgow. The City's drainage system is dependent on sinkholes and an underground network of streams. It is the City's goal to protect surface and shallow subsurface drainages while minimizing flooding and maintenance needs. To that end, the City's post construction stormwater quality program has been built on the following premises:

1. As of June 2010, none of the streams within the City's jurisdiction had been identified as impaired by the Kentucky Division of Water, and no TMDLs had been developed. As such, no City-specific pollutant of concern had been identified. Therefore, sediment was determined to be the general pollutant of concern, and total suspended solids (TSS) was determined to be the indicator pollutant. Furthermore, TSS load reduction goals are common in many municipalities, and much information about TSS reduction by BMP is readily available.
2. Once the pollutant of concern was determined, the target pollutant load reduction had to be established to fully define stormwater quality treatment to the "maximum extent practicable". Research data and literature found in the comprehensive International BMP Database (http://www.bmpdatabase.org/) was reviewed, and the majority of the BMPs were capable of a TSS removal of 80% of the average annual post-development pollutant load. Therefore, the City determined that the stormwater quality treatment goal of 80% TSS removal of the average annual post-development pollutant load constitutes MEP.
3. TSS loading is directly tied to impervious surfaces; therefore, the City's stormwater quality program treatment goals are also directly tied to impervious surfaces. (Note: Some stormwater pollutants, such as pathogens and nutrients, are not as directly tied to impervious surfaces. Land management practices may be the cause of higher loadings of pathogens and nutrients, such as landscape area management or septic system or wastewater treatment system maintenance.)
4. Low impact development principles are encouraged by several mechanisms, including:
5. The City's Conservation Subdivision design (see Section 2.6.1). This design allows residential subdivisions that meet several low impact development guidance criteria to meet all stormwater quality objectives without installing

structural BMPs. Note, however, that these subdivisions may still be required to design systems or structures that mitigate stormwater quantity increases.

6. Multi-purpose BMPs are encouraged. For example, bioretention facilities can serve landscaping and stormwater quality treatment requirements, and stormwater detention facilities can be included in a treatment train to meet both stormwater quantity and quality requirements.

2.4.3 Stormwater Quality Management Statement

All preliminary plats for residential and non-residential subdivisions that disturb more than 1 acre and add 10,000 ft^2 or more of new impervious surfaces must be accompanied by a Stormwater Quality Management Statement (see Appendix F). This statement describes the amount of imperviousness anticipated for the project, including driveways, roadways, rooftops, and sidewalks along roads. The developer must use a worst-case scenario for determining the maximum impervious surface possible at the site based upon the type of housing to be built at the site and the anticipated placement of each house. This initial analysis of the project allows City staff, the designer and the developer to have a better idea of the stormwater quality treatment criteria early in the development process.

2.4.4 As-Built Certifications and Inspections

In an effort to ensure that water quality management plans approved by the City are installed and maintained per the approved plans, the City requires certifications of the correct initial installation of BMPs, referred to as as-built certifications, as well as an annual certification of ongoing maintenance and operation of each BMP. This section describes the as-built certification requirements.

Prior to obtaining a Certificate of Occupancy, two (2) complete copies of as-built drawings with the appropriate professional certifications must be provided to Glasgow for approval. The as-built drawings will be compared to the approved stormwater management plan for any irregularities or non-conformance with the approved plans. The as-built drawings must reflect the "as-constructed" condition of the development, and must include sufficient information to demonstrate conformance with the approved stormwater management plan. The City has the authority to request the submittal of additional information with the as-built plan as necessary to allow a thorough review of the as-constructed conditions. Omission of any required items shall render the plans incomplete, and they will be returned to the applicant, or their engineer, so that they may be completed. As-built certification checklists are provided in Appendix F and must be completed and submitted with the as-built certification.

As-Built Certifications must include sufficient design information to show that stormwater BMPs will operate as approved. This must include the existing (or before site development) peak flow discharges, the after site development peak flow discharges, and/or volumes of stormwater runoff based on the proposed site development, as well as all necessary computations used to determine the reduced peak flow rates for the design storms.

Plats, easements and BMP locations shown in the Operations and Maintenance Plan must be field checked by the property owner or developer prior to submitting the as-built certification to ensure that the field locations are approximately correct. A copy of the recorded Operations and Maintenance Plan must be submitted with the as-built certification to be released from the bond. Information required in the Operations and Maintenance Plan can be found in Appendix H.

2.4.5 Bonds for Stormwater Management BMPs

The purpose of a bond is to ensure that the person(s) responsible for completing the land disturbing activities and/or construction work consistent with the design plans of the City's or County's standards. The bond provides assurance that the City will be reimbursed if it must assume the costs of corrective measures and/or work not completed by the responsible person(s) according to the required specifications and approved plans.

Prior to the release of a bond, an As-Built Certification (see Appendix F) must be provided to the City, showing that all drainage structures or facilities, facility volumes, sizes, slopes, locations, elevations, and hydraulic structures related to the stormwater management BMPs have been field verified, represent the as-built field conditions, and comply with the approved stormwater quality management plan(s). Features such as roadway lines, grades, cross slopes, locations, contours, and elevations should be provided to verify approved plans as required by Glasgow.

The following table provides guidance on determining the bond amount for each type of BMP. Note that these costs are for the initial installation only and do not take into consideration reinstallation due to failure (of filtering components, for example) or maintenance costs. A 25% surcharge has been included to cover the City's mobilization and project management, should the bond be forfeited and the City becomes responsible for installing the BMP(s).

Table 2.4-1. Bond Calculation for Water Quality BMPs

BMP Type	Cost Calculation	Notes
Bioretention facility	Bond = $(7.3WQv^{0.99})1.25$	WQv = ft^3
Wetland	Bond = $(30.6WQv^{0.71})1.25$	WQv= ft^3
Water Quality Swale (Wet or Dry)	Bond = 1.25(0.25 - 0.50)SA	SA = ft^2
Dry Detention	Bond = $(12.4WQv^{0.76})1.25$	WQv= ft^3
Wet Detention	Bond = $(24.5WQv^{0.71})1.25$	WQv = ft^3
Surface Sand Filter	Bond = 1.25(5000 - 10,000)A_{imp}	A_{imp} = acre of impervious area treated
Underground Sand Filter	Bond =1.25(10,000 - 14,000)A_{imp}	A_{imp} = acre of impervious area treated
Oil/Water Separator	Bond = 1.25 (7500A_{imp})	A_{imp} = acre of impervious area treated
Other Proprietary BMP	Bond = 1.25 (cost provided by manufacturer)	Engineer or developer must provide the product specific cost from the manufacturer or distributor
Infiltration Trench	Bond = $(173WQv^{0.63})1.25$	WQv = ft^3
Infiltration Basin	Bond = $(16.9WQv^{0.69})1.25$	WQv = ft^3

In the table above, the bond for most BMPs is calculated based upon the treatment provided. WQv is the calculated treatment volume for each BMP (see section 2.6.2 for more on calculating WQv). For filters, the impervious area treated by the BMP in feet squared is used to calculate the bond. For manufactured BMPs, the engineer or developer should submit the actual BMP costs and then 25% is added to that cost to figure the bond. For water quality swales, the calculation is the same, whether it is a wet swale or dry. In the cost equation for water quality swales, SA (surface area) represents the treatment area assuming a 6" WQv treatment depth.

2.4.6 Operation and Maintenance Plan

All new developments with privately owned and operated stormwater BMPs must have an Operation and Maintenance (O&M) Plan recorded with the property. The Plan must contain enough information to locate the BMPs and perform inspections to document the functionality of the BMP perpetually. This information must then be recorded with the Register of Deeds' office and track with the property so future property owners will be made aware of the locations of the BMPs and the requirement to perform inspections. The City will record the O&M plan after collecting the recording fee.

A draft final O&M Plan must be submitted with the construction plans for review. Once the plans are finalized and approved by the City and the BMPs constructed, an as-built certification must be completed. The O&M Plan must be recorded and submitted with the as-built certification.

The O&M Plan for a site with privately maintained BMPs contains the following elements:

1. An Inspection and Maintenance Agreement signed by the developer or BMP owner. This agreement states that the owner is responsible for maintaining the BMP perpetually and performing inspections.
2. A BMP location map clearly indicating the locations of all stormwater BMPs, drainage easements, access easements, roadways, and stormwater system components as they relate to the stormwater BMPs.
3. Schematics for each BMP. The schematics should be detailed enough to allow for future inspections of the BMP(s) and stormwater system. If more than one BMP is on the project site, schematics of each BMP must be provided.
4. Inspection and maintenance templates for each type of BMP. For manufactured BMPs, the template must have maintenance items filled out in the template prior to submission to the City.
5. Annual BMP report template. The form must be used by the BMP owner for the annual inspection of the BMP(s).

Templates and examples of these components can be found in Appendix H. All components must be included in the O&M Plan that is recorded with the Register of Deeds' office.

The City's NPDES Phase II permit (KYG20) requires the City to ensure that permanent water quality BMPs are maintained perpetually. Maintenance responsibilities are outlined below:

Table 2.4-2 BMP Maintenance Responsibilities

Water Quality BMP Maintenance Matrix	Owner Responsibilities	City Responsibilities
Residential developments	Mowing, trash and debris removal	Major maintenance and repair; routine inspections
Non-residential	All maintenance, routine inspections	Inspections based upon prioritization
City owned BMPs	All maintenance and inspections	All maintenance and inspections

2.4.7 Stormwater Quantity Management Goals

The City of Glasgow has adopted the stormwater quantity management requirements found in Barren County Government's Subdivision Regulations (Appendix B). Specifically, the following requirements apply:

- Detention areas shall be sized based on 2.95 inches of precipitation. The maximum discharge shall not exceed the pre-development discharge. Discharge to areas of known flooding hazard shall be subject to approval by the City Engineer.

- Retention basins shall be designed for the 3-hour 100-year storm. Computed high water elevation shall be recorded on the subdivision map. In areas where a proposed basin is connected with an existing basin, the recorded high water elevation shall be maintained.

- Sinkholes and dry wells shall be assumed as having no outflow for purposes of computation.

2.5 SWPPP vs. EPSC Plan vs. Stormwater Management Plan

These terms can be confusing, but they reference components of the overall erosion prevention and sediment control, good housekeeping, and stormwater management plans. While stormwater management plans typically contain permanent treatment practices (PTPs) instead of temporary practices, the initial plan submittal must address permanent stormwater management including water quality. A general description of each type of plan follows:

Stormwater Pollution Prevention Plan. A Stormwater Pollution Prevention Plan (SWPPP) is a living document that is first submitted for approval to the City and to the KDOW. It should then be updated as development continues. It includes site map(s), an identification of construction/contractor activities that could cause pollutant discharges into stormwater and a description of measures or practices to control these pollutants. The SWPPP is required by KYR10. It includes the EPSC Plan and Stormwater Management Plan. Once the development plan has been approved, a copy of the SWPPP must be maintained onsite and should include copies of all permits issued for the site. Inspection documentation and plan revisions must also be documented in the SWPPP once site development has begun.

EPSC Plan. Once the erosion prevention and sediment control (EPSC) plan has been approved, it becomes a component of the SWPPP. The EPSC Plan is a set of plans prepared by or under the direction of a licensed professional engineer detailing the specific measures and sequencing to be used to control sediment and erosion on a development site during and after construction. It includes supporting calculations, a construction schedule, and schematics and cross-sections for clarification, as well as any other material in support of the EPSC plan. As the project progresses, revisions and modifications should be tracked in the SWPPP, with major modifications requiring prior approval by the City before implementation.

Stormwater Quality Management Plan. The stormwater quality management plan (SWQMP) contains permanent water quality treatment devices, such as detention structures, outlet protection, stormwater conveyance devices, and bioretention areas. Once approved, the SWQMP becomes a component of the SWPPP. Most of these components will not be installed during initial construction activities. However, knowing the proposed locations during early construction activities can be beneficial so areas can be appropriately staged. For example, permanent detention structures can first function as sediment basins. Once permanent controls have been installed, they should be protected from sediment laden runoff, as many permanent water quality treatment devices rely on infiltration for treatment and can easily be overwhelmed.

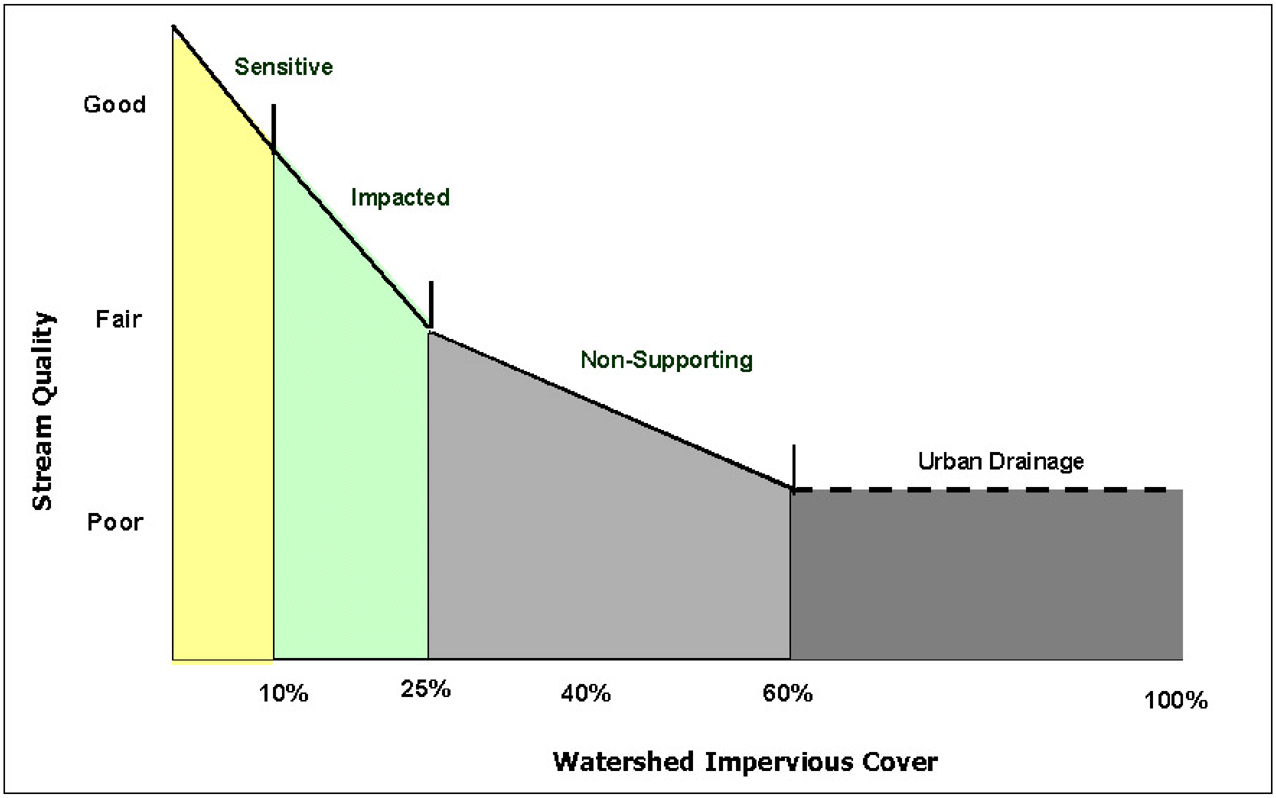
2.6 Stormwater Quality Treatment

The City has established a two-tiered approach to stormwater quality treatment, based upon land use. Some residential developments can meet their stormwater quality treatment requirements by developing in accordance with the requirements of the Conservation Subdivision Design principles, as described in Section 2.6.1. All other types of development must provide treatment of the water quality volume, as described in Section 2.6.2.

2.6.1 Conservation Subdivision Design

The City has established its stormwater quality management program based upon total suspended solids, which can be directly correlated to the amount of impervious surfaces within a watershed. As described in the Center for Watershed Protection's article, "Importance of Imperviousness" (2000), as the impervious cover increases in a watershed, stream quality begins to degrade. When the total watershed impervious cover approaches 10%, streams begin to lose sensitive stream features.

Figure 2.6-1 Impervious Cover Model



(Figure from Center for Watershed Protection)

The City has developed a Conservation Subdivision design that focuses on preserving surface and subsurface stream water quality. When a residential subdivision meets **all** of the requirements of the Conservation Subdivision, no further stormwater quality treatment will be necessary. The Conservation Subdivision must incorporate the following design principles:

§ Clearly defined disturbed area limits on the design plans and in the field, limiting the disturbed area on the total project to the smallest areas possible and preserving natural vegetation. Failure to follow these disturbed area limitations could forfeit a residential development's designation as Conservation Subdivision and require structural stormwater quality treatment best management practices to be designed and installed.

§ The total impervious cover on the development cannot exceed 15%. Impervious surfaces include rooftops, roadways, gravel (parking lots or driveways), paved driveways, and sidewalks.

§ Lot sizes must be a minimum of 1 acre each.

§ Roof drains must be disconnected from the storm drain system. Instead, roof drains should be discharged as sheet flow onto vegetated surfaces.

§ Sinkhole basins must be protected and stabilized. If a sinkhole throat must be improved or maintained to facilitate drainage, all disturbed areas within the sinkhole basin must be stabilized with vegetation. During the disturbance, the sinkhole throat must be protected from sediment, as described in the BMP Manual.

2.6.2 Structural Stormwater Quality Treatment Design

Stormwater quality treatment for Glasgow is defined as a goal of 80% total suspended solids (TSS) removal of the average annual post-development load. All stormwater BMPs shall be designed in a manner to minimize the need for maintenance and reduce the chances of failure, while maintaining the required function. The City's stormwater quality program requires new development and redevelopment to treat the runoff from up to the 85th percentile rain event in Glasgow to a load reduction goal of 80% of the average annual post-development total suspended solids (TSS) based upon data in the Nationwide Urban Runoff

Program. Treatment may be achieved using a single treatment method, such as a wet pond, or by using a treatment train. A treatment train achieves 80% removal of TSS using a combination of pretreatment and/or treatment methods.

It is presumed that a stormwater management system complies with this performance standard if:

- It is sized to capture and treat the prescribed water quality treatment volume, which is defined as the runoff volume resulting from the first 1.1 inches of rainfall from a site (see Equation 1).
- Appropriate structural stormwater controls are selected, designed, constructed, and maintained according to the specific criteria in this Manual to provide an 80% TSS removal of the average annual post-development load.
- Runoff from hotspot land uses and activities is adequately treated and addressed through the use of appropriate pre-treatment stormwater controls and pollution prevention practices.

Permanent BMPs should be proposed by the developer early in the planning stage of a project. For most projects, there will be no single BMP which addresses all the long-term stormwater quality problems. Instead, a multi-level strategy will be worked out with P&Z, which incorporates source controls, a series of on-site treatment controls, and community-wide treatment controls.

The Water Quality Volume (WQv) equation, which forms the foundation of the City's stormwater quality management program, establishes the volume that must be treated. The WQv is storage required to capture and treat stormwater runoff from 85% of the average annual rainfall, which is considered the "first flush". The 85th percentile storm event in Glasgow is 1.1 inches. All storms greater than 1.1 inches must be routed non-erosively through the water quality treatment device or routed around it. The following equation shows that this value is equal to the product of precipitation, volumetric runoff coefficient and site area, divided by twelve.

Equation 1 Water Quality Volume Calculation

$$WQv = \left[P\ Rv)\left(A\right)\right]/12$$

Where,

P is the average rainfall in inches, (in the case of Glasgow, is 1.1 inches);
Rv is the volumetric runoff coefficient, which is:
Rv = 0.05 + 0.009(I), where I is the percent impervious cover; and
A = the area in acres

In the equation above, I is based upon the percent impervious cover proposed for the area to be disturbed, and A is the total area to be disturbed.

As noted, the pollutant of concern for the City is total suspended solids, or TSS. TSS loading is associated with impervious surfaces, such as parking lots, roof tops, and roadways. Therefore, when designing water quality treatment BMPs, only impervious surfaces need to be routed through the BMP for water quality treatment. Drainage areas containing only pervious surfaces can bypass BMPs designed solely for water quality treatment.

2.6.3 Choosing the Right Permanent Treatment Practice (PTP)

Table 2.6-1 is an "at-a-glance" table of all of the Permanent Treatment Practices found in Section 3. Use Table 2.6-1 for initial screening of potential measures based upon site constraints such as drainage area, landuse, pollutant removal needed, long term maintenance requirements, and surface area available. Once potential measures have been identified for a site, the design sheets in Section 3 outline detailed design criteria.

Table 2.6-1 At-A-Glance Permanent Treatment Practices Decision Matrix

Structural BMP Category	BMP Type	Stormwater Treatment		Water Quality Performance		Drainage Area (ac)	Implementation Considerations			
		Water Quality	Water Quantity	TSS/Sediment Removal Rate	Hotspot Application		Residential	Commercial / Industrial	Unit Cost	Maintenance Burden
Fitration Systems	Surface Sand Filter	ü		80	ü	• 10		ü	Moderate	Moderate to High
	Underground Sand Filter	ü			ü	• 5		ü		
	Perimeter Sand Filter	ü			ü	• 2		ü		
	Organic Sand Filter	ü				• 5		ü		
	Pocket Sand Filter	ü			ü	• 5		ü		
	Bioretention	ü				• 5	ü	ü		Low
Open Channel System	Dry Swale	ü		90		• 5	ü	ü	Moderate	Low
	Wet Swale	ü		75		• 5		ü		
Stormwater Ponds	Micropool Extended Detention Pond	ü	ü	80		• 10	ü	ü	Low	Low
	Wet Pond	ü	ü			• 25	ü	ü		
	Wet Extended Detention Pond	ü	ü			• 25	ü	ü		
	Multiple Pond System	ü	ü			• 25	ü	ü		
	Pocket Pond	ü	ü			• 25	ü	ü		
Stormwater Wetlands	Shallow Wetland	ü		75		• 25	ü	ü	Moderate	Moderate to High
	Extended Detention Shallow Wetland	ü				• 25	ü	ü		
	Pond/Wetland System	ü				• 25	ü	ü		
	Pocket Wetland	ü				5-10	ü	ü		
Infiltration Systems[1]	Infitration Trench	ü		90		• 5	ü	ü	Moderate to High	Moderate
	Infiltration Basin	ü						ü		
Water Quality Units	Hydrodynamic Separators	ü		TBD[2]	ü	Minimal		ü	Moderate	Moderate to High
	Filtration	ü			ü			ü		
	Continuous Deflection	ü			ü			ü		
Grease Management					ü			ü	Low	High
Extended Detention/Retention Dry Basins	Detention Basin with Gravity Outfall	ü	ü	60		• 75	ü	ü	Low	Low
	Retention Basin with Drywell Outfall	ü	ü				ü	ü		
Oil & Grease/Water Separator				40	ü			ü	Low	Moderate

Notes: 1) Limited application due to karst topography; 2) To be determined based upon City-approved testing

2.6.4 Weighted total suspended solids reduction

The City's stormwater quality management program is designed to give the developer flexibility in meeting the 80% TSS reduction goal on each site. The BMPs identified in Section 3 of this manual as Permanent Treatment Practices (PTPs) give the developer options to meet the water quality requirements in numerous ways. Calculations to verify the TSS reduction for each site are provided below.

The percent TSS removal (%TSS) that is achieved on a site can be calculated using the equation below. This equation is an area-weighted TSS reduction equation which accounts for the TSS reduction that is contributed from each stormwater treatment BMP that is utilized on the site.

Equation 2 Weighted TSS Reduction

$$\%TSS = \frac{\sum_n^1 (TSS_1 A_1 + TSS_2 A_2 + \ldots + TSS_n A_n)}{\sum_n^1 (A_1 + A_2 + \ldots + A_n)}$$

where:

TSS_n = TSS removal percentage for each structural BMP located on-site (%);
A_n = the area draining to each BMP (acres).

An example calculation of weighted TSS reduction on a project is provided below.

Example 1: Weighted TSS reduction example: Wetland and Dry Detention

A 20 acre site is divided into 2 subwatersheds: Subwatershed 1 has 12 acres and contains a constructed wetland for stormwater quality treatment. Subwatershed 2 has 8 acres and contains a dry detention facility. What is the %TSS reduction?

TSS reductions from Table 2.6-1:
Wetland = 75%
Dry detention = 60%

Step 1: Calculate % TSS removal for the site:

%TSS = ((TSS_{dry} x 8 acres) + (%$TSS_{wetland}$ x 12 acres)) ÷ 20 acres
%TSS = ((60% x 8 acres) + (75% x 12 acres)) ÷ 20 acres = 69%

Therefore, the % TSS removal for the site is 69%. Additional BMPs must be constructed at the site to bring the TSS removal to 80%.

When two or more BMPs are used in series (stormwater discharges from one BMP into another), a different calculation is necessary. This scenario is called a **treatment train**. Stormwater discharging from the upper most BMP will be considerably "cleaner" than the influent, meaning TSS particle sizes will be much smaller. Pollutant removal rates for BMPs used in a treatment train are not additive. For pollutants in particulate form, such as TSS, the actual removal rate (expressed in terms of percentage of pollution removed) varies directly with the pollution concentration and sediment size distribution of runoff entering a facility. For example, a stormwater treatment pond will have a much higher pollutant removal percentage for very turbid runoff than for relatively clear water. When two stormwater ponds are placed in series, the downstream pond will treat an incoming TSS load that is very different from the upstream pond. The upstream pond easily captures the larger solids, and discharges an outflow that has a lower concentration of TSS, but with a relatively higher proportion of fine particle sizes. Therefore, further TSS reduction will be difficult for the second and subsequent BMPs. Hence, the TSS removal capability of the downstream pond is considerably less than the upstream pond. Recent studies suggest that the downstream pond in a series can provide as little as half the removal efficiency of the upstream pond.

Note that manufactured treatment devices such as oil water separators and hydrodynamic units must be a first treatment BMP when used in a treatment train design. These units are most effective at capturing gross solids.

To calculate the total % TSS removal for a treatment train comprised of two or more structural BMPs, the following equation should be used.

Equation 3 Treatment Train Calculation

$$TSS_{train} = A + B - \frac{(A \times B)}{100}$$

where:

TSS_{train} = total TSS removal for treatment train (%);
A = % TSS removal of the first (upstream) BMP, from Table 2.6-1 (%)
B = % TSS removal of the second (downstream) BMP, from Table 2.6-1 (%).

For development sites where the treatment train provides the only stormwater treatment on the site, TSS_{train} must be greater than or equal to 80%. For development sites that have other structural BMPs for stormwater treatment that are not included in the treatment train, TSS_{train} must be included in Equation 2 in the calculation of the overall % TSS removal for the site. An example application of the latter situation is presented below.

Example 2: Treatment Train Example: Wetland, Dry Pond, Bioretention
A 20 acre site is divided into 2 subwatersheds: Subwatershed 1 has 12 acres and contains a constructed wetland for stormwater quality treatment. Subwatershed 2 has 8 acres and contains a bioretention area that discharges into a dry detention facility. What is the %TSS reduction?

TSS reductions per Table 2.6-1:
Control A (wetland) = 75%
Control B (bioretention) = 80%
Control C (dry detention) = 60%
Controls B and C are part of a treatment train.

Step 1: Calculate TSS_{train}:
TSS_{train} = B + C – (B x C)/100 = 80 + 60 - (80 X 60)/100 = 92% removal

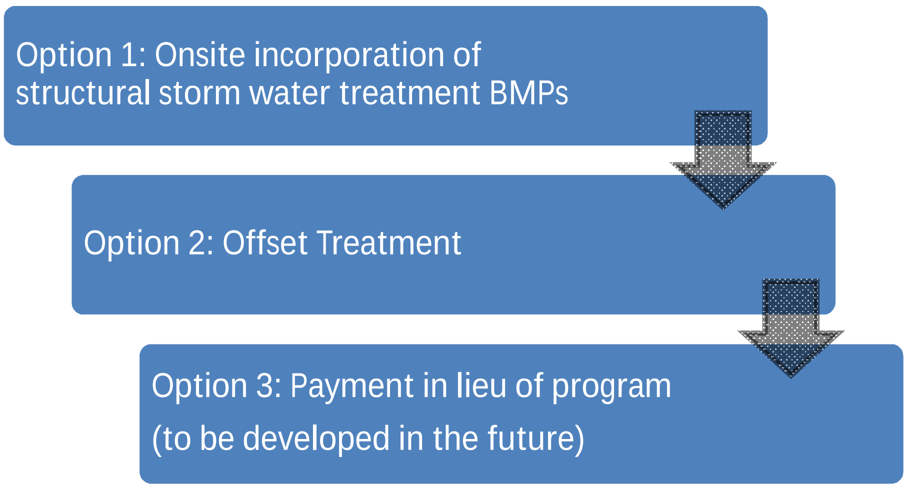
Step 2: Calculate % TSS removal for the site:
%TSS = ((TSS_{train} x 8 acres) + (%$TSS_{wetland}$ x 12 acres)) ÷ 20 acres
%TSS = ((92% x 8 acres) + (75% x 12 acres)) ÷ 20 acres = 82%

Therefore, the % TSS removal for the site is 82%. No other BMPs need to be constructed at the site.

2.6.5 Redevelopment stormwater quality treatment strategies.

Redevelopment projects in highly urbanized, built-out environments are desirable and encouraged forms of development, in that redevelopment projects typically do not need new infrastructure such as roadways to be constructed, reduce urban sprawl, and keep the overall imperviousness of a watershed the same. For the purposes of the Stormwater Quality Treatment Program, "redevelopment" is defined as any new construction on a site that has a pre-existing use on it. The preferred stormwater quality treatment strategies are outlined in Figure 2.6-1 below, in a prioritized order.

Figure 2.6-2 Stormwater Quality Treatment Strategy Steps



These strategies are described below.

Option 1: Onsite incorporation of structural stormwater treatment BMPs.
Structural stormwater quality treatment BMPs (PTPs) include bioretention, wet ponds, dry/wet swales and other practices as outlined in Section 3. These types of practices typically require some amount of surface land area for treatment, unless the system is a manufactured underground system. The WQv calculation in section 2.6.2 shall apply. Where a site has significant constraints such as limited surface area, setbacks, etc., option 2 or 3 (when developed) may be chosen for treating water quality.

Option 2: Offset treatment.
In the 2010 KYG20 Phase 2 MS4 Permit, KDOW included an allowance for developers to provide offset treatment where onsite treatment isn't feasible. The language from the permit is as follows:

> The off-site mitigation option entails infiltration/evapotranspiration/reuse measures that may be implemented at another location in the same sewershed/watershed as the original project, approved by the permittee(s). The permittee shall identify priority areas within the sewershed or watershed in which mitigation projects can be completed.

The City of Glasgow acknowledges the benefits of and need for pollutant trading credits, mitigation and/or offsets. Pollutant trading or offset isn't a new concept, as it has been applied to point source dischargers, specifically wastewater treatment facilities, for many years. Typically, trading or offsets occur within watersheds where a TMDL has been approved. However, the same approach for pollutant trading applied to TMDL watersheds can be applied to non-TMDL watersheds. The following section outlines the City's policy on pollutant offsets for new development or redevelopment. This policy is consistent with EPA's policy on water quality trading.

Redevelopment typically occurs in highly urbanized areas, where surface area for treatment of the WQ_v is typically minimal or non-existent. In such areas where the developer can demonstrate the site limitations cause the first option to be impractical or infeasible, the City Engineer has the ability to approve on a case-by-case basis pollutant treatment offsets. Pollutant treatment offset is defined as providing water quality (WQ_v) treatment adjacent to the existing redevelopment site such that, from a water quality perspective, there is no net gain of new impervious surfaces or TSS discharges. Note that the preference for water quality treatment is onsite treatment. The following factors will be considered when reviewing applications including pollutant treatment offsets:

1. The engineer and/or developer must provide an alternatives analysis that demonstrates the site constraints that make the onsite treatment of water quality impractical or infeasible. While the economic feasibility of onsite treatment versus offsite treatment can be considered, it cannot be the only constraint identified for treatment onsite.
2. The preferred pollutant treatment offset is to provide treatment of an equivalent amount of impervious surface on land contiguous to **and** within the same subwatershed of the redevelopment project. Subwatersheds have been identified by the City of Glasgow.
3. Pollutant treatment offsets must occur within the same subwatershed as the location of the redevelopment site.
4. The pollutant treatment offset BMP must be located within a drainage easement, with access from a public right-of-way. An Operation and Maintenance Plan (O&M Plan) must be submitted to and approved by the City. In addition, the O&M Plan must be recorded with the deed for the offset treatment BMP. The City will not assume ownership of the offset BMP. All other components of the Post Construction Stormwater Quality Program Standard Operating Policies and Procedures (December 2007), the City's Stormwater Ordinance and BMP Manual shall be followed.
5. For pollutant treatment offsets providing treatment of impervious surfaces located contiguous to the development site and within the same subwatershed, the offset WQ_v treatment shall be 1:1.
6. Pollutant offset treatment is NOT allowable for new subdivisions of land, residential or non-residential.
7. Pollutant offset treatment it NOT allowable when areas on the development site are available, either above ground or below ground, to provide full treatment of the required WQ_v.

2.6.6 Hot Spot Landuse Treatment Requirements

In addition to the treatment standards noted above, the City requires post construction stormwater management BMPs for "hot spot" locations. "Hot spot" landuses include the following:

Table 2- 1 Hot Spot Landuse Treatment Recommendations

Landuse	Additional Treatment Type
Automotive fueling and/or repair facilities	Oil water separator
Restaurants with outside grease collection and disposal areas	Oil water separator, water quality unit
Other landuses as determined to have a high potential of pollutant discharge into the MS4 as determined by the City Engineer	As approved by City Engineer

Hot spot BMPs shall be designed to remove targeted pollutants based on land use and typical pollutant for the land use. This hot spot landuse treatment requirement is in addition to the 80% TSS reduction goal established for all new development. For example, automotive fueling facilities are likely to have higher than normal loads of petroleum products, and the appropriate hot spot treatment device would likely be an oil/water separator in additional to other PTPs installed to meet the 80% TSS treatment goal. Most hot spot landuse treatment BMPs are pre-treatment devices, designed to remove gross solids, floatables and oils and grease. A 50% TSS reduction can be assigned to pre-treatment devices and included in the site's overall treatment train.

2.6.7 Pre-Application Meeting

Developers desiring to subdivide property should contact P&Z and make an appointment for a pre-application conference. Note that a pre-application conference is not required, however, it is strongly recommended. A Sketch Plan showing the location of the property, surrounding area, and the proposed development activities should be submitted in advance of the meeting. This submittal is not a formal plan submittal. The purpose of the pre-application conference is to discuss compliance with the Comprehensive Plan, Zoning Ordinance, the Subdivision Regulations and stormwater management requirements. Specifically, PW staff can work with a developer or engineer early in the plan development process to identify constraints and limitations of each development. PW staff can provide general recommendations on stormwater quality and quantity management for the development, as well as discuss the necessary approvals and permits required for the development as proposed. This meeting is intended to identify immediate or potential problems and avoid time-consuming and expensive rework.

2.7 Approval and Design of Proprietary Stormwater Treatment Devices

The standard PTPs included in Chapter 3 of this manual are non-proprietary BMPs and can be designed to meet the water quality treatment design. The City of Glasgow allows the use of other types of PTPs, though the approval and review process is more rigorous. Many proprietary treatment devices are designed based upon a peak flow rate as opposed to a volume of treatment. Non-proprietary treatment devices, such as detention ponds, bioretention, and wetlands, are designed based upon a treatment volume (for stormwater quality treatment) and peak flow (for flow attention). Therefore, a slightly different design approach is necessary for proprietary treatment devices. In addition, pollutant reduction rates are significantly impacted by the design flow rate.

2.7.1 Approval of manufactured treatment devices

All treatment devices designed for stormwater quality or quantity treatment in the City of Glasgow must be approved by Stormwater staff prior to installing them. Many manufactured stormwater treatment devices are available to treat stormwater runoff. However, some of these BMPs do not have established pollutant removal data based on standardized testing methods. The City of Glasgow considers proprietary BMPs as **Limited Application BMPs** because of a lack of historic pollutant removal data or because of high maintenance requirements.

The City of Glasgow accepts treatment devices that have been reviewed and approved for use by the Metropolitan Nashville and Davidson County Metro Water Services for manufactured treatment devices (see http://www.nashville.gov/stormwater/ for the most current listing of approved treatment devices). Therefore, if a treatment device is approved for full treatment in Metro, Glasgow will also accept the same treatment device based upon the data accepted by Metro, including the treatment limitations.

Proprietary devices must be approved before they can be considered for use in the City of Glasgow. Should a manufacturer desire to test a BMP for acceptance by Glasgow, the manufacturer must contact Glasgow's Stormwater staff for information on the testing and application process. Manufacturers' claims for BMP performance must be verified through data that is obtained in independent third party testing.

The City of Glasgow recognizes two levels of treatments:

1. Pretreatment. Pretreatment devices do not meet the full 80% TSS reduction goal; however, they can be used in a treatment train approach with other BMPs to fully meet the treatment goal. In addition, pretreatment BMPs are required for hot spot landuse applications, as described in Section 2.6.6.
2. Full Treatment. Manufactured treatment devices that show through testing that they meet the full 80% TSS reduction goal are considered full treatment devices if approved as such through Metro Nashville. If the manufactured treatment device is a flow-based device, the peak flow rate for the TSS reduction must be provided and cannot be exceeded in the design.

2.7.2 Design of Manufactured Treatment Devices

As noted above, most manufactured treatment devices are flow based devices. Applying the WQv equation (see Equation 1) is therefore not possible. The City developed the following design tools for use in sizing manufactured treatment devices. This design methodology is considered to provide an equivalent treatment as the treatment provided with the WQv methodology.

Most proprietary BMPs are flow based BMPs and rated for TSS removal based upon a specified flow rate. The WQv equation, which forms the foundation of Glasgow's stormwater quality program, establishes a volume that must be treated. In an effort to simulate the WQv approach for proprietary BMPs, the following peak flow design equation must be used to develop the stormwater quality treatment required.

Equation 4 Manufactured Device Stormwater Quality Design

•• = • • • • •

Where:
Qp = the peak flow through the proprietary BMP in cfs
C = runoff coefficient
I = rainfall intensity, 2.45 in/hr
A = the contributing drainage area for the BMP, in acres

2.8 Utility Work

In December of 2004, the City of Glasgow adopted a stormwater ordinance (21-2 of the City's Code of Ordinances) that included a requirement to develop and implement a utility general permit. The ordinance includes the following requirement and definition:

> 21-2.03.b.5: Utility General Permit. Utility companies shall apply for a general permit from the City for land disturbance operations. This permit shall be renewable every three (3) years.
>
> 21-2.01 Definitions: "Utility General Permit" shall mean the agreement between the MS4 Municipality and the local municipal separate storm sewer system utilities stating that Phase II regulations shall be applied and implemented.

The utility general permit applies to any land-disturbing activities conducted by utility companies that do not require building permits. Such activities include but are not limited to water and sewer line construction, installation, or repair; gas line construction, installation, or repair; power, cable television, internet, or phone line construction, installation, or repair; or other linear utility construction, installation or repair activities within the jurisdiction of the City of Glasgow. A company may obtain coverage under the utility general permit by petitioning the City for coverage and abiding by the terms and conditions of this permit. **Note that coverage under the utility general permit does not preclude coverage under other similar permits**

required by the County or State, including the Kentucky construction stormwater general permit (KPDES permit number KYR10).

To gain coverage under the utility general permit, the utility company must submit an application to the City. The permit requires each utility company to perform the following:

1. For sites that disturb less than 1 acre, EPSC controls must be installed and maintained.
2. For sites disturbing 1 acre or more, coverage under KYR10 and Glasgow's grading permit is required.
3. Inspection must be performed pursuant to Glasgow's requirements for all development sites.
4. Pollution prevention must be addressed on site.
5. An EPSC Certified Contractor must be provided on all sites disturbing 1 acre or more.
6. Where utility work damages existing EPSC controls on another development, the utility contractor must repair or reinstall the controls, including stabilization measures.

2.9 Other Permits

Various types of permitting can be required at different levels depending upon the project type. Both local permits as well as state permits can be required on construction projects.

Local Permits. The City of Glasgow has developed processes to obtain a variety of permits. Examples of permits issued by the City are building permits, grading permits, fence permits, etc. Anytime grading or excavation of material is involved it is important to determine which permit is applicable to the project and what plan submittals will be necessary for the level of construction proposed.

In addition to formal permits that are required by the City of Glasgow, private developments such as subdivisions and detailed development plans require approval through the City. Because these projects will involve land disturbance, all necessary plan submittals as described in the previous section shall apply. Additional requirements for subdivisions and detailed development plans can be obtained at the City-County Planning Commission.

State Permits. The Kentucky general permit for construction stormwater is KYR10. It is required for improvements involving site disturbances of one acre or more, or less than one acre is part of a larger common plan of development. Note that violations of KYR10 may also result in violations of the City of Glasgow's stormwater management ordinance and vice versa. The City will not issue approval of any land disturbing plans without having the Notice of Coverage under KYR10 where applicable.

3.1 Erosion Prevention Fact Sheets (EPP)

Erosion Prevention Practices	EPP-01 Tire Washing

Symbol

TW

Description

As a result of vehicular ingress and egress to the construction site, the facility would remove mud and dirt from vehicle tires and the undercarriage to prevent materials from depositing onto public roads. This application can be used in conjunction with the stabilized construction entrance, EPP-03.

Application

- Temporary construction traffic, phased construction projects and off-site road access.
- Typically used for large construction sites.

Design

- Incorporate with the stabilized construction entrance, EPP-03.
- Construct wash rack on level ground when possible, on a pad of course aggregate.
- Design tire rack to withstand anticipated traffic loads and drain to a detention pond or swale. A typical wash rack has been shown in the standard details. However, wash rack design may consist of other materials or configuration as long as it provides the intended function.
- If a swale is required, then it shall provide sufficient grade, width, and depth to carry runoff.
- The swale shall carry runoff from the wash area to a sediment-trapping device such as a check dam.
- All employees, contractors, subcontractors, and others that leave the site with mud caked tires and/or undercarriages shall use construction entrance.

Maintenance	Ø	Remove accumulated sediment to maintain system performance, in the wash rack and/or sediment trap.
	Ø	Inspect at the end of each shift or workday for damage and repair as needed.
	Ø	Remove accumulated sediment to maintain system performance, in the wash rack and/or sediment trap.
Inspection	q	Vehicles are leaving the site through designated construction exit(s).
	q	Mud, dust or dirt is removed prior to exit onto the adjacent road.
	q	The construction exit is sufficiently maintained to prevent mud, dirt, fines and dust from being tracked off-site.
	q	Stones under wash rack have been maintained and free of deleterious materials.

Erosion Prevention Practices	EPP-02 Construction Road Stabilization

Symbol

CRS

Description

Construction vehicles frequently use access roads, subdivision roads, parking areas and other on-site transportation routes that are not accessible to the public. Construction specifications and drawings should demonstrate methods and practices to stabilize these routes to reduce erosion between the time of initial grading and final stabilization.

Application

- Ø Temporary construction traffic routes, phased construction projects and off-site road access.
- Ø Detour roads for local or temporary construction traffic.
- Ø Construction during wet weather.
- Ø Construction roads utilizing a temporary stream crossing must be indicated and approved.

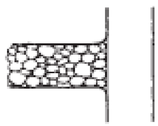
Design

- Ø Road should follow topographic contours to reduce erosion of the roadway.
- Ø Gravel roads should be of sufficient thickness to support construction traffic.
- Ø Chemical stabilizers or water are usually required on gravel or dirt roads to prevent dust. No additional costs for dust control on construction roads should be required above that needed to meet local air quality requirements.

Maintenance	Ø Periodically apply additional aggregate on gravel roads. Ø Active dirt construction roads are commonly watered three or more times per day during the dry season. Ø Remove silt and debris from road side ditches and swales to prevent clogging or damming. Ø Inspect weekly, and after each rain event and repair any eroded areas immediately.
Inspection	q Gravel roads are preventing mud and dirt from leaving project area. q Dirt and gravel roads do not show signs of erosion, including but not limited to, rill and gully erosion. q All stream crossings are maintained as mandated by the appropriate general or individual permit.

Erosion Prevention Practices

EPP-03 Stabilized Construction Exit



Symbol

SCE

Description

The construction entrance practice receives all incoming and outgoing traffic of the construction site. By stabilizing the construction entrance there will be a significant reduction in the amount of sediment to and from public right-of-ways, streets, alleys, sidewalks or parking areas. The construction entrance practice is a stabilized pad of aggregate underlain with filter cloth located at any point where traffic will be entering or leaving. This management practice is likely to create a significant reduction in sediment, nutrients, toxic materials, and oil and grease.

Application

- Ø All points of construction ingress and egress.
- Ø Unpaved areas where sediment tracking occurs from site onto paved or public roads.

Design

- Ø Construction plans must limit traffic exiting the site to properly constructed and stabilized construction exits.
- Ø The entrance must be constructed at a location that minimizes the impact to streams and storm drains and maximizes public safety.
- Ø The aggregate size for construction of the pad must be 2-3 inch stone, at a minimum (KYTC No. 1 or 2, not 57s or DGA).
- Ø The thickness of the pad must not be less than 6 inches. Use geotextile fabric below the rock, if necessary, to improve stability of the foundation in locations subject to seepage or higher water table.
- Ø The width of the pad must not be less than the full width of all points of ingress or egress and, in any case must not be less than 12 feet wide. The length of the pad must be as required but not less than 50 feet.
- Ø Stones should be sized as to remove mud from tires from the construction site.

Design (cont'd)

- Construct on level ground where possible.
- Provide ample turning radii as part of entrance.
- Should be used in conjunction with street sweeping on adjacent public right-of-way.
- Limit egress to the designated construction exit(s) by installing perimeter fencing.
- Wash rack may be included to increase efficiency of removing dirt from tires.
- Construct rock construction exit before clearing, grubbing, and grading the site. Place the gravel to the specific grade and dimensions shown on the plans, and level it out. A geotextile underliner helps to keep rock up out of the mud and functioning properly to remove mud from vehicle and equipment tires.
- Construction entrances will be located as shown on the development plans, or as directed by approving regulatory agency. Any deviation from this location must receive regulatory agency approval.
- Provide drainage to direct muddy runoff from the construction exit toward a sediment trap or other controlled area. In no case should muddy runoff from the construction exit flow onto roads, parking lots, surface waters, or adjacent properties.
- When necessary, wheels must be cleaned with a shovel, scraper, or high pressure water hose to remove sediment before entrance onto roads or other paved areas. When washing is required, it must be done on an area stabilized with KYTC No. 1 or No. 2 rock that drains into an approved sediment trap or sediment basin.

Maintenance

- Inspect weekly and after each rainfall.
- Periodically requires addition of stones for top; add gravel material when soil sub grade becomes visible.
- All sediment spilled, dropped, washed or tracked onto public rights-of-way must be removed immediately.
- Stir aggregate with back-hoe on a weekly basis or as required based on construction activity.

Inspection

- [ ] Entrance/exits are exclusively used by all traffic.
- [ ] Construction exit is sufficiently maintained to prevent mud, dirt, and dust from being tracked off-site, and stone has been stirred with back-hoe.
- [ ] Sediment from construction entrances and exits must be prevented from entering any storm drain, ditch, or watercourse through use of sediment traps, sand bags, commercial sediment dikes, inlet filters, or other approved methods. Maintain traps or other sediment trapping structures as needed.

Erosion Prevention Practices	EPP-04 Buffer Zones

BZ **Symbol**

BZ

Description

Buffer zones allow the utilization of vegetation to protect soils from erosion as well as reduce the velocity of runoff. This BMP allows the removal of sediment through filtering and settling. This management practice is likely to create a significant reduction in sediment by reducing erosion and retaining plant vegetation along waterways.

Application

- Ø There are two types of buffer strips: General Buffers and Vegetated Riparian Buffers.
  - General Buffers: A strip of original, undisturbed land adjacent to the disturbed site provides a general buffer.
  - Vegetated Riparian Buffers: Buffers that provide protection to adjacent streams by filtering overland flow of sediments and strengthening bank stabilization. These buffers are also useful by cooling streams to promote plant and fish habitation and providing food for the surrounding wildlife.
- Ø Utilization or reinforcement of existing vegetation is preferred. However, where improvements are required; sodding, plugging, use of stockpiled vegetation or seeding is acceptable.
- Ø Sodding is appropriate if it is part of the no construction activity area that contained turf prior to construction, or for any graded or cleared areas that might erode and where a robust plant cover is needed immediately.
- Ø Plantings for buffer reestablishment and enhancement can consist of bare root seedlings, container grown seedlings, container grown plants and balled and burlapped plants. Standard permanent erosion control grasses and legumes may be used in denuded areas for quick stabilization.
- Ø Soil preparation and maintenance are essential for the establishment of planted vegetation.

Design

- Site plans should specify buffer zones along existing site drainage features such as upland swales, ditches, intermittent and ephemeral (i.e. flowing only after rains or during snowmelt) and streams, ponds, wetlands, sinkholes, lakes, and rivers.
  Site development design should attempt to lay in desired structures such as buildings, roads, utilities, and so forth with minimal disturbance to the existing drainage system and its adjacent vegetated buffer zone. Where this is not possible, site plans can specify that newly constructed drainage features be vegetated with native material, with the new buffer zones established around the new drainage system.

Table EPP04-1. Buffer Zone Width Recommendations

Bank slope	Soil Type Along Banks		
	Sandy	**Silty**	**Clays**
Very Steep (2:1 or more)	100 ft	80 ft	60 ft
Steep (4:1 or more)	80 ft	60 ft	40 ft
Moderate (6:1 or more)	60 ft	40 ft	30 ft
Mostly Flat (less than 10:1)	40 ft	30 ft	25 ft

General Buffers

- A sufficient width should be selected to promote plantings' growth and to serve as a filter of overland flow entering the zone.

Vegetated Riparian Buffers

- Prior to structuring the zone, careful consideration should be given to its intent and purpose and how it should be enhanced to meet the requirements of the buffer zone. Stream characteristics such as width, slope, depth and the topography of the surrounding vicinity should be considered.
- Stream buffers must at least include the floodway plus 50 feet perpendicular to the floodway. If a floodway has not been determined, the buffer must be at least 25 feet perpendicular from each side of the stream bank, creek, or unnamed waterway, under "bank-full" conditions.
- Stream buffers are typically 50 feet wide for flat lying areas.
- A buffer should be increased 2 feet in width for every 1% of slope perpendicular to the centerline of the stream.
- If existing vegetation is disturbed or removed, a new multipurpose buffer should be created using the three following zones:
  - Zone 1 – the first 20-feet adjacent to the stream should include trees and shrubs spaced 6-10 feet apart to provide stabilization of the bank deep into the soil.
  - Zone 2 – The next 10-feet should consist of managed forest for chemical absorption and wildlife habitat.
  - Zone 3 – the upper 20-feet should be comprised of grasses for sediment and chemical capture as well as noise reduction.

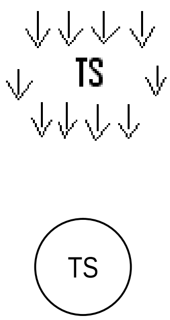
Maintenance

- Inspect sod installations weekly and after significant storm events, until the turf is established, and routinely thereafter.
- Maintenance shall consist of mowing, weeding, and ensuring that the irrigation system is operating properly and as designed to sustain growth.
- Inspect buffer strips weekly and after significant storm events until vegetation is established, and routinely thereafter. Repair eroded or damaged areas as needed to maintain original purpose and effectiveness of the buffer strip.
- Provisions to maintain and protect new plantings from native wildlife should be incorporated with the design documents and drawings.

Inspection

- [ ] Sod is properly maintained and watered.
- [ ] Buffer strips are properly maintained.
- [ ] Plantings are sufficiently protecting from wildlife.
- [ ] Significant rainstorm events have not deteriorated buffer zone.

Erosion Prevention Practices	EPP-05 Temporary Seeding



Symbol

Description

Temporary seeding is used as a means of providing stabilization subject to erosion. This management practice is likely to create a significant reduction in sediment loss and a partial reduction in nutrients and toxic materials.

Temporary seeding may also prevent costly maintenance operations on other erosion control systems and improve the visual resources of the construction area.

Application

- Ø Apply to areas that are left in rough grade condition, and will not be disturbed for 21 days or more.

Design

- Ø **Conventional Seeding**
  Common methods of application include: disc, cultivator, broadcasting, and no-till drilling.
- Ø **Hydroseeding**
  Hydroseeding uses a mixture of mulch, seed, and tactifier which is sprayed over a disturbed area for coverage.
- Ø The area must be protected from excess run-on from upgradient areas as necessary with diversions or berms.
- Ø Plant species must be selected on the basis of quick germination, growth, and time of year to be seeded. Fertilizer, lime, seedbed preparation, seed coverage, mulch, and irrigation must be used as necessary to promote quick plant growth.
- Ø Mulch should be specified for sites with slopes greater than five percent (20H:1V) and slope lengths greater than 100 feet.

Desgin (cont'd)

- Grade as needed and feasible to permit the use of conventional equipment for seedbed preparation, seeding, mulch application, and anchoring.
- Install the needed erosion control practices before seeding such as diversions, ditches, and berms.
- Do not apply fertilizer, lime, or seed before heavy rain storms (e.g., predicted to be one-half inch or more in one hour or less.)
- Mix seed, mulch, and other material for application via hydraulic spray equipment or follow the procedure below.
- Spread lime (in lieu of a soil test recommendation) on acid soil (pH 5.5 or lower) and subsoil at a rate of one ton per acre of agricultural ground limestone. For best results, test soil pH and fertility – this can reduce the expense of unneeded lime and fertilizer and potential excess nutrient loss through runoff and leaching.
- Fertilizer (in lieu of a soil test recommendation) must be applied at a rate of no more than 800 pounds per acre of 10-10-10 analysis or equivalent.
- Work the lime and fertilizer into the soil with a disk harrow, springtooth harrow, or similar tools to a depth of two inches. On sloping areas, the final operation must be on the contour.

Table EPP05-1. Seeding Rates for Temporary Site Protection

March 1 to October 31	Per 1,000 Square Feet	Per Acre
1. Oats		120 lbs.
2. Perennial Ryegrass	1 lb.	40 lbs.
3. Tall Fescue	1 lb.	40 lbs.
4. Wheat	3 lbs.	120 lbs.
5. Annual Rye	3 lbs.	120 lbs.
November 1 to February 28	Per 1,000 Square Feet	Per Acre
1. Annual Rye	3 lbs.	120 lbs.
2. Wheat	3 lbs.	120 lbs.
3. Perennial Ryegrass	1 lb.	40 lbs.
4. Tall Fescue	3 lbs.	120 lbs.

- Apply the seed uniformly with a cyclone seeder, drill, or hydroseeder (slurry can include seed and fertilizer) preferably on a firm, moist seedbed. Seed no deeper that one-fourth inch to on-half inch.
- When feasible, except where a cyclone type seeder is used, the seedbed should be firmed following seeding operations with a cyclone, roller, or a light drag.
- On sloping land, seeding operations should be on the contour wherever possible.
- Triple the seeding rate for all ditches that will carry flowing water; cover seed with erosion control blanket or turf reinforcement mat if needed to prevent ditch erosion.

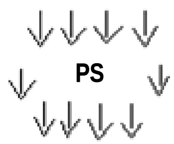
Maintenance

- Ø Inspect frequently during the first six weeks following planting to assure that appropriate moisture levels are maintained and determine if stands are uniform and dense.
- Ø Water until grass is thoroughly established, especially during dry, hot seasons, adverse conditions or when planted late in the planting season.
- Ø Check for damage caused by equipment or heavy rains. Damaged areas should be repaired, fertilized, seeded, and mulched. Tack or tie down mulch as necessary.

Inspection

- q Area is watered daily until stabilization has taken place.
- q After stabilization, water as needed.
- q Heavy equipment has not been used within area.
- q Washout areas have been repaired.
- q Vegetative coverage is (check one): ¨ 20-40% ¨ 40-60% ¨ 60-80% ¨ 80-100%

Erosion Prevention Practices	EPP-06 Permanent Seeding



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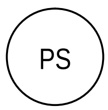


Description

Permanent seeding establishes a permanent ground cover over disturbed areas. This practice can greatly reduce erosion from a disturbed area.

Application

- Ø Permanent seeding can be used to reduce sediment runoff from disturbed areas during construction.
- Ø Permanent seeding can reduce air born pollutants arising from construction disturbances.

Design

- Ø The area must be protected from excess runoff as necessary with upgradient diversion berms or ditches. Plant species must be selected on the basis of quick germination, growth, and time of year to be seeded. Fertilizer, lime, seedbed preparation, seed coverage, mulch, and irrigation must be applied as necessary to promote quick plant growth.
- Ø **Conventional Seeding**
  Common methods of application include: disc, cultivator, broadcasting, and no-till drilling.
- Ø **Hydroseeding**
  Hydroseeding uses a mixture of mulch, seed, and tactifier which is sprayed over a disturbed area for coverage.
- Ø Permanent seeding shall be applied to disturbed areas within 14 days of final grading unless Temporary Seeding - EPP-05, is to be used in the interim.
- Ø This practice can be used in conjunction with other BMPs to reduce erosion during and after construction.

Design (cont'd)

- Soil should be capable of supporting permanent vegetation and have at least 25 percent silt and clay to provide an adequate amount of moisture holding capacity. An excessive amount of porous sand will not consistently provide sufficient moisture for good growth regardless of other soil factors.
- Plan to seed all areas as soon as final grade is reached, to take advantage of soil seedbed conditions and to minimize erosion potential.
- Where compact soils occur, they should be broken up sufficiently to create a favorable rooting depth of 6-8 inches.
- Stockpile topsoil to apply to sites that are otherwise unsuited for establishing vegetation. Approximately 400 cubic yards of topsoil per acre are needed for application depths of 3 inches (~ 9.3 cubic yards per 1,000 square feet.)
- Grade as needed and feasible to permit the use of conventional equipment for seedbed preparation, seeding, mulch application and anchoring, and maintenance. After the grading operation, spread topsoil as needed.
- Install the needed erosion control practices, such as diversion berms and ditches.
- Spread lime (in lieu of a soil test recommendation) on acid soil and subsoil, at a rate of one ton per acre of agricultural ground limestone. For best results, test the soil – this can reduce the expense of unneeded lime and fertilizer and potential excess nutrient loss through runoff and leaching.
- Fertilizer (in lieu of soil test recommendation) should be applied at a rate of no more than 800 pounds per acre of 10-10-10 analysis. For best results, test the soil to determine fertilizer requirements. In limestone areas with streams and rivers impacted by high algae concentrations, use 10-0-10 fertilizer.
- Work the lime and fertilizer into the soil with a disk harrow, springtooth harrow, or other suitable field equipment to a depth of 4 inches. On sloping land, the final operation must be on the contour.

Table EPP06-1. Kentucky Transportation Cabinet Seed Mixes

Mixture Type	Seed Mixture
Mixture No.I	75% Kentucky 31 Tall Fescue 10% Red Top 5% White Dutch Clover 10% Ryegrass (perennial)
Mixture No.III	30% Kentucky 31 Tall Fescue 15% Red Top 15% Partridge Pea 20% Sericea Lespedeza 10% Sweet Clover – Yellow 10% Ryegrass
KYTC does not specify the seeding rate but requires that sufficient seed be applied to ensure a "dense, uniform vegetative cover."	

Table EPP06-2. Recommended Seeding Rates and Other Information for Various Species and Seed Mixtures

Seed species & mixtures	Seeding rate/acre	Per 1000 sq. ft	Soil pH	Other Information
Seed and seed mixtures for relatively flat or slightly sloping areas				
Perennial ryegrass	25 to 35 lbs	1 lb	5.6 to 7.0	Apply lime at 2 tons per acre if soil pH is below 5.5; use 400-800 lb fertilizer (10-10-10) on poor soils. Use wildflower mixes to save on mowing and watering costs.
+ tall fescue	15 to 30 lbs	1 lb	5.5 to 7.5	
Tall fescue	40 to 50 lbs	1.5 lbs		
+ ladino or white clover	1 to 2 lbs	2 oz		
Steep slopes, banks, cuts, and other low maintenance areas (not mowed)				
Smooth bromegrass	25 to 35 lbs	1 lb	5.5 to 7.5	Track Steep slopes with dozer up and down hill before seeding. Mulch Slopes after seeding with 2 to 3 tons of straw or 6 tons of wood chips per acre. Use tackifier on mulch, disk it in, or punch in with sheep-foot roller. Disk or sheep-foot on the contour (across the slope, on the level). For extremely steep slopes, use erosion control blankets after seeding. Use 20" spacing on blanket staples.
+red clover	10 to 20 lbs	0.5 lb		
Tall fescue	40 to 50 lbs	1 lb	5.5 to 7.5	
+ white or ladino clover	1 to 2 lbs	2 oz		
Orchardgrass	20 to 30 lbs	1 lb	5.6 to 7.0	
+ red clover	10 to 20 lbs	0.5 lb		
+ ladino clover	1 to 2 lbs	2 oz		
Crownvetch	10 to 12 lbs	0.25 lb	5.6 to 7.0	
+ tall fescue	20 to 30 lbs	1 lb		
Lawns and other high traffic or high maintenance areas (mowed)				
Bluegrass	105 to 140 lbs	3 lbs	5.5 to 7.0	Use wildflower mixes to save on mowing and watering costs. Do not establish grassed lawns near streams or wetlands – leave a 15 to 30 foot buffer or natural vegetation.
Perennial ryegrass (turf)	45 to 60 lbs	2 lbs	5.6 to 7.0	
+ bluegrass	79 to 90 lbs	2.5 lbs		
Tall fescue (turf type)	130 to 170 lbs	4 lbs	5.6 to 7.5	
+ bluegrass	20 to 30 lbs	1 lb		
Channels and other areas of concentrated water flows				
Perennial ryegrass	100 to 150 lbs	3 lbs	5.6 to 7.0	Seed ditches and channels thickly. Do not use fertilizer near ditch or channel bottom. Use erosion control blankets or turf reinforcement mats when channel bottom slopes exceed 3%.
+ white or ladino clover	1 to 2 lbs	2 oz		
Kentucky bluegrass	20 lbs	0.5 lb	5.5 to 7.5	
+ smooth bromegrass	10 lbs	0.25 lb		
+ switchgrass	3 lbs	2 oz		
+timothy	4 lbs	0.25 lb		Silt check dams are needed when channel slopes exceed 5% or when channels begin downcutting (gullying) on the bottom. Do not use silt fencing or straw bales as silt check dams in channels with slopes greater than 3%; use rock or brush instead.
+ perennial ryegrass	10 lbs	0.25 lb		
+ white or ladino clover	1 to 2 lbs	2 oz		
Tall fescue	100 to 150 lbs	3 lbs	5.5 to 7.5	
+ ladino or white clover	1 to 2 lbs	2 oz		
+ perennial ryegrass	15 to 20 lbs	0.5 lb		
+ Kentucky bluegrass	15 to 20 lbs	0.5 lb		

Maintenance

- Water soil until the grass is firmly established, especially if seedlings are made late in the planting season.
- Inspect all seeded areas for failures and make necessary repairs.
- If stand is inadequate (less than 80% coverage) overseed, fertilize, using half of the original rates
- If stand is more than 60% damaged, reestablish following original seedbed preparation methods, seeding and mulching recommendation and apply lime and fertilizer as needed according to a new soil test.

Inspection

- [ ] Area is watered daily until stabilization has taken place.
- [ ] Area has been maintained (watered, repaired) since stabilization.
- [ ] Heavy equipment has not been used within area.
- [ ] Eroded areas have been regarded and re-established.

Erosion Prevention Practices

EPP-07 Sodding

Symbol

SO

Description

Sodding is a method used to quickly establish permanent grass stands. This practice can prove very effective in quickly stabilizing critical, erosion-prone areas.

Application

- Ø Ditches or channels carrying intermittent flow.
- Ø Areas around drop inlets in grass swales.
- Ø Residential or commercial lawns that would be aesthetically enhanced sodding.
- Ø Other critical areas not previously described.

Design

- Ø Establish permanent grass stands quickly.
- Ø Prevent erosion by stabilizing formerly denuded areas.
- Ø Reduce the amount of air borne sediment, dust and mud leaving the project site.
- Ø Stabilize channels where concentrated overland flow occurs.
- Ø Sod should be machine cut and contain one-half inch to 1 inch of soil, not including roots or shoots or thatch.
- Ø Specify that sod will be installed within 36 hours of digging and removal from the field.
- Ø Avoid planting when subject to frost heave or hot weather if irrigation is not available.
- Ø Sod should not be used on slopes steeper than 2H:1V. If it is to be mowed, installation should be on slopes no greater than 3H:1V.

Design (cont'd)

- The sod should consist of strips of live, vigorously growing grasses. The sod should be free of noxious and secondary noxious weeds and should be obtained from good, solid, thick-growing strands. The sod should be cut and transferred to the job in the largest continuous pieces that will hold together and that are practical to handle.
- The sod should be cut with smooth, clean edges and square ends to facilitate laying and fitting. The sod must be cut to a uniform thickness of not less than three-fourths of an inch measured from the crown of the plants to the bottom of the sod strips for all grasses except bluegrass. Bluegrass sod must be cut to a uniform thickness of not less than 1.5 inches.
- The sod must be mowed to a height of not less than 2 inches and no more than 4 inches before cutting.
- The sod must be kept moist and covered during hauling and preparation for placement on the sod bed.
- Soils in areas to be sodded must be capable of supporting permanent vegetation and must consist of at least 25 percent silt and clay to provide an adequate amount of moisture-holding capacity. An excessive amount of porous sand will not consistently provide sufficient moisture for the sod regardless of other soil factors.
- Compacted soils must be boken up sufficiently to create a favorable rooting depth of 6-8 inches.
- Stockpile topsoil to apply to sites that are otherwise unsuited for establishing vegetation.
- Grade as needed and feasible to permit the use of conventional equipment for the sod bed preparation. After grading operation, spread topsoil where needed.
- Apply lime (in lieu of a soil test) on acid soil and subsoil at a rate of one ton per acre. The lime should be agricultural ground limestone or equivalent. For best results, conduct a soil test. This can reduce expense of unneeded lime and fertilizer an potential excess nutrient loss through runoff and leaching.
- Apply fertilizer (in lieu of a soil test) at 1,000 pounds per acre 10-10-10 analysis. For best results, conduct a soil test.
- Work lime and fertilizer into the soil with a disk harrow, springtooth harrow, or other suitable field equipment to a depth of 4 inches.

Design (cont'd)

- No sod should be placed when the temperature is below 32° F. No frozen sod must be placed nor should any sod be placed on frozen soil.
- Sod should be carefully placed and pressed together so it will be continuous without any voids between the pieces. Stagger the joints between the ends of strips in a brick-like pattern. Ensure that the edge of the sod at the outer edge of the sod at the outer edges of all gutters is sufficiently deep so that the surface water will flow over onto the top of the sod.
- For channel sodding, carefully place the sod on rows or strips at right angles to the centerline of the channel (i.e. at right angles to the direction of flow). On steep, graded channels, stake each strip of sod with at least two stakes not more than 18 inches apart. The stakes should be wooden and approximately ½" x ¾" x 12". Drive the stakes flush with the top of the sod and with the flat side against the slope.
- On slopes 3:1, or steeper, and where drainage into a sod gutter or channel is one-half acre or larger, roll or tamp the sod and then peg chicken wire, jute, or other netting over the sod for protection in the critical areas. Stake the netting and sod with at least two stakes not more than 18 inches apart. The stakes should be wooden and approximately ½" x ¾" x 12". Drive the stakes with the flat side against the slope and on an angle toward the slope. Staple the netting on the side of each side of each stake within 2 inches of the top of the stake, then drive the stake flush with the top of the sod.
- The sod should be tamped or rolled after placing and then watered. Watering must consist of a thorough soaking of the sod and of the sod bed to a depth of at least 4 inches. Maintain the sod in a moist condition by watering for a period of 30 days.

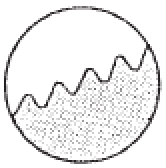
Maintenance

- Sod should be kept moist for at least the first three weeks, until properly rooted.
- Inspect sod twice a week after installation to check on moisture conditions and grass viability. Irrigate sod immediately after installation and every few days afterwards if no significant rainfall occurs during the first 2 weeks. Soak the area thoroughly to a depth of 3 inches during irrigation.
- Sod areas where original placement does not establish or take root.
- Do not mow for the first three weeks.
- Once mowing begins, cutting height should be 3" or greater.
- Fertilize and mow grasses once established.

Inspection

- [ ] Sodded areas are properly watered and maintained.
- [ ] Heavy construction equipment has been prohibited from crossing sodded areas.
- [ ] Sodded areas are mowed once established.

Erosion Prevention Practices | EPP-08 Surface Roughening



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SR

Description

This BMP corrects the affects of runoff velocities, sediment trapping and sheet flow length by constructing small furrows across a slope, and utilizing construction equipment to track soil surface. The primary function of surface roughening is to temporarily stabilize a slope until it can receive permanent vegetation.

Application

- Ø All exposed construction slopes, particularly slopes that are steeper than 3H:1V.
- Ø Exposed soils where seeding, planting, and mulching will benefit from surface roughening.
- Ø Areas that have the potential for erosion of clay (smooth, hard surfaces), silt or sand sized particles.

Design

Roughening methods include:

- Ø Terracing, (see EPP-13)
- Ø Fill Slope Roughening
- Ø Grooving
- Ø Roughening with tracked machinery

Factors to be considered in choosing a method are

- Ø Slope steepness
- Ø Mowing requirements
- Ø Soil type

Design (cont'd)

- Specify that surface roughing is perpendicular to the direction of flow

Soil Conditions vs. Erosion

If soil is:	Erosion will be:
Compacted and smooth	30 percent more
Tracks across slopes	20 percent more
Tracks up & down slopes	10 percent less
Rough and irregular	10 percent less
Rough & loose to 12" deep	20 percent less

- Stair-step grade or groove all cut all slopes that are steeper than 3H:1V.
- Use stair-step grading on any erodible material soft enough to be ripped with a bulldozer. Slopes consisting of soft rock with some subsoil are particularly suited to stair-step grading.
- Make the vertical cut distance less than the horizontal distance , and slightly slope the horizontal position of the step in toward the vertical wall
- Do not make individual vertical cuts more than 2 feet high in soft materials or more that 3 feet high in rocky materials.
- Groove the slope using machinery to create a series of ridges and depressions that run across the slope, on the contour.
- Place fill slopes with a gradient steeper than 3H:1V in lifts not to exceed 8 inches, and make sure each lift is properly compacted.
- Ensure that the face of the slope consists of loose, uncompacted fill 4-6 inches deep.
- Use grooving or tracking to roughen the face of the slopes, if necessary. Grooves and track indentions must be perpendicular to the direction of downslope flow.
- Apply seed, fertilizer, and straw mulch then track or punch in the mulch with the bulldozer.
- Do not blade or scrape the final slope face.
- Make mowed slopes no steeper 3H:1V.
- Roughen these areas to shallow grooves by normal tilling, disking, harrowing, or use a culipacker-seeder. Make the final pass of any such tillage on the contour (i.e. across the slope rather than up and down).
- Make grooves formed by such implements close together (less than 10 inches, and not less than 1 inch deep).
- Excessive roughness is undesirable where mowing is planned.

Design (cont'd)

- Limit roughening with tracked machinery to soils with a sandy component to avoid undue compaction of the soil surface. Tracking soils with heavy clay content can cause compaction and seal the slope soils, increasing runoff and making seed germination difficult.
- Operate tracked machinery up and down the slope to leave horizontal depressions in the soil. Do not back-blade during the final grading operation.
- Immediately seed and mulch roughened areas to obtain optimum seed germination and growth. Use erosion control blankets or turf reinforcement mats on long (> 50 feet) steep (> 2H:1V) slopes as necessary, or hydroseed.

Maintenance

- Periodically check the seeded or planted slopes for rills and washes, particularly after significant storm events, greater than 0.5 in.
- Fill these areas slightly above the original grade, then reseed and mulch as soon as possible.

Inspection

- ☐ Surface roughened areas inspected after recent wet weather events.
- ☐ Rills and washed areas have been re-roughened and re-seeded.
- ☐ Practice is maintained and properly functioning; other practices are not required.

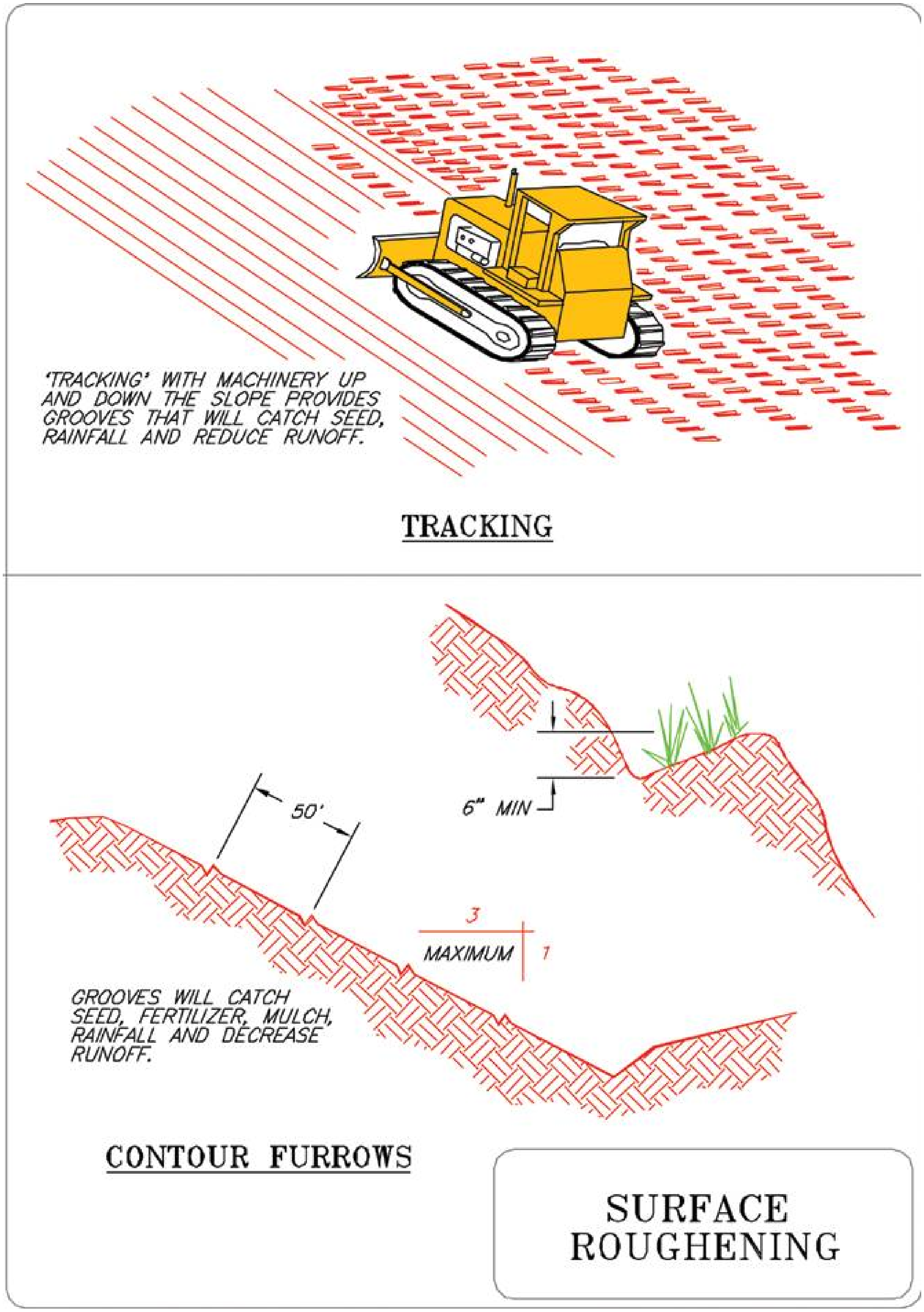
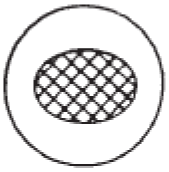


Figure EPP08-1. Kentucky Construction Site BMP Planning and Technical Specifications Manual

Erosion Prevention Practices	EPP-09 Topsoil Stockpiling



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TS

Description

Topsoil is used to enhance the final product of a construction site area. This act is done to support temporary and permanent seeding, as well as aiding in erosion control methods. By implementing this BMP, a reduction in construction waste and some reduction in sediment will occur.

Application

- Ø Where construction activities expose subsoil layers that may not be able to support vegetative growth.
- Ø The structure, pH, or nutrient balance of the available soil cannot be amended by reasonable means to provide an adequate growth medium for the desired vegetation.
- Ø The soil is too shallow to provide adequate rooting depth or will not supply necessary moisture and nutrients for growth of desired vegetation.
- Ø Stockpiling should also be used where high-quality turf or ornamental plants are desired and where slopes are 2H:1V or flatter.
- Ø Areas where reusing and preserving topsoil increases the success rate of new vegetation.

Design

- Ø Consider quality and amount of topsoil available and needed.
- Ø Select location to avoid slopes, flood plains, natural channels, and traffic routes.
- Ø Compost used on site as a recycled aspect of construction clearing.
- Ø Verify proper placement of down slope sediment control practices prior to removing topsoil.

Design (cont'd)

- Strip topsoil only from those areas that will be disturbed by excavation, filling, road building, or compaction by equipment. Normally, 4 to 6 inches are stripped for topsoil use.
- To promote bonding, scarify or rip subsoil to a depth of 8-12 inches; do not compact during topsoil placement operations.
- Avoid stripping topsoil to the extent that stormwater infiltration is significantly reduced.
- Determine depth of stripping by taking soil cores at several locations within each area to be stripped.
- Put sediment basins, diversions, and other controls into place before stripping.
- Position topsoil stockpiles where they will not erode, block drainage, or interfere with site work. Topsoil stockpiles should be on flat ground if possible, and protected by a silt fence or other sediment barrier on the downgradient sides. Top soil that will not be used for more than 14 days must be mulched or seeded.
- If stock piles will not be used within 2 months, they must be stabilized with permanent vegetation to control erosion and weed growth.
- To promote topsoil bonding, before topsoil is applied to the site, disk the subsoil to a depth of at least 4 inches to ensure bonding of the topsoil and subsoil. If no amendments have been incorporated, loosen the soil to a depth of at least 6 inches before spreading topsoil.
- Uniformly distribute topsoil to a minimum compact depth of 2 inches on 3:1 slopes and 4 inches on flatter slopes. Do not spread the soil while it is frozen or muddy or other operations prevent the formation of depressions or water pockets.If site is excavated down to rock, such as sandstone or shale, 8 to 12 inches of topsoil is recommended for good plant growth.
- Do not apply topsoil to slopes steeper than 2:1 to avoid slippage, or to a subsoil of highly contrasting texture. Sandy topsoil over clay subsoil is a particularly poor combination, especially on steep slopes. Water can creep along the junction between the soil layers and cause the topsoil layer to slip or slough.

Table EPP09-1. Cubic Yards of Topsoil Required to Attain Various Soil Depths

Depth (Inches)	Per 1,000 Square Feet	Per Acre
1	3.1	134
2	6.2	268
3	9.3	403
4	12.4	537
5	15.5	672
6	18.6	806

- If site is excavated down to rock, such as sandstone or shale, 8 to 12 inches of topsoil is recommended for good plant growth.

Design (cont'd)

- The best texture is loam, sandy loam, and silt loam. Sandy clay loam, silty clay loam, clay loam, and loamy sand are fair. Do not use heavy clay and highly organic soils such as peat or much as topsoil.
- Organic matter content should be greater than 1 percent by weight.
- The depth of material meeting the above qualifications should be at least 2 inches. Soil factors such as rock fragments, slope, depth to water table, and layer thickness affect the ease of excavation and spreading of topsoil.
- Organic soils such as mucks and peats do not make good topsoil. They can be identified by their extremely light weight when dry.
- Generally, the upper part of the soil that is richest in organic matter is most desirable; however, material excavated from deeper layers could be worth storing if it meets the other criteria listed above.
- Maintain grades on the areas to be topsoiled according to the approved plan. Adjust grades and elevations for receipt of topsoil.
- Liming is required if pH is less than 6.0 or if the soil is composed of heavy clays. Incorporate agricultural limestone in amounts recommended by soil tests or specified for the seeding mixture to be used. Incorporate lime to a depth of at least 2 inches by disking.
- Compact the topsoil enough to ensure good contact with the underlying soil, but avoid excessive compaction as it increases runoff and inhibits seed germination. Light packing with a roller is recommended where high-maintenance turf is to be established.
- On slopes and areas that will not be mowed, the surface may be left rough after spreading topsoil. A disk may be used to promote bonding at the interface between the topsoil and subsoil.
- After topsoil application, follow procedures for temporary or permanent seeding, taking care to avoid excessive mixing of topsoil into the subsoil,

Maintenance

- Maintain areas where vegetation has been re-established to remedy erosion and damage or vegetation failure by frequently checking the newly applied topsoil.

Inspection

- [ ] Effective management practices such as netting, temporary seeding, mulch and other traditional methods are used to ensure correct storage of the soil. If these practices are not available, other equivalent practices are to be enforced.
- [ ] Appropriate layer of topsoil has been established.
- [ ] Storage piles do not interfere with site drainage.

Erosion Prevention Practices — EPP-10 Mulching

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Symbol

M

Description

To secure temporary or permanently seeded areas, mulching is used as a stabilizer. There are several types of mulches to be utilized, some of which include organic materials, straw, wood chips, and bark or other wood fibers. This management practice has the possibility to significantly reduce sediment and partial reduction of nutrients.

Application

- Ø Temporary stabilization of freshly seeded and planted areas, sometimes during periods of unsuitable vegetative growth.
- Ø Temporary stabilization of areas that cannot be seeded or planted (e.g., insufficient rain, steep slope, non-growth season).
- Ø Areas which have been permanently seeded to assist in retaining moisture, and to hold seeding.
- Ø On areas to increase the survival of temporary and/or permanent vegetative cover.
- Ø As short term, non-vegetative ground cover on steepened slopes to reduce rainfall impact, decrease the velocity of sheet flow, and settle out sediment.
- Ø As ground cover around established plants, such as trees or shrubs, and on unprotected flat to minor slopes.
- Ø Apply to planting areas where slopes are 2.5:1 (H:V) or less steep. For steeper slopes the mulch material should be applied hydraulically.
- Ø Areas where climatic conditions require soil moisture retention aid to avoid cracking.

Design

The term “mulch” is commonly used to describe a variety of materials, such as:

- o Shredded tree bark and other woody materials, to protect trees and shrubs.
- o Straw or hay, scattered across a slope or disturbed area.
- o Peat mulch, used in planting trees and shrubs.

- Ø Table EPP-10.01 has a recommended application rate for various types of mulches.

Design (cont'd)

Vegetative Fibers (Straw)

Loose hay or straw are the most common mulch materials used in conjunction with direct seeding of soil. Straw mulch is preferable over hay mulch, which may contain weeds and other objectionable material. Straw mulch is the short-term protection most commonly used with seeding. Wheat or oat straw is recommended from the current season's crop (less than 12 months old). Average fiber length should exceed 6 in.

Straw mulch is applied immediately after seeding, whether by machine or by hand distribution. Anchor the mulch in place using a tacking agent, plastic netting, or punching into the soil mechanically. Plastic netting requires wire staples, wooden stakes, or plastic stakes. If the slopes are too steep for netting, then tacking agents should be selected on the basis of longevity and the ability to hold the fibers in place.

- Mulch should not be applied more than 2 inches deep on seeded sites, unless it is incorporated into the soil by tracking, disking (crimping), or other punching in techniques. If the straw is applied at rates higher than 3 tons per acre, the mulch could be too dense for the sunlight and seedlings to penetrate.
- Before mulching, install any needed erosion and sediment control practices such as diversions, grade stabilization structures, berms, dikes, grass-lined channels and sediment basins
- Obtain clean wheat, barley, oat, or rice straw to prevent the spread of noxious weeds. Avoid moldy, compacted straw because it tends to clump and is not distributed evenly
- The straw must be evenly distributed by hand or machine to the desired depth (about 2 inches) and should cover the exposed area to a uniform depth. One bale (approximately 80 lbs) of straw covers 1000 square feet adequately. The soil surface should be barely visible through the straw mulch. On steep or high-wind sites, straw must be anchored to keep it from blowing away.
- For seeded sites, apply 1.5-2 tons per acre, 1-2 inches deep, covering 80 percent of the soil surface. For unseeded sites, use 1.5-2.5 tons per acre, apply 2-4 inches deep, covering 90 percent of the soil surface.
- Mulch must be anchored immediately to minimize loss by wind or water. Straw mulch is commonly anchored by crimping, tracking, disking, or punching into the soil; covering with a netting material; spraying with asphaltic or organic tackifier; or tacking with cellulose fiber mulch at a rate of 750 pounds per acre.
- On small sites where straw has been distributed by hand, it can be anchored by hand punching it in the soil every 1-2 feet with a dull, round-nosed shovel. A sharp shovel will merely cut the straw and not anchor it. A mulch anchoring tool is a tractor-drawn implement designed to punch and anchor mulch into the top 2-8 inches of soil. This practice affords maximum erosion control but is limited to flatter slopes where equipment can operate safely. A set of disk harrows can be used for this purpose if the disks are straightened (not angled) so they cut the straw into the soil. Tracking is the process of cutting straw into the soil using a bulldozer or other equipment that runs on cleated tracks. Tracking is used primarily on slopes 3:1 or flatter where this type of equipment can safely operate. This is an effective way to crimp straw on fill slopes. Tracking equipment must operate up and down the slope so the cleat tracks are perpendicular to flow.

Design (cont'd)

- Ø Netting material made of biodegradable paper, plastic or cotton netting can be used to cover straw mulch. Netting should be specific judiciously since birds, snakes and other wildlife can get trapped in the nettings.
- Ø Polymer tackifiers are generally applied at rates of 40-60 pounds per acre, however manufacturer's recommendations vary. Organic tackifiers are generally applied at rates of 80-120 pounds per acre, however manufacturer's recommendations vary. Applications of liquid mulch binders should be heavier at edges, in valleys, and at crests of banks and other areas where the mulch could be moved by wind or water. All other areas must have a uniform application of the tackifier.

<u>Anchoring</u>

- Crimping, tracking, disking, or punching into soil
  - Small areas - Hand punch mulch 2-3 inches into the loose soil.
  - Larger areas – Use mulching tool on tractor to punch and anchor mulch 2-8 inches into the soil.
  - Tracking – Cut straw into soil by using a bulldozer with cleated tracks, placed such that the cleat marks are perpendicular to the runoff.
  - Typically used on slopes 3:1 or flatter for safe operation of equipment.

- Covering with netting or mat
  - Nettings or biodegradable paper, plastic or cotton netting can be used to cover straw mulch. The safety of animals (small birds, snakes and other wildlife) should be considered when selecting materials for this measure.

- Spraying tackifiers (Polymer or Organic)
  - Polymer tackifiers are typically applied at a rate of 40-60 lbs/acre, or per manufacturer's recommendations.
  - Organic tackifiers are typically applied at a rate of 80-120 lbs/acre, or per manufacturer's recommendations.
- Cellulose fiber mulch
  - Can be tacked at a rate of 750 lbs/acre

Shredded Vegetation

"Green" mulch is produced by recycling of vegetation trimmings such as grass, shrubs, and trees. Methods of application are generally by hand, although, pneumatic methods are currently being developed. It can be used as a temporary ground cover with or without seeding. The green mulch in place with a tacking agent on steep slopes and in areas where overland sheet flow is anticipated. The quality of green mulch may vary, and there is a strong potential establishing unwanted weeds and plants.

Design (cont'd)

Wood and Bark Chips

Wood and bark chips are suitable for landscaped areas that will not be closely mowed. Wood and bark chips may require nitrogen treatment to prevent nutrient deficiency. Bark chips do not require additional nitrogen fertilizer.

If there is a wood source near the project site, wood and bark chips can be very inexpensive. Caution must be used on steep slopes, since both wood and bark chips tend to wash down slopes exceeding 6 percent. Wood and bark chips are also used around trees and shrubs, or in ornamental or landscape gardens. Typical rates for placing wood and bark chip mulch are 5-8 tons per acre, at a depth of 2-3 inches.

If decomposition, soil building and revegetation are desired, increase the application rate of nitrogen fertilizer by 20 pounds of nitrogen per acre, to compensate for the temporary diversion (loss) of available nitrogen to the soil microbes.

Hydraulic Mulch

Hydraulic mulch can be made from virgin wood fibers or from recycled waste paper sources (newsprint, magazine). There are also mulches available which are a combination. In general, virgin wood fibers contain a longer fiber length than recycled paper mulch.

Hydraulic mulch is mixed in a hydraulic application machine (such as a hydroseeder or a mulch blower) and then applied as liquid slurry. The hydroseeder slurry contains recommends rates of seed and fertilizer for the site, usually specified with a tacking agent. Slurry must be constantly agitated to keep the proper application rate and achieve uniform effective coverage.

Apply at rate of 1.5 to 2 tons per acre – mixed with seed and fertilizer at recommended rates – to achieve uniform, effective coverage.

Paper mulch used to track and bind straw mulch can be specified at a lower rate (i.e. 750 pounds per acre.)

- Wood, paper or combination fiber mulches are typically applied with a hydraulic applicator (hydroseeder) at a minimum rate of 1.5 tons per acre. A typical construction specification and application for this type of mulch is as follows:Moisture content (total weight basis) not to exceed 12 percent +/- 3 percent.
- Organic matter content (oven dry weight basis) is 98 percent minimum.
- Inorganic matter (ash) content (oven dried basis) 2 percent maximum.
- pH at 3 percent consistency in water should be greater than 4.9
- Fiber must be dyed to aid in visual metering during application. The dye must be biodegradable and must not inhibit plant growth.
- Water holding capacity (oven dried basis) minimum 1.0 gallons per pound fiber.
- The mulch must be mixed with seed and fertilizer as specified and applied at rate recommended by the manufacturer to achieve uniform, effective coverage and provide adequate distribution of seed.

Rock

Rock is recommended for long slopes of 2H:1V or flatter that will not support thickly seeded grass. Install non-woven geotextile on graded slope, place rock of mixed sizes on geotextile, starting at bottom and working uphill. Generally rock is not suitable for residential or other areas where aesthetics are a design considerations

Table EPP-10-01 Recommended Rates for Mulching Materials

Mulch Product	Application Rate	Benefits	Limitations
Straw or Hay	1 ½ - 2 ½ tons per acre	Readily available and inexpensive; very effective in controlling erosion; can be applied on large sites via blower	Can carry unwanted seeds; might need trackifier or anchoring, especially on steep slopes
Wood Chips, Bark, Sawdust	5 - 8 tons per acre	Very low cost in some locations; chips effective on slopes up to 35%	High nitrogen demand when decompos away or blow away during rain storms.
Rock	200 – 500 tons or more per acre	Could be inexpensive and readily available in some localities; might be suitable for smaller sites.	Inhibits plant growth; adds no nutrients to the soil; can be costly to apply on slopes and large sites; adds "hardened" look to slopes
Hydraulic mulches and soil binders	1 ½ - 2 tons per acre	Easily and rapidly applied with sprayer equipment; can include seed, fertilizer, flexible/fiberous mulches, and soil binders.	Could be too expensive for small or very remote sites; must dry for at least 24 hours before rainfall.

Maintenance

- Must be inspected weekly and after rain for damage or deterioration.
- Inspect after episodes of high winds and significant rainstorms.
- Maintain an unbroken, temporary mulched ground cover throughout the period of construction that the soils are not being reworked. Inspect before expected rainstorms and repair any damaged ground cover and re-mulch exposed areas of bare soil.

Inspection

- [ ] All disturbed areas are properly covered per plans and specifications.
- [ ] Straw mulch has been properly crimped.
- [ ] Mulch has been replaced following intense wet weather events or episodes of high winds.

Erosion Prevention Practices	EPP-11 Channel Lining

Symbol

N

M

Description The security measures ensured by a protective blanket or soil stabilization mat to help prevent and reduce erosion on preceding shaped and seeded swales, channels and slopes while assisting in the establishment of temporary or permanent vegetation on steep slopes, channels, or stream banks. The implementation of this BMP will create a significant reduction in sediment.

Application

- Ø Preventing erosion of the soil surface.
- Ø Promoting seed germination.
- Ø Protecting young vegetation
- Ø Preventing wind dispersal of seed or mulch
- Ø Allowing for easy installation of seed and/or mulch.
- Ø An erosion control blanket (ECB) or a turf reinforcement mat (TRM) should be used in all drainage channels with slopes of 2 percent or more.

Design

Selection of an appropriate mat or blanket depends on the nature of the project. Manufacturers should be consulted in selecting the product for the intended purpose.

<u>Temporary Erosion Control Blankets</u>

Temporary erosion control blankets include the following options:

- plastic netting intertwined with a natural organic or manmade mulch
- jute mesh

- Ø Typically used to stabilize concentrated flow areas where velocities meet or exceed 5 ft/sec and slopes 2.5:1 or steeper.
- Ø Deteriorate in a short period of time
- Ø Provide protection of the seed and soil from raindrop impact and subsequent soil displacement.

Design (cont'd)

- Accelerates germination of grasses and legumes more completely
- Thermal consistency and moisture retention for seed.

Permanent Erosion Control Matting

Consist of permanent, non-degradable, three-dimensional plastic structures that are filled with soil prior to planting.

- Typically used to stabilize concentrated flow areas where velocities are between 5 and 10 ft/sec.
- Linings should be designed and selected by a professional experienced in the use of these materials
- Provides the same benefits as erosion control blankets.
- Protects channels from erosion within high capacity storm water conveyance channels.
- Filters fine sediment during lower flow stormwater events.

Site Preparation

- Grade and shape area of installation
- Remove all rocks, roots, clods, vegetative, or other obstructions so that the installed blankets or mats will have direct contact with the soil.
- Prepare seedbed by loosening 2-3 inches of topsoil above final grade
- Incorporate amendments, such as lime and fertilizer, into soil according to soil test and the seeding plan.

Seeding

- Seed the area before installing the blanket for erosion control and revegetation (Seeding after mat installation is sometimes specified for turf reinforcement application – check the manufacturer's instructions). When seeding before blanket installation, reseed all check slots and other areas distributed during installation.
- Where soil filling is specified for certain TRMs, seed the matting and the entire disturbed area after installation and before filling the mat with soil. Follow the manufacturer's instructions to ensure proper installation.

Anchoring

- Wire staples should be a minimum of 11 gauge.
- Metal stake pins should be 3/16 inch diameter steel with a 1.5 inch steel washer at the head of the pin.
- Wire staples and metal stakes should be driven flush to the soil surface.
- All anchors should be 6-8 inches long and have sufficient ground penetration to resist pullout. Longer anchors might be required for loose soils.
- Use biodegradable composite or wooden stakes where dislodged metal staples might cause extreme hazards, such as near airport runways or areas where future mowing might cause risk.

Installation

Dig initial check slot trench 12 inches deep and 6 inches wide across the channel (i.e. perpendicular to the flow direction) at the lower end of the project area. Seed area first, if specified for the type of TRM or ECB used.

Installation (cont'd)

- Excavate intermittent check slots, 6 inches deep and 6 inches wide across the channel at 25-30 foot intervals along the channel.
- Cut longitudinal channel anchor slots 4 inches deep and 4 inches wide along each side of the installation to bury edges of matting. These anchor slots will mark the upper elevation of the ECB or TRM along the channel side slopes, and should be above the 10 year, 24-hour peak flow line. Whenever possible extend the ECB or TRM 1 foot or more above the crest of channel side slopes.
- Beginning at the downstream end and in the center of the channel, place the initial end of the first roll in the anchor trench and secure with fastening devices at 1-foot intervals. Note: Matting will initially be upside down in anchor trench.
- In the same manner, position adjacent rolls in the anchor trench, overlapping the preceding roll a minimum of 6-8 inches.
- Secure these initial ends of mats with anchors at 1-foot intervals, backfill and compact soil.
- Unroll adjacent mats upstream in similar fashion, maintaining a 3-inch overlap.
- Fold and secure all rolls of matting snugly into all transverse check slots. Lay the mat in the bottom of the slot then fold back against itself. Anchor through both layers of mat at 1-foot intervals, then backfill and compact the soil. Continue rolling all mat widths upstream to the next check slot or terminal anchor trench.
- Alternate method for noncritical installations: place two rows of anchors on 6-inch centers at 25-30 feet intervals in lieu of excavated check slots. Shingle-lap the spliced ends by a minimum of 1 foot with the upstream mat on top (to prevent uplifting by water) or begin new rolls in a check slot. Anchor the overlapped area by placing two rows of anchors, 1 foot apart on 1-foot intervals.
- Place the edges of outside mats in previously excavated longitudinal slots, anchor them using the prescribed staple pattern, then backfill and compact the soil.
- Anchor, fill, and compact the upstream end of the mat in a 12-inch by 6-inch terminal trench.
- Secure the mat to the ground using U-shaped wire staples, geotextile pins, or wooden stakes. (Note: some TRMs require seeding after installation—check manufacturer's requirements).
- Spread and lightly rake one-half to three-quarter inch of fine topsoil into the mat apertures to completely fill the mat thickness. Use the backside of a rake or other flat implement. Spread topsoil using lightweight loader, backhoe, or other power equipment. Avoid making sharp turns with the equipment.
- Do not drive tracked or heavy equipment over the mat. Avoid any traffic over the matting if loose or wet soil conditions exist.
- Use shovels, rakes or brooms for fine grading and touch up. Smooth out soil filling, just exposing the top netting of matrix.

Design (cont'd)

Rock Lined Ditches and Channels

Rock lining may be necessary in the following conditions:

- There is not enough time to construct, seed, and establish a stabilized vegetated channel before the channel is expected to carry stormwater flows (i.e., construction during wet seasons).
- Design velocity exceeds 2 feet per second and conditions are not suitable for channel or ditch vegetation even if TRMs are used.
- Ditches or drainage channel slopes are greater than 2 percent and located in highly erodible soils that have a low-maximum permissible velocity that cannot be overcome with TRMs.
- Channel design velocity exceeds that allowable for a grass-lined channel with ECB or TRM liners.
- The channel will continue to down-cut without protection because it is adjusting to increased flow or a new base line (outlet elevation).

Table EPP 11-1. KYTC weight and size of riprap rock

Channel Lining Riprap Class	Corresponding Size
1A	Limestone with 100% passing a 5-inch sieve, and no more than 20% passing though square openings 1.5" by 1.5"
II	Limestone with 100% passing a 9-inch sieve, and no more than 20% passing though square openings 5" by 5"
III (Cyclopean Riprap)	> 80% by volume of individual stones ranging from ¼ to 1-½ cubic feet

The channel must be designed to carry the 10-year, 24-hour peak flow using the formula below:

Q = VA, where
Q = flow
V = velocity
A = flow area

The Manning equation below must be used to determine the velocity:

V = 1.486(R)2/3S1/2/n, where
V=velocity
R=flow area/wetted perimeter
S=slope in feet/foot
n = 0.0395 (D50)1/6

The maximum depth must be determined from the following equation:

Dmax = • / (62.4*S), where
Dmax = maximum depth of flow
S = slope in feet/foot
• = maximum tractive force of the liner in lbs/ft2

Design (cont'd)

The values for KYTC channel lining are shown below:

Table EPP11-2. Permissible Sheer Stress for Rock Linings

KYTC Channel Lining	D_{50}	Shear Lb/ft.^{2}	Manning's n
Class 1A	.2	1.0	0.0302
Class II	.5	2.5	0.352
Class III	1.0	5.0	0.0395

Side slopes must be 2:1 or flatter
Riprap thickness—T = 1.5 times the largest stone diameter or as shown on the plans; 6-inch thick minimum
Foundation—Use extra-strength, non-woven filter fabric or an aggregate filter layer, if required.
The outlet must be stable with a suitable outlet stabilization energy dissipator.

Construction Specifications

- Excavate the cross-section to the grades shown on plans. Overcut for thickness of rock and filter.
- Place non-woven filter fabric or gravel filter layer, and place the rock as soon as the foundation is prepared.
- Place rock so it forms a dense, uniform, well-graded mass with few voids. Hand placement might be necessary to obtain good size distribution.
- No overfall of channel construction should exist. Grass-lined channels with riprap bottoms must have a smooth contact between riprap and vegetation.
- Channel outlet must be stabilized with a suitable outlet stabilization energy dissipator.

Grass-Lined Ditches and Channels

The channel cross-section should be wide and shallow with relatively flat side slopes (e.g., 3H:1V) so surface water can enter over the vegetated banks without erosion. Riprap might be needed to protect the channel banks at intersections where flow velocities approach allowable limits and turbulence could occur.

Cross-section designs include:

V-shaped Channels

Generally these are used where the quantity of water is relatively small, such as roadside ditches. The V-shaped cross-section is desirable because of difficulty stabilizing the bottom, where velocities may be high. A sod or grass lining protected with ECBs or TRMs might suffice where velocities are low; use rock or riprap lining to protect against higher velocities.

Parabolic Grass Channels

Often these are used where larger flows are expected and sufficient space is available. The shape is pleasing and may best fit site conditions. Riprap should be used where higher velocities are expected and where some dissipation of energy (velocity) is desired. Combinations of grass with riprap centers or turf reinforcement mat centers are useful where there is a continuous low flow in the channel.

Design (cont'd)

Trapezoidal Grass Channels

These are used where runoff volumes are large and slope is low so that velocities are nonerosive to vegetated linings. Low flow channel can be lined with turf reinforcement mats, erosion control blankets, riprap, or pavement if desired.

- Grass-lined channels must not be subject to sedimentation from disturbed areas.
- An established grass-lined channel resembles natural drainage systems and is usually preferred if design velocities are below 5 feet per second.
- Channels with design velocities greater than 2 feet per second will require that turf reinforcement mats or erosion control blankets be installed at the time of seeding to provide stability until the vegetation is fully established. It might also be necessary to divert water from the channel until vegetation is established or to line the channel with sod.
- Whenever design velocities exceed 4 feet per second a permanent type of turf reinforcement mat will be necessary.
- Sediment traps might be needed at channel inlets to prevent entry of muddy runoff and channel sedimentation.

Capacity

The channel must be designed to carry the 10-year, 24-hour peak flow using the formula below:

Q = VA, where
Q = flow
V = velocity
A = flow area

The Manning equation below must be used to determine the velocity:

V = 1.486(R)2/3S1/2/n, where
V=velocity
R=flow area/wetted perimeter
S=slope in feet/foot
n= 0.045 for grass

The maximum depth must be determined from the following equation:

Dmax = • / (62.4*S), where
Dmax = maximum depth of flow
S = slope in feet/foot
• = maximum tractive force of the liner in lbs/ft2

Tables EPP11-3 through EPP

Maintenance

- Ø Inspect erosion control matting before (if anticipated) and within 24 hours following rainfall events to check for movement of topsoil, mulch or erosion. Continue checking until vegetation is firmly established.
- Ø Inspect blankets or mats at least every 14 days.
- Ø Inspect channels weekly and after rainfall events greater than one-half inch.
- Ø Repair or replace netting that has been washed out, broken, eroded, and/or needing surface repair, re-seeding, re-sodding, re-mulching or topsoil replacement.
- Ø Check the channel for debris, scour, or erosion and immediately make repairs. It is particularly important to check the channel outlet and all road crossings for bank stability and evidence of piping or scour holes and make repairs immediately.
- Ø Remove all significant sediment accumulations to maintain the designed carrying capacity.
- Ø Keep the grass in a healthy, vigorous condition at all times, because it is the primary erosion protection for the channel.

Inspection

- q Channel grades are adequately managing runoff velocity.
- q Staples are appropriately spaced to avoid loss of seed, topsoil and mulch to stormwater runoff and winds.

Nets are adequately covered or anchored to prevent erosion, washout, and poor plant establishment.

The following tables should be used in designing stable channels based upon sheer stress.

Table EPP11-3. Typical Permissible Shear Stresses for Bare Soil and Stone Linings

Lining Category	Lining Type	Permissible Shear Stress •p, lb/ft2
Bare Soil Cohesive (PI=10)[1]	Clayey sands	0.037-0.095
	Inorganic silts	0.027-0.11
	Silty sands	0.024-0.072
Bare Soil Cohesive[1] (PI•20)	Clayey sands	0.094
	Inorganic silts	0.083
	Silty sands	0.072
	Inorganic clays	0.14
Bare Soil Non-cohesive (PI<10)	Finer than coarse sand D_{75}<1.3 mm (0.05 in)	0.02
	Fine gravel D_{75}=7.5 mm (0.3 in)	0.12
	Gravel D_{75}=15 mm (0.6 in)	0.024
Gravel Mulch	Coarse gravel D_{50}=25 mm (1 in)	0.4
	Very coarse gravel D_{50}=50 mm (2 in)	0.8
Rock Riprap	D_{50}=0.15 m (0.5 ft)	2.4
	D_{50}=0.30 m (1.0 ft)	4.8

[1]Assuming a soil void ratio of 0.5

Table EPP11-4 Ultra Short Term Channel Liner Shear Stress

Type	Product Description	Material Composition	Max. Shear Stress •p
1.A	Mulch Control Nets	A photodegradable synthetic mesh or woven biodegradable natural fiber netting.	0.25 lbs/ft^2
1.B	Netless Rolled Erosion Control Blankets	Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form a RECP.	0.5 lbs/ft^2
1.C	Single-net Erosion Control Blankets & Open Weave Textiles	Processed degradable natural and/or polymer fibers mechanically bound together by a single rapidly degrading, synthetic or natural fiber netting or an open weave textile of processed rapidly degrading natural or polymer yarns or twines woven into a continuous matrix.	1.5 lbs/ft^2
1.D	Double-net Erosion Control Blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings.	1.75 lbs/ft^2

Table EPP11-5 Short Term Channel Liner Shear Stress

Type	Product Description	Material Composition	Max. Shear Stress •p
2.A	Mulch Control Nets	A photodegradable synthetic mesh or woven biodegradable natural fiber netting.	0.25 lbs/ft^2

2.B	Netless Rolled Erosion Control Blankets	Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form a RECP.	0.5 lbs/ft^2 (2
2.C	Single-net Erosion Control Blankets & Open Weave Textiles	Processed degradable natural and/or polymer fibers mechanically bound together by a single rapidly degrading, synthetic or natural fiber netting or an open weave textile of processed rapidly degrading natural or polymer yarns or twines woven into a continuous matrix.	1.5 lbs/ft^2
2.D	Double-net Erosion Control Blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings.	1.75 lbs/ft^2

Table EPP11-6 Extended-Term Channel Liner Shear Stress

Type	Product Description	Material Composition	Max. Shear Stress •p
3.A	Mulch Control Nets	A slow degrading synthetic mesh or woven natural fiber netting.	0.25 lbs/ft^2
3.B	Erosion Control Blankets & Open Weave Textiles	An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix or an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.	2.00 lbs/ft^2

Table EPP11-7 Long-Term Channel Liner Shear Stress

Type	Product Description	Material Composition	Max. Shear Stress •p
4	Erosion Control Blankets & Open Weave Textiles	An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix or an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.	2.25 lbs/ft^2

Table EPP11-8 Permanent Turf Reinforcement Channel Lining Shear Stress

Type	Product Description	Material Composition	Max. Shear Stress •p
5.A	Turf Reinforcement Mat	Turf Reinforcement Mat (TRM) – A rolled erosion control product composed of non-degradable synthetic fibers, filaments, nets, wire mesh and/or other elements, processed into a permanent, three-dimensional matrix of sufficient thickness. TRMs, which may be supplemented with degradable components, are designed to impart immediate erosion protection, enhance vegetation establishment and provide long-term functionality by permanently reinforcing vegetation during and after maturation. Note: TRMs are typically used in hydraulic applications, such as high flow ditches and channels, steep slopes, stream banks, and shorelines, where erosive forces may exceed the limits of natural, unreinforced vegetation or in areas where limited vegetation establishment is anticipated.	6.0 lbs/ft^2 (288 Pa)
5.B	Turf Reinforcement Mat		8.0 lbs/ft^2 (384 Pa)
5.C	Turf Reinforcement Mat		10.0 lbs/ft^2 (480 Pa)

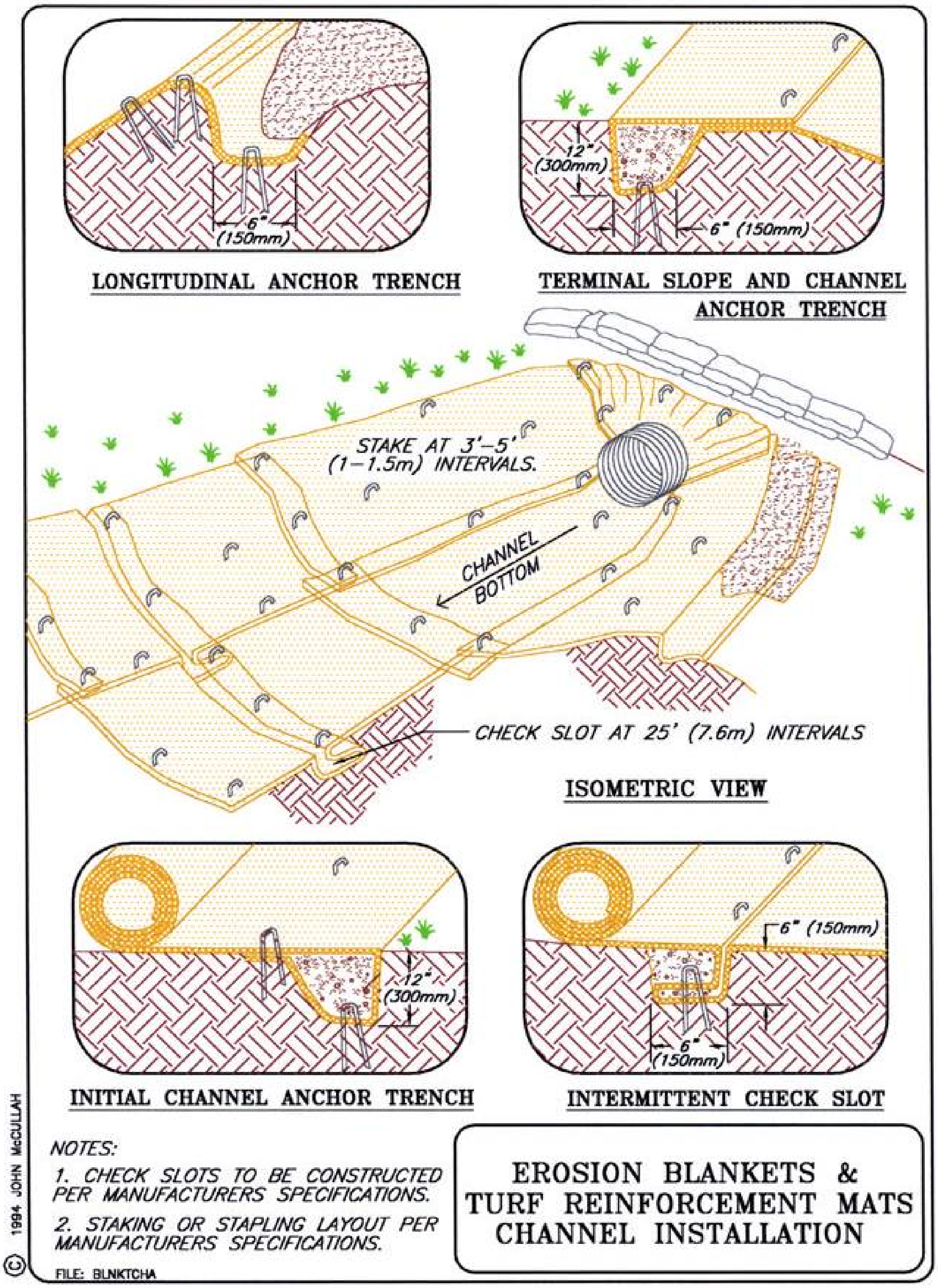


Figure EPP11-1 Blanket Installation Guidance
Kentucky Construction Site BMP Planning and Technical Specifications Manual

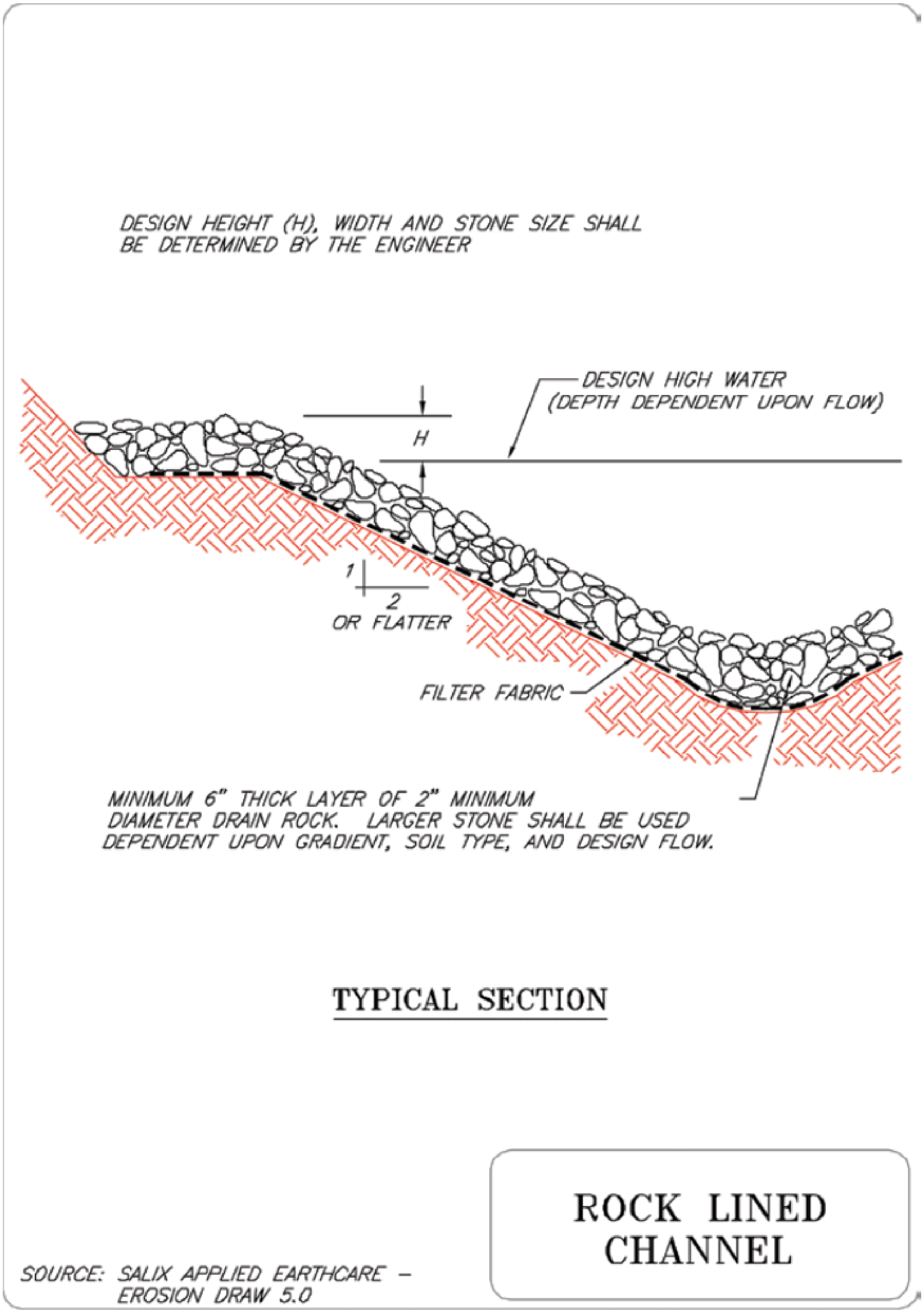


Figure EPP11-2. Rock Lined Channel Detail

Kentucky Construction Site BMP Planning and Technical Specifications Manual

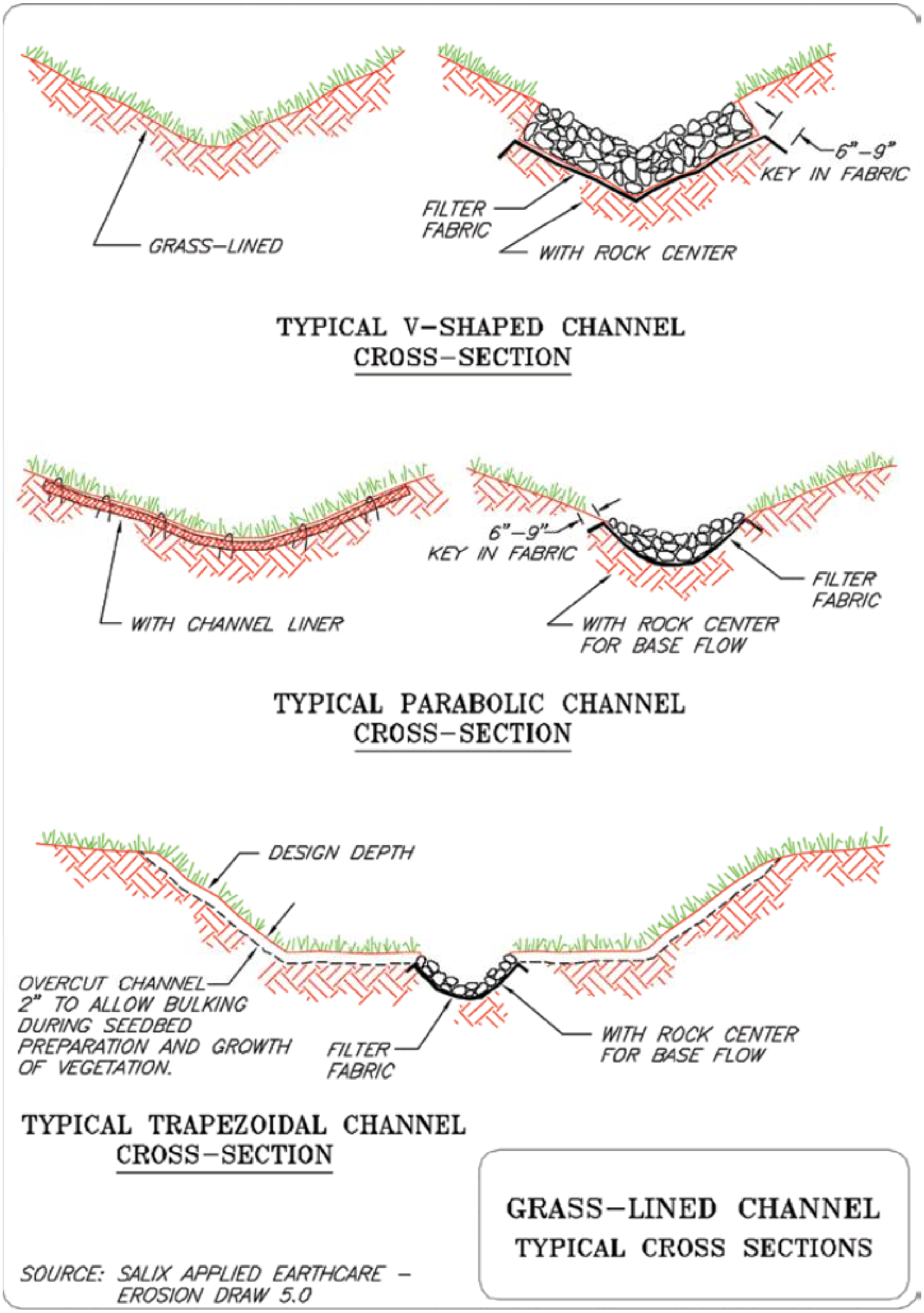


Figure EPP11-3. Typical Cross Sections for Grass Lined Channels
Kentucky Construction Site BMP Planning and Technical Specifications Manual

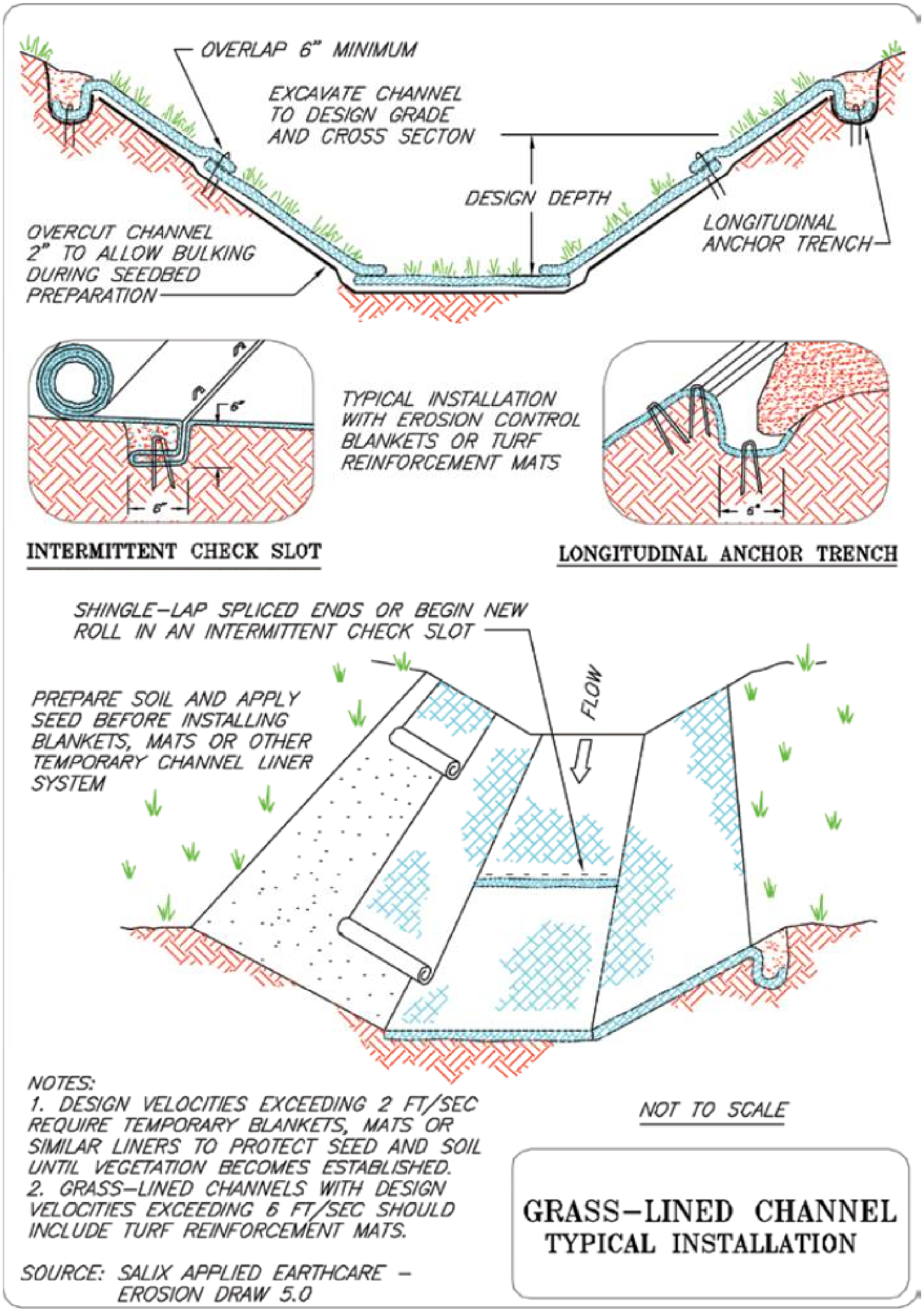
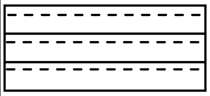


Figure EPP11-4. Erosion Control Blanket Channel Installation

Kentucky Construction BMP Planning and Technical Specifications Manual

Erosion Prevention Practices	EPP-12 ECB on Slopes

 **Symbol**

G

Description

Geotextiles are woven or non-woven fabrics, applied between surfaces or materials, to reduce flow velocities, release runoff as sheet flow, remove some sediment from runoff and are likely to create a significant reduction in sediment. Runoff and pollution caused by construction activities can be prevented or reduced with this BMP.

Application

- Ø Construction sites desiring stability for disturbed soils.
- Ø Sloppy area where anchoring must take place.
- Ø Slopes steeper than 3:1 (H:V), longer than 50 feet and/or where erosion hazard is high.
- Ø Slow growing vegetated areas.
- Ø Critical slopes adjacent to sensitive areas (streams, wetlands, etc.).

Design

Geotextiles provide stabilization, filtration, and separation properties. This BMP may be used when there is a need for separation between two materials or mediums that are likely to otherwise interfere with one another.

- Ø Separating subsoil from aggregate within a subsurface drain.
- Ø Separating subsoil from aggregate placed at the soil surface.
- Ø Stabilization of soil surface during temporary stream diversion.
- Ø Prevent buildup of hydrostatic pressure behind gabions, decorative, or retaining walls.

This BMP does not require design or selection by a professional experienced in geotextile applications. However, if hydrostatic pressure becomes a concern for stability of a retaining wall, then a professional should be consulted.

Design (cont'd)

- Geotextiles should be selected based on the standard specifications detailed in AASHTO M288.

Site Preparation

- Grade and shape area of installation
- Remove all rocks, roots, clods, vegetative, or other obstructions so that the installed blankets or mats will have direct contact with the soil.
- Prepare seedbed by loosening 2-3 inches of topsoil above final grade
- Incorporate amendments, such as lime and fertilizer, into soil according to soil test and the seeding plan.

Seeding

- Seed the area before installing the blanket for erosion control and revegetation (Seeding after mat installation is sometimes specified for turf reinforcement application – check the manufacturer's instructions). When seeding before blanket installation, reseed all check slots and other areas distributed during installation.
- Where soil filling is specified for certain TRMs, seed the matting and the entire disturbed area after installation and before filling the mat with soil. Follow the manufacturer's instructions to ensure proper installation.

Anchoring

- Wire staples should be a minimum of 11 gauge.
- Metal stake pins should be 3/16 inch diameter steel with a 1.5 inch steel washer at the head of the pin.
- Wire staples and metal stakes should be driven flush to the soil surface.
- All anchors should be 6-8 inches long and have sufficient ground penetration to resist pullout. Longer anchors might be required for loose soils.
- Use biodegradable composite or wooden stakes where dislodged metal staples might cause extreme hazards, such as near airport runways or areas where future mowing might cause risk.

Installation

- Begin at the top of the slope and anchor the blanket in a 6 inch deep by 6 inch wide trench. Backfill trench and tamp earth firmly.
- Unroll blanket downslope in the direction of water flow.
- The edges of adjacent parallel rolls mush be overlapped at least 3 inches and be stapled through the overlapped area at least every 3 feet on slopes less than 4H:1V and every two feet on steeper slopes.
- When blankets must be spliced, place uphill blanket end over downhill blanket (shingle style) with 6-inch overlap. Staple through overlapped area, approximately 12 inches apart.
- Lay blankets and mats loosely and maintain direct contact with the soil – do not stretch. Ensure good, consistent, direct soil contact.

Installation (cont'd)

- Ø ECB's and TRM's must be stapled sufficiently to anchor the blanket and maintain contact with the soil. Staples must be placed down the center and staggered with the staples placed along the edges. Steep slopes (1H:1V to 2H:1V) require at least two staples per square yard. Moderate slopes (2H:1V to 3H:1V) require 1-2 staples per square yard (1 staple every 3 feet on center). Flatter slopes require one staple per square yard.

Maintenance

- Ø Inspection to occur periodically, if any portion of the material is damaged, immediate correction is required.
- Ø Inspections may occur prior to any anticipated wet weather events.
- Ø Inspection to occur after significant rain storms to check for erosion and undermining.
- Ø Repairs to the slope and re-installation should occur as a result of wash-out or breakage.
- Ø Perform maintenance as required by the manufacturer.

Inspection

- q Site is adequately prepared (grading or shaping, rocks, vegetation and debris removal, etc.).
- q Seeding meets geotextile requirements.
- q Anchoring is established at an acceptable depth.
- q Anchoring trenches are used at the top and bottom of slopes.
- q Trenches start, join and terminate geotextiles placed in channels.
- q Soil filling is even and flat.

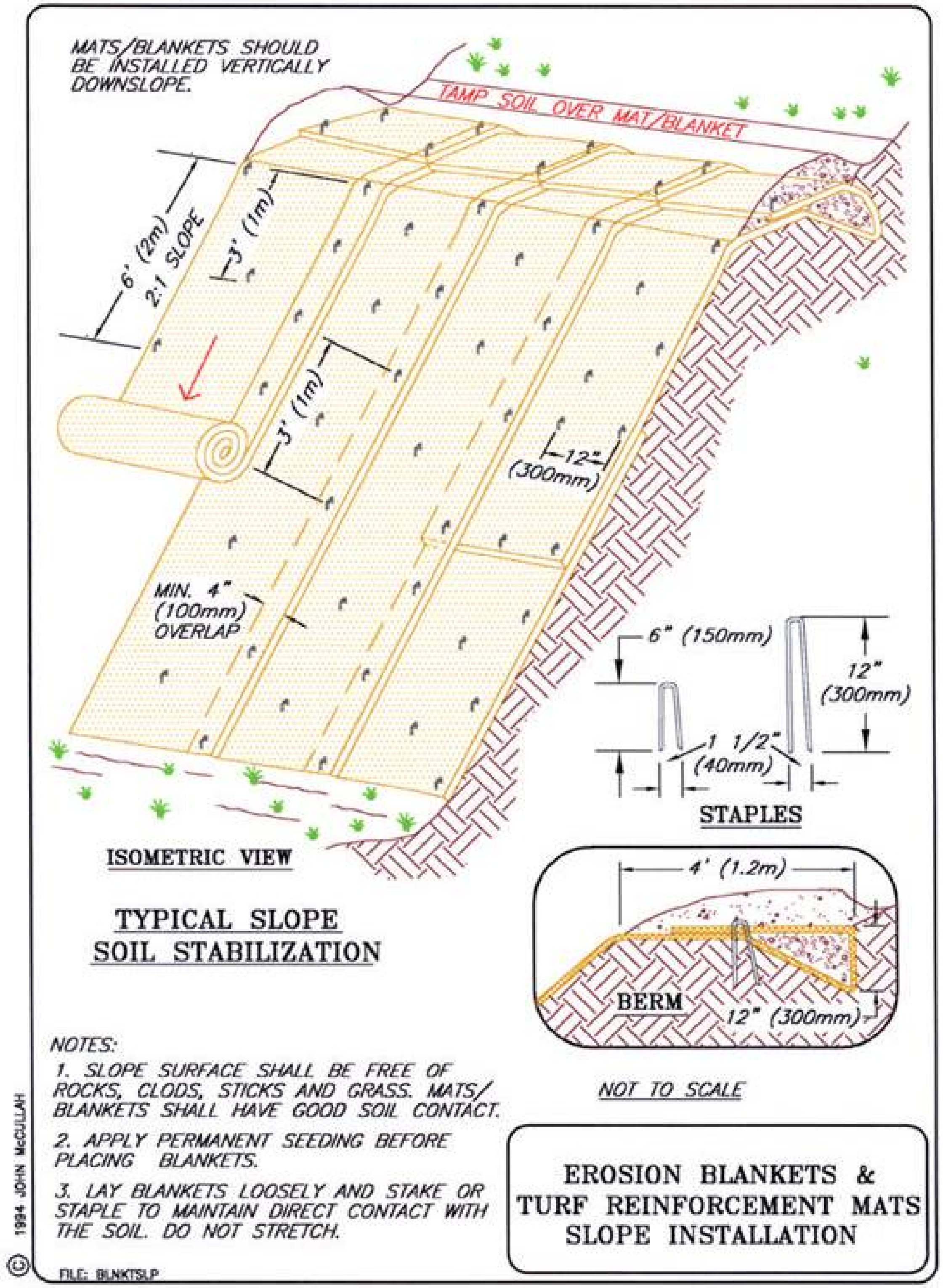


Figure EPP12-1 ECBs Installed on Slopes
Kentucky Construction Site BMP Planning and Technical Specifications Manual

Erosion Prevention Practices	EPP-13 Terracing

T Symbol

T

Description

This BMP is likely to reduce sediment by creating small areas to establish vegetation to reduce runoff velocity, increase infiltration and trap sediment. This reduces the amount of sediment leaving a site.

Application

- Cleared areas prior to temporary or permanent seeding and planting or erodible slopes steeper than 3:1 (H:V) and higher than 5 feet.
- Graded areas with smooth, hard surfaces.
- Areas where slopes need to be shortened. Adequate drainage and stabilized outlets must be a part of the design and should follow the guidelines of a licensed professional civil engineer based on site conditions.

Design

Slope roughening/terracing is performed in several ways:

- Stair-step grading
- EPP-08
- Rough grading
- No grading

On slope 3:1 (H:V) the following practices found in EPP-08 can be considered:
- Grooving
- Furrowing
- Tracking

Maintenance	Ø	Periodically check the seeded or planted slopes for rills and washes, particularly after significant storm events greater than 0.5 in. (12 mm). Fill these areas slightly above the original grade, then re-seed and mulch as soon as possible.
	Ø	Inspect roughened slopes weekly and after rainfall for excessive erosion.
Inspection Checklist	q	Furrows at least 6 in. deep.
	q	Furrows are spaced no more than 50 ft. apart.
	q	Horizontal distance is greater than vertical distance on stepped slopes.
	q	Stepped slopes or terraced slopes cut so that they drain in on themselves.

Erosion Prevention Practices

EPP-14 Check Dams

Symbol

CD

Description

Check dam are use to reduce the velocity of concentrated stormwater flows, small temporary constructions are built across swale or drainage ditch. Check dams reduce erosion and promotes sedimentation within the ditch line.

Application

- Check dams are **not** to be used in streams and rivers. However, should be used in swales or ditch lines.
- Check dams are a temporary or permanent means of protection against erosion during the establishment of vegetative lining.
- Installation of erosion-resistant lining is not practical to use for short length of service for temporary ditches or channels.

Design

The following design criteria should be used:

- **Drainage Areas**: Stone check dam (1 acre or less), Rock check dam (5 acres or less) Check dams must be limited to use in small, open ditches that drain 10 acres or less. Straw bales are not to be used as check dams because of high failure rates.
- **Spacing**: Two or more check dams should be used for areas greater than one acre. The maximum spacing should be determined by keeping the toe of the upstream dam equal to the spill-over elevation of the downstream dam (See Table SMP-01-01 or attached nomograph).
- **Dimensions:** All check dams should be 24" or less in height. The maximum height is 3 feet above the ground on which the rock is placed. The overflow point should be at least 6" lower than the outer edges. Front and back slopes shall be 2:1. The designer should take into consideration potential impacts due to impounded water (see Detail SMP-01).
- **Key-in:** Rock check dams should utilize a 6" key-in technique to aid in stabilization during peak flows.

Design (cont'd)

- Check dams for larger projects with greater slopes and wider drainage swales can be constructed of trees and brush cleared from the site, gabions, large rock, or other materials. Design and structural stability requirements for these applications, which can have significant benefits, are very site specific.
- Stone check dams must be constructed of KYTC Class 2 channel lining. Fiber bags filled with gravel are also acceptable. Bags should be of woven-type geotextile fabric because burlap or cloth bags deteriorate rapidly. The fiber bags must be filled with three-quarter inch drain rock or one-quarter inch pea gravel. Fill fiber bags just over halfway, so they can be packed tightly together without large gaps.
- Commercial products such as fiber rolls, sediment dikes, and sediment fencing can be used in seeded lined (or mulched) swales with bottoms not less than 4 feet wide and slopes not more than 3 percent, if appropriate. Follow the manufacturer's instructions for placement, staking, and maintenance. Applications in areas that exceed these parameters must be consistent with product design and performance information.
- Stone must be placed by hand or mechanically as necessary to achieve complete coverage of the ditch bottom and banks and to ensure that the center of the check dam is at least 6 inches lower than the outer edges.
- Gravel bag check dams must be placed in the ditch or channel by hand, with the tied ends of the bags pointing upstream and the center overflow area at least 6 inches lower than the outer edges.
- For all check dams, ensure that the higher elevation outer sidewalls tie into the upper portion of the ditch or channel bank to prevent bypasses.
- If stone check dams are used in grass-lined channels that will be mowed, take care to remove all stone from the channel when the dam is removed. This includes any stone that has washed downstream.

Design (cont'd)

Table EPP14-1. Check Dam Spacing

Ditch slope	Silt check dam spacing	Additional information
30%	10 ft.	Calculated for 3' high silt check dams.
20%	15 ft.	
15%	20 ft.	
10%	35 ft.	Center of dam should be 6" lower than sides
5%	55 ft.	
3%	100 ft.	
2%	150 ft.	Use 5" – 10" rock, stone bags, or commercial products.
1%	300 ft.	
0.5%	600 ft.	

Table EPP14-2. Rock Sizing for Check Dams

Flow Velocity	Average Rock Diameter
6 ft. per second	5 inches
8 ft. per second	10 inches
10 ft. per second	14 inches
12 ft. per second	20 inches

Maintenance

- Ø Sediment shall be removed before it reached one-half of the devices original height.
- Ø Any lose or displaced stone should be repaired to the original specifications.
- Ø Erosion caused by high flows around the edges of the dam must be corrected immediately, and the dam must be extended upward beyond the repaired area.

Inspection

- q Stone meets specified sizes.
- q Center of dam is lower than the edges.
- q Check dam spans the entire width of the channel.
- q Dimensions/elevations are as specified.
- q Filter fabric on upstream face is keyed into the bed (if applicable).
- q Check dams are to be removed when vegetation is stabilized, or up to 30 days after the permanent site stabilization is achieved.
- q Inspect check dams for sediment accumulation weekly.
- q Sediment is maintained less than one-half of the original height.
- q Sites with rain accumulation of 0.5" should be checked within 24 hours.

Inspection (cont'd)

- In temporary ditches and swales, check dams must be removed and the ditch filled in when it is no longer needed.
- In permanent channels, check dams must be removed when a permanent lining can be installed.
- In the case of grass-lined ditches, check dams must be removed when the grass has matured sufficiently to protect the ditch or swale.
- The area beneath the check dams must be seeded and mulched or sodded (depending on velocity) immediately after check dams are removed.

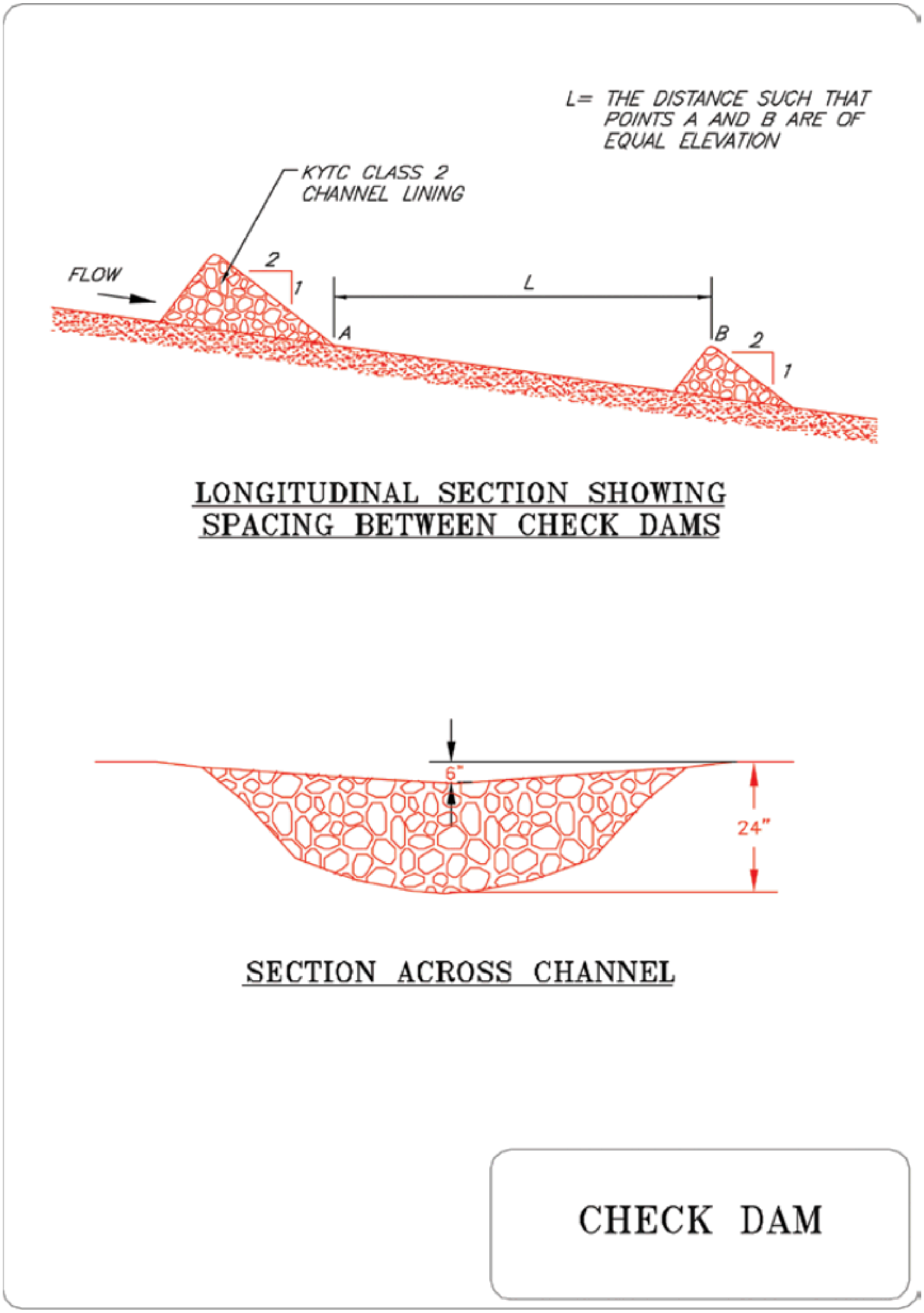


Figure EPP14-1 Check Dam Detail
Kentucky Construction Site BMP Planning and Technical Specifications Manual

Erosion Prevention Practices	EPP-15 Bank Stabilization

Symbol

BS

Description Bank stabilization is used to reduce erosion from stream banks by providing protective cover through the use of vegetation and other methods.

Application

- Ø Bank stabilization practices are used for stream banks susceptible to erosion, locations with high flow rate that are subject to produce erosion, and/or actively eroding stream banks.
- Ø Due to the nature of these practices additional permitting through the state of other agencies may be required.
- Ø Bank stabilization practices should be designed by a Professional Engineer licensed in the Commonwealth of Kentucky.

Design

- Ø Structural measures such as retaining walls, gabions, rip-rap or interlocking blocks.

Structural practices are used for projects in which a quick stabilization of stream banks is required. Generally speaking, these practices are more costly than bioengineer solutions. However, they usually require less maintenance than bioengineering measures.

- Ø Bioengineering methods are commonly used for this purpose. These methods generally take longer to establish stabilization. However, they can be quite effective and economical to implement. As with any vegetative practice, careful selection of materials, installation, and maintenance is necessary to be effective.

Design (cont'd)

Several methods of Bioengineering solution are listed as follows:

Live Stake

Live stakes are the insertion of live, rootable vegetative cuttings into the ground. Live stakes are an appropriate technique for repair of small earth slumps that are frequently wet. Or they can be used to supplement other types of bank stabilization plantings. Live stakes can also be installed through existing riprap or other aggregate materials, allowing a stabilized riprap location to eventually have natural vegetation.

Live stakes can be specified for streambanks with slopes of 3H:1V or flatter. Steeper slopes will require grooving or benching and ECBs that can withstand expected shear stresses. The following table shows recorded shear stress withstood by live staking.

Table EPP15-1. Bank Materials and Shear Stress Limits (Live Stakes)

Bank Material	Shear (lb/ft^2)
Live stakes in riprap (immediately after construction)	2.04
Live stakes in riprap (after 3-4 seasons)	6.12
Coarse gravel and stone cover with live cuttings (immediately after construction)	1.02
Coarse gravel and stone cover with live cuttings (after 3-4 seasons)	5.1
Willow cuttings / willow stakes	2.1

Source: Salix Applied Earthcare – Erosion Draw 5.0

Live stakes are usually 0.5 to 1.5 inches in diameter and approximately 2 to 3 feet in length. Typical spacing is 2 to 3 feet apart. The basal end (or root) is cut to an angled point for easy insertion. The top should be cut square. Willow branches have historically been specified for use as live stakes and are well-suited to the purpose. Other types of tree branches may be selected, depending on soil type and available moisture conditions, such as ash, alder, elm or dogwood.

Gently tamp the live stake into the ground at right angles to the slope. Approximately 80 percent of the live stake length should be installed into the ground. Pack soil firmly around live stake after installation. Do not split the stakes during installation; stakes that split should be removed and replaced. An iron bar can be helpful in establishing a pilot hole for the live stake.

- Live stake harvest and installation should be performed during the dormant season, late fall to early spring.
- Use site reconnaissance to identify willow species, growth form, soil and site conditions on adjacent sites and compare their conditions to the construction site. Planting will be more successful as soil, site and species selected match stable, vegetated nearby sites.
- If native willows are not found in the vicinity, live staking might not be a good option.
- Choose plant material adapted to the site conditions and confirm the availability of plant material that will be used on site before construction begins.

Design (cont'd)

- Stakes must be harvested and planted when the willows (or other chosen species) are dormant. This period is generally from late fall to early spring or before the buds start to break.
- When harvesting cuttings, select healthy, live wood that is reasonably straight. Harvest live wood at least one-year-old or older. Avoid suckers of the current year's growth because they lack sufficient stored energy reserves to sprout consistently. The best wood is 2-5 years old with smooth bark that is not deeply furrowed.
- Stakes should be cut so that a terminal bud scar is within 1-4 inches of the top. At least two buds of bud scars must be above the ground after planting.
- Cuttings should generally be three-quarters of an inch in diameter or larger depending on the species, and 2 to 3 feet in length. Highest survival rates are obtained from using cuttings 2-3 inches in diameter. Larger diameter cuttings are needed for planting into rock riprap. Cuttings of small diameter stock (up to 1.5 inches) must be 18 inches long minimum. Thicker cuttings should be longer.
- Make clean cuts with unsplit ends. Trim branches from cutting as close as possible. The butt end (i.e. end closest to the ground) of the cutting must be pointed or angled and the top end (away from the soil) must be cut square, to aid in soil penetration, tamping, and knowing which end is up.
- The top, square cut can be painted and sealed by dipping the top 1-2 inches into a 50-50 mix of light colored latex paint and water. Sealing the top of the stake will reduce the possibility of desiccation and disease, assure the stakes are planted with the top up, and make the stakes more visible for subsequent planting evaluations.
- Install live stakes only on streambanks that have been graded and prepared for planting. ECB installation is strongly recommended for bank areas below the 2-year peak flow line; ECBs are recommended for upper portions of the bank. Stone toe protection is recommended for the toe of the slope at the waterline.
- Stakes must not be allowed to dry out. The cuttings should be installed the same day they are harvested. If this is not possible, they should be soaked in water for a minimum of 24 hours. Stakes can be stored outdoors for a few days in a cool place under damp straw. For longer storage, refrigerate (do not freeze), keep moist, and use as soon as possible.
- Use an iron stake, bar, or other suitable instrument to make a pilot hole in firm soil.
- Plant stakes 1-3 feet apart, closer on steeper slopes and on the outside of bends, farther apart on flatter slopes and the inside of bends.
- No less than one-half of total length must be in the ground. Set the stake as deep as possible in the soil, preferably with 80 percent of its length into the soil and in contact with midsummer water table.
- It is essential to have good contact between the stake and soil for roots to sprout. Tamp the soil around the cutting. Do not damage the buds, strip the bark, or split the stake during installation. Split or damaged stakes must be removed and replaced.
- Stakes must be planted with butt-ends into the ground. Leaf bud scars or emerging buds should always point up.
- Use TRMs for temporary protection until stakes are established and to protect any bare areas.

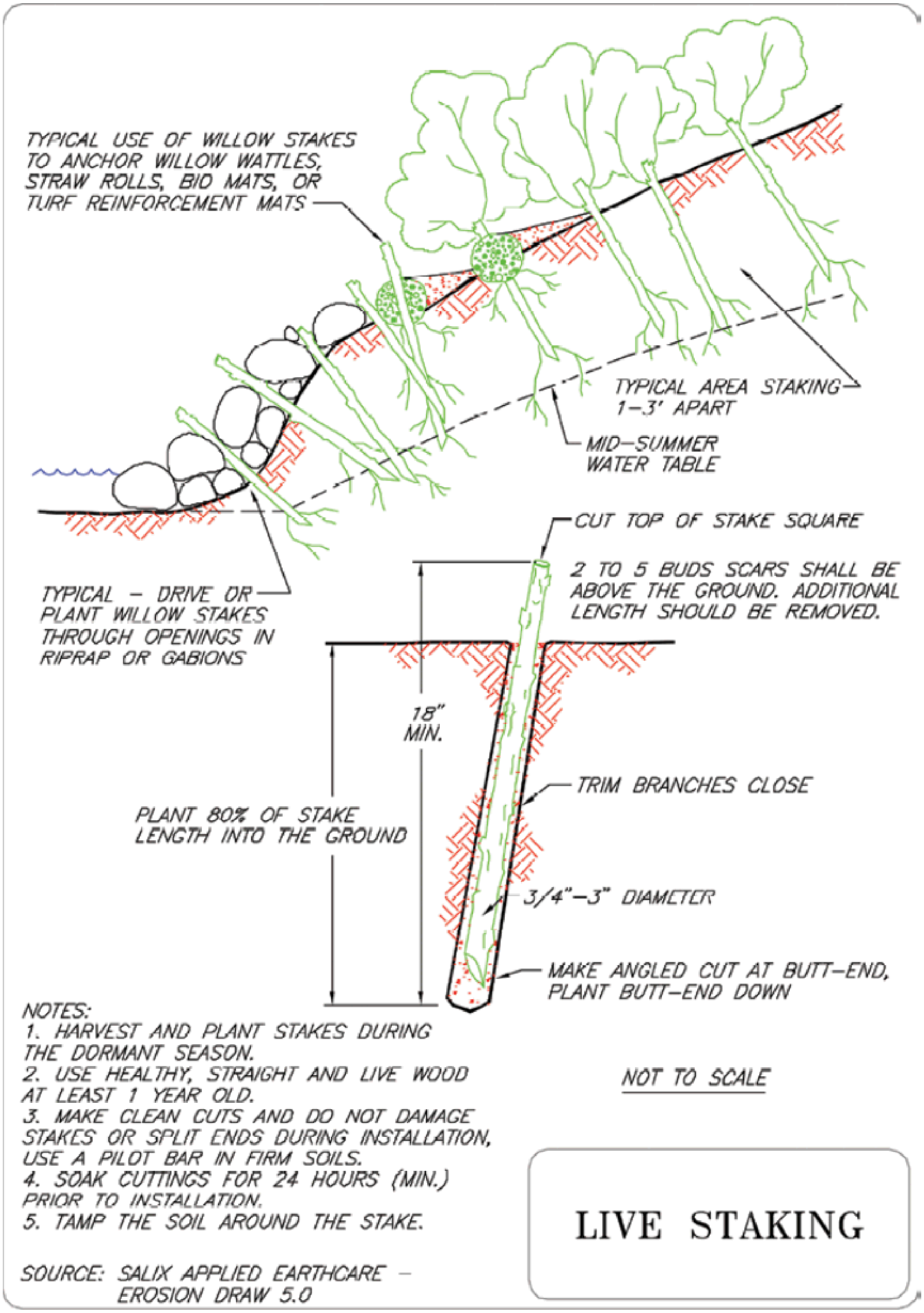


Figure EPP 15-1. Live Staking Installation Details
Kentucky Construction Site BMP Planning and Technical Specifications Manual

Design (cont'd) **Live Fascine**

A fascine is defined as a bundle of sticks or branches, tied together and used for a definite purpose such as preparing a primitive house, fort, or other structure. A live fascine is defined as a bundle containing live branch cuttings bound together into sausage-like structures, and then placed to provide slope stability or prevent erosion. Cuttings must be harvested and planted when the willows, or other chosen species, are dormant. This period is generally from late fall to early spring.

Live branch cuttings should be from species that easily root and have long, straight branches with a minimum length of 3 feet and maximum diameter of 1.5 inches. A portion (up to 50 percent) of the bundle can be of material that does not root easily or dead material. Cuttings are tied together to form live fascine bundles that vary in length from 6 to 30 feet, depending on site conditions and limitations in handling. The completed bundles should be 6 to 12 inches in diameter, with the growing tips and butt ends oriented in alternating directions. Stagger the cuttings in the bundles so that tops are evenly distributed throughout the length of the uniformly sized live fascine.

- Wattle bundles must be compressed and tightly tied with rope or twine of sufficient strength and durability. Polypropylene tree rope approximately 3/16 inch in diameter provides the necessary strength and durability.
- Wattle bundles must be tied 12-15 inches apart.
- For optimum success, wattles should be pre-soaked for 24 hours or installed on the same day they are harvested and prepared. The wattles should be installed within 2 days after harvest unless pre-soaked. Wattles must be stored in the shade and under cover or under water. They are live material and should be treated as such.

Perform any slope repairs, such as gully repair, slope scaling, diversion dike, gabion, or toe wall construction, before installing the wattle. Both live stakes and dead stakes are used to install fascine bundles. Stakes should be at least 2.5 feet long on cut slopes and at least 3 feet long on fill slopes. Dead stakes can be constructed from untreated 2x4 lumber with a minimum length of 2.5 feet. A diagonal cut across the 2x4 lumber will assist in creating stakes quickly.

Prepare the live fascine bundles and live stakes immediately before installation.
Begin at the base of the slope and work upwards. Dig a trench along a level contour just deep enough to contain the live fascine bundle. Place the wattles immediately after trenching to reduce the desiccation of the soil. A typical trench size is 12 to 18 inches across and also 6 to 8 inches deep. Place the live fascine bundle into the trench.

Drive dead stakes directly through the bundle every 2 to 3 feet to securely fasten it. Overlap the tapered ends of adjacent wattles so the overall wattle thickness is uniform. Two stakes must be used at each bundle overlap such that a stake can be driven between the last two ties of each wattle. Leave the top of stakes flush with the installed bundle. Live stakes are generally installed on the downslope side of the bundle. Drive the live stakes below and against the bundle between the previously installed dead stout stakes. The live stakes should protrude 2 to 3 inches above the top of the live fascine and should be located no more than 3 feet apart. Place moist soil along the sides of the live fascine. The top of the fascine should be slightly visible when the installation is completed as shown in Figure EPP15-1.

Design (cont'd) Proper backfilling is essential to the successful rooting of wattles. Backfill wattles with soil from the slope or trench above. The backfill must be worked into the wattle interstices and compacted behind and below the bundle by walking on and working from its wattling terrace. Repeat the preceding steps for each row, up to the top of the slope. Plant the slope with other vegetation (e.g., live stakes, tree seedlings) as specified. Seen and mulch slope. Shallow slopes, generally 3:1 or flatter can be seeded and mulched by hand. Steeper slopes should have seed applied hydraulically, and the mulch must be anchored with tackifier or other approved methods if TRMs are not used.

Place straw or similar mulching material between rows. Slopes steeper than 3:1 may need erosion control matting or some type of mesh to prevent erosion. Recommended maximum slope lengths for live fascine bundles are:

Table EPP15-2. Recommended Max Slope Lengths for Fascine Bundles

Slope	Slope distance between wattles (feet)	Recommended maximum slope length (feet)
1:1 to 1.5:1	3-4	15
1.5:1 to 2:1	4-5	20
2:1 to 2.5:1	5-6	30
2.5:1 to 4:1	6-8	40
3.5:1 to 4:1	8-12	50
4.5:1 to 5:1	10-20	60

Source: Salix Applied Earthcare – Erosion Draw 5.0

A willow mattress (also called a brush mattress) is similar to a fascine roll. Willow branches and cuttings are formed into a layered arrangement approximately 4 to 6 inches thick and then tied with twine or string. Excavate an anchor trench along the bottom of the willow mattress to a depth of 3 inches, to prevent downhill sliding. Loosen the subgrade soil throughout the mattress installation location; add lime and slow-release fertilizer as needed. A willow mattress is anchored onto a slope by using dead stout stakes and twine. Place 4 to 6 inches of fertile soil upon the willow mattress and tamp firmly.

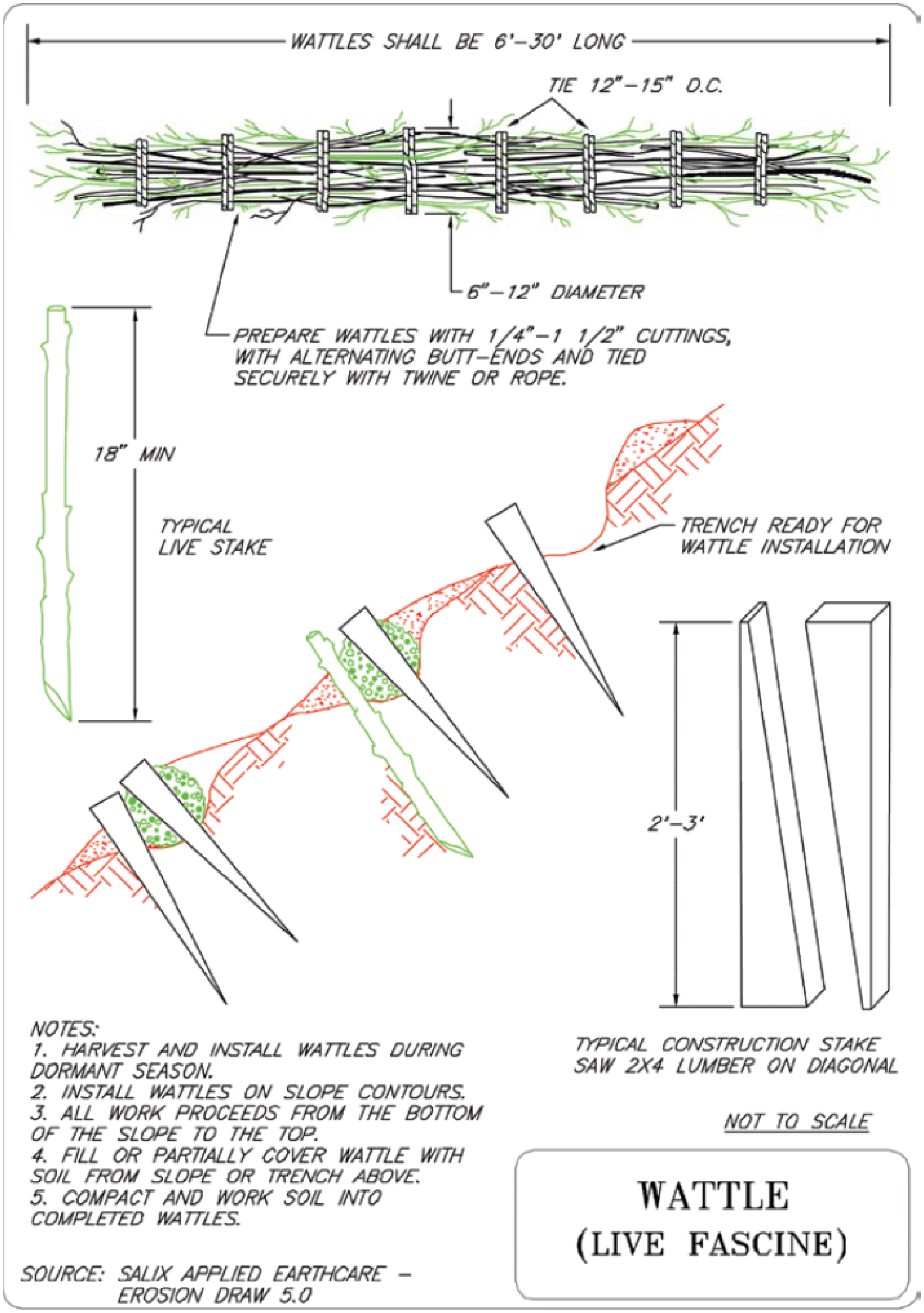


Figure EPP15-2. Wattle Installation Guidance

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Design (cont'd)

Branchpacking

Branchpacking consists of alternating layers of live branch cuttings and compacted backfill to create bank stabilization vegetation. It is often used to repair small localized slumps, gully washouts, or other small areas where the slope needs to be stabilized. Branchpacking can also be adapted as a method for planting an entire slope (see description below for brushlayering).

- Plant material harvest and installation should be performed during the dormant season, late fall to early spring.
- Use site reconnaissance to identify willow or other species, growth form, soil and site conditions on adjacent sites and compare their condition to the construction site. Planting will be more successful as the soil, site conditions and species selected match stable and vegetated nearby sites. Choose plant material adapted to the site conditions and confirm the availability of the plant material that will be used on site before construction begins.
- The ideal plant materials are those that (1) root easity; (2) are long, straight and flexible; and (3) are in plentiful supply near the job site. Will makes ideal material.
- When choosing live willow material for bioengineering applications, remember that young (less than one year old) wood or suckers will often sprout easier under optimum conditions but healthy, older wood (1 to 4 years) has greater vegetative (energy) reserves necessary to consistently sprout, and the older wood is much stronger. If possible, mix younger wood with older wood for the bioengineering application so that a majority of the material is 1-4 years old.
- Willows have several different growth forms – from shrubs to large trees. Small-to-medium sized shrub-type and rhizomatous or creeping-type willows are used for planning channel banks. Upland willow species are found in relatively dry areas and should be used on similar sites. Tree-type willows are selected for the upper bank and floodplain area.
- If branch cuttings are not pre-soaked for at least 24 hours, then they must be harvested no earlier than 48 hours before installation. Cuttings must be kept moist and cool at all times between cutting and installation. All cuttings need to be thoroughly wet and covered with moistened wrapping before being transported.

Live branch cuttings may range from 1/2 inch to 2 inches in diameter. Cuttings should be long enough to touch the undisturbed soil at the back of the trench. Wooden stakes (typically made from 2x4 lumber, untreated) are 5 feet or longer, depending on the depth of the hole and field conditions. Starting at the lowest point, drive the wooden stakes vertically 3 to 4 feet into the ground, at a typical spacing of 1 to 2 feet apart.

Design (cont'd)

Place a 6-inch layer of live branch cuttings in the bottom of the hole or trench, between the vertical stakes and perpendicular to the slope face (as shown in Figure EPP15-2). Cuttings should be placed in a crisscross configuration with the growing tips generally oriented toward the slope face. Most branch basal ends should touch the back of the hole or slope. Each layer of branches is followed by a layer of compacted soil, typically 6 to 8 inches thick, to ensure soil contact with the branch cuttings. Final grade should match the existing slope, and branches should protrude slightly from the filled face. The soil should be moist so that the live branch cuttings do not dry out.

Branchpacking may not be effective in slumped areas or gullies which are greater than 5 feet wide. Examine the slope closely to determine the cause of slumped areas and gullies. Wet soils, inadequate drainage, excessive stormwater runoff or other site conditions may require additional solutions.

- Make repairs when necessary.

Bushlayering

Brushlayering is a variation of branchpacking suitable for gentle slopes with only a moderate potential for erosion. The live branch cuttings are oriented perpendicular (up and down) to the slope level contours, installed in a trench or cut slope, and then covered with soil as before. The difference is that the soil for each downhill trench comes from the next excavated trench immediately uphill. The presence of branch cuttings in the soil will limit the amount of compaction that can be obtained on a slope, so that additional erosion control measures may be necessary. Straw mulch, temporary seeding, jute mesh and erosion control mats may be necessary, particularly for slopes steeper than 3:1 Slopes steeper than 4H:1V will require turf reinforcement mats below the 2-year peak flow line. Avoid slopes steeper than 2:1 and generally limit slope lengths to 20 feet or less. Reinforced earth design guidelines suggest that the slope height should not exceede three times the width of reinforced volume. Therefore, for brushlayering with 6-8 foot long cuttings, the slope height should not exceed 18-24 feet.

- Construction personnel must be made aware that brushlayering uses live plant material and must be treated as such.
- Spacing between the brush layers is determined by the erosion potential of the slope (i.e. soil type, rainfall, and length and steepness of the slope). Spacing can be from 3 to 8 feet. On long slopes, brushlayer spacing should be closer at the bottom and spacing can increase near the top of the slope.

Table EPP15-3. Brush Materials and Shear Stress Limits (Brush Layers)

Brush Matierial	Shear (lb/ft^2)
Willow brushlayer (immediately after construction)	.41
Willow brushlayer (after 3-4 seasons)	2.86
Willow cuttings / willow stakes	2.1

Source: Salix Applied Earthcare – Erosion 5.0

Design (cont'd)

- Branch cuttings must be 4-8 feet long, ¾-2 inches diameter. Presoak cuttings for a minimum of 24 hours before installing.
- Complete grading and other work on streambank slopes. Install rock or other toe protection if specified in construction plans. Prepare first (lowest elevation) bench, removing soil or using it to backfill toe protection zone. The surface of the bench must be sloped so the outside (near stream) edge is higher than the inside (bank) edge, so that the butt ends of the cuttings angle down slightly into the slope.
- Place branch cuttings, 3-8 inches thick, in a crisscross or over lapping configuration. The growing tips must protrude 6-12 inches from the slope face with the butt end dipping into the slope.
- Immediately cover brushlayer with 6 inches of fill soil and compact according to construction specifications. For ease of installation, use soil excavated from the bench immediately upslope to cover cuttings placed in the lower bench excavations. Water the soil cover immediately to wet the cuttings and achieve adequate compaction.
- Earth moving equipment must not travel directly over the cuttings. Six inches of soil must be maintained between the brushlayer and equipment at all times.
- Fill and compact the soil placed above the brushlayer in successive lifts, maximum 6-8 inches deep. Install the next brushlayer 3-8 feet above the previous row.
- Seed and mulch the slope, or install erosion control blanket or turn reinforcement mat as needed. Shallow slopes, generally 3:1 or flatter might be seeded and mulched by hand. Steeper slopes should have seed applied hydraulically, and the mulch must be anchored with tackifier or other approved methods if TRMs are not used.

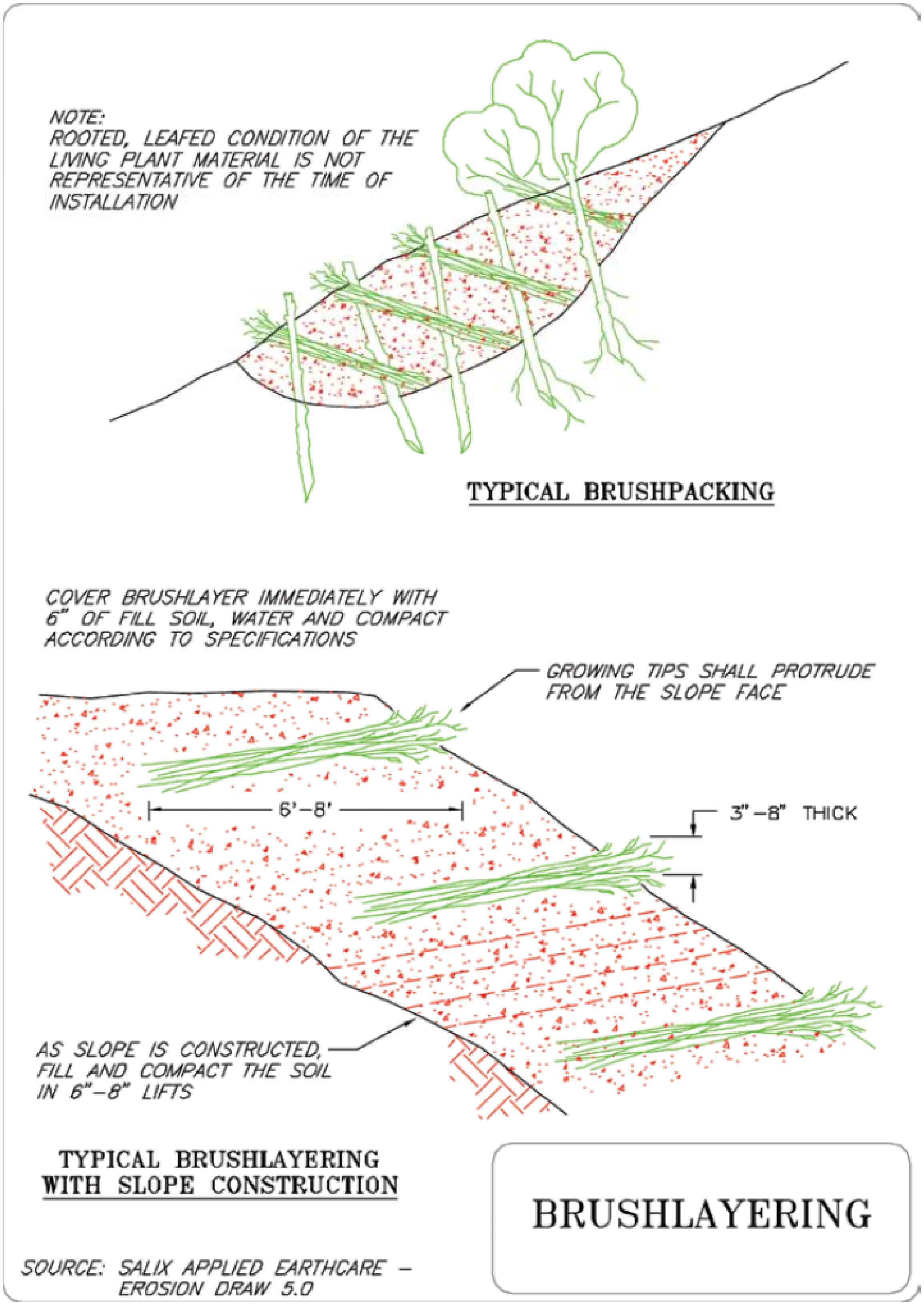


Figure EPP15-3. Brushlayering Detail
Kentucky Construction Site BMP Planning and Technical Specifications Manual

Design (cont'd)

Vegetative Crib Walls

A crib wall is a hollow, box-like, interlocking arrangement of structural members to create a retaining wall. A retaining wall is an engineered structure, with calculated loads and stresses used for the material selection and design. Crib walls made from prefabricated metal or reinforced concrete beams can be designed as very tall retaining walls that can handle large surcharge loads and traffic impacts; these types of crib walls must be designed by a professional engineer. Crib walls are filled with compacted soil or gravel, with provisions for subsurface drainage.

Adding vegetation may or may not affect structural stability of a retaining wall in the future. It would certainly affect large structural crib walls, but should not impact small crib walls such as the type shown in Figure SMP-06-03 for a relatively short height using untreated logs or timber. The structure is filled with suitable backfill material and layers of live branch cuttings which will root inside the crib structure and extend upward into the slope or outward into the wall face. This technique is appropriate at the base of a slope where a low wall may be required to stabilize the toe.

Live branch cuttings should be long enough to reach the back of the wooden crib structure. Logs or timbers are usually 6 inches in diameter or thickness. Large nails or rebar are required to secure the logs or timbers together. Place foundation of wall 2 to 3 feet below grade, as shown on Figure SMP-06-03.

Place the first course of logs or timbers at the front and back of the excavated foundation, approximately 4 to 5 feet apart. Place the second course of logs or timbers at right angles (perpendicular to the slope) on top of the previous course to overhang the front and back of the previous course by 3 to 6 inches. Repeat course in same manner and nail to the preceding course with nails or reinforcement bars. When the crib wall structure reaches the existing ground elevation, place live branch cuttings on the backfill perpendicular to the slope. Then cover the branch cuttings using fertile soil as backfill and compact firmly.

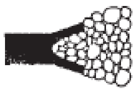
Maintenance

- Ø Inspect structure before and after rainfalls.
- Ø Make repairs when necessary.
- Ø Replace live stakes that do not sprout after 45 days if possible, or wait until the following dormant season to harvest and replant.Periodic repair and maintenance will be required during the first 2 years or until the vegetation is established.

Inspection

- q Licensed Professional Engineer's stamp is clearly placed on plans in order to construct the appropriate retention structure.
- q Changes to site conditions have been transmitted for review by the Project Engineer.

Erosion Prevention Practices	EPP-16 Outlet Protection



Symbol

TOP

Description This protection outlet is constructed of rock, grouted rip-rap or concrete rubble. This practice prevents scour of the soil due to high pipe flow velocities. The dissipation of flow energy to produce non-erosive velocities is also a function of this BMP.

Application

- Areas where culverts, conduits or channels are sufficient to erode the immediate downstream reach.
- Outlets of pipes, drains, culverts, conduits, channels, locations at the bottom of mild to steep slopes, outlets of which carry continuous flows of water, short intense flows of water, lined conveyances discharge to unlined conveyance
- A sediment trap is recommended if runoff is sediment laden
- Do not use grouted rip-rap during freezing, which will cause grout to break

Design

- Should be designed and sized by a licensed professional as a part of the culvert, conduit or channel design.
- Apply a rip-rap apron for temporary use during construction. Ensure that riprap consists of a well-graded mixture of stone. Larger stone should be predominant, with sufficient smaller sizes to fill the voids between the stones. The diameter of the largest stone size should be no greater than 1.5 times the d50 size.
- Apron should consist of a zero grade, alignment with receiving stream. Avoid damaging the underlain filter fabric. Keep apron straight throughout the length of the stream, curving in the upper section of the harpoon if curve is needed. Bank reinforcement should be downstream to account for the curved apron.
- Sizing for average rock diameter and apron dimensions are found in Table EPP16-1 and EPP16-2..

Design (cont'd)

- Capacity – Design dissipaters to handle the 10-year, 24-hour peak flow event
- Tailwater Depth – Determine the depth of the tail water immediately below the pipe outlet based on the design discharge plus other contributing flows. If the tailwater depth is less than half the diameter of the outlet pipe and the receiving stream is sufficiently wide to accept the divergence flow, it is classified as a minimum tailwater condition. If the tailwater depth is greater than half the pipe diameter, it is classified as a maximum tailwater condition. Pipes that outlet onto broad flat areas with no defined channel may be assumed to have a minimum tailwater condition unless site conditions indicate otherwise.
- Thickness - The minimum thickness of riprap must be 1.5 times the maximum stone diameter.
- Stone quality – Select stone for riprap from fieldstone or quarry stone. The stone should be hard, angular, and highly weather-resistant. The specific gravity of the individual stones should be at least 2.5.
- Filter – Install a non-woven geotextile liner (filter) under the rock to prevent soil movement through the openings in the riprap. Geotextile underliners for rock outlet energy dissiptors are highly recommended to prevent erosion and undermining of the dissipator. Specify non-woven fabric tailored to the strength needed to support the rock load.
- Ensure that the subgrade for the underliner and riprap follows the required lines and grades shown in the plan. Compact any fill required in the subgrade to the density of the surrounding undisturbed material. Low areas in the subgrade on the undisturbed soil can also be filled by increasing the riprap thickness.
- Filter (non-woven geotextile) cloth, when used, must meet design requirements and be properly protected from punching or tearing during installation. Repair any damaged fabric by removing the riprap and placing another piece of filter cloth over the damaged area. All connecting joints should overlap a minimum of 1 foot. If the damage is extensive, replace the entire filter cloth.
- Riprap can be placed by equipment, but take care to avoid damaging the filter.
- Immediately after construction, stabilize all disturbed areas with vegetation.

Maintenance

- Grouted or wire-tied rock rip-rap minimizes maintenance requirements.
- Inspect weekly and before and after rainfall events.
- Inspect apron for displacement and/or damage to the underlying fabric, scour beneath the rip-rap and around outlet.
- Remove devices as soon as work is completed to the construction site.
- Grouted rip-rap may break up in areas of freeze and thaw.
- Grouted rip-rap may break up from hydrostatic pressure without adequate drainage.

Inspection	- Stones that have been displaced by wet weather events have been re-set and/or replaced. - Inspect riprap weekly and after every rainfall event greater than one-half inch to see if any erosion around or below the riprap has taken place or if stones have been dislodged. Immediately make all needed repairs to prevent further damage. - Apron has been cleaned and properly maintained.

Table EPP16-1. Riprap Aprons for Low Tailwater (downstream depth < 0.5 x pipe diameter)															
Culvert Diameter	Lowest Value			Intermediate Values to Interpolate From									Highest Value		
	Q Cfs	L_A Ft	D_{50} In	Q Cfs	L_A Ft	D_{50} In	Q Cfs	L_A Ft	D_{50} In	Q Cfs	L_A Ft	D_{50} In	Q Cfs	L_A Ft	D_{50} In
12”	4	7	6	6	10	6	9	13	6	12	16	7	14	17	8.5
15”	6.5	8	6	1	12	6	15	16	7	20	18	10	25	20	12
18”	10	9	6	15	14	6	20	17	7	30	22	11	40	25	14
21”	15	11	6	25	18	7	35	22	10	45	26	13	60	29	18
24”	21	13	6	35	20	8.5	50	26	12	65	30	16	80	33	19
27”	27	14	6	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

Source: Knoxville Engineering Department
L_A = Apron Length
Apron Width = L_A + Culvert Length

Table EPP16-2. Riprap Aprons for High Tailwater (downstream depth > 0.5 x pipe diameter)															
Culvert Diameter	Lowest Value			Intermediate Values to Interpolate From									Highest Value		
	Q Cfs	L_A Ft	D_{50} In	Q Cfs	L_A Ft	D_{50} In	Q Cfs	L_A Ft	D_{50} In	Q Cfs	L_A Ft	D_{50} In	Q Cfs	L_A Ft	D_{50} In
12”	4	8	6	6	18	6	9	28	6	12	36	7	14	40	8
15”	7	8	6	10	20	6	15	34	6	20	42	7.5	25	50	10
18”	10	8	6	15	22	6	20	34	6	30	50	9	40	60	11
21”	15	8	6	25	32	6	35	48	7	45	58	11	60	72	14
24”	20	8	6	35	36	6	50	55	8.5	65	68	12	80	80	15
27”	27	10	6	50	41	6	70	58	10	90	70	14	110	82	17
30”	36	11	6	60	42	6	90	64	11	120	80	15	140	90	18
36”	56	13	6	100	60	7	140	85	13	180	104	18	220	120	23
42”	82	15	6	120	50	6	160	75	10	200	96	14	260	120	19
48”	120	20	6	170	58	7	220	85	12	270	105	16	320	120	20

Source: Knoxville Engineering Department
L_A = Apron Length
Apron Width = L_A + Culvert Length

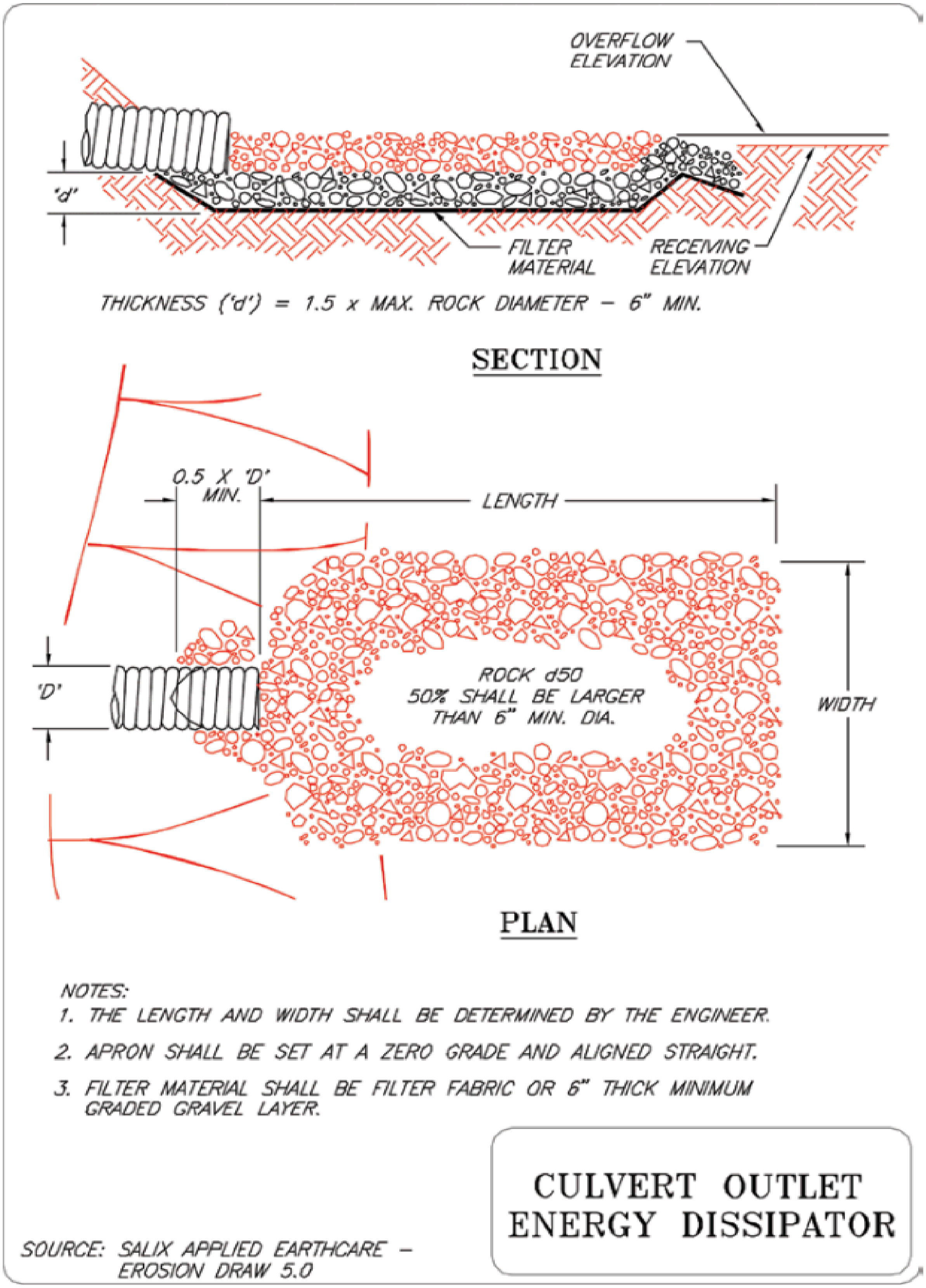


Figure EPP16-1. Outlet Protection Installation Details.
Kentucky Construction Site BMP Planning and Technical Specifications Manual

3.2 Sediment Control Practices Fact Sheets (SMP)

Sediment Control Practices	SMP-01 Silt Fence

Symbol

SF

Description

To detain sediment-laden water, silt fences are used to promote silt deposition behind the fence. These fences are made of filter fabric that has been entrenched, attached to support poles and occasionally supported by a wire fence. Silt fence is intended as a temporary sediment barrier and requires routine maintenance.

Application

- Ø Silt fence should be used in area accepting sheet flow conditions.
- Ø Silt fence should **not** be used in ditch lines, streams, or other areas of concentrated flows.
- Ø Silt fencing can be used along the downstream perimeter, below the toe of a cleared slope, upstream of sediment traps or basins, along streams and channels and around temporary spoil areas.

Design

The design criteria for silt fence is as follows:

- Ø Silt fencing should be installed along the contour. It should not be installed up and down slopes or around the perimeter of large construction sites unless accompanied by measures such as "J" Hooks or other methods.
- Ø The length of silt fence is determined by the amount of run-off area. The minimum area should not exceed 0.25 acre per 100 linear feet of silt fence.
- Ø Spacing of silt fence is variable depending on the slope of land draining to the fence. See Table SMP1-01 for spacing requirements.

Design

- Silt fencing must be installed only where water can pond. Specify silt fencing downgradient from bare soil areas with the ends turned up to prevent bypassing.
- Provide adequate setbacks from slope toe for routine maintenance and access.
- Silt fencing can be used where:
  - Non-concentrated sheet flow will occur
  - Protection of adjacent property or nearby surface waters is required
  - The size of the drainage area is no more than ¼ acre per 100 linear feet of silt fence
  - The maximum flow path length above the barrier is 100 feet for slopes less than 2 percent, and 50 feet for slopes up to 10 percent
  - The maximum slope gradient above the barrier is 2H:1V
  - Silt fencing can be used in flat, short swales (i.e. slope is less than 2 percent; length is less than 200 feet) that drain less than 2 acres, if silt fencing is spaced every 50 feet
  - Reinforced silt fence must be required when the contributing slope is longer than 100 feet and greater than 3 percent and the design life of the silt fence is greater than 6 months.

Table SMP01-1. Silt Fence Spacing on Long Slopes

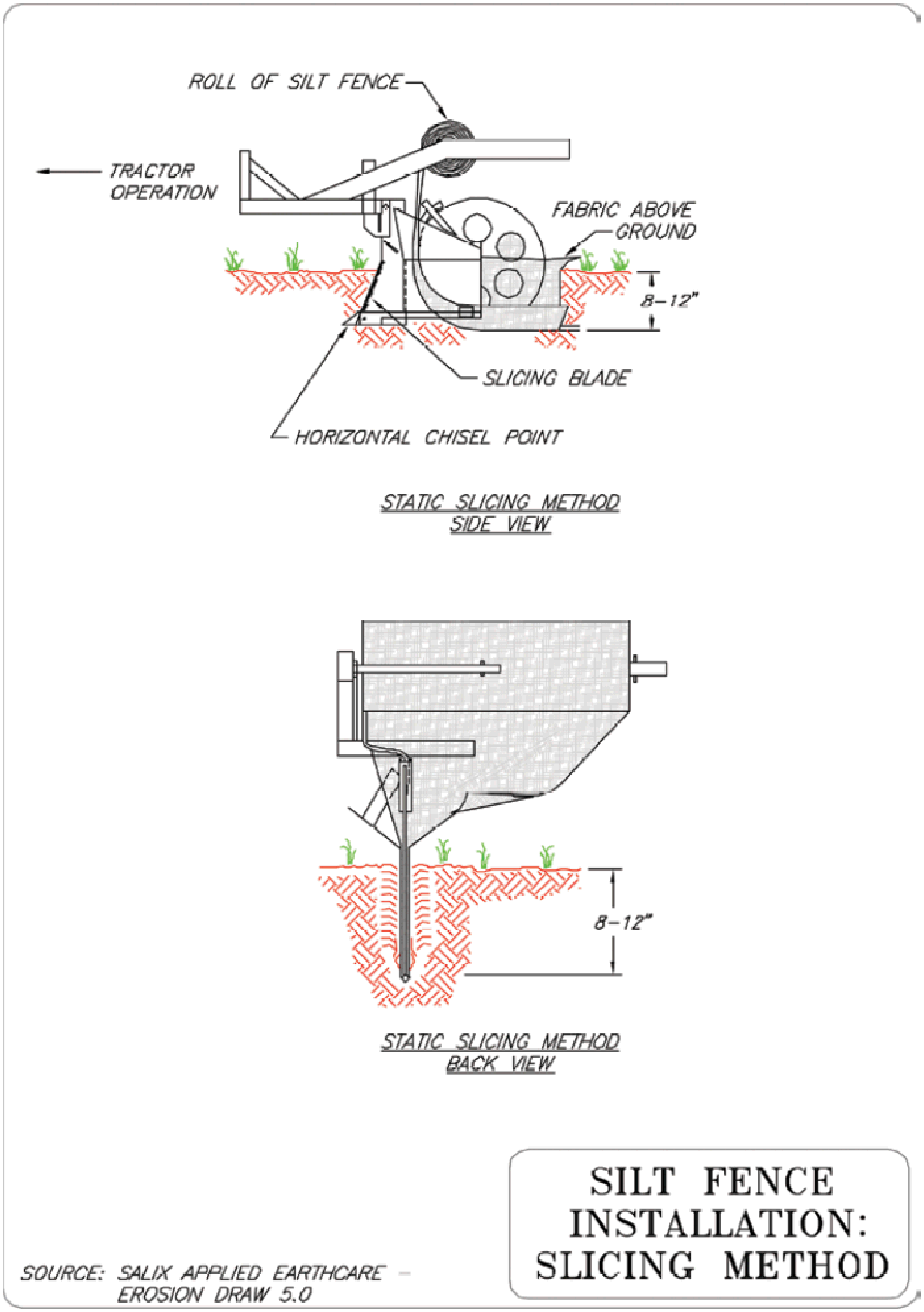
Land Slope	Max. Slope Distance
3% - 5%	100 ft.
5% - 10 %	75 ft.
10% - 20%	50 ft.
20% - 50%	25 ft.

- Silt fences should be located where only shallow pools (i.e., 1.5 feet or less) can form. Their use is limited to situations in which sheet or overland flows are expected.
- Dig a trench on the contour at least 6 inches wide and 6 inches deep below the area to be treated, taking care to install J-hooks where flows will travel along the silt fence. Turn fence ends uphill to trap potential bypasses as needed.
- If posts are already attached to fabric, position the fencing so the posts are installed on the downhill side of the fabric. Drive posts to a depth of 1 foot below the bottom of the trench, against downslope trench wall for extra support. Posts for all silt fencing are spaced 6 feet apart.
- Push fabric into the trench, and spread fabric along trench bottom and sides; backfill the trench and compact the soil. A preferred installation technique is deep, easily-worked soils with minimal rock content involves static slicing of the fence into the ground with a chisel-plow implement such as the Tommy Silt Fence Machine or equivalent. The filter fabric is wire-tied directly to the posts with three diagonal ties.
- The height of a silt fence must be 18 inches minimum and 30 inches maximum. Sediment storage height and ponding height must not exceed 18 inches.
- Silt fences placed at the toe of a slope must be set at least 6 feet back from the toe to increase ponding volume and provide room for maintenance.

Maintenance	Ø	Silt fences and filter barriers must be inspected weekly or ever 14 days and after each storm of greater than one-half inch. Any required repairs must be made immediately.
	Ø	Sediment height not to exceed one-third the height of the fence.
	Ø	Perform required maintenance before a storm event.
	Ø	Remove fence when vegetation is established and any sediment stored behind the silt fence has been removed. Silt fences and other temporary controls must be removed before project close out.
Inspection	q	Silt fence has proper placement.
	q	Inspect fence for proper installation and compaction by pulling up on the fence while kicking the toe of the fabric. If the fence comes out of the ground, do not accept the installation.
	q	If there are long, linear runs of silt fence without J-hooks, do not accept the installation.
	q	The last 6 feet of the silt fence is turned uphill and secured to the post.
	q	Color band of the anchor trench is not visible.
	q	Accumulated sediment does not exceed one third the height of the fence or 18 inches maximum.
	q	If washaround or underwash occurs then fence should be reset.
	q	The removed sediment must be spread and vegetated or otherwise stabilized so that it does not result in muddy runoff to nearby ditches or surface waters.

Figure EPP01-1. Silt Fence

Installation – Slicing Method Kentucky Construction Site BMP Planning and Technical Specifications Manual



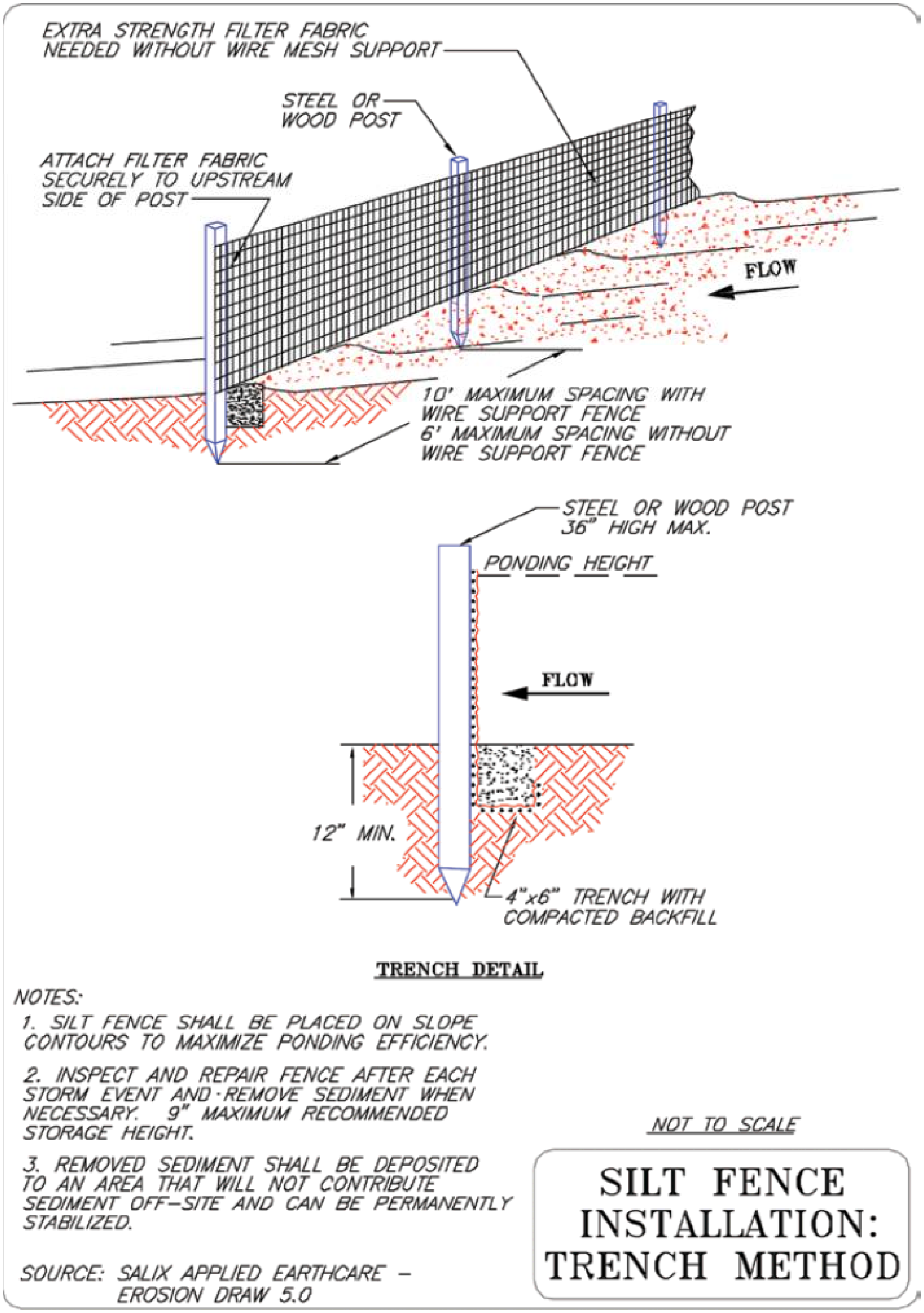
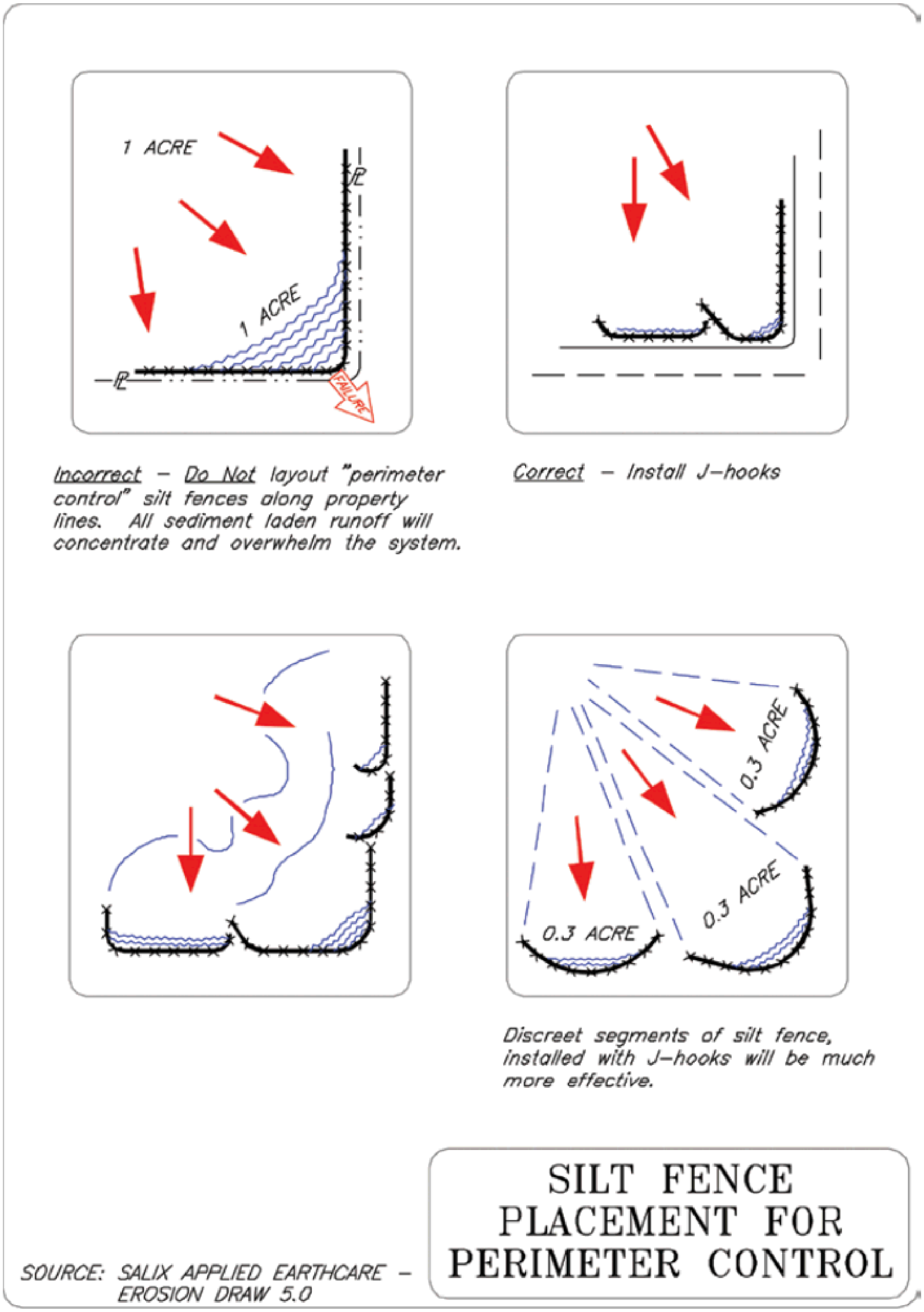


Figure EPP01-2. Silt Fence Installation – Trenching Method

Kentucky Construction Site BMP Planning and Technical Specifications Manual **Figure EPP01-3.**

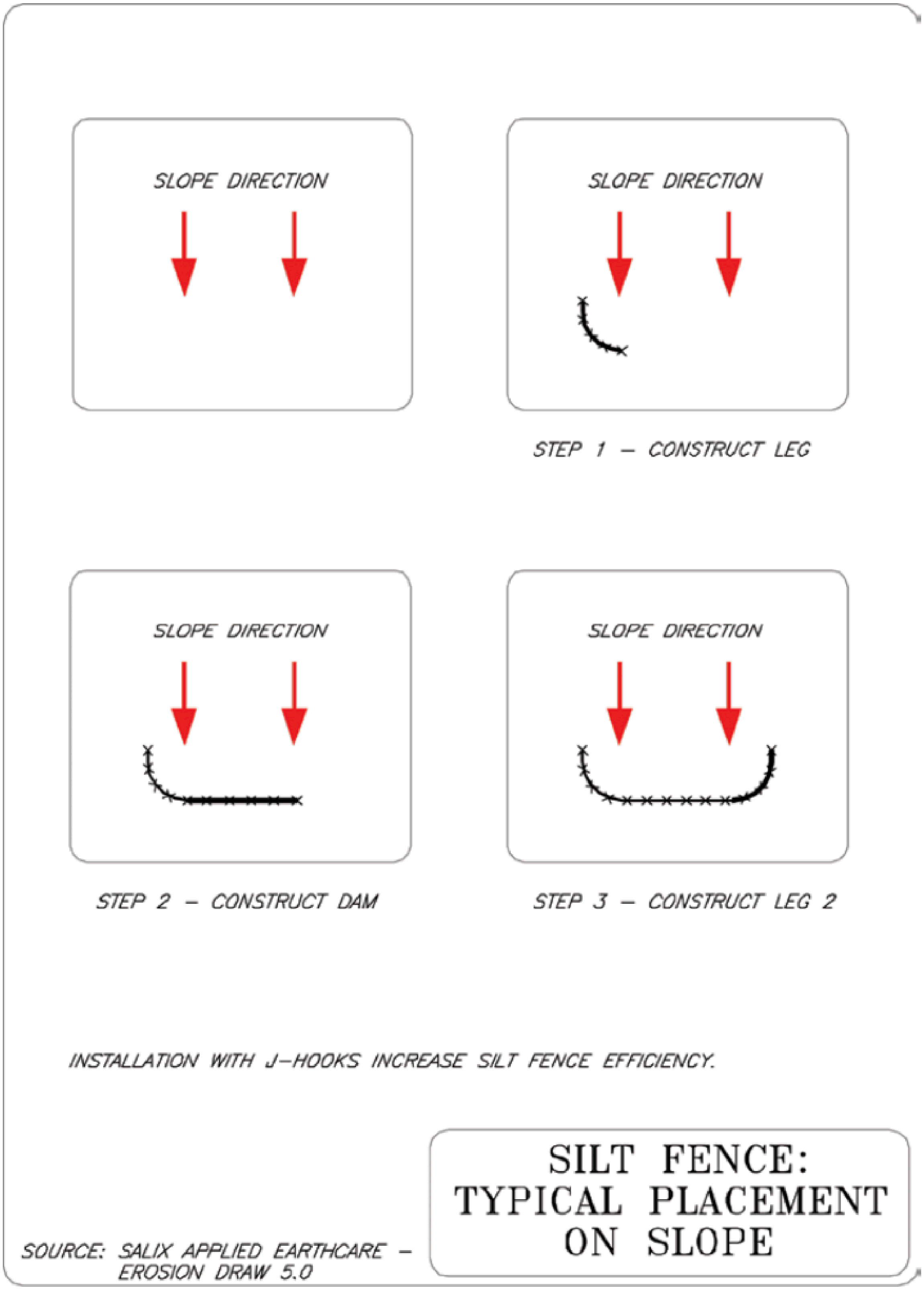
Silt



Fence Perimeter Placement

Kentucky Construction Site BMP Planning and Technical Specifications Manual

Figure EPP01-4. Silt Fence



Placement on Slopes

Kentucky Construction Site BMP Planning and Technical Specifications Manual

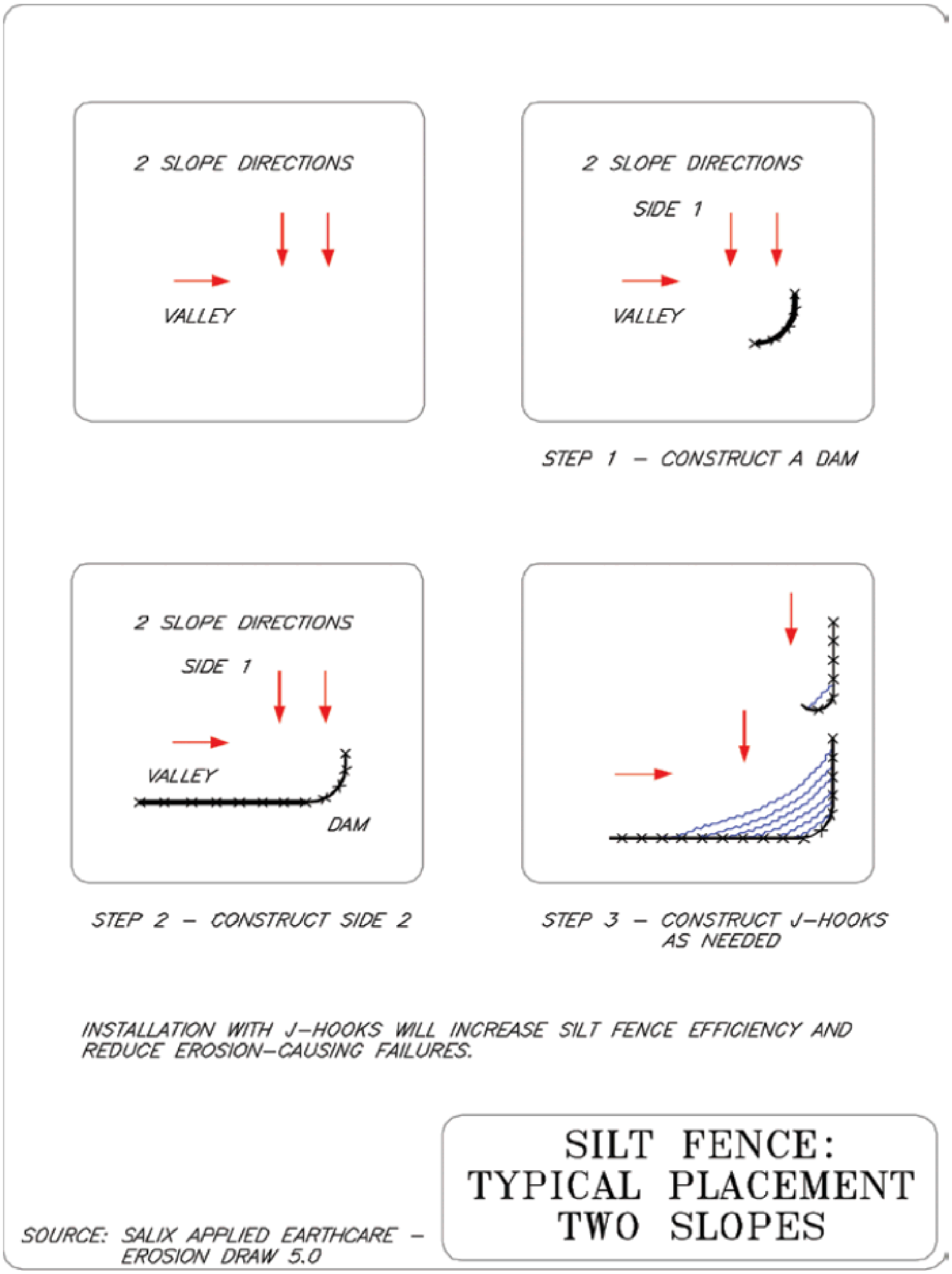


Figure EPP01-5. Silt Fence

Placement on Compound Slope

Kentucky Construction Site BMP Planning and Technical Specifications Manual

Sediment Control Practices	SMP-02 Rock Filters and Continuous Berms

CB

Symbol

CB

Description

Filters, brush and berms are used to dissipate sediment in construction runoff by anchoring rock deposits, roles of fabric and/or brush barriers. These barriers are constructed of rocks ¾ to 5 inches in diameter that make up a berm to be placed along a contour. Brush wrapped in filter cloth and anchored to the toe of the slope creates a brush barrier, which acts as another trapping method. Additionally, a continuous role of fabric that captures sand, rock or native soil is an example of one more method to capture sediment.
This BMP is used for sediment trapping and velocity reduction that will aid in significantly reducing sediment.

Application

- Rock filters should be applied near the toe of the slope, along the site perimeter, stream channels, spoil areas, small cleared areas, sediment traps
- Rock filters may also be used as check dams with temporary roads

Design

A filter berm can often be constructed from natural materials, such as brush or rocks. This is generally an efficient operation for the site contractor if these materials are already present on the project site, both timewise and in terms of installation cost. Brush and rock filter berms can also be installed with a geotextile fabric to increase sediment removal filtration and the overall stability of the berm. Wire netting (such as poultry fencing) can also be used to increase the stability for brush or rock berms. Gabions and other wire mattresses can also be used as a rock filter for erosion control.

Design (cont'd) Both types of filter berms are placed along a level contour. Common applications are along the edge of a gravel roadway or 5 to 7 feet beyond the toe of a slope, where overland sheet flow can be detained and ponded. They should not be used in ditches, channels, or streams unless they can withstand predicted flows. Brush or rock filter berms slow the velocity of overland runoff, allowing sediment to settle out or become trapped in the filter. In this manner, the brush and rock filter berms are very similar in function to SMP-01, Check Dams, except that filter berms handle overland sheet flow and check dams handle stormwater runoff channels.

Brush and rock filter berms both contain materials (dirt, leaves, dust, silt) which could potentially cause more pollution than they might remove. These measures should be constructed and managed carefully in order to become effective BMPs. A silt fence or straw bale barrier may be needed as a secondary measure to control dirt and leaves.

- Place filter on downhill edge of bare soil areas.
- Make sure the filter catches all the muddy runoff.
- Turn the ends of the barrier uphill to prevent bypasses
- The goal is to pond runoff, to filter and settle it out
- Install multiple sediment filters on long slopes
- Spacing on long slopes is every 50 to 100 feet

- **Brush Filter (F-B)**

A brush filter berm is composed of brush, small tree limbs, rootmat, grass and leaves, or other material which is commonly generated as waste during the clearing and grubbing stage. The brush filter berm is constructed by piling these materials into a continuous and compacted mound along a level contour which is downhill from a disturbed area. Large logs or tree stumps should generally be avoided as part of the brush filter berm; they cause large voids or gaps in the berm and so defeat the purpose of detaining stormwater. However, large logs by themselves can be used to slow stormwater runoff in wooded areas, along paths and trails, or at the bottom of slopes.

A brush filter berm height of approximately 2-5 feet is recommended to slow or detain stormwater. The minimum height of 2 feet may be used for short slopes less than 100 feet long. A corresponding width is generally 4 to 10 feet, with a shape that can either be triangular or somewhat rounded. Standard dozers or other grading equipment are used to compact and shape the brush filter berm to be more dense. Use rope or sturdy string to shape the brush filter berm and to hold it together.

Design (cont'd)

A geotextile fabric can be used to increase the sediment retention or to provide a more stable brush filter berm. Install the filter fabric into a trench 6 inches deep immediately uphill from the formed berm. Then lay the filter fabric over the front face of the brush filter berm. Secure the filter fabric using staples, stakes, ropes or wires so that the fabric will not be uplifted by winds or storms. Overlap edges of filter fabric by 6 inches.

Brush filter berms are generally not used in developed areas or wherever aesthetics will be of concern. Brush filter berms may also be unpredictable in terms of performance. Since they are composed of natural materials, they may or may not need to be removed after the uphill sites are stabilized. Brush filter berms may provide a habitat for various types of desirable wildlife, or they could harbor pests and rodents in areas where these problems are known to exist.

Ø **Rock Filter (F-R)**

A rock filter berm can be created from natural gravel or rock at the project site, or from imported gravel and rock. It is placed and compacted along a level contour, where sheet flow may be detained and ponded to promote sedimentation. Some type of geotextile fabric or wire screen is recommended to keep the berm shape intact. A gabion or wire mattress may be used to construct a rock filter berm, provided that the gabion wire spacing is compatible with size of aggregate or rock.

Rock filter berms can be used along the downslope edge of roadways or 5 to 7 feet beyond the toe of a slope. Longer rock berms constructed as sheet runoff sediment barriers shuld be 18" to 30" in height and consist of stone 2-6 inches in diameter. Rock filter berms can also be incorporated as part of a gravel road and other type of unpaved traffic area, in order to prevent stormwater from flowing into paved roads.

Construct a rock filter berm by first placing larger rocks as a base. If available, smaller rocks or gravel are placed on the uphill side of the larger rocks to form a natural filter. Geotextile filter fabric can be underneath the rock filter berm itself, which would adequately anchor the fabric. For areas where concentrated flows may occur, use larger rock without any dust or fine material, placed in a gabion or other type of staked woven-wire mattress.

Maintenance

Ø Daily Inspection is required when installing in stream beds
Ø After each heavy rainfall inspect berms
Ø Maintain berms to guarantee proper utilization
Ø Inspect for sediment accumulation removing when depth reaches ¼ of berm height or 9 inches
Ø Look for signs of bypassing along the sides, undercutting below the barrier, overtopping, or blowout.
Ø Make required repairs immediately
Ø Remove berms upon completion of the project

Inspection

q Sufficient space for ponded water.

q Brush filters are performing.

q Drainage to structure does not exceed 5 acres.

Sediment Control Practices	SMP-03 Sediment Traps

Symbol

ST

Description

The sediment trap is a control measure that detains sediment-laden runoff from small disturbed areas in an earthen embankment that will allow ponding long enough to allow the sediment to settle within the depression.

Application

- Install detention areas below disturbed vicinities of less than 10 acres.
- Along the perimeter of the site at locations where sediment-laden runoff is discharged off-site or areas where runoff can enter stabilized areas or waterways.
- Temporary sediment traps shall **not** be used in live or continuously-flowing streams. Sediment traps may kill nearby vegetation by excessive sediment or by long periods of submergence.
- Temporary sediment traps only remove coarse particles which settle quickly. Sediment traps are not effective for fine-grained soils such as silt or clay. Additional upstream erosion control measures are necessary.

Design

- **Volume**

Minimum volume of a sediment trap shall be 67 cubic yards per acre for the total drainage area. The volume shall be measured at an elevation equivalent to the spillway invert.

Optimal design volume of sediment trap depends on type of soil, size and slope of drainage area, amount of land disturbance, desired sediment removal efficiency, and desired cleanout frequency. A recommended volume for temporary sediment trap in heavily disturbed areas is 134 cubic yards per acre, which equates to 1 inch of stormwater runoff. Optimal design of this type of sediment trap includes an upper zone of at least 67 cubic yards per acre (to be dewatered using one of the outlet design alternatives) and a lower wet zone for sediment storage and settling.

Design (cont'd)

Ø **Location**

Traps cannot be placed in blue-line streams or other regulated water unless space limitations or design limitations provide no other feasible option. A USACE Clean Water Ace (CWA) section 404 permit is required in these cases.

Ø **Shape**

The designer should attempt to plan a basin that has a minimum 3:1 length to width ratio.

Ø **Slopes**

Basin side slopes should be restricted to 4:1 or flatter. However, the permeable, filter, portion should have a maximum cross section of 2:1. Trap berm width at base must be sufficient to support 2H:1V berm.

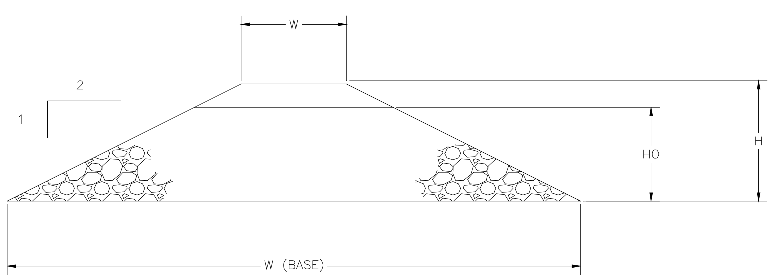
Ø **Emergency Spillway**

The emergency overflow outlet of the temporary sediment trap must be stabilized with rock, riprap, geotextile, vegetation or another suitable material which is resistant to erosion. A stable emergency spillway must be installed to safely convey stormwater runoff for the 10-year storm event.

An emergency overflow weir should be provided at an elevation of at least 1.5 feet below the top of embankment, with a minimum freeboard of 1 foot. The minimum bottom width of a trapezoidal section for an emergency overflow weir should be:

4 feet	-	1 acre (total drainage area)
6 feet	-	2 acres (total drainage area)
8 feet	-	3 acres (total drainage area)
10 feet	-	4 acres (total drainage area)
12 feet	-	5 acres (total drainage area)

*Drainage areas over 5 acres as designed



Design (cont'd)

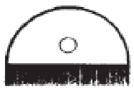
- Construct traps of rock (KYTC No. 2 mixed with smaller stone), rock-filled fiber bags, or use approved commercial sediment trap products installed and spaced according to manufacturer's instructions.
- Site sediment traps in areas where they can be maintained (i.e. sediment removed).
- Set traps back from property lines or water bodies as much as possible.
- Minimum sediment storage capacity is 134 cubic yards (3600 cubic feet) of upland area drained by the trap. Where space restrictions exist, install multiple traps in a series at least 50 feet apart.
- Maximum drainage area is 5 acres.
- Basin flow length should be at least two times the flow width.
- Recommended traps depth for open areas is 2 feet at the inlet and 4 feet at the oulet.
- Trap height must be 1.5 feet minimum in ditches, 3-5 feet in open area drainageways.
- Trap length must be sufficient to tie into upper banks in ditches or high enough to prevent side bypasses in drainageways. Overflows must in the center of the berm.
- Construct the trap, seed and stabilize before clearing and grading work begins.
- Embankment shall have a maximum height of 5 feet.
- The outlet must consist of an overflow spillway wide made of stone (KYTC No. 2 minimum)
- Any material excavated from the trap must be uniformly spread to a depth no exceeding 3 feet and graded to a continuous slope away from the trap.
- Field-approved installations should be noted on weekly or bi-weekly inspection reports an on plan documents within 7 days.

Inspection Checklist

- [ ] Inspect weekly or every 14 days or after a rainfall greater than one-half inch.
- [ ] Constructed traps serve 10 acres or less.
- [ ] Type of outlet structure used matches EPSC plan.
- [ ] Structure is stabilized to prevent erosion.
- [ ] Gage is visible and correctly indicates the depth of the trap.
- [ ] Sediment accumulation does not exceed $^1/_3$ the height of trap. Plans for sediment trap must indicate the methods for disposing of the sediment removed.
- [ ] Trap is constructed in such a way that no damage occurs to life or property.
- [ ] Trap is maintained
- [ ] Remove upon stabilization or cover of the upland drainage area with vegetation, pavement, and so on.

Sediment Control Practices

SMP-04 Temporary Sediment/Detention Basin



Symbol

DB

Description

Typically temporary sediment/detention basins require the construction of an embankment across the drainage path in order to create a pond to trap sediment and inhibit the potential of downstream flooding. Sediment basins are usually designed by a professionally licensed engineer.

Application

- Ø For disturbed areas between 5 to 10 acres. Areas greater than 10 acres will require a design by a licensed professional engineer.
- Ø Collect and store sediment from areas that have been cleared in preparation for construction.
- Ø Used in areas where sediment-laden runoff may enter waterways.
- Ø Suitable for almost all construction projects.

Design

- Ø The sediment control basin should be designed by a professional engineer licensed in Kentucky using SEDCAD, or another suitable computer program.
- Ø It is recommended that the dams be located in a natural drainageway in a deep construction that has a wide area upstream for ponding detained stormwater.
- Ø The intent of this BMP is to trap sediment before it leaves the construction area.
- Ø Construction phase performance goal is to reduce the total suspended solids by 80 percent for the 10-year, 24-hour storm, or provide a detention time of 24-48 hours for a 10-year 24-hour wet weather event.
- Ø Provide a minimum storage capacity of 3600 cf per acre of bare soil. The maximum capacity for the impoundment must not exceed 10 acre-feet. If more impoundment capacity is needed, install basins in a series or site them to intercept tributary drainage areas.

Design (cont'd)

- Ø The ratio of basin flow length to flow width is 2:1.
- Ø Do not locate dams where a failure would result in severe property damage or danger to human life.
- Ø Sediment basins should be designed or modified to drain down slowly for 2-4 days after a storm event. Modify the outlet if necessary to achieve the maximum detention time.
- Ø Minimum drainage area is 5 acres; the maximum drainage area is 120 acres.
- Ø Basin flow length should be at least two times the flow width; the longer, the better. Baffles constructed of filter fabric and metal posts can be used inside the basin to create a longer (e.g., serpentine) flow path between inlet(s) and the outlet.
- Ø Basins that drain more than 10 acres can be designed as retention (rather than detention) basins (i.e. wet ponds). Design outlet to drain top of the pool farthest away from muddy inflows. Incorporating a sediment collection forebay is recommended to aid in maintenance.
- Ø There are three components to the successful design of a sediment basin:
  - Embankment
  - Principal Spillway
  - Emergency Spillway

Embankment Recommendations

- Dam height should not exceed 20 feet.
- Slopes of the embankments for a Class 1 basin shall not be steeper than 3:1 on the upstream side, and not steeper than 5:1 on the downstream side of the basin, in order to allow the area to be safely mowed and maintained. (See SMP-05-01).
- Slopes on either side of the embankment of Class 2 or 3 basins shall not be steeper than 3:1 for, in order to allow the area to be safely mowed and maintained. (See SMP-05-01).
- Provide for a minimum of 1-foot of freeboard for a 100-year 6-hour wet weather event to the top of the embankment.
- The minimum width at the top of the embankment is 12-inches.
- Stabilize the slope with vegetation or rip rap.
- Antiseep collars around discharge pipe are required

Principal Spillway Requirements

- Provide a subsurface drain, a solid riser pipe, or both, with sufficient dewatering holes to allow sufficient detention time. Risers with one-half inch holes every 3 to 6 inches apart are recommended.
- No large holes or slots should appear in the lower two thirds of the riser. Risers with large openings can be modified as described below or wrapped with filter fabric to cover lower openings during the construction period.

Design (cont'd)

- During construction, risers should be modified with an inlet protection dike, pile of stone at the riser base, or other structure to provide longer ponding times (e.g., 1-2 days) for small flow events.
- The outlet pipe diameter shall be a minimum of 12-inches.
- Operational design goal is to reduce the peak flow to predevelopment levels for the 2-year and 10-year, 24-hour storms.
- Trash rack and anti-vortex device on the riser pipe are required.
- Prepare a stabilized apron for the outlet pipe.
- Provide a minimum of one foot of freeboard between the top of the riser pipe and the crest of the spillway.

Emergency Spillway Requirements

- Emergency spillway shall be designed to pass a 100-year 6-hour wet weather event, to the top of the embankment.
- Crest elevation at least one foot above the tip of the riser pipe.
- Rock used for the emergency spillway must be KYTC No. 2 or larger, depending on flow volumes and spillway slope.
- Emergency spillway energy dissipator must be extended at least 4 feet beyond the toe of the dam.

Construction Specifications

- Construct the basin by excavating or building an embankment dike before any clearing or grading work begins.
- Areas under the embankment and any structural works must be cleared, grubbed and stripped of any vegetation and rootmat as shown on the erosion and sediment control plan.
- To facilitate cleanout and restoration, the basin area must be cleared, grubbed and stripped of any vegetation.
- A cut-off trench must be excavated along the centerline of the earth fill embankments. The minimum depth must be 2 feet. The cut-off trench must extend up both abutments to the riser crest elevation.
- Fill material for the embankment must be clean, low-permeability, mineral soil free of roots, woody vegetation, oversized stones, rocks, or other objectionable material.
- Fill material must be placed in 6 inch lifts, continuous layers over the entire length of the fill. Compacting must be obtained by routing the hauling equipment over the fill so that the entire surface of each layer of the fill is traversed by at least one wheel or tread track of the equipment or by the use of a compactor. Each layer must be compacted to 95 percent of maximum density and +/– 2 percent of optimum moisture content.

Design (cont'd)

- The embankment should be constructed to an elevation of 10 percent higher than the design height to allow for settlement if compacting is achieved with hauling equipment. If compactors are used for compacting, the overbuild may be reduced to not less than 5 percent.
- The principle spillway riser must be securely attached to the discharge pipe by welding all around. All connections must be watertight.
- The pipe and riser must be placed on a firm, smooth soil foundation. The connection between the riser and the riser base must be watertight. Pervious materials such as sand, gravel, or crushed stone must not be used as backfill around the pipe or antiseep collars.
- The fill material around the pipe spillway must be placed in 4-inch layers and compacted under the shoulders and around the pipe to at least the same density as the adjacent embankment. A minimum of 2 feet of compacted backfill must be placed over the pipe spillway before crossing it with construction equipment.
- Risers might require a rock berm or other flow restrictor during the construction phase to ensure that muddy flows are detained sufficiently to promote settling of sediment.
- Steel base plates must have at least 2.5 feet of compacted earth, stone, or gravel over them to prevent flotation.
- An emergency spillway is required, and must not be installed in fill. Appropriate overflow channel lining and energy dissipator must be constructed.
- Baffles, if used, must be constructed of 4 inch by 4 inch posts and of 4 foot by 8 foot half-inch exterior plywood. The posts must be set at least 3 feet into the ground, no farther apart than 8 feet center to center, and must reach a height 6 inches below the riser crest elevation. Silt fencing with metal posts can also be used if flow velocities in the basin are low and ponding heights during the 2-year, 24-hour storm will not exceed 5 feet.
- The embankment, emergency spillway, incoming channels, and other site features must be stabilized with vegetation and mulched or blanketed immediately following construction.
- Construction operations must be carried out in such a manner that erosion and water pollution will be minimized.
- Local and state requirements must be met concerning fencing and signs warning the public of hazards of soft sediment and floodwater.

Maintenance

- Inspect weekly as well as before and after wet weather events greater than one-half inch.
- If incoming flows are exiting the basin quickly because of large holes in the outlet, modify the lower portion of the riser with a stone berm, filter fabric, or other flow restrictor that retains incoming flows for at least 12-24 hours.
- Repair all damages to and within the basin due to construction by the end of the work day.
- Maintain all aspects of the basin (outlet area, outlet structures, etc.).
- Remove sediment when storage is $^{1}/_{2}$ full.
- Ensure that all sediment removed from the basin will not erode from the site. The sediment must not be deposited downstream from the embankment or in or adjacent to a stream or floodplain.
- When temporary structures have served their intended purpose and the contributing drainage area has been properly stabilized, the embankment and resulting sediment deposit must be leveled or otherwise disposed of according to the approved erosion and sediment control plan.
- If the sediment basin is designed to function as a permanent stormwater treatment pond, the basin and riser will be configured to that mode upon stabilization of the upland drainage area. Temporary flow restrictors on risers and other construction phase modifications must be removed.
- Basin failure should not affect loss in life, property, roads, or utilities.

Inspection Checklist

- [ ] Structure has appropriate outlet design.
- [ ] Stabilized outlet prevents erosion.
- [ ] Sediment accumulation does not exceed 1/2 depth of basin.
- [ ] Outlet is free of trash and deleterious materials that will clog the pipe and restrict flow.
- [ ] Trash rack and anti-vortex device on riser is free of debris and other deleterious materials that will clog and restrict flow.

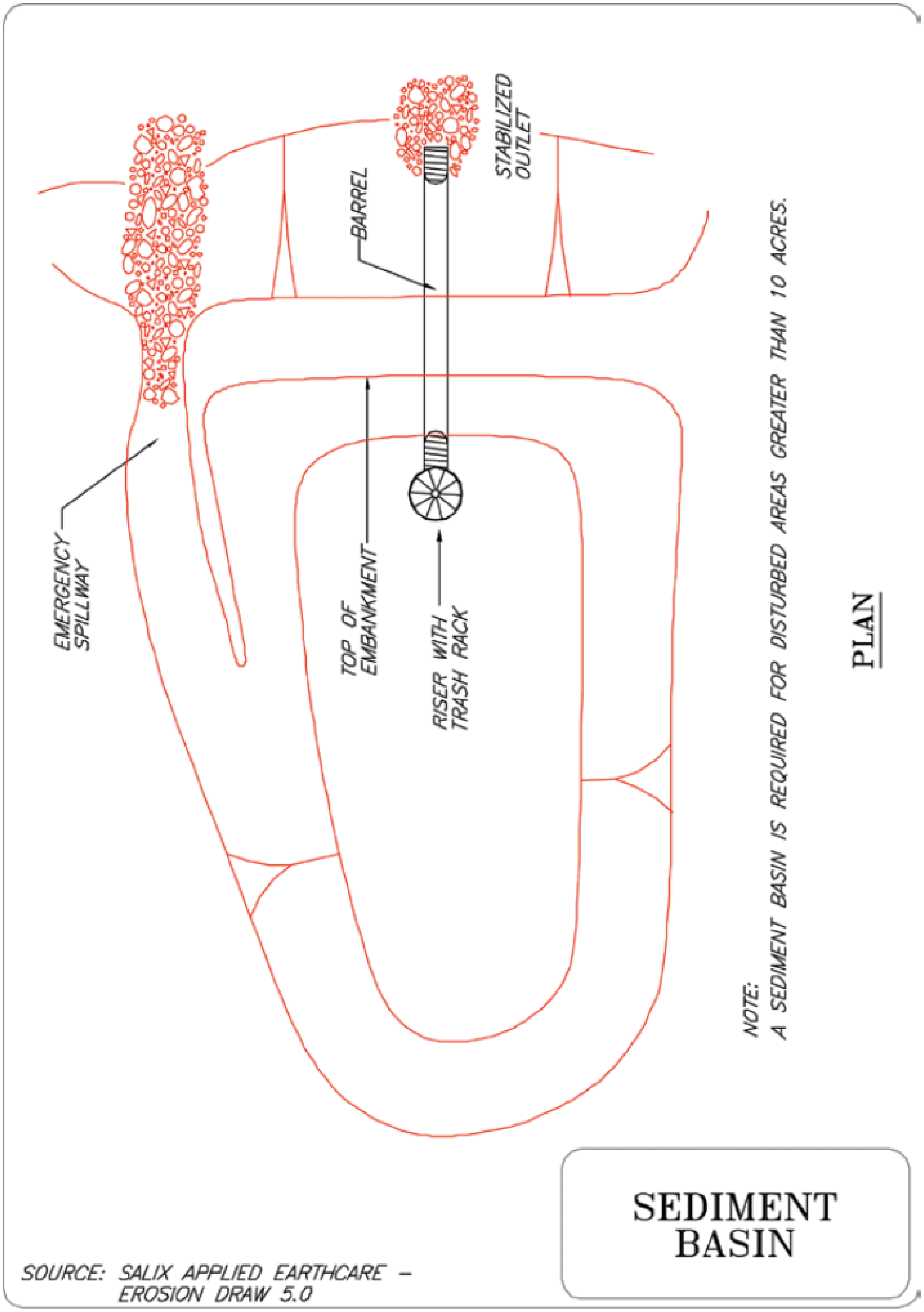


Figure SMP04-1. Sediment Basin Schematic

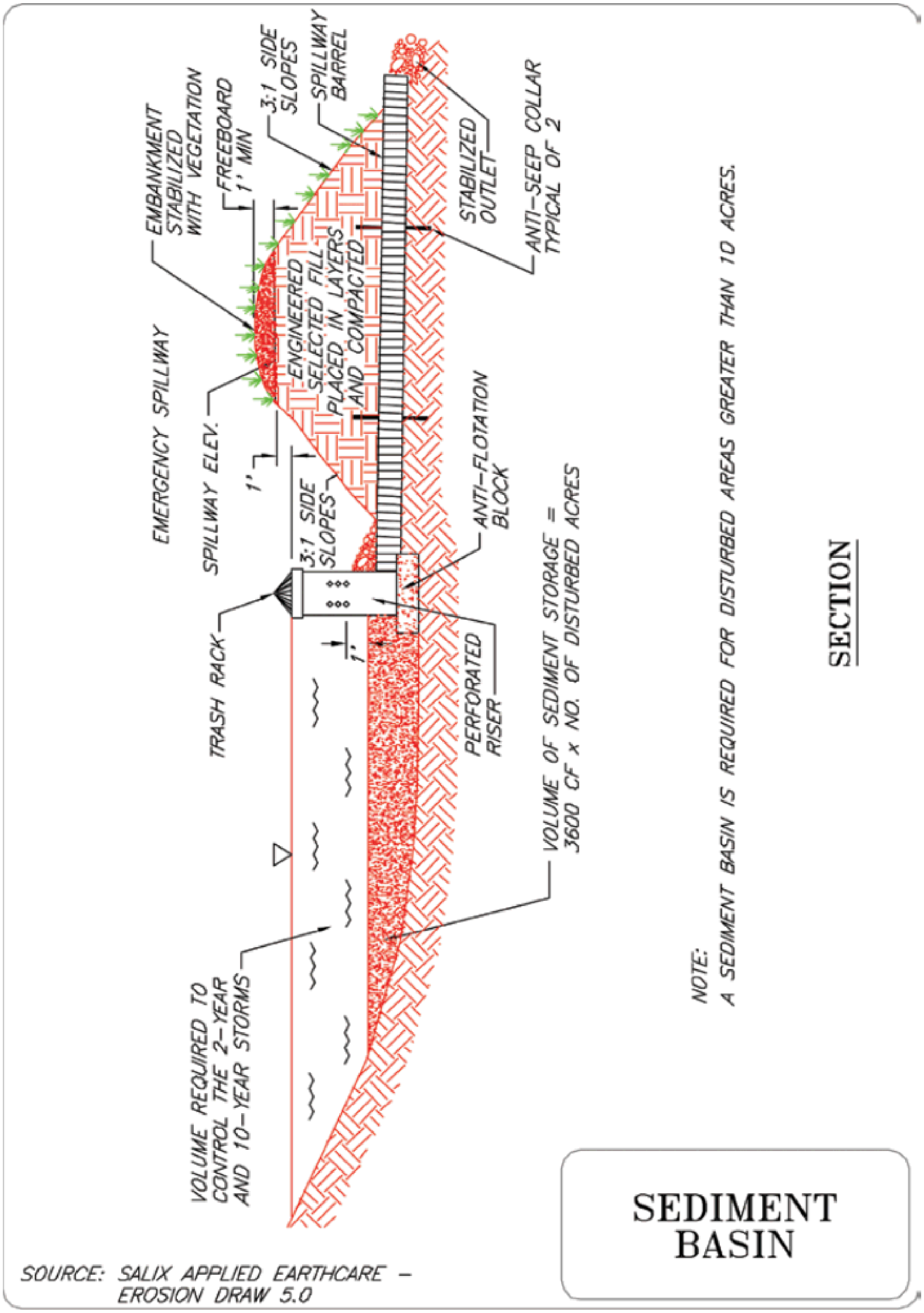


Figure SMP03-2. Sediment Basin Cross Sectional View'

Sediment Control Practices	SMP-05 Temporary Diversions, Berms or Ditches

→ TD → TD →

Symbol

TD

Description

These temporary drains offer features such as conveyance for runoff down cut or fill slopes, subsurface drains that drain off excessive soil saturation, minimization of sheet flow over slope surfaces and reduced sedimentation. Once stabilized, diversions require relatively little maintenance.

Application

- Ø Provide drains to prevent slope failures, damage to adjacent property, erosion and sediment control and removes excess water from soil.
- Ø Diversions to catch runoff at the end of an undisturbed slope before entering a bared area, direct runoff, preserve stable conveyance and to prevent overflow.

Design

A diversion prevents erosion by directing runoff to an erosion control device such as a sediment trap or directing runoff away from an erodible area. Temporary diversions should not adversely impact adjacent properties and must conform to local floodplain management regulations. This practice should not be used in areas with slopes steeper than 10%. The advantages of the temporary earth dike include the ability to handle flows from large tributary areas. Additionally, they are relatively inexpensive to install since the soil material required for construction may be available on-site, and can be constructed as part of the initial grading operations, while the equipment is on-site.

Temporary swales will effectively convey runoff and avoid erosion if constructed and maintained properly:

- Ø Size temporary swales in the same manner as a permanent channel.
- Ø A permanent channel must be designed by a licensed professional civil engineer.
- Ø At a minimum, the swale should conform to predevelopment flow patterns and capacities.
- Ø Construct the swale with an uninterrupted, positive grade to a stabilized outlet.

Design (cont'd) **Drains**

Diversion drains are only effective if they are properly installed. Swales are more effective than dikes because they tend to be more stable. The combination of a swale with a dike on the downhill side is the most cost-effective diversion.

- Can be placed on or buried underneath the slope surface.
- Should be anchored at regular intervals of 50 to 100 ft.
- If a slope drain conveys sediment-laden water, direct flows to a sediment trap or basin.
- When using slope drains, limit tributary area to 2 acres per pipe. For larger areas, use a rock-lined channel or a series of pipes.
- Maximum slope generally limited to 2:1 (H: V), as energy dissipation below steeper slopes is difficult.
- Freeboard should be at least 0.5 feet.
- Drain or swale should be laid at a minimum grade of 1%, but not more than 15%.
- The swale must not be overtopped by the 10-year, 24-hour storm, meeting or exceeding the design criteria stated above.
- Remove all trees, stumps, obstructions, and other objectionable material from the swale when it is built.
- Compact any fill material along the path of the swale.
- Stabilize all swales immediately. Triple-seed and mulch swales at a slope of less than 5 percent, and use rip-rap or sod for swales with a slope between 5 and 15 percent.
- Do not operate construction vehicles across a swale unless a stabilized crossing is provided.
- Direct surface runoff to slope drains with diversion swales, dikes and berms.
- When installing slope drains:
  - Install slope drains perpendicular to slope contours.
  - Compact soil around and under entrance, outlet, and length of pipe.
  - Securely anchor and stabilize pipe and appurtenances into soil.
  - Check to ensure that pipe connections are watertight.
  - Protect inlet and outlet of slope drains: use standard flared end section at entrance for pipe slope drains 12 in. and larger.
  - Protect area around inlet with filter cloth.
  - Protect outlet with geosynthetics and rip-rap or other energy dissipation device. For high-energy discharges, reinforce rip-rap with concrete or use reinforced concrete devices.

Design (cont'd)

- When installing subsurface drains:
  - Slightly slope subsurface drain towards outlet.
  - Check to ensure that pipe connections are watertight.
  - Review relative size of soil and slot/perforation size in the pipe to prevent sediment from entering pipe.
  - Relief drains lower groundwater table. Install parallel to slope and drain to side of slope. Use gridiron, herringbone or random pattern.
  - Interceptor drains prevent excessive soil saturation on sensitive slopes. Install perpendicular to slope and divert discharge to the side of the slope.

Diversions

- Select design flows and safety factor based on careful evaluation of risks due to erosion of the measure, over topping, flow backups, or washout.
- High flow velocities may require the use of a lined ditch, or other methods of stabilization.
- When installing diversion ditches and berms:
  - Protect outlets from erosion.
  - Utilize planned permanent ditches/berms early in construction phase when practicable.
- All dikes and berms should be compacted by earth-moving equipment.
- All dikes should have positive flow to a stabilized outlet.
- Top width may be wider and side slopes may be flatter at crossings for construction traffic.
- Dikes should direct sediment-laden runoff into a sediment trapping device.
- Dikes should be stabilized with vegetation, chemicals, or physical devices.
- Compact any fills to prevent unequal settlement.
- Dikes should remain in place until disturbed areas are permanently stabilized.
- Examine the site for run-on from off-site sources (control off-site flows through or around site).
- Select flow velocity limit based on soil types and drainage flow patterns for each project site
- Establish a maximum flow velocity, shear stress or 3-5 ft/s, for using earth dikes and swales, above which a lined ditch must be used.
- Temporary diversion berms or ditches must be installed as a first step in the land-disturbing activity and must be functional before downslope land disturbance.

Design (cont'd)

- Ø Design an emergency overflow section or bypass area for larger storms that exceed the 10-year design storm.
- Ø Conveyances must be lined or reinforced when velocities exceed allowable limits for soil. Consider use of geotextiles, engineering fabric, vegetation, rip-rap or concrete.
- Ø The berm or ditch must not be overtopped by the 10-year, 24-hour storm, meeting or exceeding the design criteria stated above.
- Ø Maximum slope generally limited to 2:1 (H: V), as energy dissipation below steeper slopes is difficult.

Maintenance

- Ø Inspect drains before and after each storm event greater than one-half inch.
- Ø Inspect weekly and after any repairs are made until drainage area is stabilized
- Ø Maintain drains and swales to eliminate erosion, accumulation of debris and sediment
- Ø Check status of water ponding activities. Remove water if such activities occur
- Ø Temporary conveyances should be removed when surroundings become stable or when the construction is complete
- Ø If vegetation has not been established, reseed damaged and sparse areas immediately. Triple seed (see seeding rates in Section 4.3.1) areas below the flow line, and use erosion control blankets or turf reinforcement mats as necessary.
- Ø Damages caused by construction traffic or other activity must be repaired before the end of each working day.

Inspection

- q Routine visit after every heavy rain water event.
- q No evidence of washout, accumulated debris and build up in ditches or berms.

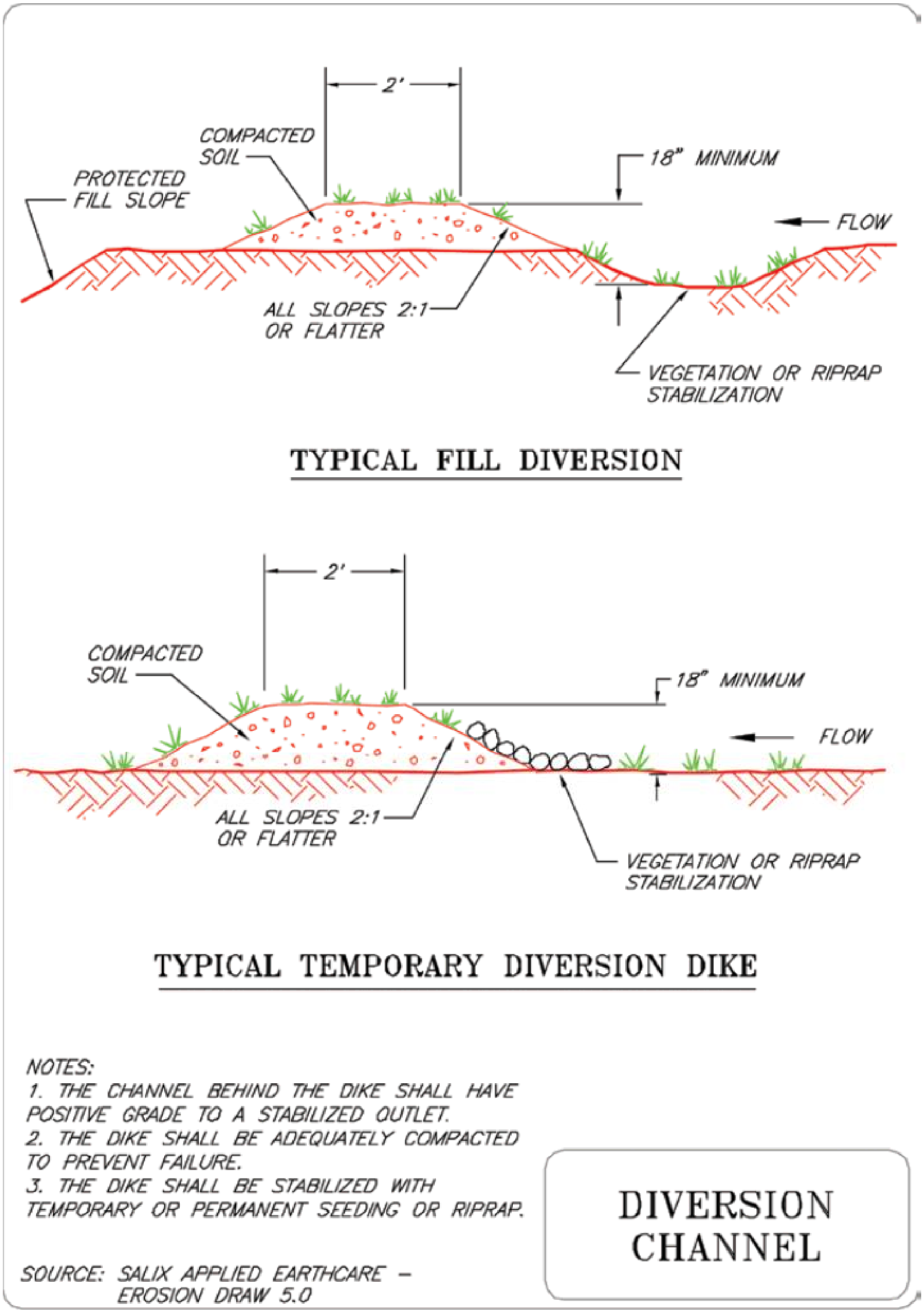


Figure SMP05-1. Typical Diversion Channel Cross Section

Sediment Control Practices	SMP-06 Filter Strips

FS

Symbol

FS

Description

Utilizing vegetation allows soil to be protected from erosion and velocity flow while reducing or preventing discharge of pollutants to the storm system or waterways. This method uses filter strips to accomplish the goal of filtering sediment needing to be settled out of runoff.

Application

- Ø Filter strips should be used only to address potential water quality problems associated with overland (sheet) flow. They are not effective in removing sediment from concentrated flows unless those flows are dispersed on flat ground before discharge into the filter strip. Areas that need immediate cover (such as sodding and plugging) due to having turf prior to construction, areas subject to erosion (graded or cleared areas), and permanent vegetative areas
- Ø Wetlands and/or sensitive water bodies
- Ø Steep and unstable slopes
- Ø Temporary or permanent buffer areas that include the floodway and 50 feet perpendicular to the floodway. If a floodway has not been determined then the buffer must be 25 feet perpendicular from each side of the stream bank, creek, or unnamed waterway under "bank-full conditions" (See EPP-03 Buffer Zones.)
- Ø Area within the buffer must not be cleared. It should be surveyed, flagged and delineated by a colored temporary fence and these instructions explained to each employee on the site

Design

- Ø Cultivate the area then install the irrigation system
- Ø Areas should be excavated and backfilled (plant holes)
- Ø Areas are to be fine graded and rolled prior to sodding
- Ø Sodded areas are to be uniform and smooth (prior to sodding) and distributed with top soil were needed (to even out the areas)

Design (cont'd)

Table SMP06-1. Vegetated Filter Strip Width Recommendations for Kentucky

Stream Type	**Conditions**	**Minimum Buffer Width**	**General Considerations**
Urban streams	> 25% imperviousness in drainage area	25 ft each bank	At least two-thirds of the buffer—nearest to the water—should be undisturbed native or natural vegetation. Remainder can be permanent managed vegetation. Avoid turf grass in managed area if possible; use native grasses, wildflower mixes. Mow annually or less.
Suburban streams	10% to 25% imperviousness in drainage area	50 ft each bank	
Rural streams	< 10% imperviousness in drainage area	• 60 ft each bank	
Large rivers	Rivers with floodplains > 500 ft wide	> 100 ft each bank	
Wetlands	For sloping sites, add more buffer	25 to 50 ft	
Sinkholes or other karst features	Will vary according to size and flow characteristics	25 to 50 ft radius	

- Ø Sod end of adjacent strips should stagger by half the width or length
- Ø Areas adjacent to sidewalks, concrete headers, header boards and other paved borders shall be 1.5 in-0.25 in below the top grade of the facilities
- Ø Seed beds should be added to fertilizers and added to the correct site condition to slow the velocity of runoff and allow sedimentation to take place
- Ø Roll sod to eliminate air pockets and allow a closer contact with the soil.
- Ø Water sod so that the soil at a minimum depth of 4 feet is moistened
- Ø Do not allow sod to dry out
- Ø Sod should not be planted on slopes that are greater than 3:1 (H:V) if no mowing is to occur
- Ø Vegetate sodded areas
- Ø Do not use buffer strip for vehicular traffic
- Ø All fertilization efforts should follow the outline of the state, county, and/or local government
- Ø If vegetative filter strips are proposed as a sediment control device and they do not already exist, they must be planned and established before initiating general land-disturbing activities if possible.
- Ø Minimum filter strip width should be 25 feet for urban streams, 50–75 feet for suburban and rural streams, and at least 100 feet for large rivers. Plans should show the location, width, and length of filter strips. The type of vegetation and specifications for soil preparation and seeding must be included. If existing vegetation is to be used, plans for protecting or improving it must be provided.
- Ø The width of filter strips expected to treat runoff from long slopes should be at least one-fourth the length of the slope for slopes up to 20 percent and at least half the slope length for steeper areas.

Design (cont'd)

- When establishing new seeded areas, consideration must be given to aesthetics and wildlife needs and soil conditions on the site. Native grass and wildflower mixtures are attractive, commercially available, and can be seeded with standard equipment for the most part.

- It is easier and cheaper to protect and preserve existing areas than to establish new ones. Existing grass wildflower, or grass/legume areas to be used as filter strips should be flagged off as a buffer zone (see the Buffer Zone section). Equipment and vehicular traffic in these areas should be restricted to avoid damage to vegetation. Vegetation should be dense and well established with no bare spots.

- Seed species for native grass and wildflower mixes are available from county extension and NRCS offices. Specify quality seed mixtures selected on the basis of climate, soils, drainage, shading, and other factors. Note that taller grass mixtures might not be appropriate near residential areas because of security concerns regarding visibility.

- Specify planting of grasses and forbs at the same time. Seeding rates will vary by species, but should generally be specialized and low, unlike agricultural seeding rates. Consider a cover/nursery crop of annual or short-lived native species (e.g., rye) to protect the site until grasses and wildflowers emerge.

- Seed should be from current production, no more than one year old, and free of mold or insects and disease. Seed origin should be furnished and have characteristics similar to the site. Seed collected or grown in the region is usually best.

Table SMP06-2. Filter Strip Seeding Mixture and Site Suitability Chart

Seeding Mixture	Seeding Rate Lbs/Acre	Soil Suitability
1. Alfalfa	10	Well Drained
or Red Clover	10	
Plus		
Timothy	4	
or Orchardgrass	6	
or Bromegrass	6	
2. Ladino Clover	½	Wet or Well Drained
Plus		
Timothy	4	
or Orchardgrass	6	
or Bromegrass	8	
3. Tall Fescue	40	Wet or Well Drained
4. Reed Canarygrass	15	Wet
Plus		
Tall Fescue		

Design (cont'd)

Construction Specifications
When planting filter strips, prepare the seedbed, incorporate fertilizer (if necessary), and apply mulch consistent with the seeding sections of this manual. Filter strips using areas of existing vegetation must be overseeded, as necessary, with the above mixtures to obtain an equivalent density of vegetation. The over seeding must be accomplished before the land disturbing activity if no grading will occur in the area. See the Permanent Seeding section of this manual for further details. For areas to be seeded in native grass and wildflower mixes, use the following approach:

Vegetation removal before seeding—If undesirable vegetation exists on the site, kill with nonselective, nonresidual herbicide, a glyphosate without surfactant if possible. After evidence of kill (7–14 days) mow to 2 inches. Mow or rake off.
Avoid soil disturbance—Avoid deep tillage, which pulls up new weed seed to compromise plantings. Scarify soil no deeper than one-half inch, on the contour, to reduce weed and erosion problems. No-till planters are now available to plant into existing dead stubble. Avoid adding imported topsoils unless it is certified to be weed-free.
Soil amendments—Amendments should be limited because of cost concerns. Fertilizers assist weed growth. Native forbs and grasses, if matched to the site, should establish without fertilizers if moisture is available. Amendments, if used, should be monitored for potential runoff impacts. Addition of peat moss has not proven beneficial to these plantings over time. Addition of native mychorizae has proven beneficial.
Equipment—Follow the seed distributor's instructions for planting. Specialized drills, broadcasters, and hydroseeders are available. Choose carefully and experiment on small areas to determine the best approach. The bottom line is that the seed germinates only if it makes contact with the soil and moisture.
Follow-up—Cover the seed by harrowing, dragging, raking or cultipacking. Mulch with weed-free straw or hay or native grass straw. Use ECBs on long, steep slopes if mulch and netting will not suffice. Avoid irrigation unless experiencing periods of drought, when supplementary watering might be in order. A high (6–8 inches) mowing once or twice during the first season reduces weed competition.

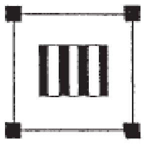
Maintenance

- Inspect weekly after rainfall events until turf is established
- Mowing shall consist of "tall" mowing, weeding and the irrigation system is growing and operating properly
- Fertilize as needed and as indicated by soil testing
- Construction traffic must not be permitted to drive upon filter strips.
- Overseed, repair bare spots, or apply additional mulch as necessary
- Regular liter removal

Inspection

- Practice has been properly mowed and maintained.
- Construction vehicles have been kept off BMP.
- Dead areas have been re-seeded, plugged or re-sodding.
- Underwash turf has been maintained and compacted.

Sediment Control Practices	SMP-07 Temporary Inlet Protection



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TIP

Description

This practice allows sediment to settle prior to entering into a stormwater catch basin or inlet. The detainment of sediment-laden runoff through filtering devices allows a cleaner runoff to be discharged into the environment.

Application

- Ø Protection of storm drain inlets or catch basins from sedimentation upstream of the inlet.
- Ø Areas where ponds are not encroached into access road or highway traffic.
- Ø Disturbed tributary areas have not yet been permanently stabilized.
- Ø Areas where drainage is 1 acre or less.
- Ø Areas with drainage more than 1 acre must be accompanied by a downstream sediment trap or basin.

Design

Sediment control can be maintained using one of the following practices:

- Ø Filter Fabric Fences
- Ø Block and Gravel Filter
- Ø Gravel and Wire Mesh Filter
- Excavated Inlet Sediment Traps

The ponding area must be relatively flat (less than 1 percent slope) with a sediment storage of 35 cubic yards per disturbed acre. All incoming storm flows must be intercepted and ponded or filtered by the structure, and pass over the structure and into the storm drain without bypasses. Temporary diking around the structure might be necessary to prevent bypass flow. Material can be excavated from inside the sediment storage area for this purpose. Drop inlet bag and frame filters are available from commercial vendors. These devices work very well if installed and maintained properly. Specify frames or filters that fit tightly around inlets and eliminate bypass opportunities. Filters can be reused if they are not damaged and washed out after prior use.

Design (cont'd) **Construction Specifications**

Silt Fence Sediment Barrier

- Support posts for a silt fence must be steel fence posts or 2 by 4 inch wood, length 3-foot minimum, spacing 3-foot maximum, with a top frame X-brace or other support recommended.
- Excavate a trench 4 inches wide and at least 8 inches deep and bury the bottom of the silt fence in the trench.
- Backfill the trench with gravel or soil. Compact the backfill well.
- The height of the silt fence must be a 1.5-foot maximum, measured from the top of the inlet.

Gravel Doughnut

- Keep the stone slope toward the inlet at 3:1 or flatter or use concrete blocks to help prevent the stone from being washed into the drop inlet. A minimum 1-foot-wide level area set 4 inches below the drop inlet crest will add further protection against the entrance of material.
- Stone on the slope toward the inlet should be 3 inches or larger for stability, and 1 inch or smaller on the slope away from the inlet to control flow rate. Mix various size stone for best results.
- Wire mesh with 2-inch openings can be placed over the drain grating, but it must be inspected frequently to avoid blockage by trash. If concrete blocks are used, the openings should be covered with wire screen or filter fabric.

Maintenance

- Replace or clean clogged fabric or gravel immediately.
- Remove sediment when depth exceeds half the height of the filter or half the depth of the sediment trap or after each significant rainfall (one-half inch in 24 hours) to provide adequate storage volume for the next rain.
- Inspect all inlets and catch basins weekly before and after each rain event greater than one-half inch, and promptly make repairs as needed.
- Inspect once every 24 hours during heavy rainfall events.
- After site is stabilized remove all inlet devices within 30 days.
- Bring disturbed area to final grade and smooth and compact it.
- Clean around and inside the storm drain inlet.
- Deposit the removed sediment in an area that will not contribute sediment off-site and can be permanently stabilized.

Inspection

- [ ] Filter fabric stakes are secure.
- [ ] Filter fabric is cleaned or replaced to prevent clogging.
- [ ] Sediment from behind the fabric less than ½ the height of the silt fence.
- [ ] Gravel filter is in working order. No evidence of gravel washing through.
- [ ] Do not clean any gravel adjacent to any inlet or waterway.
- [ ] Bags are properly maintained.
- [ ] No evidence of displacement of the practice.

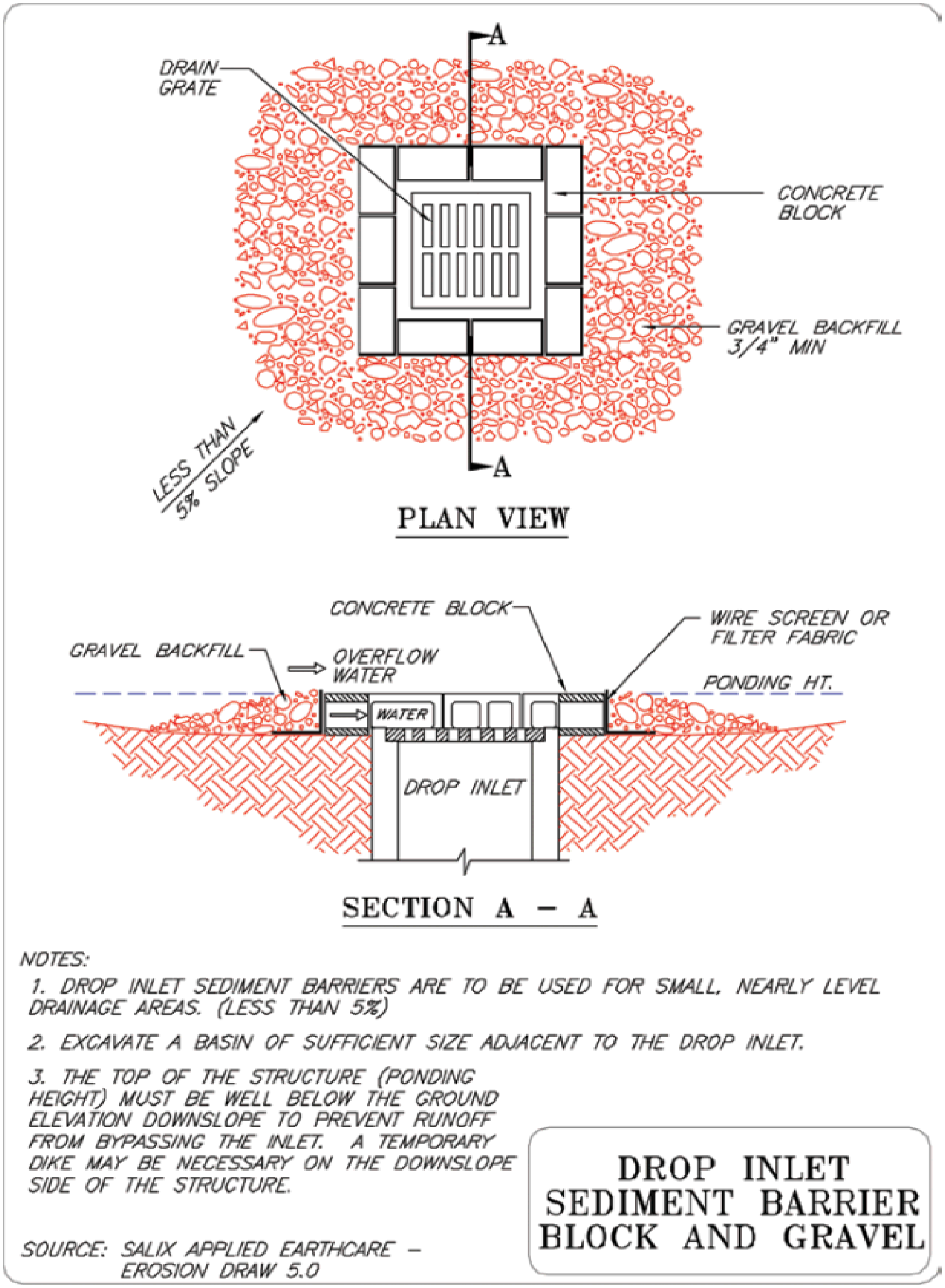

Figure SMP07-1. Block and Gravel Drop Inlet Protection

Sediment Control Practices	SMP-08 Temporary Slope Drains

SD

Symbol

SD

Description The slope drain is constructed of pipe or lined (rock or concrete) channel that extends from the top of a cut or fill slope to the bottom. This practice is used to direct and intercept storm water runoff to a controlled path to minimize slope erosion.

Application Storm drains may be used on land development sites where slopes are steep or susceptible to erosion.

Design

- Pipe capacity should be designed using the 10-year 24-hour storm or size chart listed below.

Drainage Area (acres)	Pipe Diameter (in.)
0.5	12
1.5	18
2.5	21
3.5	24
5.0	30

- Use heavy-duty materials such as corrugated plastic pipe or corrugated metal pipe.
- Conduit should be staked down at intervals equal to or less than 10 feet.
- Extend conduit beyond the toe of the slope.
- A standard flared-inlet pipe should be used at the entrance.
- Fittings should be water tight.

Design (cont'd)

- **General**—It is very important that these temporary structures be sized, installed, and maintained properly, because their failure will usually result in severe erosion of the slope. The entrance section to the drain should be well entrenched, staked down, and stable so that surface water can enter freely. The drain should extend downslope beyond the toe of the slope to a stable area or appropriately stabilized outlet.

- **Pipe capacity**—The pipe should be able to handle peak flow from the 10-year, 24-hour storm. Use 10-inch diameter or larger pipe to convey runoff from areas up to one-third acre; 12-inch or larger pipe for up to half-acre drainage areas, and 18-inch pipe for areas up to one acre. Multiple pipes or channels are often required for large areas, spaced as needed.

- **Conduit**—Construct the slope drain pipes from heavy-duty, flexible materials such as non-perforated, corrugated plastic pipe, or open top overside drains with tapered inlets, or corrugated metal pipe (CMP). Install reinforced, hold-down grommets or stakes to anchor the conduit at intervals not to exceed 10 feet with the outlet end securely fastened in place. CMP or corrugated plastic pipe must have one anchor assembly for every 20 feet of slope drain. The conduit must extend beyond the toe of the slope.

- **Entrance**—Construct the entrance to the slope drain of a standard flared-inlet section of pipe with a minimum 6-inch metal toe plate. Make all fittings watertight. A standard Tsection fitting can also be used at the inlet. An open top flared inlet for overside drain can also be used.

- **Temporary diversion**—Generally, use an earthen diversion with a dike ridge or berm to direct surface runoff into the temporary slope drain. Make the height of the ridge over the drain conduit a minimum of 1.5 feet and at least 6 inches higher than the adjoining ridge on either side. The lowest point of the diversion ridge should be a minimum of 1 foot above the top of the drain so that design flow can freely enter the pipe.

- **Outlet protection**—Protect the outlet of the slope drain from erosion with an energy dissipator. (i.e., rock apron or other armoring).

Construction Specifications

A common failure of slope drains is caused by water saturating the soil and seeping along the pipe. Proper backfilling around and under the pipe haunches with stable soil material and hand-compacting in 6 inch lifts to achieve firm contact between the pipe and the soil at all points will reduce this type of failure.

- Place slope drains on undisturbed soil or well-compacted fill at locations and elevations shown on the plans.
- Slightly slope the section of pipe under the dike toward its outlet.
- Compact the soil under and around the entrance section in lifts not to exceed 6 inches.

- Ensure that fill over the drain at the top of the slope has a minimum depth of 1.5 feet and a minimum top width of 4 feet. The sides should have a 3H:1V slope.
- Ensure that all slope drain connections are watertight.
- Ensure that all fill material is well compacted. Securely fasten the exposed section of the drain with grommets or stakes spaced no more than 10 feet apart.
- Extend the drain beyond the toe of the slope and adequately protect the outlet from erosion.
- Make the settled, compacted dike ridge no less than 1 foot higher than the top of the pipe inlet.
- Immediately stabilize all disturbed areas following construction.

Maintenance

Ø Inspect slope drains and supporting diversions weekly and after every significant rainfall and promptly make necessary repairs.

Ø After stabilization remove temporary measures.

Ø Re-set or replace displaced stones after wet weather events.

Ø Remove sediment accumulation from slope drain inlet, channel, and outlet.

Ø When the protected area has been permanently stabilized, temporary measures can be removed, materials disposed of properly, and all disturbed areas stabilized appropriately

Inspection

q Stones that have been displaced by wet weather events have been re-set and/or replaced.

q Pipe connections are watertight.

q Inlet/outlet has been cleaned and properly maintained.

q Remove sediment accumulation from channel.

q Construction traffic removed from slope drain.

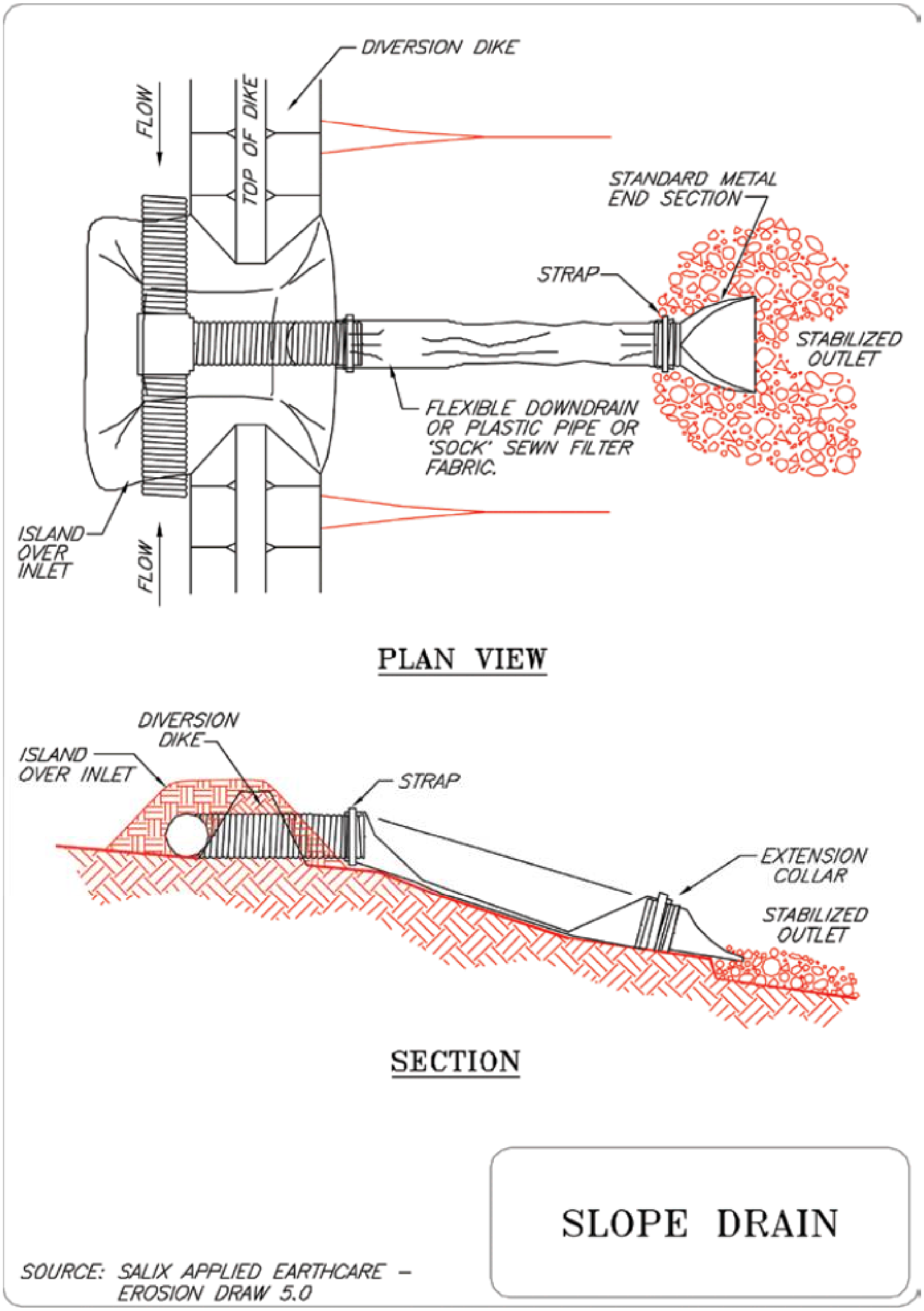

Figure SMP08-1. Slope Drain Installation

Kentucky Construction Site BMP Planning and Technical Specifications Manual

4.4 Good Housekeeping Practices Fact Sheets (GHP)

Good Housekeeping Practices	GHP-01 Dewatering Operations

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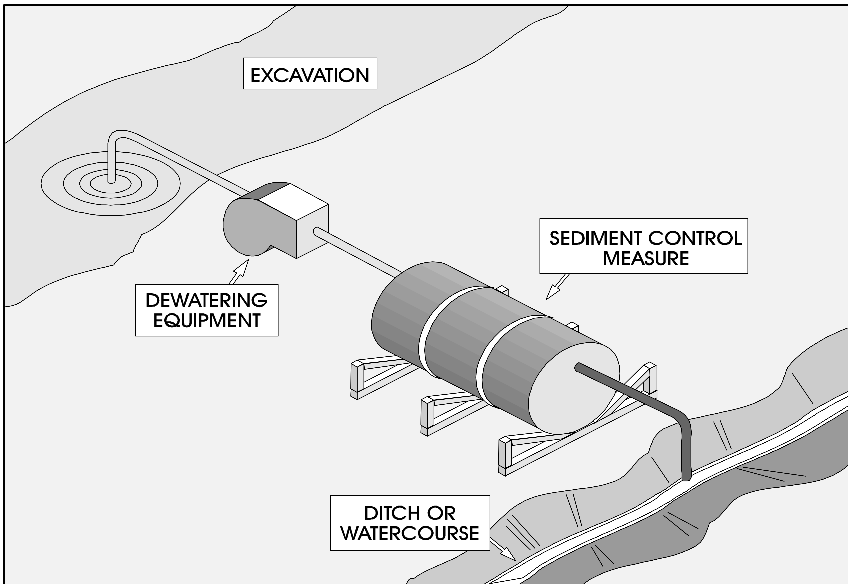
Symbol



Description

Testing of groundwater for pollution accumulation by using sediment controls is the basis of this BMP. This dewatering operation will reduce or prevent discharge of pollutants and aid in a partial reduction in toxic materials.

Application

Sediment and toxic and petroleum products are two general classes of pollutants that may result from dewatering operations. Toxics and petroleum are rarely found in dewatering discharges unless the site or the surrounding vicinity has been used for light or heavy industrial activities. Sediment, on the other hand, usually has a high content in dewatering discharges due to the commonality of the operation. **This BMP only addresses capture of sediment.** If it is determined that dewatering will result in transfer or accumulation of toxics or petroleum products then the Kentucky Division of Water (KDOW) should be consulted before any dewater activities are performed.

Design

Methods for Mitigating sediment discharge

- Ø Use of sock filters or sediment filter bags on discharge pipes.
- Ø Discharge muddy water into silt fence enclosures installed in vegetated areas away from water ways.
- Ø Discharge muddy water to a de-silting basin.
- Ø Afterwards sediment can be removed once water has dispersed and stabilized. Seeding the area is also suggested.

Dewatering operations should not discharge to a ditch, pipe, or other conveyance that leads to a regulated water body (e.g., stream, river, wetland, lake) except as authorized by a KPDES permit.

Design (cont'd)

There are several types of dewatering structures or devices that can be used. A flat, well stabilized, vegetated area can serve as a filtering structure if it can withstand the velocity of the discharged water and infiltrate or assimilate it without erosion. The minimum filter radius or length must be at least 75 feet. It is recommended that sediment basins or temporary sediment traps receive sediment laden water from bore pits and trenches. This will ensure that the 80 percent trapping efficiency goal will be upheld. Take special care to ensure that pumping this water does not cause the sediment control structure to fail. Also take care at the outlet of the hose from the pump to ensure that erosion does not occur because of high concentrated flows.

Another option is to use an infiltration trench—a shallow, excavated trench back-filled with stone—to form a reservoir. This reservoir can contain subsurface drainage pipe or just stone. This trench allows water to filter through the stone and then be diverted to a suitable discharge point. The soils and the depth to the water table must be suitable for this sort of dewatering. Typical trench depths range from 2 to 8 feet. The stone fill material consists of washed aggregate 1.5 to 3 inches in diameter.

Other methods that can be used include a portable sediment tank, a silt fence pit, or a commercial sediment filter bag or sock. The structure must be sized to allow pumped water to flow through the structure without overtopping.

This shows a dewatering sediment filter bag (center) in use at residential construction site. Muddy water pumped into the bag is physically filtered, with clear water passing through the bag fabric. Pumping muddy, unfiltered water directly into curb drains (center left) or surface streams constitutes a direct KPDES permit violation.

Construction Specifications

See the specifications in this manual for sediment traps and basins. Follow the manufacturer's recommendations for commercial products.

Maintenance/ Inspection

- Inspect filtering device frequently and repair or replace once the sediment build-up prevents the structure from functioning as designed.
- Sediment removal must be disposed of at a disposal site or spread and stabilized onsite.
- Inspect excavated areas daily for signs of contaminated water (signs such as discolored water, oily sheen or odor).
- Silt fence enclosures and commercial sediment filters will likely require cleaning to remove fine particles and restore performance. This can be done with a stiff brush when the filter is dry, or via other manufacturer's recommendations.

Good Housekeeping Practices	GHP-02 Paving Operations

No Symbol

Symbol

Description

Paving operations have the potential to introduce a large amount of pollutants to into the environment. This BMP will reduce or prevent the discharge of pollutants by using measures to prevent run-on and runoff pollution along with proper disposal of waste, and proper training of employees and subcontractors.

Application

- Ø Do not pave during wet weather.
- Ø Store paving materials away from water courses to prevent stormwater run-off.
- Ø Protect water courses, particularly in areas with a grade, by implementing BMPs to divert runoff or trap/filter sediment.
- Ø Leaks and spills can contain toxic levels of heavy metals and oil and grease generated from paving equipment. To alleviate these pollutants into the area, place drip pans or absorbent materials under paving equipment when they are not being used. When spills do occur, clean up spills with absorbent materials (see GHP-05).
- Ø Cover catch basins and manholes when applying seat coat, tack coat, slurry seal or fog seal.
- Ø Most commercial covers will magnetically seal flat catch basins and inlets.
- Ø If paving involves Portland cement concrete, see GHP-09.
- Ø If paving involves asphalt concrete do the following:
    1. Keep sand or gravel placed over new asphalt from being washed into storm drains, streets or creeks by sweeping. Refer to GHP-06 for proper disposal.
    2. Old asphalt must be disposed of properly. Collect and remove all broken asphalt from the site and recycle.
    3. If paving involves on-site mixing plant, follow the stormwater permitting requirements for Industrial activities.

Maintenance

- Maintain inlet protection so that water is not allowed to back up onto areas subject to traffic. Alternative measures should be employed if back up occurs.
- When sediment reaches storage capacity inlets need to be cleaned and repair as needed.
- Keep ample supplies of drip pans or absorbent materials on-site.

Inspection Checklist

- ☐ Machinery is not leaking and properly maintained.
- ☐ Inspect employees and subcontractors to ensure that measures are being followed.

Good Housekeeping Practices	GHP-03 Structure Construction and Painting

No Symbol

Symbol

Description

A number of preventive measures around the construction site greatly decrease the amount of pollution entering the environment. Enclosing, covering or berming building material storage areas, using good housekeeping practices, utilizing safer products and training employees and subcontractors will make a significant difference in the amount of pollutants entering stormwater runoff. This will cause a significant reduction in floatable materials, other construction waste and a partial reduction of toxic materials.

Application

- Keep the work site clean and orderly. Remove debris in a timely fashion. Sweep the area regularly.
- Use soil erosion control techniques if bare ground is exposed. See Erosion Prevention Practices (EPP).
- Buy recycled or less hazardous products to the maximum extent practicable.
- Conduct painting operations consistent with local air quality and Occupational Safety and Health Administration (OSHA) regulations.
- Properly store paints and solvents. See GHP-04: Material Delivery, Storage and Use in this section.
- Properly store and dispose waste materials generated from the activity. See the waste management BMPs GHP-06,-07, -08,-09 and -10 in this section.
- Recycle residual paints, solvents, lumber, and other materials to the maximum extent practicable.
- Make sure that nearby storm drains are well marked to minimize the chance of inadvertent disposal of residual paints and other liquids.
- Clean the storm drain system in the immediate construction area after construction is completed.

Application (cont'd)

- Educate and remind employees who are doing the work of the importance of keeping pollutants out of the stormwater system.
- Inform subcontractors of company policy on these matters and include appropriate provisions in their contract to make certain proper housekeeping and disposal practices are implemented.
- For a quick reference on disposal alternatives for specific wastes, see the table presented in the GHP 14-1, Employee/Subcontractor Training BMP fact sheet.
- For oil-based paints, paint out brushes to the extent practical, and filter and reuse thinners and solvents.
- Never clean paintbrushes or rinse paint containers into a street, gutter, storm drain or watercourse.
- Dispose of any paint, thinners, residue, and sludges that cannot be recycled as hazardous waste. For a quick reference on disposal alternatives for paint, thinners, residue and sludges see the table presented in the Employee/Subcontractor Training BMP fact sheet, Table GHP-14-1.
- Latex paint and paint cans, used brushes, rags, absorbent materials, and drop cloths, when thoroughly dry and are no longer hazardous, may be disposed of with other construction debris.
- Use recycled and less hazardous products when practical.
- Recycle residual paints, solvents, lumber, and other materials.

Maintenance

- Minimum maintenance required.
- Spot check employees and subcontractors monthly to assure appropriate practices are being employed.

Inspection

- [ ] Unused materials are properly contained, sealed and stored.
- [ ] Containment measures are being used to keep materials from entering watercourses.
- [ ] Used or discarded materials are properly disposed.

Good Housekeeping Practices	GHP-04 Material Delivery, Storage and Use

No Symbol

Symbol

Description A properly maintained and organized construction site can partially reduce the amount of contaminated sediment, nutrients, toxic materials, oil and grease and floatables from leaving the vicinity. By limiting the amount of onsite hazardous materials, storing materials in designated areas, installing secondary containment, conducting regular inspections and training employees and subcontractors, pollution can be prevented or reduced.

Application The following materials are commonly stored on construction sites:

- Soil
- Concrete compounds
- Pesticides and herbicides
- Fertilizers
- Detergents
- Plaster or other products
- Petroleum products such as fuel, oil, and grease

Other hazardous chemicals such as acids, lime, glues, paints, solvents, and curing compounds.

Storage of these materials on-site can pose various degrees of the following risks:

- Stormwater pollution,
- Injury to workers or visitors,
- Groundwater pollution, and
- Soil contamination.

Application (cont'd)

Therefore, the following steps should be taken to minimize your risk:

1. Designate areas of the construction site for material delivery and storage.
2. Place near the construction entrances and away from waterways.
3. Avoid transport near drainage paths or waterways.
4. Surround with earth berms, dikes, swales or other containment practices.
5. Place in an area which will be paved.
6. Storage of reactive, ignitable, or flammable liquids must comply with the fire codes of your area. Contact the local Fire Marshal to review site materials, quantities, and proposed storage area to determine specific requirements. See the Flammable and Combustible Liquid Code, NFPA30.
7. Follow manufacturer's instructions regarding uses, protective equipment, ventilation, flammability, and mixing of chemicals.
8. For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet, Table GHP-14-1.
9. Keep an accurate, up-to-date inventory of materials delivered and stored on-site.
10. Keep your inventory as close to "when you need it" levels as possible.
11. Minimize hazardous materials stored on-site and handle hazardous materials as infrequently as possible.
12. Consider storing materials in a covered area. Store materials in secondary containment's such as an earthen dike, horse trough, or even a children's wading pool for non-reactive materials such as detergents, oil, grease, and paints. Small amounts of material may be secondarily contained in 'bus boy' trays or concrete mixing trays.
13. Do not store chemicals, drums, or bagged materials directly on the ground unless otherwise contained. Place these items on a pallet and, when possible, in secondary containment.
14. Try to keep chemicals in their original containers, and keep them well labeled. If other containers are used then be sure they are well marked and can be adequately sealed and stored in an appropriate place.
15. Train employees and subcontractors.
16. Provide secondary storage for materials

Maintenance

Ø Keep designated storage areas clean and organized.
Ø Conduct routine weekly inspections and check for external corrosion of material containers.
Ø Keep an ample supply of clean up material on hand.
Ø Inspect storage areas before and after rainfall events.
Ø Repair or replace perimeter controls, containment structures and covers needed for functionality.

Inspection

q Inspect storage area frequently for cleanliness and spills and leaks.

q Functions are appropriately utilized and ensured to allow proper procedures for delivery, storage and use.

Good Housekeeping Practices	GHP-05 Spill Prevention and Control

No Symbol

Symbol

Description

Leaks and spills increase the amount of pollution entering stormwater runoff. The reduction of chances of spills, stopping the source of spills, containing and cleaning up spills, properly disposing of spill material, and training employees all lead to a cleaner environment. The incorporation of this BMP and GHP-04 (Material, Delivery, Storage, and Use) has information that will lead to a reduction toxic materials and oil and grease.

A number of familiar hazardous substances that affect construction sites are: soil stabilizers, palliatives, herbicides, growth inhibitors, fertilizers, deicing/anti-icing chemicals, fuels, lubricants, and other petroleum distillates.

Application

Determine the citeria for defining significant and insignificant spills and which materials should be used in response for each incident. Review of the Materials Safety Data Sheet (MSDS) or other documentation will clarify what is and is not a significant spill. A few measures to follow concerning spill prevention and control:

General Measures

- Store Materials away from waterways and storm drain inlets.
- Store hazardous materials and wastes in covered containers to protect against vandalism.
- Place a stockpile of spill cleanup materials where it will be readily accessible.
- Educate employees and subcontractors on potential dangers to humans and the environment that result from spills and leaks.
- Train employees in spill prevention and cleanup procedures for the site.

Application (cont'd)

- Hold regular meetings to discuss and reinforce appropriate disposal procedures (incorporate into regular safety meetings).
- Establish a continuing education program to indoctrinate new employees.
- Designate a foreman or supervisor to oversee and enforce proper spill prevention and control measures.

NOTE: The first step for any spill cleanup, whether minor or significant, is for the employee to identify the spilled material or to find a co-worker that can do so. Once identified it may be necessary for personnel to use Personal Protective Equipment (PPE) prior to continuing with the cleanup. If the spill is significant or hazardous, then it will likely require help from a local emergency response team with more experience.

Cleanup

- Clean up leaks and spills immediately.
- Use as little water as possible when cleaning spills. 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 (rags) or disposed of as hazardous waste.
- Never hose down or bury dry material spills. Clean up as much of the material as possible and dispose of properly. See the waste management BMPs in this section for specific information.

Minor Spills

- Minor spills typically involve small quantities of oil, gasoline, paint, etc. which can be controlled by the first responder at the discovery of the spill.
- Use absorbent materials on small spills rather than hosing down or burying the spill.
- Remove the absorbent materials promptly and dispose of by placing in double plastic bagging and discarding with solid waste.
- The practice commonly followed for a minor spill is:
  1. Contain the spread of the spill.
  2. Recover spilled materials.
  3. Clean the contaminated area and/or properly dispose of contaminated materials.

Semi-Significant Spills

- Remove the absorbent materials promptly and dispose of properly.
- Semi-significant spills still can be controlled by the first responder along with the aid of other personnel such as laborers and the foreman, etc. This response may require the cessation of all other activities and the use of PPEs.
- Clean up spills immediately:
  1. Notify the project foreman immediately. The foreman shall notify the Engineer or Safety Manager.
  2. Determine if spill response construction personnel are qualified to perform the cleanup in a safe manner. Alert additional trained personnel if necessary including a Haz-Mat team or dial 911 for local authorities.

Application (cont'd)

3. Contain spread of the spill.
4. Refer to material safety data sheets and KY Division of Waste Management (502.564.2380 or www.waste.ky.gov) disposal requirements. If the spill occurs on paved or impermeable surfaces, clean up using "dry" methods (absorbent materials, cat litter and/or rags). Contain the spill by encircling with absorbent materials and do not let the spill spread widely.
5. If the spill occurs during rain, cover spill with tarps or other material to prevent contaminating runoff.

Significant/Hazardous Spills

For significant or hazardous spills that cannot be controlled by personnel in the immediate vicinity, the following steps shall be taken:

1. Notify the Engineer immediately and follow up with a written report.
2. Notify the local emergency response by dialing 911. In addition to 911, the contractor will notify the proper county officials. It is the contractor's responsibility to have all emergency phone numbers at the construction site.
3. For spills of state reportable quantities or into a waterbody or adjoining shoreline, the contractor shall notify the Kentucky Division of Water (KDOW) general hotline – environmental assistance at 1-800-928-2380.
4. For spills of federal reportable quantities or into a waterbody or adjoining shoreline, the contractor shall notify the National Response Center at (800) 424-8802.
5. Notification should first be made by telephone and followed up with a written report.
6. The services of a spill contractor or a Haz-Mat team shall be obtained immediately. Construction personnel should not attempt to clean up until the appropriate and qualified staff has arrived at the job site.
7. Other agencies which may need to be consulted include, but are not limited to, the Fire Department, the Public Works Department, the City/County Police Department, Occupational Safety and Health Administration (OSHA), etc.

See GHP-12 and -13 for details about spill prevention and control while maintaining or fueling vehicles and equipment.

Construction sites and other facilities that have aboveground storage capacity in excess of 1,320 gallons for petroleum products are required to comply with federal regulations posted at 40 CFR Part 112, which mandates the preparation and implementation of Spill Prevention, Control, and Countermeasure (SPCC) Plan. The purpose of the SPCC Plan is to establish procedures, methods, and equipment to prevent or mitigate the discharge of oil from nontransportation-related onshore and offshore facilities into or upon the navigable waters of the United States. SPCC Plans must be prepared in accordance with sound engineering practices. The Kentucky Transportation Cabinet has a template for developing a SPCC Plan, posted at www.kytc.state.ky.us/EnvAnalysis/Stormwaterquality/PDF/Appendix_1-6.pdf.

Maintenance	Ø	Keep an ample supply of spill control and cleanup material on-site, near storage, unloading and maintenance areas.
	Ø	Employee Training
Inspection	q	Required amount of clean up material available at the site.
	q	Employees clearly understand their duties when a spill occurs.

Good Housekeeping Practices	GHP-06 Solid Waste Management

No Symbol

Symbol

Description

The management of waste in and out of a construction site reduces and in some cases prevents the discharge of pollutants to stormwater. This waste may be solid or construction waste, and can be disposed of at designated waste collection areas and in containers. This management practice will significantly reduce the quantity of floatable materials and other construction waste materials from escaping the construction site.

Application

Solid waste is one of the major pollutants resulting from construction. Construction debris includes:

- Solid waste generated from trees and shrubs removed during land clearing, demolition of existing structures (rubble), and building construction;
- Copper (pipe and electrical wiring)
- Packaging materials including wood, paper and plastic;
- Scrap or surplus building materials including scrap metals, rubber, plastic, glass pieces, and masonry products;
- Concrete, brick, and mortar;
- Pipe and electrical cuttings;
- Insulation
- Shingles and Roofing Materials
- Pavement planning or grinding and removal;
- Gypsum board
- Wood framing or false work; and
- Domestic wastes including food containers such as beverage cans, coffee cups, paper bags, and plastic wrappers, and cigarettes.

Application (cont'd)

The following steps will help keep a clean site and reduce stormwater pollution:

- Stress to employees the importance of keeping the work site clean
- Whenever possible, minimize production of debris and trash.
- Designate waste storage areas that are away from storm drain inlets, stormwater facilities, or watercourses.
- Provide containers in areas where employees congregate for breaks and lunch.
- Inform trash-hauling contractors that you will accept only watertight dumpsters for on-site use. Inspect dumpsters for leaks or open drain valves and repair any dumpster that is not watertight and tightly close the drain valve.
- Do not hose out dumpsters on the construction site. Leave dumpster cleaning to trash hauling contractor.
- Arrange for regular waste collection before containers overflow.
- Do not allow waste materials to accumulate on the ground.
- Prohibit littering by workers and visitors.
- If a container does spill, clean up immediately.
- Locate storage containers in a covered area and/or in secondary containment.
- Segregate potentially hazardous waste from non-hazardous construction site waste.
- Provide an adequate number of containers with lids or covers that can be placed over the container to keep rain out or to prevent loss of wastes when it is windy.
- Plan for additional containers and more frequent pickup during the demolition phase of construction.
- Collect site trash daily, especially during rainy and windy conditions.
- Erosion and sediment control devices tend to collect litter. Remove this solid waste promptly.
- Make sure that toxic liquid wastes (used oils, solvents, and paints) and chemicals (acids, pesticides, additives, curing compounds) are not disposed of in dumpsters designated for construction debris.
- Clearly mark on all debris and trash containers which materials are acceptable.
- Segregate recyclable construction debris from other nonrecyclable materials.
- Salvage or recycle any useful material. For example, trees and shrubs from land clearing can be used as a brush barrier or converted into wood chips, then used as mulch on graded areas.
- General construction debris may be hauled to a licensed construction debris landfill (typically less expensive than a sanitary landfill).
- Make sure that construction waste is collected, removed, and disposed of only at authorized disposal areas. Educate all workers on solid waste storage and disposal procedures.
- Instruct workers in identification of solid waste and hazardous waste.

Application (cont'd)	Ø Train employees and subcontractors in proper solid waste management. Ø Have regular meetings to discuss and reinforce disposal procedures (incorporate in regular safety seminars). Ø Designate a foreman or supervisor to daily oversee and enforce employees and subcontractors to follow solid waste handling and storage procedures. Ø For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet, Table GHP-14-1.
Maintenance	Ø Collect site trash daily. Ø The foreman or construction supervisor should inspect construction waste area regularly. Ø Arrange for regular waste collection. Ø Discipline workers who repeatedly violate procedures.
Inspection	q There are no major limitations to this best management practice.

Good Housekeeping Practices	GHP-07 Hazardous Waste Management

No Symbol

Symbol

Description Educating employees and subcontractors on methods for properly managing, storing, and disposing hazardous waste will aid in reducing pollution leaving the construction site, thus resulting in a partial reduction of toxic materials entering stormwater conveyance systems.

Application Most chemicals used on-site can be hazardous materials which become hazardous waste upon disposal. These wastes may include:

- Paints and solvents
- Stains
- Wood preservatives
- Petroleum products such as oils, fuels, and grease
- Roofing tar
- Herbicides, pesticides, and fertilizer
- Acids for cleaning masonry
- Concrete curing compounds
- Antifreeze

In addition, sites with existing structures may contain wastes which must be disposed of in accordance with Federal, State, and local regulations. These wastes include:

- Sandblasting grit mixed with lead-, cadmium-, or chromium-based paints;
- Asbestos; and
- PCBs (particularly in older transformers).

Application (cont'd)

The following steps will help reduce stormwater pollution from hazardous wastes:

Material Use

- Use the entire product before disposing of the container. Do not dispose of liquid wastes on pavement or near ditches or stormwater inlets.
- Do not remove the original product label, it contains important safety and disposal information.
- Material Safety Data Sheets should be provided for each product being handled. All persons using or handling the product should be made aware of the safety information and the location of the readily available Material Safety Data Sheets.
- Do not over-apply herbicides and pesticides. Prepare only the amount needed. Follow the recommended usage instructions. Over-application is expensive, environmentally harmful and generally doesn't provide the intended additional benefit. Apply surface dressings in several smaller applications, as opposed to one large application, to allow time for infiltration and to avoid excess material being carried off-site by runoff. Do not apply these chemicals just before it rains. People applying pesticides must be trained and certified in accordance with Federal and State regulations.
- Minimize water usage during paint wash-up. Dispose of paint wash water with other liquid wastes, spread on graveled sites prepared for new concrete pouring, or areas being prepared for paving. Do not dispose of wash water in ditches or stormwater inlets.
- Allow paint rollers, drop cloths, cans, and other wastes to dry thoroughly, then discard in solid waste containers.

Waste Recycling/Disposal

- Recycle or dispose of all liquid wastes in accordance with material safety data sheets.
- Select designated hazardous waste collection areas on-site.
- Ensure that adequate cleanup and containment materials are available on-site.
- Use only licensed hazardous waste haulers.
- Regularly schedule hazardous waste removal to minimize on-site storage.
- Hazardous materials and wastes should be stored in covered containers and protected from vandalism. They should be stored in the original containers or in other well marked containers.
- Place hazardous waste containers in secondary containment.

Storage Procedures

- Ensure that adequate hazardous waste storage volume is available.
- Ensure that hazardous waste collection containers are conveniently located.
- Designate hazardous waste storage areas on site, away from storm drains or watercourses.
- Minimize production or generation of hazardous materials and hazardous waste on the jobsite.

Application (cont'd)

- Use containment berms in fueling and maintenance areas and where the potential for spills is high.
- Segregate potentially hazardous waste from non-hazardous construction site debris.
- Store hazardous materials and wastes in covered containers and protected from vandalism.
- Designate a foreman or supervisor to oversee hazardous materials handling procedures.
- Keep liquid or semi-liquid hazardous waste in appropriate containers (closed drums or similar) and under cover.
- Clearly mark on all hazardous waste containers which materials are acceptable for the container.
- Place hazardous waste containers in secondary containment.
- Do not allow potentially hazardous waste materials to accumulate.
- Enforce hazardous waste handling and disposal procedures.
- Do not mix wastes as this can cause unforeseen chemical reactions, make recycling impossible and complicate disposal.
- Recycle any useful material such as used oil or water-based paint.
- Make sure that toxic liquid wastes (used oils, solvents, and paints) and chemicals (acids, pesticides, additives, curing compounds) are not disposed of in dumpsters designated for non-hazardous construction debris.
- Arrange for regular waste collection before containers overflow.
- Make sure that hazardous waste (e.g. excess oil-based paint and sludges) is collected, removed, and disposed of only at authorized disposal areas.
- For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet, Table GHP-14-1.

Training

- Educate employees and subcontractors on hazardous waste storage and disposal procedures.
- Educate employees and subcontractors of potential dangers to humans and the environment from hazardous wastes.
- Instruct employees and subcontractors on safety procedures for common construction site chemical storage.
- Instruct employees and subcontractors in identification of chemical pollutants..
- Hold regular meetings to discuss and reinforce disposal procedures (incorporate into regular safety meetings).
- Designate a foreman or supervisor to oversee and enforce proper solid waste management procedures and practices.
- Make sure that hazardous waste is collected, removed, and disposed of only at authorized disposal areas.

Training (cont'd)	Ø Train employees and subcontractors in proper hazardous waste management including review of material safety data sheets. Ø Place a stockpile of spill cleanup materials where it will be readily accessible. Ø Warning signs should be placed in areas recently treated with chemicals. Ø If a container does spill, clean up immediately. Ø Establish a continuing education program to train new employees.
Maintenance	Ø Inspect hazardous waste receptacles and area regularly. Ø Arrange for regular hazardous waste collection.
Inspection	q Hazardous waste receptacles are properly maintained. q Hazardous waste material is properly and routinely removed from the site by a licensed hazardous waste hauler.

Good Housekeeping Practices	GHP-08 Contaminated Soil Management

No Symbol

Symbol

Description

Contaminated soil and highly acidic or alkaline soils produce pollutants in stormwater. Contaminated Soil Management allows preventive measures such as pre-construction surveying, inspecting excavations regularly, and remediating contaminated soil promptly all reduce or prevent the discharge of pollutants to stormwater.

Application

- Applicable to many construction projects, especially those in highly urbanized or industrial areas, where soil contamination may have occurred due to spills, illicit discharges, and underground storage tanks.
- Applicable to highway widening projects in older areas where median and shoulder soils may have been contaminated by aerially deposited lead.

Design

Contaminated soils are often identified in the project material report with known locations identified in the plans and specifications. The contractor shall review applicable reports and investigate appropriate callouts in the plans and specifications.

Contaminated soils may occur on your site for several reasons including:

- Past site uses and activities;
- Detected or undetected spills and leaks; and
- Acid or alkaline solutions from exposed soil or rock formations high in acid or alkaline-forming elements.

Design (cont'd)

Most developers conduct pre-construction environmental assessments as a matter of routine. Recent court rulings holding **contractors liable for cleanup costs** when they unknowingly move contaminated soil, highlight the need for contractors to confirm that a site assessment is completed **before earth moving begins.**

The following steps will help reduce stormwater pollution from contaminated soil:

- Conduct thorough site planning including pre-construction geologic surveys.
- Look for contaminated soil as evidenced by discoloration, odors, differences in soil properties, abandoned underground tanks or pipes, or buried debris.
- Prevent leaks and spills to the maximum extent practicable. Contaminated soil can be expensive to treat and/or dispose of properly. However, addressing the problem before construction is much less expensive than after the structures are in place.
- For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet, Table GHP-14-1.

Application of this BMP Fact Sheet

Excavation, transport, and disposal of contaminated material and hazardous material shall be in accordance with the rules and regulations of the following agencies (the specifications of these agencies shall supersede the procedures outlined in this BMP):

- United States Environmental Protection Agency (USEPA)
- Kentucky Division of Water (KDOW)
- UST Branch, Kentucky Division of Waste Management (KDWM)
- Kentucky Division of Occupation Safety and Health Administration (OSHA)

Education

- Prior to performing any excavation work at the locations containing material classified as hazardous, employees and subcontractors shall complete a safety-training program.
- Educate employees and subcontractors on contaminated soil handling and disposal procedures.
- Instruct employees and subcontractors in identification of contaminated soil.
- Hold regular meetings to discuss and reinforce disposal procedures (incorporate into regular safety meetings).
- Provide additional training for field supervisors and inspectors, including hazardous material safety training.

Handling Procedures for Material with Aerially Deposited Lead

- Materials from areas designated as containing aerially deposited lead may, if allowed by the contract special provisions, be excavated, transported, and used in the construction of embankments and/or backfill.
- Excavation, transportation, and placement operations shall result in no visible dust.
- Use caution to prevent spillage of lead containing material during transport.
- Monitor the air quality during excavation of soils contaminated with lead.

Design (cont'd)

Handling Procedures for Contaminated Soils or Hazardous Materials

- Test suspected soils at a certified laboratory.
- If the soil is contaminated, work with KDOW or environmental contractor to develop options for treatment and/or disposal.
- Avoid temporary stockpiling of contaminated soils or hazardous material.
- If temporary stockpiling is necessary:
  1. Cover the stockpile with plastic sheeting or tarps.
  2. Install a berm around the stockpile to prevent runoff from leaving the area.
  3. Do not stockpile in or near storm drains or watercourses.
  4. Implement stockpile controls as presented in GHP-04: Material Delivery, Storage, and Use.
- Contaminated material and hazardous material on exteriors of transport vehicles shall be removed and placed either into the current transport vehicle or the excavation prior to the vehicle leaving the exclusion zone.
- Monitor the air quality continuously during excavation operations at all locations containing hazardous material.
- Procure all permits and licenses, pay all charges and fees, and give all notices necessary and incident to the due and lawful prosecution of the work, including registration for transporting vehicles carrying the contaminated material and the hazardous material.
- Collect water from decontamination procedures and dispose of at an appropriate disposal site.
- Collect non-reusable personal protective equipment (PPE), once used by any personnel, and dispose of at an appropriate disposal site.
- Install temporary security fence to surround and secure the exclusion zone. Remove fencing when no longer needed.

Procedures for Underground Storage Tank Removals

- Prior to commencing tank removal operations, obtain the required underground storage tank removal permits and approval from UST Branch, Kentucky Division of Waste Management, which has jurisdiction over such work.
- Arrange to have tested, as directed by the design professional, any liquid or sludge found in the underground tank prior to its removal to determine if it contains hazardous material.
- Following the tank removal, take soil samples beneath the excavated tank and perform analysis as required by UST Branch, Kentucky Division of Waste Management and the local agency representative(s).
- The underground storage tank, any liquid and/or sludge found within the tank, and all contaminated material and hazardous material removed during the tank removal shall be transported to disposal facilities permitted to accept such material by a licensed hazardous waste hauler.

Design (cont'd)

Water Control

- Take all necessary precautions and preventive measures to prevent the flow of water, including ground water, from entering hazardous material or underground storage tank excavations. Such preventative measures may consist of, but are not limited to berms, cofferdams, grout curtains, freeze walls, and seal course concrete or any combination thereof.
- If water does enter an excavation and becomes contaminated, such water, when necessary to proceed with the work, shall be discharged to clean, closed top, watertight, transportable holding tanks, and disposed of in accordance with federal, state, and local laws.

Maintenance

- Inspect excavated areas daily for indications of contaminated soil.
- Implement GHP-05: Spill Prevention and Control, to prevent leaks and spills as much as possible.
- Monitor air quality continuously during excavation operations at all locations containing hazardous material.
- Coordinate contaminated soils and hazardous material management with the appropriate federal, state, and local agencies.
- Inspect hazardous waste receptacles and areas regularly.

Inspection

- The procedures and practices presented in this BMP are general. The contractor shall identify appropriate practices and procedures for the specific contaminants known to exist or discovered on site.
- Contaminated soils that cannot be treated on-site must be disposed of off-site by a licensed hazardous waste hauler.
- The presence of contaminated soil may indicate contaminated water as well. See GHP-01: Dewatering Operations for more information.

Good Housekeeping Practices	GHP-09 Concrete Waste Management

No Symbol

Symbol

Description

Concrete waste management requires simple measures including off-site washouts, performing on-site washout in a designated area, and training employees and subcontractors. These procedures will help reduce concrete pollutant discharge to stormwater.

Design

The following steps will help reduce stormwater pollution from concrete wastes:

- Ø Store dry and wet materials under cover, away from drainage areas.
- Ø Avoid mixing excess amounts of fresh concrete or cement on-site.
- Ø Perform washout of concrete trucks off site or in designated areas only – such as a specially designed soil mixing sump protected by a sediment trap. Do not allow wash water from trucks and chutes into storm drains.
- Ø Avoid dumping into storm drains, open ditches, streets, or streams.
- Ø Do not allow excess concrete to be dumped on-site, except in designated areas. For onsite washout: Locate washout area at least 50 feet from storm drains, open ditches, or water bodies. Do not allow runoff from this area by constructing a temporary pit or bermed area large enough for liquid and solid waste;
- Ø Wash out wastes into the temporary pit where the concrete can set, be broken up, and then disposed of properly.
- Ø Be sure the stormwater collection system is protected by means of a sediment trap or similar practice.
- Ø If possible, dump waste and wash water into areas prepared for new concrete pouring.
- Ø If no future pour site is available, develop other safe concrete disposal areas.

Design (cont'd)

- Provide a washout area with a minimum of 6 cubic feet of containment area volume for every 10 cubic yards of concrete poured.
- When washing concrete to remove fine particles and expose the aggregate, avoid creating runoff by draining the water to a bermed or level area.
- Do not wash sweepings from exposed aggregate concrete into the street or storm drain. Collect and return sweepings to aggregate base stockpile, or dispose in the trash.
- Train employees and subcontractors in proper concrete waste management.
- For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet, Table GHP-14-1.
- Illicit dumping on-site or off-site without property owner's knowledge and consent is unacceptable.
- Washout locations may be flagged with lath and surveyors tape or designated as necessary to insure that truck drivers utilize proper areas.
- Wash water much be handled in a manner that does not result in a violation of groundwater or surface water quality standards.

Education

- Instruct drivers and equipment operators on proper disposal and equipment washout practices.
- Educate employees, subcontractors, and suppliers on concrete waste storage and disposal procedures.
- Designate a foreman or supervisor to oversee and enforce concrete waste management procedures. Make supervisors aware of the potential environmental consequences of improperly handled concrete wastes.
- Employees violating disposal or equipment cleaning directives must be reeducated or disciplined if necessary

Demolition Practices

- Monitor weather and wind direction to ensure concrete dust is not entering storm drains, watercourses, or surface waters.
- Where appropriate, construct sediment traps or other types of sediment detention devices downstream of demolition activities.

Maintenance

- Inspect subcontractors to ensure that concrete wastes are being properly managed.
- If using a temporary pit, dispose hardened concrete on a regular basis that will prevent the pit from being more than half-full.
- Foreman and/or construction supervisor shall monitor on site concrete waste storage and disposal procedures at least weekly.

Inspection

- Concrete waste receptacles are maintained and emptied routinely.
- On-site wash out area is located at least 50 ft. from storm drains, open ditches, or other water bodies
- On-site wash out area is properly maintained and cleaned.

Performance Indicators

- Use predetermined disposal sites for waste concrete
- Prohibit dumping waste concrete anywhere but predetermined areas
- Assign predetermined truck and equipment washing areas
- Educate drivers and operators on proper disposal and equipment cleaning procedures.

Good Housekeeping Practices	GHP-10 Sanitary/Septic Waste Management

No Symbol

Symbol

Description

Providing convenient well-maintained sanitary and septic waste facilities with regular service and disposal reduces or prevents discharge of pollutants to stormwater from sanitary/septic waste.

Design

- Sanitary or septic wastes should be treated or disposed of in accordance with Kentucky Division of Water (KDOW) and local health department requirements.
- Locate sanitary facilities in a convenient location.
- Portable toilets must be provided if no permanent facilities are available.
- Never discharge untreated or raw wastewater to a ditch, creek or other waterway, or bury on site.
- Temporary septic systems should treat wastes to appropriate levels prior to discharging. KDOW should be consulted to determine appropriate levels.
- If using an on-site disposal system (OSDS), such as a septic system, comply with local health agency requirements.
- Temporary sanitary facilities that discharge to the sanitary sewer system should be properly connected and inspected by the local sewer authority to avoid illicit discharges to the storm sewer system and other pertinent requirements.
- Privately held sanitary/septic facilities should be maintained in good working order by a licensed service.
- Arrange for regular waste collection by a licensed hauler before facilities overflow.
- For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet, Table GHP-14-1.

Design (cont'd)

- Anchor portable sanitary facilities, when needed, to prevent them from tipping by vandals.
- Locate portable toilets a minimum of 20 feet away from storm drain inlets, conveyance channels, or surface waters.
- If unable to meet the 20-foot distance requirement, provide containment for portable toilets.

Maintenance

- Inspect facilities regularly.
- Arrange for regular waste collection.

Inspection

- There are no major limitations to this best management practice other than those that may be imposed by the local sewer authority.

Good Housekeeping Practices	GHP-11 Vehicle and Equipment Cleaning

No Symbol

Symbol

Description

Proper vehicle and equipment cleaning can prohibit pollutants from entering stream and ditches by cleaning equipment using an off-site facility, washing in designated contained areas only, infiltrating or recycling the wash water and by training employees and subcontractors.

Design

- Use off-site commercial washing businesses as much as possible except for removing mud and dirt off equipment while on site. Washing vehicles and equipment outdoors or in areas where wash water flows onto paved surfaces or into drainage pathways can pollute stormwater. If you wash a large number of vehicles or pieces of equipment, consider conducting this work at an off-site commercial business.
- Off-site commercial businesses are better equipped to handle and dispose of the wash waters properly. Performing this work off-site can also be economical by eliminating the need for a separate washing operation at your site.
- If washing must occur on-site, use designated, bermed wash areas to prevent wash water entering stormwater infrastructure, creeks, rivers, and other water bodies. The wash area can be sloped for wash water collection and subsequent infiltration into the ground.
- Use phosphate-free, biodegradable soaps.
- Educate employees and subcontractors on pollution prevention measures about the importance of this practice.
- Do not permit steam cleaning on-site. Steam cleaning can generate significant pollutant concentrations.
- Clean all vehicles/equipment off-site that regularly enter and leave the construction site.

Design (cont'd)

- Ø When vehicle/equipment washing/cleaning must occur on-site, and the operation cannot be located within a structure or building equipped with sanitary sewer facilities, the outside cleaning area shall have the following characteristics:
  1. Located away from storm drain inlets, drainage facilities, or watercourses;
  2. Paved with concrete or asphalt, or stabilized with an aggregate base;
  3. Configured wash area with a sump to allow collection and disposal of wash water;
  4. Discharge wash water to a sanitary or process waste sewer (where permitted), or to a dead end sump. Wash waters shall not be discharged to storm drains or watercourses.
- Ø When cleaning vehicles/equipment with water:
  1. Use as little water as possible to avoid having to install erosion and sediment controls for the wash area. High-pressure sprayers may use less water than a hose, and should be considered.
  2. Use positive shutoff valve to minimize water usage.
- Ø DO NOT use solvents to clean vehicles/equipment on site.

Maintenance

- o Minimal, some berm repair may be necessary, inspect weekly.
- o Service sump regularly.

Inspection

- q Phosphate-free, biodegradable soaps are being used.
- q Vehicles and equipment are sent off-site using the stabilized construction entrance and mud tracking removal.
- q The local sewer authority has been contacted and is aware of all pretreatment and monitoring of wash water discharges to the sanitary sewer.

Good Housekeeping Practices	GHP-12 Vehicle and Equipment Fueling

No Symbol

Symbol

Description

This BMP prevents fuel spills and leaks and their impact to stormwater by using off-site facilities, fueling in designated areas only, enclosing or covering stored fuel, implementing spill controls, and training employees and subcontractors.

Design

- Use off-site fueling stations as much as possible. Fueling vehicles and equipment outdoors or in areas where fuel may spill/leak onto paved surfaces or into drainage pathways can pollute stormwater. If you fuel a large number of vehicles or pieces of equipment, consider using an off-site fueling station. These businesses are better equipped to handle fuel and spills properly. Performing this work off-site can also be economical by eliminating the need for a separate fueling area at your site.
- If on-site fueling cannot be avoided, designated areas, located away from drainage courses, can be used to prevent the run-on of stormwater and the runoff of spills.
- Educate employees and subcontractors not to “top-off” fuel tanks.
- When fueling, use secondary containment, such as a drain pan or drop cloth, to catch spills/leaks.
- Place a stockpile of spill cleanup materials where it will be readily accessible.
- Use adsorbent materials on small spills rather than hosing down or burying the spill. Remove the adsorbent materials promptly and dispose of properly.

Design (cont'd)

- Observe Federal and State requirements regarding stationary above-ground storage tanks with special attention given to secondary containment.
- Avoid mobile fueling of mobile construction equipment around the site; rather, transport the equipment to designated fueling areas. With the exception of tracked equipment such as bulldozers and perhaps forklifts, most vehicles should be able to travel to a designated area with little lost time.
- For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet, Table GHP-14-1.
- Locate fueling areas on a paved surface where practical.
- Protect fueling areas with berms and/or dikes to prevent run-on, runoff, and to contain spills.
- Use vapor recovery nozzles to help control drips as well as air pollution where required by Air Quality Management Districts.

Maintenance

- Keep ample supplies of spill cleanup materials on-site.
- Inspect fueling areas and storage tanks daily.

Inspection

- [ ] Secondary containment area is properly maintained and preventing petroleum products from runoff to streams and ditches.
- [ ] Construction site has proper materials for cleaning spills.
- [ ] Fueling tanks are working properly.

Good Housekeeping Practices	GHP-13 Vehicle and Equipment Maintenance
No Symbol Symbol	

Description

Contractors occasionally require an on-site vehicle and equipment maintenance area to avoid work stoppage for extended periods due to inoperable equipment. Whenever possible, the contractor should operate a "dry site" to reduce or prevent discharge of pollutants to stormwater from vehicles and equipment maintenance. This involves using off-site facilities (whenever feasible), performing work in designated areas only, providing cover for materials stored outside, checking for leaks and spills, containing and cleaning up spills immediately and training employees and subcontractors.

Design

- Keep vehicles and equipment clean; don't allow excessive build-up of oil and grease.
- Use off-site repair shops as much as possible. Maintaining vehicles and equipment outdoors or in areas where vehicle or equipment fluids may spill or leak onto the ground can pollute stormwater. If you maintain a large number of vehicles or pieces of equipment, consider using an off-site repair shop. These businesses are better equipped to handle vehicle fluids and spills properly. Performing this work off-site can also be economical by eliminating the need for a separate maintenance area.

Waste Reduction

- Reducing the number of solvents used for cleaning equipment makes recycling easier and reduces hazardous waste management costs.
  - Replace chlorinated organic solvents (1,1,1-trichloroethane, methylene chloride, etc.) with non-chlorinated solvents. Non-chlorinated solvents like kerosene or mineral spirits are less toxic and less expensive to dispose of properly.

Design (cont'd)

  - § Check for inactive ingredients to see whether it contains chlorinated solvents. The "chlor" term indicates that the solvent is chlorinated.
  - § Substitute a wire brushes for solvents to clean parts.
- Ø If maintenance must occur on-site, use designated areas, located away from watercourses, to prevent the run-on of stormwater and the runoff of spills.
- Ø Use secondary containment, such as a drain pan or drop cloth, to catch spills or leaks when removing or changing fluids.
- Ø Place a stockpile of spill cleanup materials where it will be readily accessible.
- Ø Place drip pans or absorbent materials under paving equipment when not in use.
- Ø Use adsorbent materials on small spills rather than hosing down or burying the spill. Remove the adsorbent materials promptly and dispose of properly.
- Ø Regularly inspect on-site vehicles and equipment for leaks, and repair immediately.
- Ø Promptly transfer used fluids to the proper waste or recycling drums. Don't leave full drip pans or other open containers lying around.
- Ø Check incoming vehicles and equipment (including delivery trucks, and employee and subcontractor vehicles) for leaking oil and fluids. Do not allow leaking vehicles or equipment on-site.
- Ø Oil filters disposed of in trashcans or dumpsters can leak oil and pollute stormwater. Place the oil filter in a funnel over a waste oil recycling drum to drain excess oil before disposal. Oil filters can also be recycled. Ask your oil supplier or recycler about recycling oil filters.
- Ø Store cracked batteries in a non-leaking secondary container. Do this with all cracked batteries, even if you think all the acid has drained out. If you drop a battery, treat it as if it is cracked. Put it into the containment area until you are sure it is not leaking.
- Ø Segregate and recycle wastes, such as greases, used oil or oil filters, antifreeze, cleaning solutions, automotive batteries, hydraulic, and transmission fluids.
- Ø Train employees and subcontractors in proper maintenance and spill cleanup procedures.
- Ø For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet, Table GHP-14-1.
- Ø Perform maintenance activities on paved surfaces where practical.
- Ø Use diversion berms to protect maintenance areas from run-on.
- Ø Provide spill containment dikes or secondary containment around stored oil and chemical drums.
- Ø For long-term projects, consider using portable tents or covers over maintenance areas.
- Ø Do not dump fuels and lubricants onto the ground.
- Ø Do not place used oil in a dumpster or pour into a storm drain or watercourse.
- Ø Do not bury used tires.

Design (cont'd)

Recycling/Disposal

- Separating wastes allows for easier recycling and may reduce disposal costs. Keep hazardous and non-hazardous wastes separate, do not mix used oil and solvents, and keep chlorinated solvents (like 1,1,1-trichloroethane) separate from non-chlorinated solvents (like kerosene and mineral spirits).
- Do not dispose of extra paints and coatings by dumping liquid onto the ground or throwing it into dumpsters. Allow coatings to dry or harden before disposal into covered dumpsters.
- Do not store batteries, oil, or other materials where they could be exposed to runoff.
- Use drip pans or absorbents under leaking vehicles or equipment.
- Properly dispose of used oil, lubricants, and grease.

Maintenance

- Keep ample supplies of spill cleanup materials on-site.
- Inspect maintenance areas on a regular schedule.
- Maintain waste fluid containers in leak proof condition.
- Vehicle and equipment maintenance areas shall be inspected regularly.
- Inspect equipment for damaged hoses and leaky gaskets routinely. Repair or replace as needed.

Inspection

- [ ] On-site maintenance area is cleaned and properly maintained.
- [ ] Construction site has proper materials for cleaning spills.
- [ ] Watercourses in the vicinity are protected from spills by a diversion berm.
- [ ] Sending vehicles/equipment off-site should be done in conjunction with a stabilized construction entrance.

Good Housekeeping Practices	GHP-14 Employee/Subcontractor Training

No Symbol

Symbol

Description

Employee or subcontractor training will determine the success of the stormwater pollution prevention program. This BMP will focus on approaches to assure that employees and subcontractors are familiar with Bowling Green's the Storm Water Pollution Prevention Plan (SWPPP) and will turn the attention from an individualized source control into a comprehensive training program.

Application

Employee/subcontractor training should be based on three objectives:

1. Promote a clear identification and understanding of the problem, including activities with the potential to pollute stormwater;
2. Identify solutions (BMPs);
3. Promote employee/subcontractor ownership of the problems and the solutions; and

Integrate employee/subcontractor feedback into training and BMP implementation.

Design

- Ø Use the Kentucky BMP Planning and Technical Specifications Manual as the training workbook
- Ø Integrate training regarding stormwater quality management with existing training programs that may be required for your business by other regulations such as the 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) standard (29 CFR 1910.120); and the Spill Prevention Control and Countermeasure (SPCC) Plan (40 CFR 112).
- Ø Supervisors and inspectors should receive additional annual 8-hour refresher courses.
- Ø Businesses, particularly smaller ones that may not be regulated by Federal, State, or local regulations, may use the information in this BMP Manual to develop a training program to reduce their potential to pollute stormwater.

Design (cont'd)

- Use the quick reference on disposal alternatives (Table GHP-14-1) to train employee/ subcontractors in proper and consistent methods for disposal.
- Consider posting the quick reference table around the job site or in the on-site office trailer to reinforce training.
- Train employee/subcontractors in standard operating procedures and spill cleanup techniques described in the fact sheets. Employee/subcontractors trained in spill containment and cleanup should be present during the loading/unloading and handling of materials.
- Personnel who use pesticides should be trained in their use.
- Proper education of off-site contractors is often overlooked. The conscientious efforts of well trained employee/subcontractors can be lost by unknowing off-site contractors, so make sure they are well informed about what they are expected to do on-site.
- Integrate erosion and sediment control training with spill response training, safety training, or other training where appropriate.
- Consider sending employees to erosion and sediment control training courses.

TABLE GHP-14-1 QUICK REFERENCE – DISPOSAL ALTERNATIVES

All of the waste products on this chart are prohibited from discharge to the storm drain system. Use this matrix to decide which alternative disposal strategies to use. **ALTERNATIVES ARE LISTED IN PRIORITY ORDER.**

Key: HHW Household hazardous waste; MWS Municipal Waste System
NPDES National Pollutant Discharge Elimination System (NPDES) Office.; POTW Publicly Owned Treatment Plant
"Dispose to sanitary sewer" means dispose into sink, toilet, or sanitary sewer clean-out connection.
"Dispose as trash" means dispose in dumpsters or trash containers for pickup and/or eventual disposal in landfill.
"Dispose as hazardous waste" for business/commercial means contract with a hazardous waste hauler to remove and dispose.

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	BUSINESS/COMMERCIAL Approval	RESIDENTIAL Disposal Priorities
General Construction and Painting: Street and Utility Maintenance			
Excess paint (oil based)	1. Recycle/reuse. 2. Solidify and dispose as hazardous waste.		1. Recycle/reuse. 2. Take to HHW drop-off.
Excess paint (water based)	1. Recycle/reuse 2. Dry residue in cans, dispose as trash. 3. If volume is too much to dry, solidify and dispose as hazardous waste.		1. Recycle/reuse. 2. Dry residue in cans, dispose as trash. 3. If volume is too much to dry, take to HHW drop-off.
Paint cleanup (oil based)	Wipe paint out of brushes, then: 1. Filter & reuse thinners, solvents. 2. Solidify and dispose as hazardous waste.		Wipe paint out of brushes, then: 1. Filter & reuse thinners, solvents. 2. Take to HHW drop-off.
Paint cleanup (water-based)	Wipe paint out of brushes, then 1. Rinse to sanitary sewer.		Wipe paint out of brushes, then 1. Rinse to sanitary sewer.
Empty paint cans (dry)	1. Remove lids, dispose as trash.		1. Remove lids, dispose as trash.
Paint stripping (with solvent)	1. Dispose as hazardous waste.		1. Take to HHW drop-off.
Building exterior cleaning (high-pressure water)	1. Prevent entry into storm drain and remove offsite. 2. Wash onto dirt area, spade in. 3. Collect (e.g. mop up) and discharge to sanitary sewer.	POTW-MWS	

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
Cleaning of building exteriors which have **HAZARDOUS MATERIALS** (e.g. mercury, lead) in paints	1. Use dry cleaning methods. 2. Contain and dispose washwater as hazardous waste (Suggestion: dry material first to reduce volume).		
Non-hazardous paint scraping/sand blasting	1. Dry sweep, dispose as trash.		1. Dry sweep, dispose as trash.
HAZARDOUS paint scraping/sand blasting (e.g. marine paints or paints containing lead or tributyl tin)	1. Dry sweep, dispose as hazardous waste.		1. Dry sweep, take to HHW drop-off.
Soil from excavations during periods when storms are forecast	1. Should not be placed in street or on paved areas. 2. Remove from site or backfill by end of day. 3. Cover with tarpaulin or surround with silt fences, or use other runoff controls. 4. Place filter mat over storm drain. Note: Thoroughly sweep following removal of dirt in all four alternatives.		
Soil from excavations placed on paved surfaces during periods when storms are not forecast	1. Keep material out of storm conveyance systems and thoroughly remove via sweeping following removal of dirt.		
Cleaning streets in construction areas	1. Dry sweep and minimize tracking of mud. 2. Use silt ponds and/or similar pollutant reduction techniques when flushing pavement.		
Soil erosion, sediments	1. Cover disturbed soils, use erosion controls, block entry to storm drain. 2. Seed or plant immediately.		
Fresh cement, grout, mortar	1. Use/reuse excess 2. Dispose to trash		1. Use/reuse excess 2. Dispose to trash
Washwater from concrete/mortar (etc.) cleanup	1. Wash onto dirt area, spade in. 2. Pump and remove to appropriate disposal facility. 3. Settle, pump water to sanitary sewer.	POTW-MWS	1. Wash onto dirt area, spade in. 2. Pump and remove to appropriate disposal facility. 3. Settle, pump water to sanitary sewer.

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
Aggregate wash from driveway/patio construction	1. Wash onto dirt area, spade in. 2. Pump and remove to appropriate disposal facility. 3. Settle, pump water to sanitary sewer.	POTW-MWS	1. Wash onto dirt area, spade in. 2. Pump and remove to appropriate disposal facility. 3. Settle, pump water to sanitary sewer.
Rinsewater from concrete mixing trucks	1. Return truck to yard for rinsing into pond or dirt area. 2. At construction site, wash into pond or dirt area.		
Non-hazardous construction and demolition debris	1. Recycle/reuse (concrete, wood, etc.). 2. Dispose as trash.		1. Recycle/reuse (concrete, wood, etc.). 2. Dispose as trash.
Hazardous demolition and construction debris (e.g. asbestos)	1. Dispose as hazardous waste.		1. Do not attempt to remove yourself. Contact asbestos removal service for safe removal and disposal. 2. Very small amounts (less than 5 lbs.) may be double-wrapped in plastic and taken to HHW drop-off.
Saw-cut slurry	1. Use dry cutting technique and sweep up residue. 2. Vacuum slurry and dispose off-site. 3. Block storm drain or berm with low weir as necessary to allow most solids to settle. Shovel out gutters; dispose residue to dirt area, construction yard or landfill.		
Construction dewatering (Nonturbid, uncontaminated groundwater)	1. Recycle/reuse. 2. Discharge to storm drain.		
Construction dewatering (Other than nonturbid, uncontaminated groundwater)	1. Recycle/reuse. 2. Discharge to sanitary sewer. 3. As appropriate, treat prior to discharge to storm drain.	POTW-MWS MDPW-NPDES	
Portable toilet waste	1. Leasing company shall dispose to sanitary sewer at POTW.	POTW-MWS	
Leaks from garbage dumpsters	1. Collect, contain leaking material. Eliminate leak, keep covered, return to leasing company for immediate repair. 2. If dumpster is used for liquid waste, use plastic liner.		

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
Leaks from construction debris bins	1. Insure that bins are used for dry nonhazardous materials only (Suggestion: Fencing, covering help prevent misuse).		
Dumpster cleaning water	1. Clean at dumpster owner's facility and discharge waste through grease interceptor to sanitary sewer. 2. Clean on site and discharge through grease interceptor to sanitary sewer.	POTW-MWS POTW-MWS	
Cleaning driveways, paved areas (Special Focus = Restaurant alleys, grocery dumpster areas)	1. Sweep and dispose as trash (Dry cleaning only). 2. For vehicle leaks, restaurant/grocery alleys, follow this 3-step process: a. Clean up leaks with rags or absorbents. b. Sweep, using granular absorbent material (cat litter). c. Mop and dispose of mopwater to sanitary sewer (or collect rinsewater and pump to the sanitary sewer). 3. Same as 2 above, but with rinsewater (2c)(no soap) discharged to storm drain.		1. Sweep and dispose as trash (Dry cleaning only). 2. For vehicle leaks follow this 3-step process: a. Clean up leaks with rags or absorbents; dispose as hazardous waste. b. Sweep, using granular absorbent material (cat litter). c. Mop and dispose of mopwater to sanitary sewer.
Steam cleaning of sidewalks, plazas	1. Collect all water and pump to sanitary sewer. 2. Follow this 3-step process: a. Clean oil leaks with rags or adsorbents. b. Sweep (Use dry absorbent as needed). c. Use no soap, discharge to storm drain.		
Potable water/line flushing Hydrant testing	1. Deactivate chlorine by maximizing time water will travel before reaching creeks.		
Super chlorinated (above 1 ppm) water from line flushing	1. Discharge to sanitary sewer. 2. Complete dechlorination required before discharge to storm drain.		

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
Landscape/Garden Maintenance			
Pesticides	1. Use up. Rinse containers, use rinsewater as product. Dispose rinsed containers as trash. 2. Dispose unused pesticide as hazardous waste.		1. Use up. Rinse containers, use rinsewater as pesticide. Dispose rinsed container as trash. 2. Take unused pesticide to HHW drop-off.
Garden clippings	1. Compost. 2. Take to Landfill.		1. Compost. 2. Dispose as trash.
Tree trimming	1. Chip if necessary, before composting or recycling.		1. Chip if necessary, before composting or recycling.
Swimming pool, spa, fountain water (emptying)	1. Do not use metal-based algicides (i.e. Copper Sulfate). 2. Recycle/reuse (e.g. irrigation). 3. Determine chlorine residual = 0, wait 24 hours and then discharge to storm drain.	POTW-MWS	1. Do not use metal-based algicides (i.e. Copper Sulfate). 2. Recycle/reuse (e.g. irrigation). 3. Determine chlorine residual = 0, wait 24 hours and then discharge to storm drain.
Acid or other pool/spa/fountain cleaning	1. Neutralize and discharge to sanitary sewer.	POTW-MWS	
Swimming pool, spa filter backwash	1. Reuse for irrigation. 2. Dispose on dirt area. 3. Settle, dispose to sanitary sewer.		1. Use for landscape irrigation. 2. Dispose on dirt area. 3. Settle, dispose to sanitary sewer.
Vehicle Wastes			
Used motor oil	1. Use secondary containment while storing, send to recycler.		1. Put out for curbside recycling pickup where available. 2. Take to Recycling Facility or auto service facility with recycling program. 3. Take to HHW events accepting motor oil (i.e. car parts store).
Antifreeze	1. Use secondary containment while storing, send to recycler.		1. Take to Recycling Facility.
Other vehicle fluids and solvents	1. Dispose as hazardous waste.		1. Take to HHW event.
Automobile batteries	1. Send to auto battery recycler. 2. Take to Recycling Center.		1. Exchange at retail outlet. 2. Take to Recycling Facility or HHW event

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
			where batteries are accepted.
Motor home/construction trailer waste	1. Use holding tank. Dispose to sanitary sewer.		1. Use holding tank, dispose to sanitary sewer.
Vehicle washing	1. Recycle. 2. Discharge to sanitary sewer, never to storm drain.	POTW-MWS	1. Take to Commercial Car Wash. 2. Wash over lawn or dirt area. 3. If soap is used, use a bucket for soapy water and discharge remaining soapy water to sanitary sewer.
Mobile vehicle washing	1. Collect washwater & discharge to sanitary sewer.	POTW-MWS	
Rinsewater from dust removal at new car fleets	1. Discharge to sanitary sewer. 2. If rinsing dust from exterior surfaces for appearance purposes, use no soap (water only); discharge to storm drain.	POTW-MWS	
Vehicle leaks at Vehicle Repair Facilities	Follow this 3-step process: 1. Clean up leaks with rags or absorbents. 2. Sweep, using granular absorbent material (cat litter). 3. Mop and dispose of mopwater to sanitary sewer.		
Other Wastes			
Carpet cleaning solutions & other mobile washing services	1. Dispose to sanitary sewer.	POTW-MWS	1. Dispose to sanitary sewer.
Roof drains	1. If roof is contaminated with industrial waste products, discharge to sanitary sewer. 2. If no contamination is present, discharge to storm drain.		
Cooling water Air conditioning condensate	1. Recycle/reuse. 2. Discharge to sanitary sewer.	POTW-MWS	
Pumped groundwater, infiltration/foundation drainage (contaminated)	1. Recycle/reuse (landscaping, etc.) 2. Treat if necessary; discharge to sanitary sewer. 3. Treat and discharge to storm drain.	MDPW-NPDES POTW-MWS MDPW-NPDES	
Fire fighting flows	If contamination is present, Fire Dept. will attempt to		

DISCHARGE/ACTIVITY	BUSINESS/COMMERCIAL Disposal Priorities	Approval	RESIDENTIAL Disposal Priorities
	prevent flow to stream or storm drain.		
Kitchen Grease	1. Provide secondary containment, collect, send to recycler. 2. Provide secondary containment, collect, send to POTW via hauler.	POTW-MWS	1. Collect, solidify, dispose as trash.
Restaurant cleaning of floor mats, exhaust filters, etc.	1. Clean inside building with discharge through grease trap to sanitary sewer. 2. Clean outside in container or bermed area with discharge to sanitary sewer.		
Clean-up wastewater from sewer back-up	1. Follow this procedure: a. Block storm drain, contain, collect, and return spilled material to the sanitary sewer. b. Block storm drain, rinse remaining material to collection point and pump to sanitary sewer (no rinsewater may flow to storm drain).		

Good Housekeeping Practices	GHP-15 Pesticides, Herbicides, and Fertilizer Use

No Symbol

Symbol

Description

Fertilizers, herbicides and pesticides are potentially harmful chemicals require safe and organized practices to assure that pollution does not enter into stormwater.

Design

- Ø For a quick reference on disposal alternatives for specific wastes, see the table presented in the Employee/Subcontractor Training BMP fact sheet, Table GHP-14-1, and MSDS.
- Ø Contractors/subcontractors should develop controls on the application of pesticides, on-site. Controls may include:
  - § List of approved pesticides and selected uses
  - § Product and application information for users
  - § Equipment use and maintenance procedures
  - § Record keeping and public notice procedures
  - § MSDS

The following discussion provides some general information on good housekeeping:

- Ø Always use caution when handling any pesticide or fertilizer product. Many products contain toxic chemicals that can cause severe injury or death.
- Ø Store pesticide or fertilizer products securely and away from children, pets, and sources of heat, sparks, and flames.
- Ø 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.

Design (cont'd)

- Ø Work in only well ventilated areas if handling these materials in doors.
- Ø Use up the entire product before disposing the container.
- Ø Do not dispose of pesticide or fertilizer wastes:
  1. in trash
  2. down storm drains or into creeks
  3. onto the ground
  4. by burning
- Ø Do dispose of hazardous wastes at household hazardous waste collection events or facilities.

Maintenance

- Ø Employee and subcontractor training,
- Ø Contractor and subcontractor employees who handle potentially harmful materials should be trained in good housekeeping practices. Personnel who use pesticides must be trained in their use.
- Ø The primary cost is for staff time as noted above.

Inspection

- q Fertilizers, herbicides and pesticides are properly stored.
- q Fertilizers, herbicides and pesticides are clearly marked for easy identification.
- q Old or used fertilizers, herbicides and pesticides have been properly disposed.
- q Storage unit is properly ventilated.

Good Housekeeping Practices	GHP-16 Dust Control and Tracking

No Symbol

Symbol

Description

Dust control measures are used to stabilize soil from wind erosion and reduce dust generated by construction activities. This temporary measure-an intermediate treatment between disturbance in construction, paving, or vegetation, reduces the amount of eroded material exposed to stormwater runoff.

Design

- Clearing and grading activities.
- Construction vehicle traffic on temporary or unpaved roads or construction site access paths.
- Drilling and blasting activities.
- Sediment tracking onto paved roads.
- Soil and debris storage piles.
- Batch drop from front end loaders.
- Areas with unstabilized soil.
- Final grading/site stabilization usually is sufficient to control post-construction dust sources. Stabilize the site using temporary or permanent seed and mulch or other measures.
- Dust control should be practiced at all construction sites by performing phased clearing and grading operations, using temporary stabilization methods, and/or placing undisturbed vegetative buffers of at least 50 ft. (15 m) length between areas being graded and those areas to remain undeveloped.
- Dust control is particularly important in windy or wind-prone areas.
- Use mulch with mulch binders as an interim dust control measure in areas where vegetation might not be appropriate.

Design (cont'd)

- Schedule construction activities to minimize exposed area by clearing only areas where phased construction is to take place.
- Quickly stabilize exposed soils using vegetation, mulching, spray-on adhesives, calcium chloride, sprinkling, and stone/gravel layering.
- Identify and stabilize key access points prior to commencement of construction. See SMP-02 and -03.
- Minimizing the impact of dust by anticipating the direction of prevailing winds.
- Direct most construction traffic to stabilized roadways within the project site.
- Dust control BMP's generally stabilize exposed surfaces and minimize activities that suspend or track dust particles. Table GHP-16-1 shows which Dust Control BMPs apply to site conditions which cause dust. For heavily traveled and disturbed areas, wet suppression (watering), chemical dust suppression, gravel or asphalt surfacing, temporary gravel construction entrances, equipment wash-out areas, and haul truck covers can be employed as dust control applications. Permanent or temporary vegetation and mulching and sand fences can be employed for areas of occasional or no construction traffic.
- Preventive measures would include minimizing surface areas to be disturbed, limiting on-site vehicle traffic to 15 miles per hour, and controlling the number and activity of vehicles on a site at any given time.
- Pave, vegetate, or chemically stabilize access points where unpaved traffic surfaces adjoin paved roads.
- Provide covers for haul trucks transporting materials that contribute to dust.
- Provide for wet suppression or chemical stabilization of exposed soils.
- Provide for rapid clean-up of sediments deposited on paved roads. Furnish stabilized construction road entrances and vehicle wash down areas.
- Stabilize unpaved haul roads, parking and staging areas. Reduce speed and trips on unpaved roads.
- Implement dust control measures for material stockpiles.
- Prevent drainage of sediment-laden stormwater onto paved surfaces.
- Stabilize abandoned construction sites using vegetation or chemical stabilization methods.
- For the chemical stabilization, there are many products available for chemically stabilizing gravel roadways and stockpiles. The types of chemicals available and recommendations for their use are tabulated in Table GHP-16-2, Commonly Used Chemicals for Dust Control.

Selection of Methods

Selection of dust control agents should be based primarily on cost-effectiveness and environmental hazards.

Chemical methods are dust suppressant or binding agents that are used on the soil surface to bind finer particles together. Chemical dust control agents must be environmentally benign, easily applied, easily maintained, economical and not significantly detrimental to traffic ability.

Design (cont'd)

Approximately three-quarters of chemical dust control agents are inorganic compounds which are compatible with soil and biota. After application, the compounds dampen and penetrate into the soil; a hygroscopic reaction pulls moisture from the atmosphere into the surface and adheres fines to aggregate surface particles. The compounds may not penetrate soil surfaces made up primarily of silt and clay, so soil tests are required.

Anionic polyacrylamide (PAM) is an effective dust control agent for undisturbed areas (see Section 4.4.5). Calcium chloride has proven effective in controlling dust on roadways, but repeat applications are necessary and the product could restrict establishment of vegetation on treated areas. A permit might be needed for using calcium chloride.

Petroleum-based products are not recommended because of their adverse effects on plants and water resources.

Key factors in determining the method include the following:

- Soil types and surface materials - both fines and moisture content are key properties of surface materials.
- Properties of the agents - the five most important properties are penetration, evaporation, resistance to leaching, abrasion, and aging.
- Traffic volumes – the effectiveness and life span of dust control agents decreases as traffic increases. For high traffic areas, agents need to have strong penetrating and stabilizing capabilities.
- Climate – some hygroscopic agents lose their moisture-absorbing abilities with lower relative humidity, and some may lose resilience. Under rainy conditions, some agents may become slippery or even leach out of the soil.
- Environmental requirements – the primary environmental concern is the presence and concentration of heavy metals in the agent that may leach into the immediate ecosystem, depending on the soil properties.
- Frequencies of application – rates and frequencies of application are based on the type of agent selected, the degree of dust control required, sub grade conditions, surface type, traffic volumes, types of vehicles and their speeds, climate, and maintenance schedule.

Application of Methods

For dust control agents, once all factors have been considered, the untreated soil surface must first contain sufficient moisture to assist the agent in achieving uniform distribution (except when using a highly resinous adhesive agent). The following steps should be followed in general:

- Ideally, application should begin in late spring, after seasonal rains - not during or just before heavy rainfall- so that sub grade and surface materials will not have dried.
- If the surface has minimal natural moisture, the area to be protected must be pre-wetted so that the chemicals can uniformly penetrate the surface.
- In general, cooler and/or more humid periods result in decreased evaporation, increased surface moisture, and thus significant increase in control efficiency. However, chemical and organic agents should not be applied under frozen conditions, rainy conditions, or when the temperature is below 40° F. Tar and bitumen agents should not be applied in fog or in rain or below 55°F

Design (cont'd)

- More than one treatment with salts or organic compounds per year is often necessary, although the second treatment should probably be significantly diluted.
- Roughening the soil to create ridges perpendicular to the prevailing wind direction can reduce surface wind velocities and sediment loss significantly. However, if winds shift to become parallel to the ridges, blown sediment will increase.
- Silt fences or board fencing that is perpendicular to the prevailing wind direction can also be used to lower surface wind velocities and reduce airborne sediment problems. Fences do not have to be trenched in, but may need to be 50–100 feet apart to appreciably reduce wind velocities.
- See sections on Temporary Seed, Permanent Seed, Sod, Mulch, and Construction Entrance.

Dust Control BMPs for Various Site Conditions

Site Condition	Grass/Seeding	Mulching	Watering	Chemical application	Gravel or asphalt surfacing	Silt or sand fencing	Rock pad or wash-down
Disturbed areas – no traffic	•	•	•	•	•	•	
Disturbed areas – with traffic			•	•	•		
Soil stockpiles	•	•	•	•		•	
Demolition			•				•
Clearing/ Excavation	•	•	•	•		•	
Unsurfaced roads			•	•	•		
Site exit to paved road					•		•

Maintenance

Ø Most dust control measures require frequent, often daily, attention.

Ø The primary maintenance requirement is the reapplication of the selected dust control agent at intervals appropriate to the agent type. High traffic areas shall be inspected on a daily basis, and lower traffic areas shall be inspected on a weekly basis.

Inspection

q Water is applied daily to reduce dust.

q Trucks hauling soil or rock have dust covers over materials.

q Material stockpiles have fabric, mulch or ground cover to provide sediment control.

TABLE GHP16-1. DUST CONTROL BMPs FOR GIVEN SITE CONDITIONS

	DUST CONTROL BMPs								
SITE CONDITION	Permanent Vegetation	Mulching	Wet Suppression (Watering)	Chemical Dust Suppression	Gravel or Asphalt Surfacing	Silt or Sand Fences	Temporary Gravel Construction Entrances/ Equipment Wash Down	Haul Truck Covers	Minimize Extent of Area Disturbed
Disturbed Areas not Subject to Traffic	X	X	X	X	X				X
Disturbed Areas Subject to Traffic			X	X	X				X
Material Stock Pile Stabilization			X	X		X			X
Demolition			X				X	X	
Clearing/ Excavation			X	X					X
Truck Traffic on Unpaved Roads			X	X	X			X	
Mud/Dirt Carry-Out					X		X		

TABLE GHP16-2. COMMONLY USED CHEMICALS FOR DUST CONTROL

	SALTS	ORGANIC, NON PETROLEUM-BASED	PETROLEUM BASED PRODUCTS [1]
CHEMICAL TYPES	• Magnesium Chloride • Natural Brines	• Calcium Lignosulfonate • Sodium Lignosulfonate • Ammonium Lignosulfonate	• Bunker Oil • Asphalt Primer • Emulsified Asphalt
LIMITATIONS	Can lose effectiveness in dry periods with low humidity. Leaches from road in heavy rain. Not recommended for gravel road surfaces with low fines. Recommended 10-20% fines.	Not affected by dry weather and low humidity. Leached from road in heavy rain if not sufficiently cured. Best performance on gravel roads with high surface fines (10-30%) and dense compact surface with loose gravel.	Generally effective regardless of climatic conditions may pothole in wet weather. Best performance on gravel roads with 5-10% fines.
COMMENTS	Calcium Chloride is popular. May become slippery when wet on gravel surfaces with high fines.	Ineffective on gravel surfaces low in fines. May become slippery when wet on gravel surfaces with high fines content.	Creates a hardened crust.

1 Motor oils and oil treatments are not recommended due to adverse effects on plant life and groundwater. They should only be applied in areas that will soon be paved.

Good Housekeeping Practices

GHP-17 Maintenance of Collection Facilities and Appurtenances

No Symbol

Symbol

Description

The sediment sump in catch basins are designed to trap sediments below the overflow point or basin outlet. As sediment fills the sump, runoff enters the basin and immediately discharges through the outlet without depositing any sediment in the sump. Proper use of this practice will reduce high pollutant concentration during first flush of storms, prevent clogging of the downstream conveyance system and restore the catch basins' sediment trapping capacity. Proper maintenance and siltation removal is required to have an effective storm water pollutant removal system for both wet and dry detention ponds and infiltration devices.

Design

- The catch basins must be regularly maintained. Clogged catch basins are not only useless but may act as a source of sediments and pollutants.
- Proper maintenance of detention ponds and infiltration device systems is a source control procedure necessary to ensure effective stormwater pollutant removal efficiency. Proper maintenance of these structures requires periodic silt/sediment and trash removal, as well as timely vegetation control. They should be cleaned out when it is recognized that they have filled from $^{1}/_{5}$ to $^{1}/_{3}$ of their pollutant (sediment) storage capacity.
- More frequent sediment removal is recommended, especially in areas where roadway drainage provides a significant runoff component. High accumulation rates of heavy metal contaminants (lead, zinc, and copper) have been identified in these BMP structures adjacent to high traffic areas. In order to avoid situations of hazardous waste disposal, sediment dredging and excavation should be given frequent priority.

Design (cont'd)	Ø	Clean catch basins in high pollutant load areas just before the wet season to remove sediments and debris accumulated during the summer.
	Ø	Clean catch basins in high pollutant load areas just before the wet season to remove sediments and debris accumulated during the summer.
	Ø	Catch basins should be inspected weekly and cleaned if necessary to reduce the possibility of sediment and other pollutants from leaving the construction site. This should be checked after all areas have been stabilized and at the end of the project.
	Ø	To prevent sediment and pollutant build-up in on-site catch basins, be sure to follow the guidelines set out in Temporary Inlet Protection, SMP-11.
	Ø	Maintain a clean work site, free of litter that can build-up and clog catch basins and downstream conveyance systems.
	Ø	Discourage dumping into catch basins and stormwater inlets whenever possible.
	Ø	Removal of accumulated paper, trash, and debris should occur weekly or as needed to prevent clogging of control devices throughout the construction project.
	Ø	Vegetation growth in stormwater quality devices should not be allowed to exceed 24 inches in height.
	Ø	Mow the slopes periodically and check for clogging, erosion and tree growth on the embankment.
	Ø	Corrective maintenance may require more frequent attention (as required).
	Ø	Keep accurate maintenance logs to evaluate materials removed and improvements made
Maintenance	Ø	Maintenance crews may require access vehicles, dump trucks, bulldozers, and dredging/excavation equipment. Manual use equipment (such as rakes, shovels, sickles, and machetes) may suffice for maintenance of dry detention ponds and infiltration device systems. Staffing will require a minimum crew of two (2) properly trained person for health and safety reasons and effective structural BMP maintenance.
	Ø	Crews must be trained in proper maintenance, including record keeping and disposal.
	Ø	Appropriate excavation and maintenance procedures.
	Ø	Proper waste disposal procedures.
	Ø	Channel maintenance and use of heavy equipment.
	Ø	Identification and handling of hazardous materials/wastes.
	Ø	Application of this technique in "blue line" streams requires permits from the U.S. Army Corps of Engineers, and the Kentucky Division of Water
	Ø	Frequent sediment removal is labor and cost intensive.
Inspection	q	Dredged sludge is dried prior to removal to waste management facility. (See GHP-01: Dewatering Operations.)
	q	All drainage activities are approved by Kentucky Division of Water (KDOW) and the local drainage authority.

Good Housekeeping Practices	GHP-18 Preservation and Maintenance of Existing Vegetation

No Symbol

Symbol

Description

The careful preservation of existing vegetation minimizes the potential of removing or injuring existing trees, vines, shrubs and/or grasses that serve as erosion controls or otherwise stabilize or slopes.

Applications

This technique is applicable to all types of construction sites. Areas where preserving vegetation can be particularly beneficial are floodplain, buffers, wetlands, streambanks, steep slopes, and other areas where erosion control would be difficult to establish, install, and maintain, or areas where there are critical resources downstream.

- Preservation of existing vegetation should be practiced in the following locations:
- Areas within site where construction activity is not permitted (such as buffers) or does not occur or occurs at a later date.
- Sensitive areas where natural vegetation exists and should be preserved, such as: steep slopes, watercourses, and building sites in wooded areas.
- Areas where local, state and federal government requires preservation, such as: vernal pools, wetlands, marshes, certain oak trees, etc.

Maintenance

- During construction, the limits of disturbance should remain clearly marked at all times. Irrigation or maintenance of existing vegetation should conform to the requirements in the landscaping plan.
- If damage to protected trees still occurs, maintenance guidelines described below should be followed:

Maintenance (cont'd)

- Soil, which has been compacted over a tree's root zone, should be aerated by punching holes 12 in. deep with an iron bar, and moving the bar back and forth until the soil is loosened. Holes should be placed 18 in. apart throughout the area of compacted soil under the tree crown. Any damage to the crown, trunk, or root system of a retained tree should be repaired immediately.
- Damaged roots should be immediately cut cleanly inside the exposed area and surfaces painted with approved tree paint, and moist soil or soil amendments should be spread over this area.
- If bark damage occurs, all loosened bark should be cut back into the undamaged area, with the cut tapered at the top and bottom, and drainage provided at the base of the wound. Cutting of the undamaged area should be as limited as is possible.
- Serious tree injuries should be attended to by an arborist, forester or tree specialist.
- Stressed or damaged broadleaf trees should be fertilized to aid recovery.
- Trees should be fertilized in the late fall or early spring.
- Fertilizer should be applied to the soil over the roots and in accordance with label instructions, but never closer than 3 ft. to the trunk. The fertilized area should be increased by one-fourth of the crown area for conifers that have extended root systems.

Inspection

- Protecting existing vegetation requires detailed planning, and may constrict the area available for construction activities.
- It is appropriate to evaluate the existing vegetation for species type for use in landscaping plans. Natural vegetation and invasive or "alien" species should be delineated. The use of natural vegetation is preferred.

Good Housekeeping Practices	GHP-19 System Flushing

No Symbol

Symbol

Description

Storm drain pipes with grades to flat to be self cleansing require routine flushing. This helps to maintain flow as well as removes pollutants from the storm drain system. The suspension and removal of deposited materials are "flushed" out of storm drains.

Design

- Locate reaches of storm drain with deposit problems and develop a flushing schedule that keeps the pipe clear of excessive buildup.
- Whenever possible, flushed effluent should be collected and pumped to a sediment trap, or basin, or a detention pond.
- Storm drain flushing usually takes place along segments of pipe with grades that are too flat to maintain adequate velocity to keep particles in suspension. An upstream manhole is selected to place an inflatable device that temporarily plugs the pipe. Further upstream, water is pumped into the line to create a flushing wave. When the upstream reach of pipe is sufficiently full to cause a flushing wave, the inflated device is rapidly deflated with the assistance of a vacuum pump, releasing the backed up water and resulting in the cleaning of the storm drain segment.
- If the flushed water does not drain to a stormwater treatment device (e.g., detention pond or swale), then a second inflatable device, placed well downstream, may be used to re-collect the water after the force of the flushing wave has dissipated. A pump may then be used to transfer the water and accumulated material to a stormwater treatment practice. In some cases, an interceptor structure may be more practical or required to re-collect the flushed waters.

Design (cont'd)

Regulations

- Kentucky Division of Waste Management (KDWM) regulations prohibit the discharge of soil, debris, refuse, hazardous waste, and other pollutants that may hinder the designed conveyance capacity or damage stormwater quality or habitat in the storm drain system. This includes flushing a system to "Waters of the State". Do not execute this practice until the KDWM has been consulted.

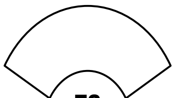
Equipment

- Water source (water tank truck, fire hydrant).
- Sediment collector (educator/vacuum truck, dredge).
- Inflatable devices to block flow.
- Sediment/turbidity containment/treatment equipment required if flushing to an open channel.

Inspection

- [ ] BMP is properly applied to an appurtenance 36" in diameter or smaller.
- [ ] Contractor is using the nearest available water source.
- [ ] Flushed effluent is captured and treated downstream prior to being released into a waterway.
- [ ] Requires liquid/sediment disposal.

Post Construction Stormwater Control Practices	PTP-01 Sand Filters



FS

Symbol

TSS Reduction: 80%

Figure PTP-01- 1 Surface Sand Filter
Showing the sedimentation (foreground) and the filter bed (background)
Source, Center for Watershed Protection and Stormwater Managers Resource Center, www.stormwatercenter.net

Description

Sand filters are structural water quality control devices that capture and temporarily store, treat, and release stormwater runoff by passing the stormwater through a sand media. Sand filters consist of two main components: a pretreatment basin and filtration chamber. The pretreatment basin removes floatable materials and heavy sediments, and helps reduce flow velocities. The filtration chamber traps and strains pollutants, and in some instances allows the microbial removal of pollutants. Target pollutants for sand filters include suspended solids, suspended particulates, biochemical oxygen demand (BOD), fecal coliform bacteria, and others. The pretreatment basin and filtration chamber must also include an underdrain collection system to return stormwater to a conveyance system, and may also include or be enhanced by one or more of the following components: grass buffer strips, ponding area, sand bed, and plant material.

Sand filters types documented in this fact sheet include:

- Surface sand filters
- Underground sand filters
- Perimeter sand filters

3.4 POST CONSTRUCTION STORMWATER CONTROL FACT SHEETS (PTP)

Applications

Sand filters are often used to manage stormwater runoff from urban areas where space is limited, and can be applied to areas where retrofit is needed, and are typically suitable in the following applications:

- Small stabilized drainage areas up to 5 acres (up to 10 acres for surface sand filters)
- Areas with low sediment loads and high pollutant loads
- Impervious area runoff – well suited for greater than 50% impervious area
- Off-line facilities adjacent to parking lots
- Underground installation
- Retrofit applications

Sand filters are **not** suitable in the following applications:

- Water quantity control
- Within drainage areas that have not been stabilized
- Residential applications
- Adjacent to areas with slopes greater than 5:1 (H:V) or 20%
- Areas that experience continuous flow from surface water, groundwater, sump pumps, or other sources

The use of sand filters as a retrofit practice primarily depends on existing infrastructure and the compatibility of existing storm drain inverts that need to connect to the filter under-drain outflow. In general, four to six feet of elevation above the existing collection system invert is needed for sand filter retrofits (2-3 feet is needed for perimeter filters). Underground sand filters are excellent for ultra-urban settings where space is at a premium.

Sand filters should only be applied in stabilized drainage areas, as heavy sediment loads from construction areas will clog and disable the filter. Likewise, they should not be used in areas where stormwater has the potential for high silt or clay content, and areas with a high water table. As a guide, sites implementing sand filters should have over 50% impervious cover in the drainage area.

Sand filters are designed for off-line use to capture the water quality volume (WQ_v). A diversion structure such as a flow splitter or weir may be necessary to separate and route the WQ_v to the sand filter, allowing larger stormwater flows to bypass the water quantity control device. For designs where no flow splitter is used, the recommended contributing drainage area should be limited to about 0.5 acres with an overflow at the filter to pass part of the WQ_v to a stabilized watercourse or storm drain. Where a flow splitter will be used, the flow splitter should allow 75% of the WQ_v to enter the filter system before allowing flows to bypass the system to a stabilized outlet. The sand filter can be adjusted to minimize bypassing before filling the filter to 75% of the WQ_v by adjusting the elevation of the overflow weir between the sedimentation and filter chambers so that the overflow weir elevation is lower than the flow splitter weir elevation. Sand filters are most effective when turbulent flow is minimized and the flow is spread uniformly across the filter media.

Sand Filter Variations

Sand filters are an excellent stormwater treatment practice with the primary pollutant removal mechanism being filtering and settling. Less significant processes can include evaporation, infiltration, transpiration, biological and microbiological uptake, and soil absorption. While it is possible to design sand filters to discharge a portion of the effluent to the ground water, applications in Bowling Green are typically designed as enclosed systems that discharge to a specific discharge location (i.e., no "infiltration") due to the widespread presence of karst geology.

Ø **Surface Sand Filters**

Figure PTP-01- 2 Surface Sand Filter
Showing the sedimentation (foreground) and the filter bed (background)
Source, Stormwater Managers Resource Center, www.stormwatercenter.net

Surface sand filters are open-air, at-grade structures that serve as off-line water quality systems and include two system components. A flow diversion such as a flow splitter diverts runoff into the off-line surface filter. The first component is a sediment forebay or sedimentation chamber. Flow enters the forebay where heavier sediment particles settle out of suspension. This pre-treatment forebay may be either wet or dry. A perforated standpipe moves pre-treated runoff from the first component to the second. The second component is a filter bed chamber or filtration chamber with an approximately 18-inch thick sand bed. Runoff is temporarily stored above the bed, with pollutants filtered out at the bed surface. The top bed surface is covered with either sand or grass. Runoff exiting the bed bottom is collected by the underdrain system and discharged to the outflow.

Surface sand filters are suitable for multiple location types and use different configurations. For effective pollutant removal with surface sand filters, the contributing drainage areas should be no more than 10 acres. The two components may be designed using riprap, excavations with earthen embankments, a concrete structure or a block structure. For earthen embankments, the bottom and side slopes of the earthen walls should be lined with a permeable filter fabric before installing the filtration system and underdrain. See Figures PTP-01-3, PTP-01-4 and PTP-01-5 for the typical surface sand filter schematics.

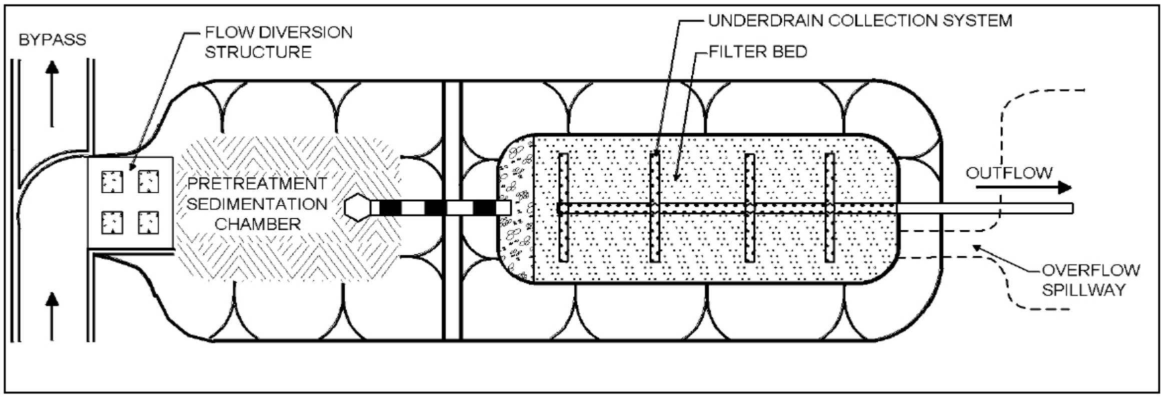


Figure PTP-01- 3 Surface Sand Filter
Source, Georgia Stormwater Management Manual

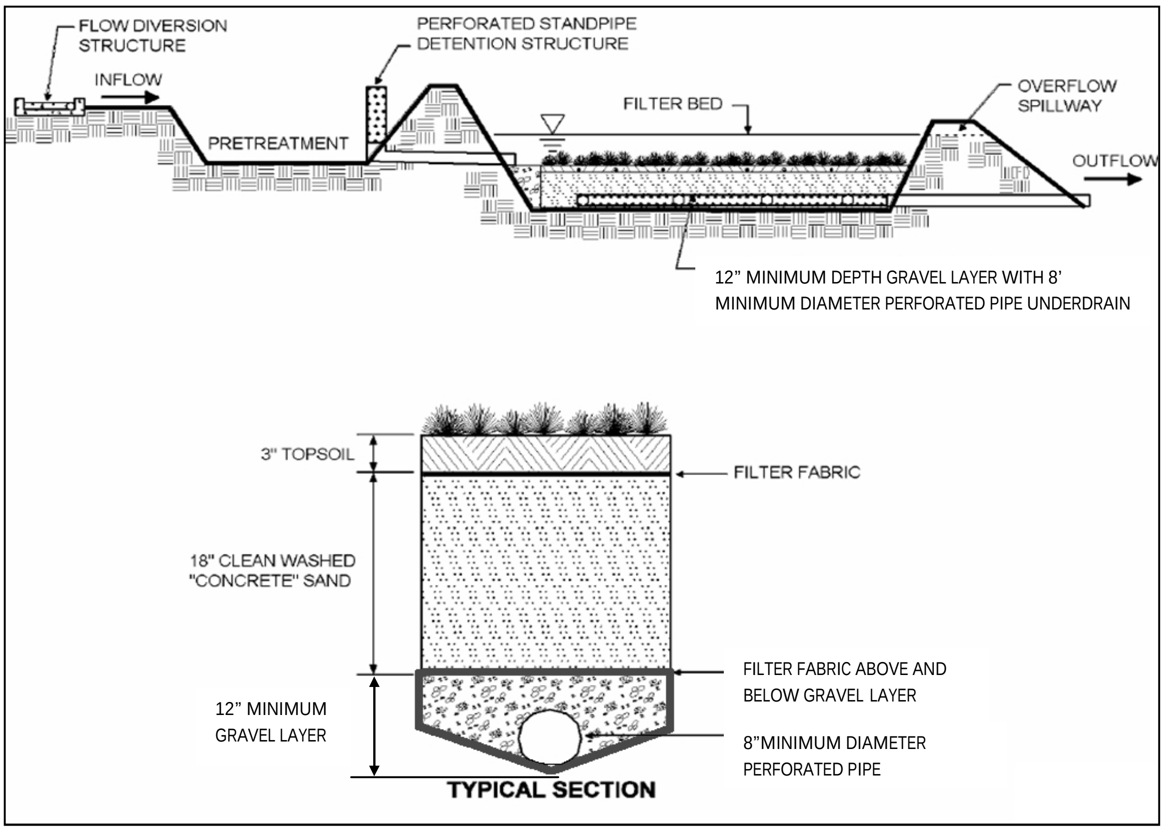
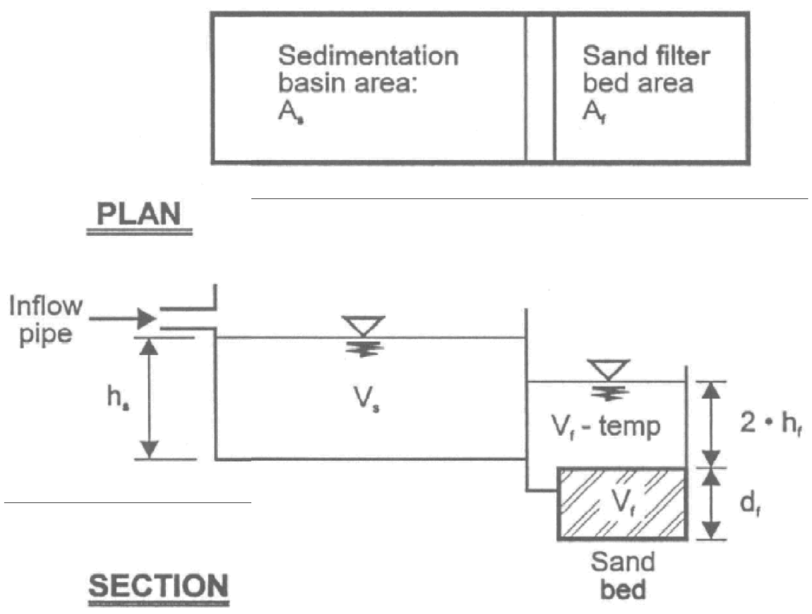


Figure PTP-01- 4 Surface Sand Filter (cross sectional view)
Source, Georgia Stormwater Management Manual

Sand Filter Variations



V_s = Sedimentation basin volume
V_f = Volume of voids in the filter bed
$V_{f\text{-}temp}$ = Temporary volume stored above the filter bed
A_s = Surface area of the sedimentation basin
A_f = Surface area of the filter media
h_s = Depth of water in the sedimentation basin
h_f = Average depth of water above the filter media
d_f = Depth of the filter media

Figure PTP-01- 5 Surface Sand Filter (cross sectional view)
Source, Georgia Stormwater Management Manual

Figure PTP01-03
Source, Georgia Stormwater Management Manual

Sand Filter Variations

Ø **Perimeter Sand Filters**

Figure PTP-01- 6 Perimeter Sand Filter
Source, Stormwater Managers Resource Center, www.stormwatercenter.net

Figure PTP-01- 7 Perimeter Sand Filter
Showing pre-cast concrete form with 2 chambers
Source, Stormwater Managers Resource Center, www.stormwatercenter.net

Sand Filter Variations

Ø Perimeter Sand Filters (cont.)

Perimeter sand filters are constructed just below grade with two enclosed parallel trench-like chambers. Typically, perimeter sand filters are installed along the perimeter of a parking lot for off-line treatment. The first chamber is a sedimentation chamber that also has a shallow permanent pool of water. The second chamber is a filtration chamber that contains the sand filter (depth 12 – 18 inches) as well as an underdrain system that discharges filtered runoff to the outflow location. The first and second chambers are separated by an overflow weir. Runoff from impervious areas enters the device via an inlet grate and first fills the sedimentation chamber. Once water levels in the sedimentation chamber reach the top of the overflow weir between the two chambers, flow spills over the weir and into the filtration chamber. The sand bed filters runoff, and runoff is then collected by the perforated pipe and gravel underdrain system for discharge to the outflow location. During storm conditions, runoff normally temporarily ponds in the two chambers until both chambers fill up to capacity. Once both chambers are filled to capacity, excess runoff is routed to a separate bypass drop inlet.

Perimeter sand filters consume a small amount of surface space, and are ideal for small impervious areas, particularly hot spot applications and retrofits. Perimeter sand filters are best suited for effective pollutant removal for drainage areas up to 2 acres. The perimeter sand filters should be constructed along the boundary, or perimeter, of an impervious area (i.e., a parking lot). See Figures PTP-01-8 through PTP-01-11 for typical perimeter sand filter schematics.

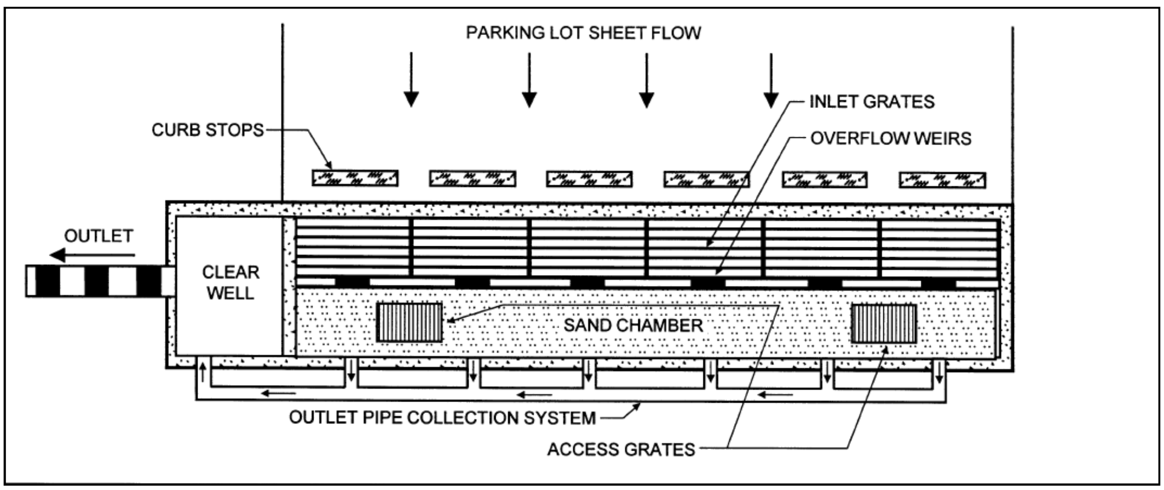


Figure PTP-01- 8 Perimeter Sand Filter
Source, Georgia Stormwater Management Manual

Sand Filter Variations

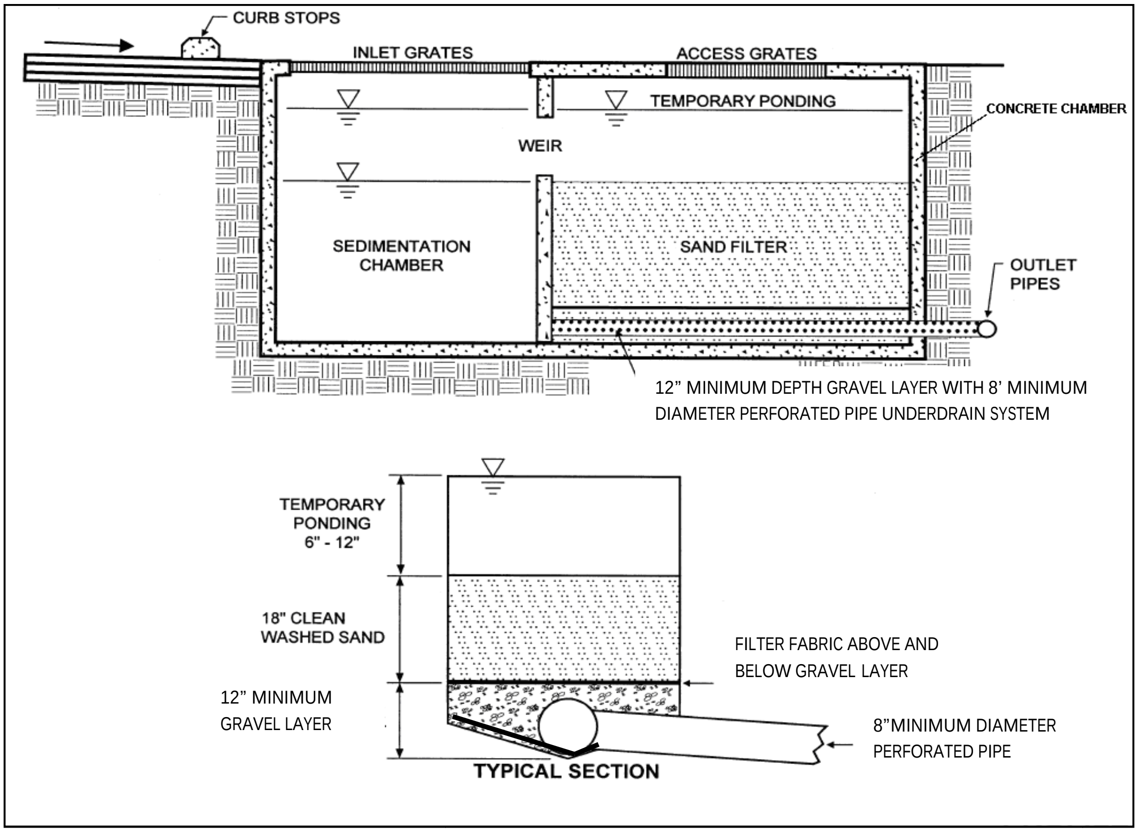
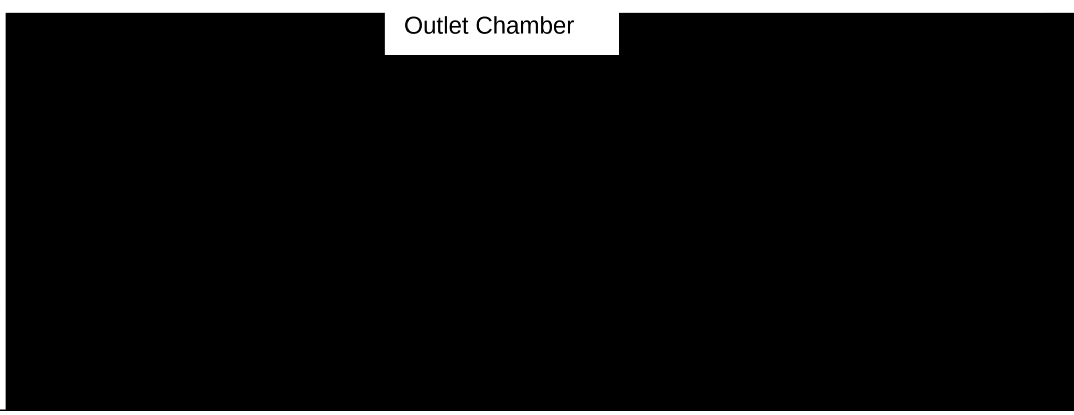


Figure PTP-01- 9 Perimeter Sand Filter (cross sectional view)
Source, Georgia Stormwater Management Manual



V_w = Wet pool volume of the sedimentation basin
V_f = Volume of voids in the filter bed
V_{temp} = Temporary volume stored above the filter bed
A_s = Surface area of the sedimentation basin
A_f = Surface area of the filter media
h_s = Depth of water in the sedimentation basin
h_f = Average depth of water above the filter media (½ h_{temp})
d_f = Depth of the filter media

Figure PTP-01- 10 Perimeter Sand Filter Chamber Design
Source, Georgia Stormwater Management Manual

Sand Filter Variations

Ø **Perimeter Sand Filters (cont.)**

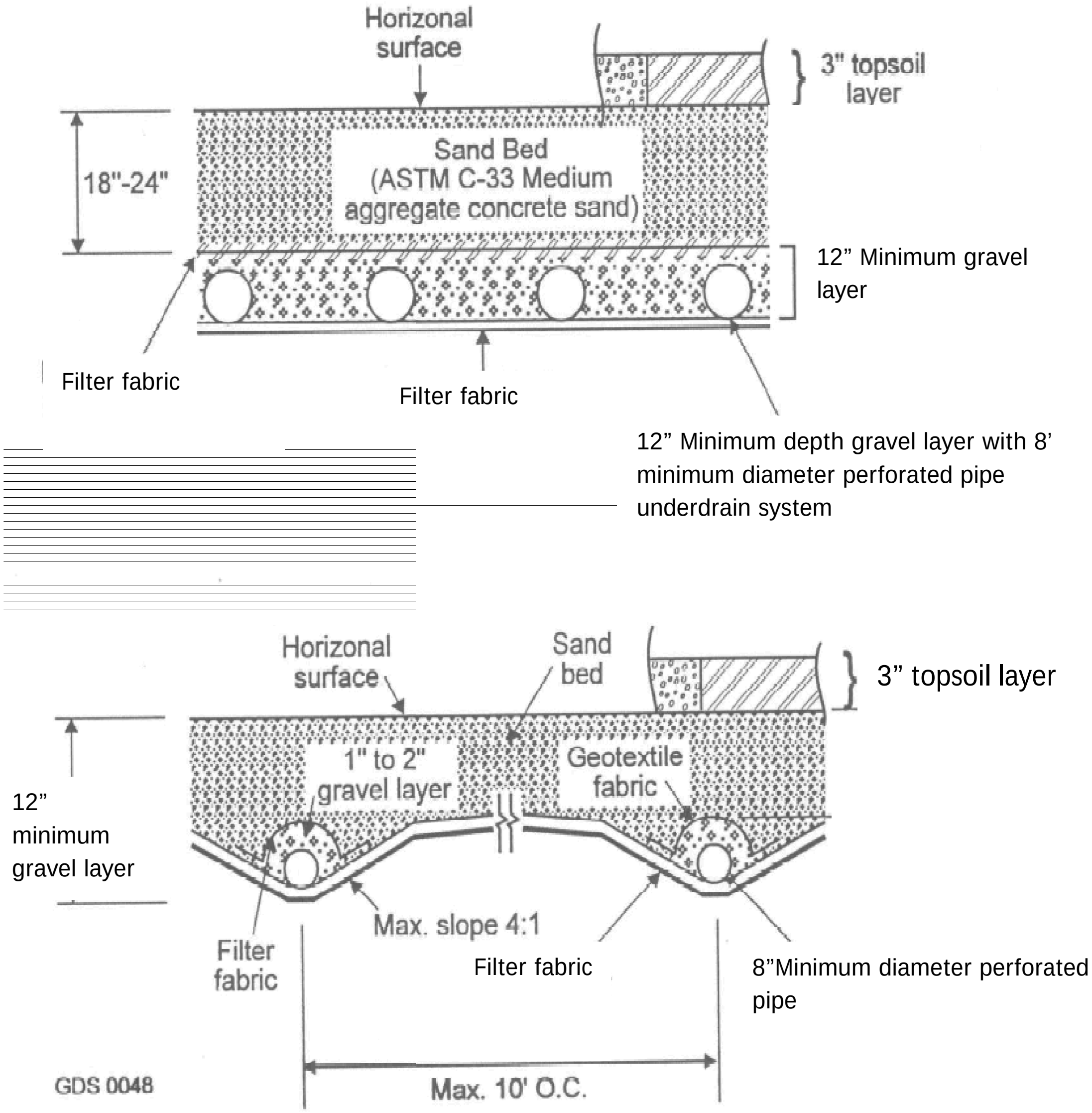


Figure PTP-01- 11
Source, Georgia Stormwater Manual

Sand Filter Variations

Ø Underground Sand Filters

Figure PTP-01- 12 Underground Sand Filter
Source, University of Virginia Stormwater and Watershed Group,
http://www.people.virginia.edu/~engstorm

Underground sand filters are designed for applications with extreme space constraints or high density areas such as parking lots where a surface sand filter cannot be constructed due to space limitations. They are typically used as on-line systems for impervious areas of 1 acre or less. An underground sand filter should not be designed to treat a drainage area greater than 5 acres. Underground sand filters may be used to effectively remove pollutants for drainage areas up to 2 acres. One key consideration for underground sand filters is accessibility for inspection and maintenance. Access is often provided by manholes or grate openings.

This type of filtration system utilizes a three-chamber vault, where the first two chambers temporarily store and treat runoff, and the third chamber collects the filtered runoff. For a storm event, the water quality volume is temporarily stored in both of the first two chambers. When flows exceed the filter's capacity in the first two chambers, the overflows are diverted through an overflow weir to exit the filter.

Each of the underground sand filter chambers performs a separate function. The first chamber is known as a sedimentation chamber or a wet pool chamber. This first chamber provides pre-treatment with a wet pool as well as temporary runoff storage. The first chamber is connected to the second chamber by either a submerged wall or an inverted elbow. This connection between the first two chambers helps obstruct oil and floatables from passing from the first chamber into the second chamber. The second chamber is called the sand filter or filter bed chamber. The second chamber's filter bed depth should be between 18 to 24 inches. Permeable geotextiles or a gravel screen may be used to limit filter bed clogging. The second chamber also contains a perforated drain pipe to collect and pass the filtered runoff to the third chamber. The third chamber, or the overflow chamber, discharges the filtered runoff as well as any overflows to the outlet. See Figures PTP-01-13 and PTP-01-14 for schematics of a typical underground sand filter.

Sand Filter Variations

Ø **Underground Sand Filters (cont.)**

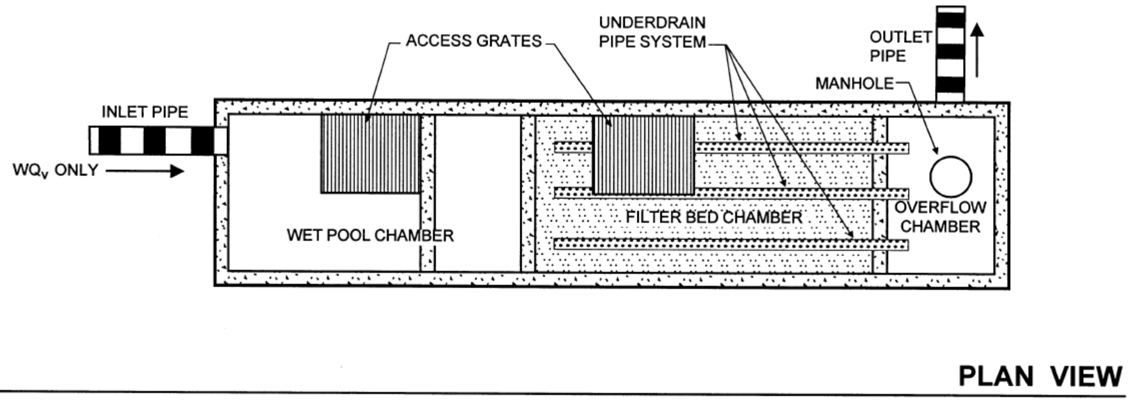


Figure PTP-01- 13 Underground Sand Filter
Source, Georgia Stormwater Management Manual

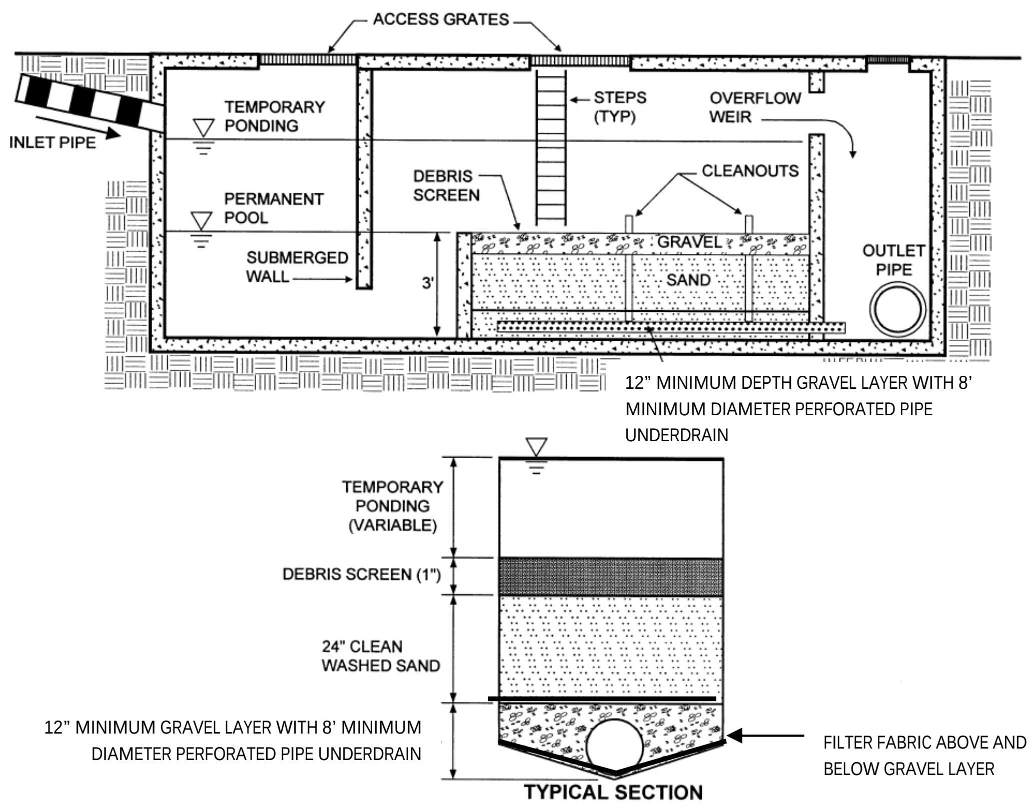


Figure PTP-01- 14 Underground Sand Filter (cross sectional view)
Source, Georgia Stormwater Management Manual

Maintenance

Maintenance Plan

A site-specific maintenance plan describing maintenance responsibilities shall be developed. that addresses the following items:

- Maintenance access for appropriate equipment, vehicles, and personnel.
- Operating instructions for drawdown valves, gates and removable weirs (if applicable)
- Vegetation maintenance schedule
- Inspection checklist
- Maintenance agreement between the facility owner and the City with these items:
  - Sediment removal from sedimentation chamber when sediment depth is ½ of the total depth to the outlet, or is greater than 12 inches (whichever is less)
  - Clean and/or repair sediment chamber outlet devices if drawdown times exceed 48 hours
  - Trash and debris should be removed as necessary
  - Sediment accumulations exceeding one inch should be removed from the bed
  - If filtering capacity is substantially diminished (i.e., for surface filters, water ponds on filter surface for more than 48 hours, remove and replace the top three inches of filter media with same fresh media and acceptably dispose of removed material)
- Grass cover filters should be mowed as needed (maximum grass height of 12 inches)

Monthly

- Remove trash or debris from drainage area, inlets, outlets and filter system
- Check that drainage area is stabilized and mowed (with clippings removed), with measures in place to minimize oil/grease and sediment released to filter system
- Inspect the filter surface for clogging monthly and after storm events greater than one inch (sand filters – rake the first inch of sand)
- For pre-treatment chambers with a permanent water level (e.g., perimeter sand filter), check the pre-treatment chamber for leakage and for retention of the normal pool level

Quarterly/After Major Storm Events

- Monitor water level in sand filter chamber (underground sand filter)
-

Annually

- Check filter bed and sediment chamber sediment depths

Maintenance

Annually (cont'd)

- Inspect concrete and grates (perimeter sand filters)for deterioration and damage
- Check inlets, outlets and overflow spillway for proper operation and for erosion
- Repair or replace any damaged structural parts
- Stabilize any eroded areas
- Look for signs of flow bypassing the facility (the exception is the expected flow bypassing for high flow events)
- Check for noticeable odors detected outside the facility

3-5 Years

- Remove and replace the top 2-5 inches of media. High sediment yield or high oil and grease may require more frequent media removal/replacement

As Needed

- Clean out sedimentation chamber when sediment depth reaches 12 inches (underground sand filter)
- Clean and/or repair sediment chamber outlet devices if drawdown times exceed 48 hours
- Remove accumulated oil and floatables from the sedimentation chamber (underground sand filter)
- For clogged or partially clogged sand beds (i.e., water ponds on filter surface for more than 48 hours), remove the top three inches of sand from the surface, till, or cultivate the bed, and replace with fresh sand meeting the appropriate design specifications
- Properly dispose of any material generated during maintenance activities.
- Grass cover filters should be mowed as needed (maximum grass height of 12 inches)
- Replace clogged filter fabric

Inspection Checklist

All appropriate items should be checked on the inspection checklist. If an applicable item does not meet the condition on the checklist, maintenance and/or repairs should be implemented to correct the situation.

As Needed

- ☐ Accumulated oil and floatables were removed from the sedimentation chamber (underground sand filter)
- ☐ Filtration system (sand bed, filter fabric, etc.) is not clogged or partially clogged
- ☐ Sediment depth in sedimentation chamber is less than ½ of the total depth to the outlet or is less than 1.5 feet 12 inches (whichever is greater)
- ☐ Filter's drawdown times do not exceed 48 hours
- ☐ The top 2-5 inches of media material has been removed and replaced within the past 3-5 years (if the system has been operational for 3-5 years)

Monthly

- ☐ Contributing area, facility, inlets, and outlets are clear of debris
- ☐ Contributing area is stabilized and mowed, with clippings bagged or removed and with measures in place as needed to minimize oil/grease and sediment released to system
- ☐ For filters with grass cover, grass height is less than 12 inches
- ☐ Filter surface is not clogging – also inspect after moderate/major storm events (> 1")
- ☐ Activities in the drainage area minimize oil/grease and sediment entering the system
- ☐ Permanent water level is not present (for perimeter sand filter)
- ☐ For filtration systems utilizing a permanent pool in a pre-treatment chamber, the chamber or vault does not leak, and normal pool water surface elevation is retained

Quarterly

- ☐ For underground sand filters, water level in sand filter chamber is acceptable

Annually

- ☐ Filter bed is clean of sediment, and the sediment chamber contains no more than 6 inches or 50% depth of sediment, whichever is less (or 12 inches for underground sand filters)
- ☐ There are no eroded areas that require stabilization
- ☐ There were no signs of flow bypassing the filter (except for expected high flow bypass)
- ☐ No evidence of deterioration, spalling, or cracking is present on concrete
- ☐ Inspect grates, where applicable
- ☐ Structural parts are free of damage and do not need repair or replacement
- ☐ Flow is not bypassing the filtration system
- ☐ No noticeable odors are detected outside of the facility.

Design Criteria

All sand filters:

- The drainage area size typically dictates the sand filter size, with a preferred drainage area between 0.5 – 2 acres. Maximum drainage area limits are as follows:
  - Surface sand filter maximum of 10 acres
  - Perimeter sand filter maximum of 2 acres
  - Underground sand filter maximum of 2 - 5 acres
- Sloped areas immediately adjacent to the sand filter system should be no greater than 5:1 (H:V) nor less than 1% to promote positive flow toward the system.
- The sand filter system surface slope should not exceed 1%, to promote even distribution of flow throughout the system.
- The sand filter system should be designed such that it is drained within 48 hours from the peak water level in the system.
- Most sand filters are configured off-line, so that flows greater than the water quality volume (WQ_v) capacity can be diverted downstream. The exception is underground sand filters, which are typically designed on-line.
- Sand filters require pre-treatment. Most sand filters will use a sediment chamber for pretreatment.
  - The recommended minimum length to width ratio for the sediment chamber is 2:1.
  - Inlet and outlet structures should be built at opposite ends of the sedimentation chamber.
  - The minimum wet pool volume required in the sedimentation chamber should be calculated using $V_w = A_s$ x 3 feet.
- Sand filters must include appropriate elevation differences and head considerations.
  - For most sand filters, the recommended elevation difference between the inflow and the outflow is between 4-6 feet.
  - For perimeter sand filters, the elevation difference may be 2-3 feet.
  - Sand filters typically require 2-6 feet of head.
- A minimum of 3 feet of separation is required between the sand filter bottom and seasonally saturated soils. A 5-foot separation is recommended between the sand filter bottom and seasonally saturated soils.
- During construction, disturbed areas draining to the sand filter should be identified and stabilized as soon as possible as they may clog the filter bed. Flow should not be directed into the sand filter until after impervious area construction is completed and pervious areas have established, dense, healthy vegetation.

Design Criteria

All sand filters (cont'd):

- Safety considerations must be considered and included in the design.
  - Mosquito breeding risks should be reduced for surface systems by ensuring that the structure dewaters within 72 hours.
  - Fencing may be desirable or required to limit entry. Measures that are more than 5 feet deep require OSHA safe construction health and safety guidelines.
- Site access for maintenance should also be considered in the design process.
- For sand filters located in sensitive areas (i.e., potential stormwater hotspots), additional treatment practices are recommended for partial treatment during the winter when the filter bed may be frozen.
- The filtration system must be designed to temporarily hold a capacity equal to or greater than 75% of the water quality volume (WQ_v) of the system prior to filtration.

Surface sand filters:

- The sedimentation chamber must have a capacity to hold 25% of the water quality volume (WQ_v), and have a ratio of 2:1 (H:V).
- Required space is a function of available head at the site for surface filters.
- Grass covers for surface filters should use grasses suited for withstanding frequent periods of inundation and drought.
- Protect underground sand beds from trash accumulation by placing a wide mesh geotextile screen on the sand bed surface. This screen may be rolled up, removed, cleaned and reinstalled during maintenance.

Perimeter sand filters:

- The sedimentation chamber should be sized to accommodate at least 50% of the calculated WQ_v.
- For perimeter sand filters with grates, the grates should be heavy so that the grates are not easily removed.
- The permanent pool depth in the sedimentation chamber should consider factors such as mosquito control and maintenance requirements.

Underground sand filters:

- Underground filters have little or no surface space requirements except for access. No building structures should be located above underground filters.
- Underground sand filters would require entry by individuals with confined space entry training.

Design Criteria

Underdrain system:

- Sand filters must use an underdrain/collection system to carry flow to another conveyance element. This system should contain a minimum 8-inch perforated PVC pipe surrounded by a 12-inch thick gravel layer. Increasing the diameter of the underdrain makes freezing less likely, and provides a greater capacity to drain standing water from the system.

Design Components

- **Pre-treatment** – Pre-treatment areas function to capture and remove coarse sediment particles from runoff prior to runoff entering the treatment component. Incorporation of pre-treatment helps to reduce required maintenance for the treatment component and reduces the potential for filter clogging. These pre-treatment areas vary in name depending on the sand filter type used. For sand filters located in sensitive areas (i.e., potential stormwater hotspots), additional treatment practices are recommended for partial treatment during the winter when the filter bed may be frozen. Pre-treatment component information specific to the sand filter type are presented in the following bullet sections:
    - **Surface Sand Filters** – The sedimentation chamber must have a capacity to hold 25% of the water quality volume (WQ_v).
        - The chamber must also have a ratio of 2:1 (H:V) and have a minimum length to width ratio of 2:1.
        - The chamber inlet and outlet structures should be located at opposite ends of the chamber.
        - The minimum wet pool volume required in the sedimentation chamber should be calculated using $V_w = A_s$ x 3 feet.
    - **Perimeter Sand Filters -** The sedimentation chamber should be sized to accommodate at least 50% of the calculated WQ_v.
    - **Underground Sand Filters –** Underground filters have little or no surface space requirements except for access.
        - No building structures may be located above the underground filters.
        - Underground sand filters would require entry by individuals with confined space entry training.
- **Treatment** – The treatment areas house the sand filters, which remove pollutants.
    - **General Requirements –**
        - Sloped areas immediately adjacent to the sand filter system should be no greater than 5:1 (H:V) nor less than 1% to promote positive flow toward the system.
        - The sand filter system surface slope should not exceed 1%, to promote even distribution of flow throughout the system.
        - The sand filter system should be designed such that it is drained within 48 hours from the peak water level in the system.

Design Components

- § The filtration system must be designed to temporarily hold a capacity equal to or greater than 75% of the water quality volume (WQ_v) of the system prior to filtration.
- § For sand filters located in sensitive areas (i.e., potential stormwater hotspots), additional treatment practices are recommended for partial treatment during the winter when the filter bed may be frozen.
- § Required space is a function of available head at the site for surface filters. Except where discussed below for specific filter types, the recommended elevation difference between the inflow and the outflow is between 4-6 feet.
- § Use Darcy's law to size the filter bed area. The permeability coefficients (k) for different filter materials are shown below:
  - Sand - 3.5 ft/day
- § The filter media for all sand filters should include a minimum layer depth of 18 inches of clean, washed, medium sand (ASTM C-33 concrete sand).

- o **Surface Sand Filters** – Grass covers for surface filters should use grasses suited for withstanding frequent periods of inundation and drought.
- o **Perimeter Sand Filters -**. For perimeter sand filters, the elevation difference may be 2-3 feet. The grates should be heavy so that the grates are not easily removed.
- o **Underground Sand Filters –** Place filter beds for underground filters below the frost line to prevent the filtering medium from freezing during the winter.

Ø **Underdrain/Collection System** – Sand filters must use an underdrain/collection system to carry flow to another conveyance element. This type of underdrain system is recommended for tight impermeable soils where infiltration is limited. Otherwise, refer to the guidance for "hot spot" areas discussed below.

- o For areas that are known as potential stormwater "hot-spots" (e.g., gas stations, transfer sites, and transportation depots), the underdrain system must also include an impervious liner designed to reduce or eliminate the possibility of ground water contamination. This type of facility should consider how to address accidental spills. For instance, the underdrain discharge point can be blocked and the objectionable materials maybe siphoned through an observation well and safely contained.
- o The underdrains should be equipped with a minimum 8-inch perforated PVC pipe surrounded by a 12-inch thick gravel layer. Increasing the pipe diameter decreases the potential for freezing. The porous gravel layer promotes drainage and is less susceptible to frost heaving than media with smaller particle size.
- o The gravel shall be washed and 1-1/2" in size or clean, washed aggregate at a diameter no greater than 3.5 inches and no less than 1.5 inches. The porous gravel layer prevents standing water in the system by promoting drainage.

Design Components	o The minimum slope of the underdrain system is $^{1}/_{8}$-inch per foot (1% slope) o A minimum of 3 feet of separation is required between the bottom of the sand filter and seasonally saturated soils. o A permeable filter fabric must be placed between the gravel layer and the filter bed material. The filter fabric does not need to extend to the side walls. The filter fabric may be installed horizontally above the gravel blanket, extending just 1-2 feet on either side of the underdrain pipe below. o Do **not** wrap the under-drain with filter fabric. o A permeable filter fabric must also be placed between the underdrain gravel layer (beneath the perforated pipe) and the native soil material under the filter system. Note that permeable fabric will allow potential infiltration into the native soil material beneath the filter system. For scenarios where this infiltration is not desirable, use an impermeable liner as described for "hot spot" land use areas. o Pipe perforations must be sized approximately 3/8 inch in diameter spaced at 6-inch intervals on center. At a minimum, 4 holes per row should be used, and pipe grade placement should be at least 0.5%. Pipes should be spaced no more than 10 feet on center.

Design Procedure

Step 1 – Make a preliminary judgment as to whether site conditions are appropriate for the use of a sand filter system, and identify the sand filter type and function in the overall treatment system. This includes performing an initial suitability screening for the site.

- Consider basic issues for initial suitability screening, including:
  - Site drainage area
  - Site topography and slopes
  - Soil type and infiltration capacity
  - Depth to water table and bedrock
  - Site location/minimum setbacks
  - Presence of active karst features
  - % Impervious Area
  - Intermittent Flow
  - Sufficient Flow Elevation Difference
  - Proposed development use (Is development commercial, industrial, or institutional?)
- Determine how the sand filter system will fit into the overall stormwater treatment system.
  - Decide whether the sand filter system will be the only BMP to be employed, or if there are other BMPs addressing some of the treatment requirements.
  - Decide where on the site the sand filter system is most likely to be located.

Step 2 – Confirm design criteria, site constraints, and applicability.

- Determine the design criteria that will be used.
- Determine any constraints the site will place on the sand filter system such as:
  - High pervious area in the drainage area
  - Limited amount of surface area available for treatment
  - High water table
- Determine the TSS reduction provided, using the equations below for weighted TSS reduction, $TSS_{weighted}$, and TSS treatment train, TSS_{train}. The minimum TSS reduction required for the site is 80% and can be weighted for the site.

$$\%TSS_{\text{weighted}} = \frac{\sum_n^1 (TSS_1 A_1 + TSS_2 A_2 + \ldots + TSS_n A_n)}{\sum_n^1 (A_1 + A_2 + \ldots + A_n)}$$

Where runoff is treated by two or more BMPs in series, the TSS reduction provided is calculated with the following equation for a treatment train:

$$TSS_{train} = A + B - \frac{(A \times B)}{100}$$

Design Procedure

Where A is the TSS reduction provided by the first BMP and B is the TSS reduction provided by the next BMP.

Step 3 –Select a sand filter type based on the initial suitability screening, design criteria, site constraints and applicability. Perform field verification of site suitability.

- The field verification should be conducted by a qualified geotechnical professional.

Determine the depth to groundwater. A minimum of 3 feet of separation between the bottom of the sand filter system and seasonally saturated soils (or from bedrock) is required (5 feet of separation is recommended).

Step 4 – Compute runoff control volumes and peak flows.

- Calculate the Water Quality Volume (WQ_V).

$$\mathbf{WQ_v = [P\ Rv)(A)]/12}$$

Where:

P = 1.1 inches

R_V = 0.05 + 0.009(I), where I is the percent impervious cover

A = the area of imperviousness, (acres)

- The volume of voids in the sand filter's underdrain system may be subtracted from the WQ_v. The volume of voids should be estimated at 35% of the total volume of the underdrain system.
- Calculate the peak flow for the Water Quality Volume (Q_{wq}), 25 yr peak runoff rate (Q_{P25}), and the 100 yr peak runoff rate (Q_{P100}). Refer Appendix B for more information on Q_{P25} and Q_{P100}.
  - Determine the peak flow for Water Quality Volume (Q_{wq}).

$$\mathbf{Q_{wq} = C \times I_{WQ} \times A}$$

Where:
Q_{wq} = the water quality volume peak flow, (cfs)

C = the runoff coefficient

I_{WQ} = the rainfall intensity, 2.45 in/hr

A = the area of imperviousness, (acres)

The common reference used for runoff coefficients is Design and Construction of Sanitary and Storm Sewers, American Society of Civil Engineers and the Water Pollution Control Federation, 1969.

Note that designs for managing Q_{P25} and Q_{P100} must be consistent with the City-County Planning Commission requirements and are not addressed in this manual. Information about these requirements is contained in Section 2.4.7.

Design Procedure

Note: Steps 5-12 are iterative

Step 5 – Size flow diversion structure, if needed.

- A flow regulator or flow splitter should be used to divert WQ_V into the sand filter system.
- The most common approach used is setting a bypass weir within the diversion based on the elevation of the water quality volume within the system.
- Size low flow orifice, weir or other device to pass WQ_V.

STEP 6 – Size the filtration basin (sand filter) chamber..

- The filter area is sized using the following equation (based on Darcy's Law):

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

Where:

A_f = surface area of filter bed, (ft^2)

WQ_v = Water Quality Volume, (ft^3)

NOTE: The volume of voids in the sand filter's underdrain system may be subtracted from the WQ_v. The volume of voids should be estimated at 35% of the total volume of the underdrain system.

d_f = filter bed depth, (ft) - minimum depth is 18 inches, maximum depth is 24 inches

k = coefficient of permeability of filter media, (ft/day) use 3.5 ft/day for sand

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

t_f = design filter bed drain time, (days) - 2 days or 48 hours maximum

- Use these calculations to set the preliminary dimensions for the filtration basin chamber. See the Design Criteria for filter media specifications.

STEP 7 – Size the sedimentation chamber.

- Sedimentation chamber size is based on volume requirements, maximum ponding depth and the particle settling ability.
- **Surface sand filter:** The sedimentation chamber should be sized to at least 25% of the computed WQ_v and have a length-to-width ratio of 2:1. The Camp-Hazen equation is used to compute the required surface area:

$$A_s = -(Q_o/w) * \ln(1-E)$$

Where:

A_s = sedimentation basin surface area (ft^2)
Q_o = rate of outflow = the WQ_v over a 24-hour period
w = particle settling velocity (ft/sec)
E = trap efficiency

Design Procedure

Assuming:

- E = 90% sediment trap efficiency (0.9)
- w = particle settling velocity (ft/sec) = 0.0004 ft/sec for imperviousness < 75%
- w = particle settling velocity (ft/sec) = 0.0033 ft/sec for imperviousness ≥ 75%
- average of 24 hour holding period

Then:

$$\mathbf{A_s = (0.066)\,(WQ_v)\ ft^2\ for\ I < 75\%}$$

$$\mathbf{A_s = (0.0081)\,(WQ_v)\ ft^2\ for\ I \geq 75\%}$$

Where:

I = percent impervious

Perimeter sand filter:

The sedimentation chamber should be sized to hold at least 50% of the computed WQ_v. Use same approach as for surface sand filter.

- Use Table PTP-01-1 to set the preliminary surface area for the sedimentation chamber (settling chamber). Select the filter type, drainage area imperviousness and the maximum ponding depth.

Table PTP-01- 1 Sedimentation Chamber (Settling Chamber) Surface Area

Sand Filter		**Maximum Ponding Depth (feet)**	
		<4	4-10
Impervious	•75%	$(0.25{*}WQ_v)/D_{max}$	$(0.25{*}WQ_v)/D_{max}$
	<75%	$(0.25{*}WQ_v)/D_{max}$	$(0.066{*}WQ_v)/D_{max}$
Perimeter Sand Filter		**Maximum Ponding Depth (feet)**	
		<7.5	8-10
Impervious	•75%	$(0.5{*}WQ_v)/D_{max}$	$(0.5{*}WQ_v)/D_{max}$
	<75%	$(0.5{*}WQ_v)/D_{max}$	$(0.066{*}WQ_v)/D_{max}$

STEP 8 – Compute V_{min} (the minimum volume that can be stored within the filtration chamber).

$$V_{\mathbf{min}} = 0.75 * WQ_{\mathbf{v}}$$

STEP 9 – Compute storage volumes within the entire facility as well as the sedimentation chamber orifice size.

<u>Surface sand filter:</u>

$$\mathbf{V_{min} = 0.75\ WQ_v = V_s + V_f + V_{f\text{-}temp}}$$

- V_f = water volume within filter bed/gravel/pipe

$V_f = A_f * d_f * n$, where:

- o n = porosity = 0.35 for filter material including gravel as specified in Design

Design Procedure

- $V_{f\text{-}temp}$ = temporary storage volume above the filter bed

  $V_{ftemp} = 2 * h_f * A_f$

- V_s = volume within sediment chamber

  $V_s = V_{min} - V_f - V_{f\text{-}temp}$

- h_s = height in sedimentation chamber

  $h_s = V_s/A_s$

- Ensure that h_s and h_f fit the available head and that the other dimensions still fit. Make iterative changes as necessary in design until all site dimensions fit.
- Size the orifice that carries flow from the sedimentation chamber to the filter chamber so that V_s is released within 24 hours at an average release rate with 0.5 h_s as the average head.
- Design the outlet structure with perforations that allow for a safety factor of 10.
- Size distribution chamber to spread flow over filtration media – level spreader weir or orifices.

Perimeter sand filter:

- V_f = water volume within filter bed/gravel/pipe

  $V_f = A_f * d_f * n$

  Where: n = porosity = 0.35 for filter material including gravel as specified in Design Criteria and Design Components
- V_w = wet pool storage volume

  $V_w = A_s$ * wet pool depth

- Minimum wet pool depth = 2 feet
- Vf_{temp} = temporary storage volume

  $Vf_{temp} = V_{min} – (V_f + V_w)$

- h_{temp} = temporary storage height

  $h_{temp} = = Vf_{temp} / (A_f + A_s)$

Design Procedure

- Ensure $h_{temp} \geq 2 * h_f$, otherwise decrease h_f and re-compute. Ensure that the dimensions fit the available head and area. Change as necessary in design iterations until all site dimensions fit.
- Size distribution slots from sediment chamber to filter chamber. The elevation and size of these distribution slots should consider the desired permanent pool elevation as well as factors such as mosquito control and maintenance requirements. A minimum pool depth of 2 feet should be maintained in the sediment chamber.

STEP 10 – Design inlets, pre-treatment facilities, underdrain system and outlet structures according to Design Criteria and Design Components.

- Pre-treatment of runoff is provided by the sedimentation chamber. Surface sand filter inlets should be provided with energy dissipaters. Sedimentation chamber exit velocities must be non-erosive.
- The outlet pipe should connect the facility's underdrain system with the facility's discharge location. Outlet protection is not generally necessary due to the slow rate of filtration. The exceptions are that emergency overflows and spillways may require outlet protection.

Surface sand filters:

- The surface sand filter must include an emergency or bypass spillway that will safely pass flows that exceed the design storm flows.
- The emergency spillway location should be sited away from downstream buildings and structures that could be impacted by the spillway discharge.
- The surface sand filter inlets should include energy dissipaters.
- This spillway prevents the filter water levels from overtopping the embankment and causing structural damage.

STEP 11 – Compute the overflow weir sizes.

Surface sand filters:

- Size overflow weir at elevation h_s in sedimentation chamber (above perforated stand pipe) to handle surcharge of flow through filter system from 25-year storm.
- Plan inlet protection for overflow from sedimentation chamber.
- Size the overflow weir at elevation h_f in filtration chamber (above perforated stand pipe) to handle surcharge of flow through filter system from 25-year storm.

Perimeter sand filter:

- Size the overflow weir at the end of the sedimentation chamber to handle excess inflow, set at WQ_v elevation.

STEP 12 - Check volume, peak discharge rates and period of inundation against any applicable state, local and other requirements.

- Water quality volume (WQ_v) - If the filtration system does not meet the requirement to treat the WQ_v, the sand filter's storage volume must be increased or the excess part of the WQ_v must be treated with another BMP (either upstream or downstream).

Design Procedure

- The sand filter must be able to discharge through the filter media in no more than 48 hours. Any additional flows that cannot be filtered within 48 hours should be routed to bypass the system to a stabilized discharge location.
- If the sand filter does not meet the period of inundation requirements, one approach to meet the inundation requirement is to increase the filter surface area (decrease the height of water above the filter bed). Another approach is to add one or more additional BMPs that reduce the portion of the WQ_v treated by the sand filter, which also changes the water level range for the sand filter.
- The 48-hour window considers the following factors: wet-dry cycling between rain events, unsuitable mosquito breeding habitat, suitable conditions for vegetation (where applicable), aerobic conditions and storage for back-to-back precipitation events.

STEP 13 – Prepare Vegetation and Landscaping Plan

- All sites must include plan information that includes completing impervious area construction and establishing dense and healthy vegetation for pervious area before stormwater is introduced into the sand filter.
- For surface filters with vegetation and organic filters, a Vegetation and Landscaping Plan should be prepared. The landscaping plan should address how the filter surface will be stabilized and how vegetation will be established. The vegetative cover must be able to withstand frequent periods of inundation and drought.

STEP 14 – Prepare operations and maintenance plan

Prepare the sand filter's operations and maintenance plan based on the guidance given in the Maintenance Section.

STEP 15 – Complete the Design Summary Table

Design Parameter	Required Size	Actual Size
Sand Filter Type:		
WQ_v:		
A_f:		
Filtration Basin (LxW)		
A_s:		
Sedimentation Basin (LxW)		

Example Design

Figure PTP-01- 18 Sand Filter Design Example Site Plan.

Proposed development of an undeveloped site into an office building and associated parking.

Table PTP-01- 2 Sand Filter Design Example Site Base information.

Base Data	**Hydrologic Data**
Site Area = 3.54 ac	Pre Post
Total drainage = 5.0 ac	CN 71 89
Soils Type "C"	
	WQ_v Depth = 1.1 in
Pre-Development	
Impervious Area = 0 ac; or I = 0%	**Precipitation**
Meadow (CN = 71)	I_{WQ} 2.45 in/hr
Post-Development	2yr, 24hr 3.54 in
Impervious Area = 1.72 ac; or I = 1.72/3.54 = 49%	25yr, 24hr 5.88 in
Open Space, Fair (CN = 79)	100yr, 24hr 7.43 in
Paved parking lots, roofs, driveways, etc. (CN =98)	

Example Design

This example focuses on the design of perimeter sand filter facilities to meet the water quality treatment requirements of the site. Peak flow reduction is not addressed in this example other than quantification of preliminary storage volume and peak discharge requirements. In general, the primary function of sand filters is to provide water quality treatment and not large storm attenuation. As such, flows in excess of the water quality volume typically bypass the facility or pass through the facility. Where quantity control is required, the bypassed flows can be routed to conventional detention pond (or some other facility such as underground storage vaults).

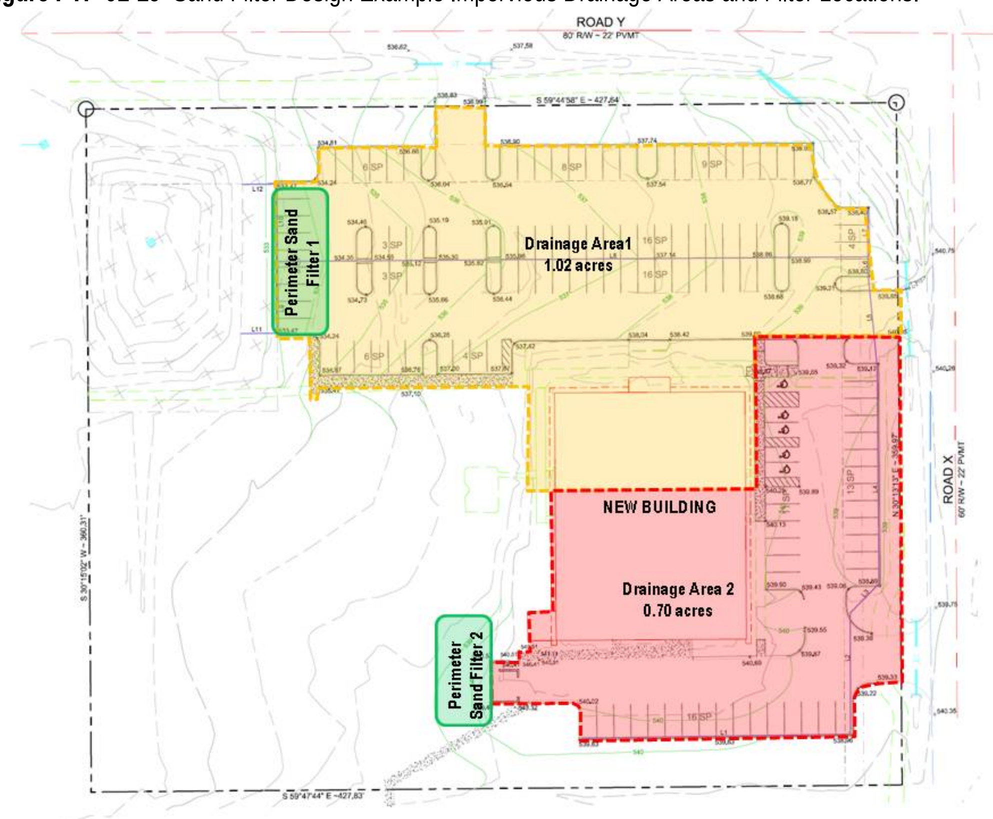
Problem: Design a post-construction stormwater water quality treatment plan for this site. A dry detention pond will be constructed to meet the required detention standards and will provide 60% TSS reduction for the site. The total drainage area to the pond is 5 acres. Try designing one or more perimeter sand filter systems in or near the parking areas in addition to the dry detention pond to achieve the required 80% TSS reduction.

Step 1 – Make a preliminary judgment as to whether site conditions are appropriate for the use of a sand filter system, and identify the sand filter type and function in the overall treatment system. This includes performing an initial suitability screening for the site.

- Consider basic issues for initial suitability screening, including:
  - The site has type "C" soils
  - There are no minimum setbacks
  - There are active karst areas on the site. The sand filter systems will not be located close to the sinkhole.
  - The total drainage to the detention pond is 5 acres.
  - The site's topography, slopes, flow elevation difference and depth to water table and bedrock will support installation of sand filter systems away from active karst areas.
  - The percentage of impervious area is 49%.
  - The proposed development is a commercial office building with associated parking.
- Determine how the sand filter system will fit into the overall stormwater treatment system.
- The proposed sand filter systems will be part of a treatment train for TSS removal. A dry detention pond will be constructed to meet the required detention standards and will provide 60% TSS reduction for the site. The perimeter sand filters provide 80% TSS reduction when used as a single BMP. Try 2 sand filters:
  - The desired sand filter systems are perimeter sand filters. These units may be located under parking areas.
  - Try 2 sand filters, as noted above.
    - Sand filter 1 – 1.02 acres drainage
    - Sand filter 2 – 0.7 acres drainage
  - The treated water quality volume will be collected by an underdrain system and routed to the dry pond located in the northwest corner of the site for water quantity control. Flows greater than the water quality volume will bypass the perimeter sand filter systems and be routed to the dry pond for water quantity control and final polishing prior to discharging.

Example Design

Figure PTP-01-19 Sand Filter Design Example Impervious Drainage Areas and Filter Locations.



Step 2 – Confirm design criteria, site constraints, and applicability.

- Ø The following minimum criteria will be used in the design.
  - o The desired sand filter bed depth is 18 inches (1.5 feet).
  - o Maximum 36 hour drain time from peak water level
  - o Minimum 8-inch diameter underdrain enveloped in a 12-inch gravel layer
  - o Minimum 3 foot separation from bottom to seasonally saturated soils
  - o The percentage of pervious area and the percentage of impervious area in the contributing drainage area are nearly equal (49% impervious, 51% pervious).
  - o The contributing drainage areas to each sand filter do not include large amounts of pervious area (i.e., drainage from pervious areas is routed around the contributing areas to the sand filters). This approach reduces the potential for clogging the sand filters.

Example Design

- **TSS removal** – The required TSS removal is a minimum of 80% reduction for average annual post-development load. All site areas drain toward the dry detention pond. Impervious site areas drain through the two perimeter sand filters en route to the dry detention pond. The total impervious area for this site is 1.72 acres. The % TSS removal is calculated using a treatment train for each of the impervious areas to show the combined effects of both the sand filters and the dry detention pond.

$$\%TSS = \frac{80 + 60 - (80 x 60)}{100}$$

%TSS = 92% ü

Therefore, the combination of two perimeter sand filters with the dry detention basin does meet the requirement for at least 80% TSS removal.

Step 3 –Select a sand filter type based on the initial suitability screening, design criteria, site constraints and applicability. Perform field verification of site suitability.

- The site geotechnical investigation showed that both the northwest and the south potential perimeter sand filter locations were suitable for installing sand filters.
- The soil borings indicated that the underlying soils in the vicinity of the sand filter locations had limited infiltration capacity and that the high water elevation was a minimum of 8 feet or more below the parking lot at both the northwest and south locations. This depth to the water table elevation is sufficient to maintain the minimum 3-foot separation between the bottom of the sand filter and the high water elevation.
- No impermeable layers/lenses or bedrock was encountered during the geotechnical field evaluation of the site.
- The site has a sinkhole in the location where the dry detention is proposed. The throat will be improved and used as the primary spillway for the detention pond.

Step 4 – Compute runoff control volumes and peak flows.

- Calculate the Water Quality Volume (WQ_V). This WQ_v calculation will be performed using each of the two contributing areas to allow individual sand filter sizing.

Sand Filter 1:

$$WQ_v = [(P\ R_v)(A)]/12$$

Where:

P = 1.1 inches

$R_v = 0.05 + 0.009(I)$

I = 49

$R_v = 0.05 + 0.009(49) = 0.491$

$A_1 = 1.02$ acres

$$WQ_{v1} = (1.1in \times 0.491 \times 1.02ac)/12 = 0.046 \text{ acre-ft} = 2000 \text{ ft}^3$$

Example Design

FIRST ITERATION:

Step 5 – Size flow diversion structure, if needed.

- Since the perimeter filter system is a subsurface system, flows in excess of WQ_v will bypass the perimeter sand filter grates during higher runoff events. However, bypassing will not occur until the total volume, WQv, has been captured by the treatment mechanism of the sand filter. A separate drop inlet will be added beyond each perimeter sand filter system to convey runoff from these higher flow events to the dry detention pond once the perimeter sand filter reached maximum capacity.

STEP 6 – Size the filtration basin (sand filter) chamber.

- The filter area is sized using the following equation (based on Darcy's Law):

$$\mathbf{A_f = (WQ_v)\,(d_f)\,/\,[(k)\,(h_f + d_f)\,(t_f)]}$$

Where:

A_f = surface area of filter bed, (ft^2)

NOTE: The volume of voids in the sand filter's underdrain system may be subtracted from the WQ_v. The volume of voids should be estimated at 35% of the total volume of the underdrain system. For the first design iteration, the volume of voids for the underdrain system is not included. However, the underdrain system's volume of voids will be subtracted from WQ_v in subsequent iterations.

d_f = filter bed depth, (ft) - minimum depth is 18 inches, maximum depth is 24 inches

k = 3.5, coefficient of permeability of filter media, (ft/day)

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

t_f = design filter bed drain time, (days) - 2 days or 48 hours maximum

Sand Filter 1:

$\mathbf{WQ_{v1} = 2000\ ft^3}$

d_f = 18 inches = 1.5 feet

k = 3.5 ft/day

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

Assume h_{max} = 2 feet for this site. Therefore, $h_f = ½\ h_{max}$ = 1 feet

t_f = 1.5 days

$$\mathbf{A_{f1} = (2000\ ft^3)\,(1.5\ feet)\,/\,[(3.5\ ft/day)\,(1\ feet + 1.5\ feet)\,(1.5\ days)] = 228.6\ ft^2}$$

Round up to the nearest square foot to size for minimum surface area of filter bed of 229 ft^2.

Example Design

Sand Filter 2:

WQ_{v2} = 1373 ft^3

Assume h_{max} = 2 feet for this site. Therefore, h_f = ½ h_{max} = 1 feet

t_f = 1.5 days

A_{f2} = (1373 ft^3) (1.5 feet) / [(3.5 ft/day) (1 feet + 1.5 feet) (1.5 days)] = 156.9 ft^2

Round up to the nearest square foot to size for minimum surface area of filter bed of 157 ft^2.

- Use these calculations to set the preliminary dimensions for the filtration basin chamber. See the Design Criteria for filter media specifications.

  Sand Filter 1:

  Set the filtration basin chamber at 46 ft x 5ft

  Sizing took into consideration minimum surface area requirements and the site's configuration.

  A_{r1} = 230 ft^2 ü

  Sand Filter 2:

  Set the filtration basin chamber at 20 ft x 8 ft

  The location for Sand Filter 2 is more limited by site constraints such that the maximum filter length would be 20 feet.

  A_{r2} = 160 ft^2 ü

Example Design

STEP 7 – Size the sedimentation chamber.

- For a perimeter sand filter, the sedimentation chamber should be sized to at least 50% of the computed WQ_v. The sedimentation chamber will be sized using an approach similar to that used for a surface sand filter.
- Table PTP 01-01 was used to set the preliminary surface area for the sedimentation chamber (settling chamber). The desired maximum ponding depth (D_{max}) used was 3 feet. The site's percentage of impervious area is 49%. A cross-section view for both sand filters is shown below.

Sand Filter 1:

A_{s1} = **Surface Area of Sedimentation Chamber** = $(0.5*WQ_{v1})/D_{max}$ = $(0.5*2000\ ft^3)/3$ **feet**

$A_{s1} = 334\ ft^2$ ü

- For the sedimentation chamber, the preliminary dimensions will use the same length (46 feet) used for the filter chamber's preliminary dimensions. This would require that the sedimentation chamber's width be at least 8 feet to achieve the surface area calculated above. Using the preliminary dimensions, A_{s1} becomes 46 feet x 8 feet = 368 ft^2, and this value will be used for A_s in the subsequent calculations for the first iteration

Sand Filter 2:

A_{s2} = **Surface Area of Sedimentation Chamber** = $(0.5*WQ_{v2})/D_{max}$ = $(0.5*1373\ ft^3)/3$ **feet**

$A_{s2} = 229\ ft^2$ ü

- For the sedimentation chamber, the preliminary dimensions will use the same length (20 feet) used for the filter chamber's preliminary dimensions. This would require that the sedimentation chamber's width be at least 12 feet to achieve the surface area calculated above. Using the preliminary dimensions, A_{s2} becomes 20 feet x 12 feet = 240 ft^2, and this value will be used for A_s in the subsequent calculations for the first iteration

STEP 8 – Compute V_{min} (the minimum volume that can be stored within the filtration chamber).

Sand Filter 1:

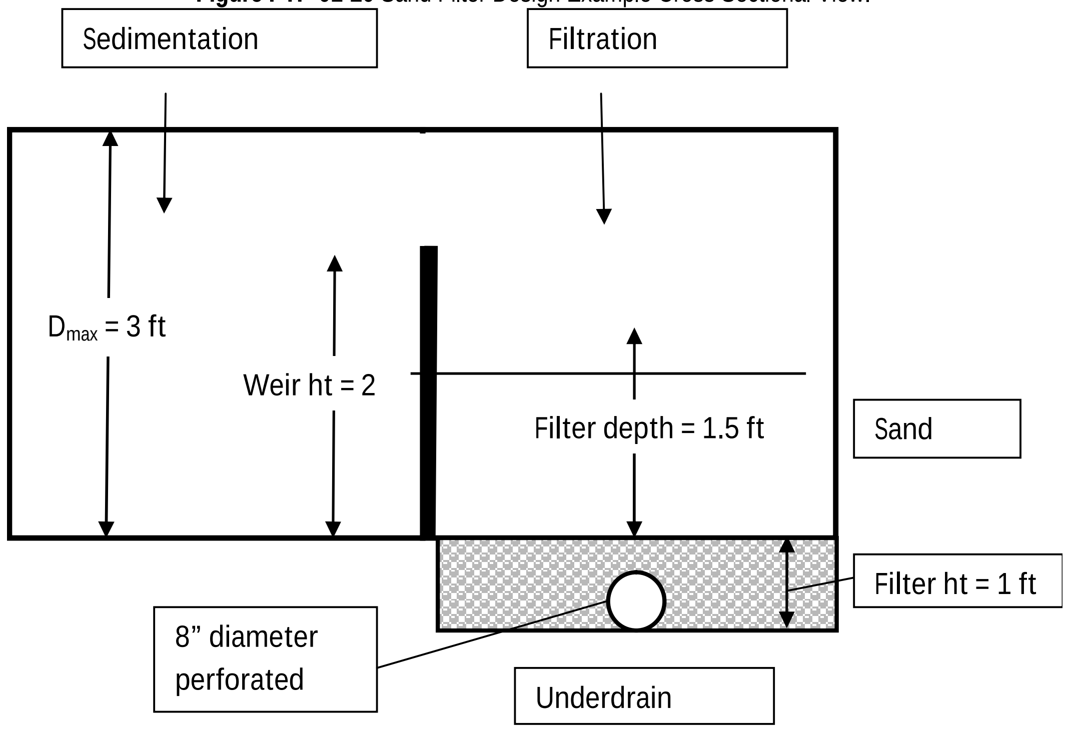
$$V_{min1} = 0.75 * WQ_{v1} = 0.75 * 2000\ ft^3 = 1500\ ft^3$$

Sand Filter 2:

$$V_{min2} = 0.75 * WQ_{v2} = 0.75 * 1373\ ft^3 = 1030\ ft^3$$

Example Design

Figure PTP-01-20 Sand Filter Design Example Cross Sectional View.



STEP 9 – Compute storage volumes within the entire facility as well as the sedimentation chamber orifice size.

- Where: n = porosity = 0.35 for filter material including gravel as specified in Design Criteria and Design Components
- The filter layer depth (d_r) is the minimum depth of 1.5 ft.
- The minimum wet pool depth is 2 feet. For this design example, use the 2-foot minimum depth.

Sand Filter 1:

- Compute V_{f1} = water volume within filter bed/gravel/pipe = A_{f1} * d_f * n

$$V_{f1} = 230\ ft^2 * 1.5\ ft * 0.35 = 120.75\ ft^3$$

- Compute V_{w1} = wet pool storage volume = A_{r1} * wet pool depth

$$V_{w1} = 230\ ft^2 \times 2\ feet = 460\ ft^3$$

Example Design

Ø Compute Vf_{temp1} = temporary storage volume for Sand Filter 1 = $V_{min1} – (V_{f1} + V_{w1})$

Vf_{temp1} = 1500 ft^3 – (120.75 ft^3 + 460ft^3) = 919.25 ft^3

Ø Compute h_{temp1} = temporary storage height for Sand Filter 1 = $Vf_{temp1} / (A_{f1} + A_{s1})$

h_{temp1} = 919.25 ft^3/ (230 ft^2 + 368 ft^2) = 1.5 feet

Ø Check that h_{temp1} • 2 * h_f; 2 * hf = 2* 1.5' = 3 ft. For Sand Filter 1, the design fits the chamber.

Ø The distribution slots from the sediment chamber to the filter chamber were assumed to be similar in function to broad-crested weirs that allow flow to exit the sediment chamber and enter the filter chamber once the sediment chamber's water level reaches the minimum wet pool depth of 2 feet. The sedimentation and filter chambers then continue to fill up to D_{max} elevation. The D_{max} elevation was set assuming that the sediment chamber should be sized to hold 50% of WQ_V. These slots would be sized to handle the desired weir flow between the two chambers without allowing the sedimentation chamber's water level to reach the higher bypass weir elevation before the required WQv is contained in the two filter chambers. (Note that the minimum wet pool elevation affects the permanent pool elevation in the sedimentation chamber, required maintenance for the sedimentation chamber, mosquito control and possible undesirable odors due to the permanent pool elevation.)

Sand Filter 2:

Ø Compute V_{f2} = water volume within filter bed/gravel/pipe = $A_{f2} * d_f * n$

V_{f2} = 160 ft^2*1.5 ft * 0.35 = 84 ft^3

Ø Compute V_{w2} = wet pool storage volume = A_{f2} * wet pool depth

V_{w2} = 160 ft^2 x 2 feet = 320 ft^3

Ø Compute Vf_{temp2} = temporary storage volume for Sand Filter 2 = $V_{min2} – (V_{f2} + V_{w2})$

Vf_{temp2} = 1030 ft^3 – (84 ft^3 +320 ft^3) = 626 ft^3

Ø Compute h_{temp2} = temporary storage height for Sand Filter 2 = $Vf_{temp2} / (A_{f2} + A_{s2})$

h_{temp2} = 626 ft^3/ (160 ft^2 + 240 ft^2) = 1.6 feet

Ø Check that h_{temp2} • 2 * h_f = 2 * 1.5 feet = 3ft.

Example Design

- The distribution slots from the sediment chamber to the filter chamber were assumed to be similar in function to broad-crested weirs that allow flow to exit the sediment chamber and enter the filter chamber once the sediment chamber's water level reaches the minimum wet pool depth of 2 feet. The sedimentation and filter chambers then continue to fill up to D_{max} elevation. The D_{max} elevation was set assuming that the sediment chamber should be sized to hold 50% of WQ_v.

STEP 10 – Design inlets, pre-treatment facilities, underdrain system and outlet structures according to Design Criteria and Design Components.

- **Design inlets** - The inlets to the perimeter filter system are the slotted grates. These grates will be located in the parking area, and must be capable of handling vehicle traffic. For safety, these grates must also be heavy enough so that the grates are not easily removed.
- **Design pre-treatment facilities** – The contributing drainage area to the perimeter sand filter is almost entirely impervious and has low potential for sedimentation. Therefore, no pre-treatment facilities will be installed prior to the perimeter sand filter.
- **Design underdrain system** - Install a 12-inch (1-foot) thick gravel layer with a perforated 8-inch diameter pipe underdrain collection system. The underdrain gravel will be washed and 1½" diameter. The underdrain system will include a 1% slope.
- **Design outlet structures** – The outlet pipes for both sand filter underdrain systems will discharge into the dry detention pond located in the northwest corner of the site.

  Sand Filter 1:

  The parking lot elevation is at approximately 533 feet near the perimeter sand filter location. With the 3-foot maximum depth for the sedimentation chamber, set the outlet pipe's outlet invert elevation into the dry detention pond at 530 feet. No outlet protection will be required at this outlet pipe, as sheer stress and velocities are non-erosive. A second overflow outlet pipe will discharge the overflow runoff collected by the drop inlet when flow conditions exceed the perimeter sand filter's capacity. The overflow outlet pipe will also discharge to the dry detention pond, and will require rock outlet protection as an energy dissipater. The outlet invert for overflow outlet pipe may be at a higher elevation than the sand filter's outlet pipe, but must be below 533 feet.

Example Design

Sand Filter 2:

The parking lot elevation is at approximately 540 feet near the Sand Filter 2 location. With the 3-foot maximum depth for the sedimentation chamber, the outlet pipe's outlet invert elevation into the dry detention pond will be no higher than 537 feet. The discharge from Sand Filter 2 and any overflow runoff will be conveyed overland to the dry detention pond in the northwest corner of the site. The overland area between Sand Filter 2 and the dry detention pond will be well-vegetated to reduce the potential for erosion. For the underdrain outlet pipe, no outlet protection will be required. A second overflow outlet pipe will discharge the overflow runoff collected by the drop inlet when flow conditions exceed the perimeter sand filter's capacity. The overflow outlet pipe will also discharge into the overland areas that drain toward the dry detention pond. Due to the anticipated concentrated flows and velocities at the overflow pipe outlet, rock outlet protection will be installed as an energy dissipater. The approximate slope from the pipe outlets to the dry detention basin is approximately 3%.

STEP 11 – Compute the overflow weir sizes.

- Ø For a perimeter sand filter, the overflow weir is the weir at the end of the sedimentation chamber and allows flows above the weir elevation to enter the filtration chamber.
- Ø The D_{max} for the sedimentation chamber is 3 feet for both sand filters, and defines the maximum chamber heights.
- Ø The overflow weir between the sedimentation chamber and the filtration chamber sets the permanent pool elevation for the sedimentation chamber. The weir elevations for both filters were set at 2 feet above the bottom elevation of the sedimentation chamber to maintain a permanent pool depth that would discourage mosquito breeding here.
- Ø For both perimeter sand filter systems, water levels above the top of the inlet grate would be diverted to the drop inlet for overflow. This flow diversion would not occur until the sand filter had filled to capacity.

STEP 12 – Check volume, peak discharge rates and period of inundation against any applicable state, local and other requirements.

- Ø **Volume** – Both perimeter sand filters were sized to treat the required WQ_v as required by the City.
- Ø **Peak discharge rates** – The peak discharge rate check for the site is more applicable for water quantity control rather than water quality control. The main control for the peak discharge rate is the dry detention pond.
- Ø **Period of inundation** – The underdrain systems for both sand filters were designed using a dewatering time of 36 hours, which is less than the 48-hour maximum.

ADDITIONAL ITERATIONS:

The preliminary designs for both sand filters did not assume that the void space in the underdrain system would count toward the required WQ_v used to size each filter. The preliminary design dimensions could be further refined by subtracting the volume of voids in the underdrain system from the required WQ_v used to size each filter. This refinement may reduce the required filter size as well as other variables such as filter cost. The assumed void space (porosity) for the underdrain filter systems as discussed in the Design Criteria and Design Components is 35% or 0.35.

Example Design

STEP 13 – Prepare Vegetation and Landscaping Plan

Prior to installing the sand filters, all pervious areas will be stabilized with grass. No additional landscaping requirements apply to the sand filter.

STEP 14 – Prepare operations and maintenance plan

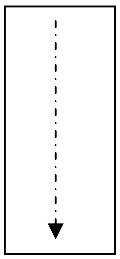
Complete the sand filter operations and maintenance plan based on the guidance given in the Maintenance Section.

STEP 15 – Complete the Design Summary Table

Design Parameter	Required Size	Actual Size
Sand Filter Type:	Perimeter Sand Filter 1	
WQ_v:		2000 ft^3
A_f:	228.6 ft^2	230 ft^2
Filtration Basin (LxW)		46ft x 5ft
A_s:	334 ft^2	368
Sedimentation Basin (LxW)		46ft x 8ft

Design Parameter	Required Size	Actual Size
Sand Filter Type:	Perimeter Sand Filter 2	
WQ_v:		1373 ft^3
A_f:	156.9 ft^2	160 ft^2
Filtration Basin (LxW)		20 ft x 8 ft
A_s:	229 ft^2	240 ft^2
Sedimentation Basin (LxW)		20 ft x 12 ft

3.4 Post Construction Stormwater Control Fact Sheets (PTP)

Post Construction Stormwater Control Practices	PTP-02 Open Channel Systems
Symbol  **TSS Reduction** Wet Swale: 75% Dry Swale: 90%	

Description

Open channel systems are vegetated swales that are designed to capture, treat, and release stormwater runoff. Open channel systems consist of treatment via dry or wet cells created through the installation of check dams or berms. Wet swales (shown above) and dry swales are two types of open channel systems. Dry swales typically utilize a permeable soil layer, and wet swales typically have wetland plants. Open channel systems treat stormwater while also acting as a stormwater runoff conveyance system. They incorporate water quality features that typical drainage channels do not offer. Installation costs are less expensive than a curb and gutter system, although maintenance costs are typically higher.

Open channel systems must be designed with limited longitudinal slopes to reduce runoff velocities and allow particulates to settle. Berms or check dams placed perpendicular to the flow path also aid in reducing velocities and promoting infiltration.

Inlets to open channel systems can be enhanced through the use of the following options:

- Riprap or other energy dissipaters
- Pretreatment through a sediment forebay
- Flow spreader for situations of direct and concentrated flow

Applications

Open channel systems are designed to manage stormwater runoff for water quality purposes. Open channel systems are typically suitable in the following applications:

- Residential subdivisions of low to moderate density (dry swales)
- Small impervious area in the contributing drainage area
- Along roads and highways (off right-of-way)
- Adjacent to parking lots
- Small drainage areas (less than 5 acres)
- Landscaped commercial areas (wet swales)
- As a pretreatment practice to other BMPs

Open Channel Variations

Figure PTP-02- 1 Dry Swale
Source, Stormwater Managers Resource Center, www.stormwatercenter.net

- **Dry Swales**

Dry swales are open channel systems that convey stormwater runoff through vegetation and a filter bed. Sizing for dry swales should allow the entire water quality volume to be filtered or infiltrated through the swale, such that there is no standing water between rain events. Dry swales are the preferred option in residential areas.

Dry swales are made up of an open conveyance channel with a filter bed of prepared soil that overlays an underdrain system. Flow is conveyed into the main channel of the swale where it is filtered by the soil bed. Runoff is then collected and passes into a perforated pipe and gravel underdrain system to the outlet.

Open Channel Variations

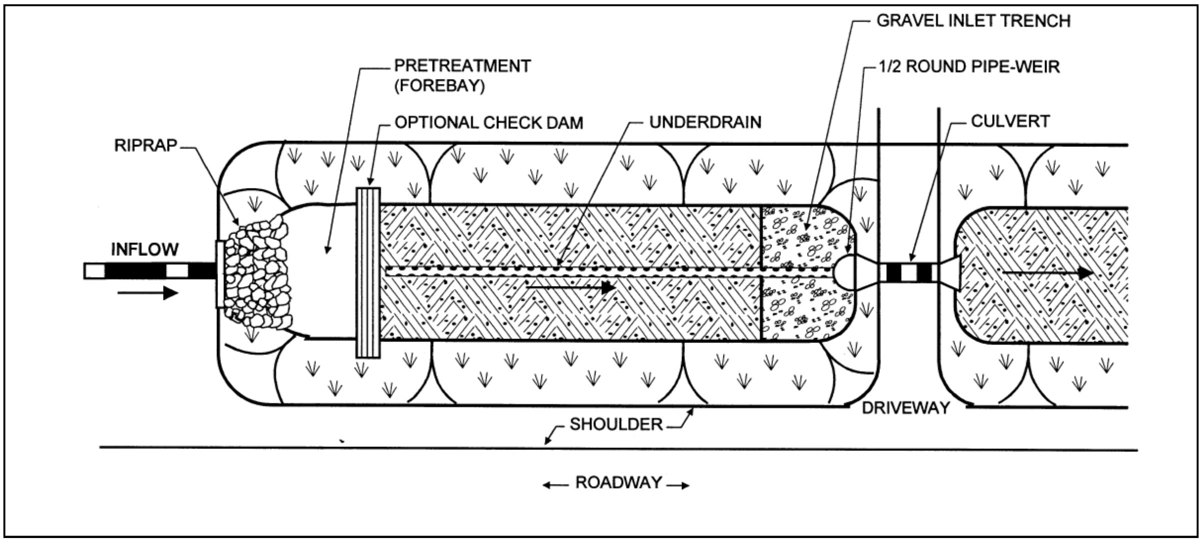


Figure PTP-02- 2 Dry Swale, Plan View
Source, Georgia Stormwater Management Manual

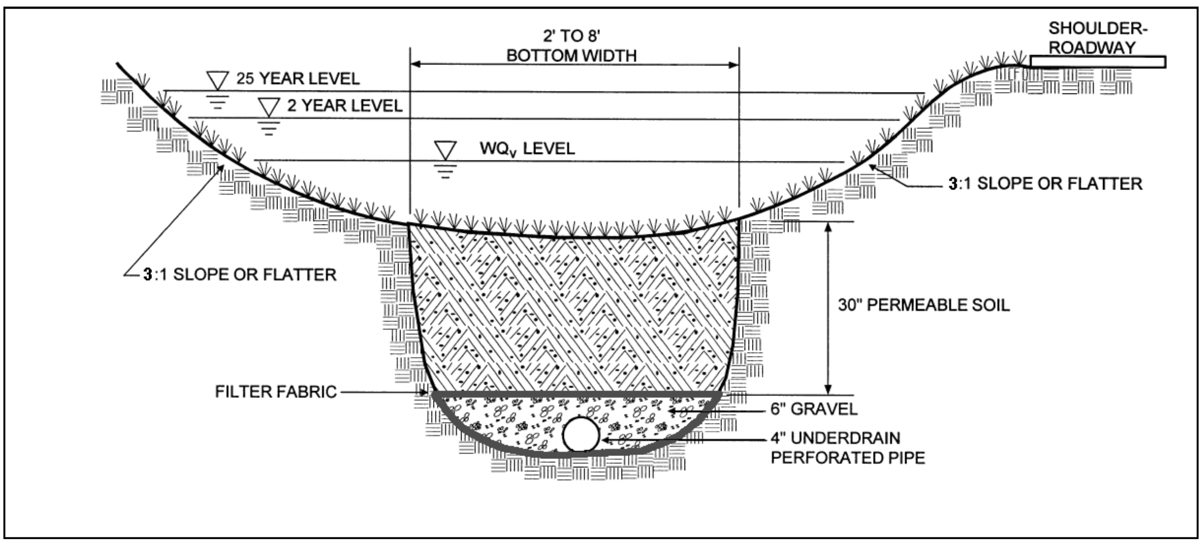


Figure PTP-02- 3 Dry Swale, Cross Sectional View
Source, Georgia Stormwater Management Manual

Open Channel Variations

Figure PTP-02- 4 Wet Swale
Source, Stormwater Managers Resource Center, www.stormwatercenter.net

Ø **Wet Swales**

Wet swales are also referred to as wetland channels. Like the dry swale, wet swales are vegetated channels that treat stormwater runoff. They differ in that wet swales are designed to retain water, imitating marshy conditions and supporting wetland vegetation. A high water table or soils that retain water are necessary to retain water in the system. In these regards, a wet swale is much like a wetland, with a shallow and linear design.

Wet swales are constructed by excavating the channel to the water table or to poorly drained soils. Check dams are installed to create wetland "cells". These cells contain the runoff similar to a shallow wetland.

Open Channel Variations

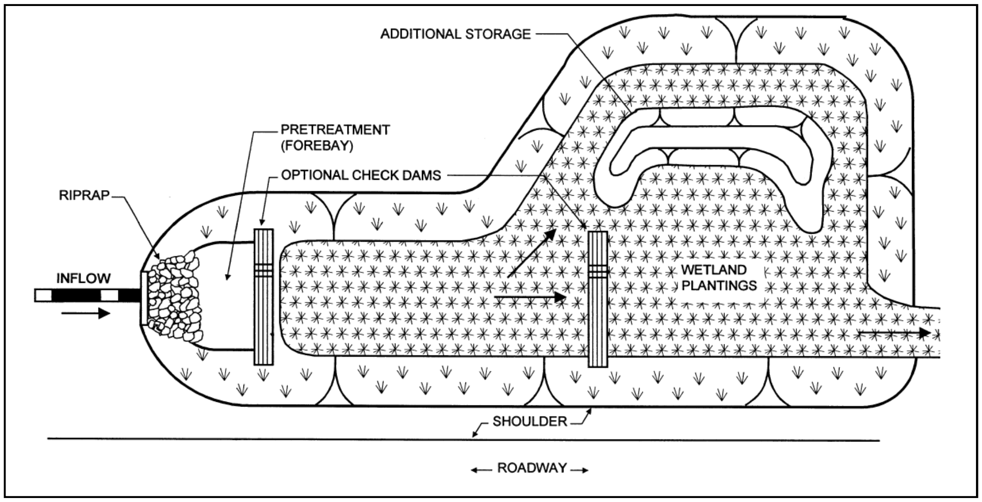


Figure PTP-02- 5 Wet Swale Plan View
Source, Georgia Stormwater Management Manual

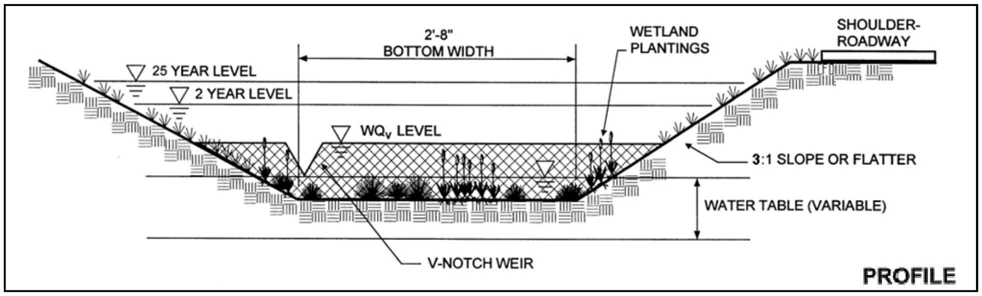


Figure PTP-02- 6 Wet Swale Profile
Source, Georgia Stormwater Management Manual

Design Criteria

Design Criteria

- Limit the contributing drainage to a maximum of 5 acres. One-half (0.5) to two (2) acre drainage areas are preferred.
- Size assuming no losses to infiltration.
- Size channels to store the entire water quality volume with less than 18 inches of ponding.
- Design dry swales to dewater in 24 to 48 hours (24-hours preferred).
- Channel excavation should not result in soil compaction.
- Outlet structures for open channel systems should discharge into the storm drainage system or a stable outfall. For wet swales, incorporate outlet protection to prevent scour and downstream erosion.
- Integrate open channels into the site planning process, and design then to fit aesthetically into the design as attractive green spaces.
- Dry swales require 30 inches of permeable bed material.
- The bottom of dry swales should be at least three feet above the seasonably high water table. For wet swales the seasonably high water table may inundate the swale.
- Dry swales require an underdrain system.
- For wet swales, incorporate check dams and wetland plantings into the channel to form wetland cells. Flow direction can be achieved through the use of V-notch weirs in the check dams.
- The longitudinal slope must be between 1-4% with a channel bottom width of 2'-8'.
- Side slopes must be 3:1 or flatter.
- The channel must be designed to safely and non-erosively convey the 10-year storm event with a minimum of 6 inches of freeboard.

Design Components

- Pretreatment
  - Level Spreader – at locations where lateral flow enters to allow coarse sediment to settle and to evenly distribute flow across the full width of the open channel.
  - Forebay – at locations where concentrated flow enters to allow coarse sediment to settle. The forebay should be sized to contain 10% of the WQ_v.
  - Filter Strip – reduces velocity of runoff and filters particles in the stormwater. The length of the filter strip depends on the drainage area, imperviousness, and the buffer strip slope.
  - Street/Parking Lot Sweeping – may be used as pretreatment where spatial limitations make structural pretreatment measures infeasible.
- Treatment
  - Channel - the bottom width, depth, length, and slope should be sized to store WQ_v with less than 18 inches of ponding at the downstream end.
    - Longitudinal slopes must be between 1% and 4% (1-2% preferred). Slopes steeper than 2% may require 6- to 12-inch drop structures to limit the energy to within the recommended 1 to 2% slope range. Spacing between drops should not be closer than 50 feet. Energy dissipation is required below the drops.
    - Bottom width should range from 2 to 8 feet.
    - Side slopes should be no greater than 3:1 (4:1 recommended)
    - Must convey the 10-yr storm with 6 inches of freeboard

Design Components

- Soil Layer (dry swale) –
  - The channel bed shall consist of a 30 inch permeable soil layer.
  - Soil media should have an infiltration rate of at least 0.5 feet per day (fpd) with a maximum of 1.5 fpd.
  - Soil media should have a high organic content to allow pollutant removal
- Underdrain System (dry swale) –
  - Underdrain should consist of an 8 inch diameter perforated PVC pipe, installed longitudinally in a 12 inch gravel layer.
  - Permeable filter fabric must be installed that encompasses the stone underdrain
  - Designed to draw down the WQv in 24-48 hours

Maintenance

Adequate access shall be provided to allow for inspection and maintenance.

- Grass heights should be maintained at heights of approximately 4 to 6 inches for dry swales
- Sediment should be removed from forebay and channel regularly and disposed of properly
- Measure shall be located in a drainage easement.

Design Procedures

Step 1 – Make a preliminary judgment as to whether site conditions are appropriate for the use of an Open Channel System, and identify the function of open channels in the overall treatment system.

- Consider basic issues for initial suitability screening, including:
  - Site drainage area
  - Site topography and slopes
  - Local depth to ground water and bedrock
  - Site location/minimum setbacks
  - Presence of active karst features

- Determine how the open channel system will fit into the overall stormwater treatment system.
  - Decide whether the open channel system is the only BMP to be employed, or if there are other BMPs addressing some of the treatment requirements.
  - Decide where on the site the open channel system is most likely to be located.

Step 2 – Confirm design criteria, site constraints, and applicability.

- Determine the design criteria that will be used.
- Determine any constraints the site will place on the open channel system.
- Ensure that stormwater runoff from impervious surfaces is being treated to the 80% TSS reduction standard.
  - The equation for determining the weighted TSS reduction for a site with multiple outlet points is below.

$$\%TSS = \frac{\sum_n^1 (TSS_1 A_1 + TSS_2 A_2 + \ldots + TSS_n A_n)}{\sum_n^1 (A_1 + A_2 + \ldots + A_n)}$$

Where:

TSS_1 = TSS reduction by BMP providing treatment for A_1
A_1 = area 1, (acres)
TSS_2 = TSS reduction by BMP providing treatment for A_2
A_2 = area 2, (acres)

  - Where one BMP discharges into another, the treatment train TSS reduction can be found by the following equation:

$$TSS_{train} = A + B - \frac{(A \times B)}{100}$$

Where:

TSS_{train} = total TSS reduction through successive BMPs
A = TSS reduction through first BMP
B = TSS reduction through second BMP

Design Procedures

Step 3 – Calculate WQ_v.

- Calculate the Water Quality Volume (WQ_V). Channel practices are not designed for stormwater quantity design.
  - The required water quality treatment volume is 1.1 inches of runoff from the new impervious surfaces created by the project.
  - Determine Water Quality Volume (WQ_V).

$$WQv = [P\ Rv)(A)]/12$$

Where:

P = is the average rainfall, (inches)
R_V = 0.05 + 0.009(I), where I is the percent impervious cover
A = the area of imperviousness, (acres)

Step 4 – Determine pretreatment method.

- Level Spreader,
- Forebay,
- Filter Strip, or
- Street/Parking Lot Sweeping

Storage volume created for pre-treatment counts toward the total WQ_v requirement, and can be subtracted from the WQ_v for subsequent calculations.

Step 5 – Determine open channel dimensions.

Size bottom width, depth, length, and slope necessary to store WQ_v with less than 18 inches of ponding.

- Longitudinal slope cannot exceed 4% (1 to 2% recommended) or be flatter than 1%
- Bottom width should range from 2 to 8 feet
- Ensure that side slopes are no greater than 3:1 (4:1 recommended)

See Design Criteria for more details.

Step 6 – Compute number of check dams (or similar structures) required to detain WQ_v.

See Design Criteria for more details.

Step 7 – Calculate draw-down time.

- Dry swale channels are sized to store and filter the entire WQ_v and allow for full filtering through the permeable soil layer. The underdrain system in dry swales must be designed to draw down the WQv within 24-48 hrs.
- When designing the underdrain, infiltration of the in situ soils should not be considered. Zero drawdown through the in situ soils should be assumed. The underdrain system must be sized to drain the entire water quality volume (WQ_v) within 48hrs

Design Procedures

Ø The open channel surface area is computed using the following equation, for those systems that are designed with an underdrain:

$$A_f = (WQ_V \times d_f) / [k \times (h_f + d_f) \times t_f]$$

Where:

A_f = surface area of the dray swale system, (ft^2)
WQ_V = water quality volume, (ft^3)
d_f = filter bed depth, (ft)
k = coefficient of permeability of filter media, (ft/day) (0.5 ft/day is the recommended k for the permeable soil layer. This value is conservative to account for clogging associated with accumulated sediment.)
h_f = average height of water above filter bed, (ft)
t_f = design filter bed drain time, (days)
(24- 48 hours is the required drawdown time, t_f, for dry swales)

Ø Wet swale channels are sized to store the WQ_V.

Step 8 – Design inlets, sediment forebay(s), and underdrain system (dry swale). See Design Criteria for more details.

Step 9 – Prepare Vegetation and Landscaping Plan.

A landscaping plan for a dry or wet swale should be prepared to indicate how the enhanced swale system will be stabilized and established with vegetation. The appropriate grass species and wetland plants should be chosen based on the site location, soil type, and hydric conditions.

Step 10 – Complete the Design Summary Table.

Design Parameter	Required Size	Actual Size
Open Channel Type		
WQ_v		
Channel Dimensions (WxL)		
Slope		
Check Dams or other		

Example Design

Proposed development of an undeveloped site into an office building and associated parking.

Base Data Total Drainage Area = 5 ac Site Area = 3.54 ac Soils Type "C" **Pre-Development** Impervious Area = 0 ac; or I = 0% Meadow (CN = 71) **Post-Development** Impervious Area = 1.72 ac; or I = 1.72/3.54 = 49% Open Space, Fair (CN = 79) Paved parking lots, roofs, driveways, etc. (CN =98)	**Hydrologic Data** Pre Post CN 71 89 **WQ_v Depth** = 1.1 in **Precipitation** I_{WQ} 2.45 in/hr 2yr, 24hr 3.54 in 25yr, 24hr 5.88 in 100yr, 24hr 7.43 in

Example Design

This example focuses on the design of a dry swale to meet the water quality treatment requirements of the site. Stormwater quantity design is not addressed in this example. In general the primary function of dry swales is to provide water quality treatment and not large storm attenuation. As such, flows in excess of the water quality volume are typically routed to bypass the facility. Where quantity control is required, the bypassed flows can be routed to conventional detention basins (or some other facility such as underground storage vaults).

Problem: Design a water quality treatment plan for this site. A dry detention pond will be constructed to meet the required detention standards and will provide 60% TSS reduction for the site (note that this design example does not address the design of the detention structure). The total drainage area to the pond is 5 ac. Try designing a dry swale to convey the stormwater from the parking area to the dry pond.

Step 1 – Make a preliminary judgment as to whether site conditions are appropriate for the use of an Open Channel System, and identify the function of open channels in the overall treatment system.

- Consider basic issues for initial suitability screening, including:
  - The site has type “C” soils
  - There are no minimum setbacks
  - A sinkhole is located on the property where the dry detention facility will be constructed. The dry swale will not be located close to the sinkhole.
- Determine how the open channel system will fit into the overall stormwater treatment system.
  - A dry swale will be constructed in combination with a dry detention pond for water quality and quantity control on the site. Design of the dry detention pond can be found in Section 4.8.
  - See the figure further in the example for site layout. The site has 2 drainage basins, DA1 and DA2. DA1 drains to the dry swale and then discharges into the dry pond. DA2 flows only into the dry detention pond for treatment.
  - The WQ_v treated by the dry swale will be collected by an underdrain and routed to the dry pond located in the northwest corner of the site for water quantity control. Flows greater than the water quality volume will bypass the dry swale and be routed to the dry pond for water quantity control and final polishing prior to discharging.

Step 2 – Confirm design criteria, site constraints, and applicability.

- Determine the design criteria that will be used.
  - Maximum 6 in ponding depth
  - Maximum 48hr drain time from peak water level
  - Minimum 8 in underdrain enveloped in a 12 in gravel layer
  - Minimum 3 ft separation from bottom to seasonally saturated soils
  - 2% longitudinal slope
- Determine any constraints the site will place on the open channel system such as:
  - The dry swale will not be place near an active sinkhole.
  - Due to topography and layout of the parking area only a portion of the WQ_v can be treated by the dry swale. The other portion of the WQ_v will enter the dry pond directly from the parking area.

Example Design

Ø Ensure that stormwater runoff from impervious surfaces is being treated to the 80% TSS reduction standard.

- o DA_1 = 1.03 acres and will discharge into the dry swale and dry pond.
- o Determine the treatment train TSS reduction for D_{A1}.

  After the water quality volume for 1.03 acres of the impervious area is treated by a dry swale it is then treated in the dry pond before leaving the site. Dry Swales have a 90% TSS reduction. Dry ponds have a 60% TSS reduction.

$$TSS_{train} = A + B - \frac{(A \times B)}{100}$$

$$TSS_{train} = 90 + 60 - \frac{(90 \times 60)}{100}$$

$$TSS_{train} = 96\%$$

- o Dry swale and dry pond treatment train has a 96% TSS reduction • 80 % TSS reduction ü
- o DA_2 = 0.69 acres and will only be treated by the dry pond. Dry ponds have a 60% TSS reduction.
- o Determine the weighted TSS reduction for the site.

$$\%TSS = \frac{\sum_n^1 (TSS_1 A_1 + TSS_2 A_2 + \ldots + TSS_n A_n)}{\sum_n^1 (A_1 + A_2 + \ldots + A_n)}$$

$$\%TSS = \frac{\sum_2^1 (96x1.03 + 60x0.69)}{\sum_n^1 (1.03 + 0.69)}$$

- o $\%TSS = 81.5$ • 80 % TSS reduction ü

Step 3 – Compute runoff control volumes.

Ø Calculate the Water Quality Volume (WQ_V).

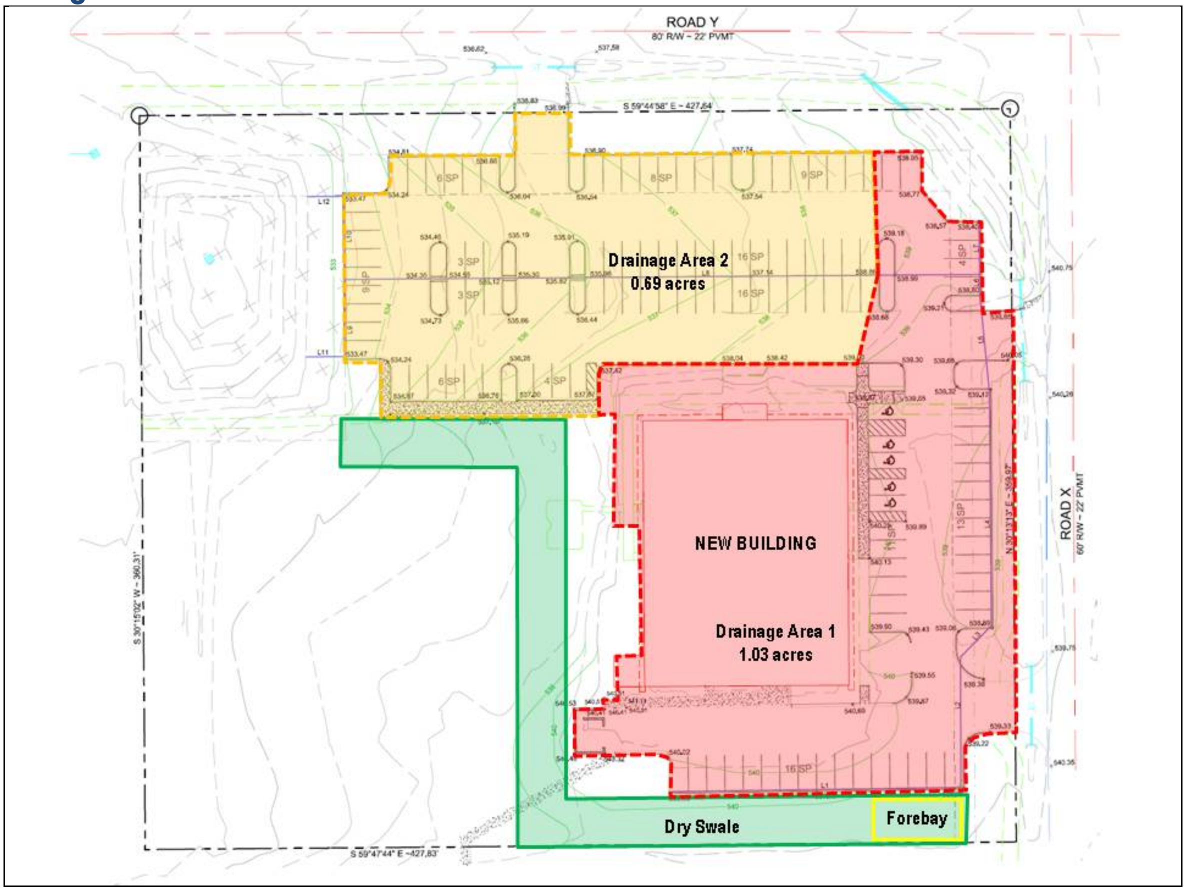
Water Quality Volume Treated By Dry Swale:

WQv = [P R_v)(A)]/12

Where:
P = 1.1 inches
R_v = 0.05 + 0.009(I)
I = 49
R_v = 0.05 + 0.009(49) = 0.491
A = 1.03 acres

WQv = (1.1in x 0.491 x 1.03ac)/12 = 0.046 acre-ft = **2004 ft³**

Example Design



Step 4 – Determine pretreatment method.

Ø A forebay will be used as pretreatment for the WQ_v.

Forebay Volume = 0.10 (2004 ft^3) = **200 ft^3**

Ø Use a 2 foot deep pea gravel drain at the head of the dry swale to provide erosion protection and to assist in the distribution of the inflow.

Ø Stormwater will be collected in the parking area and conveyed to the forebay of the dry swale. There will be no significant inflow to the dry swales along its length.

Step 5 – Determine open channel dimensions.

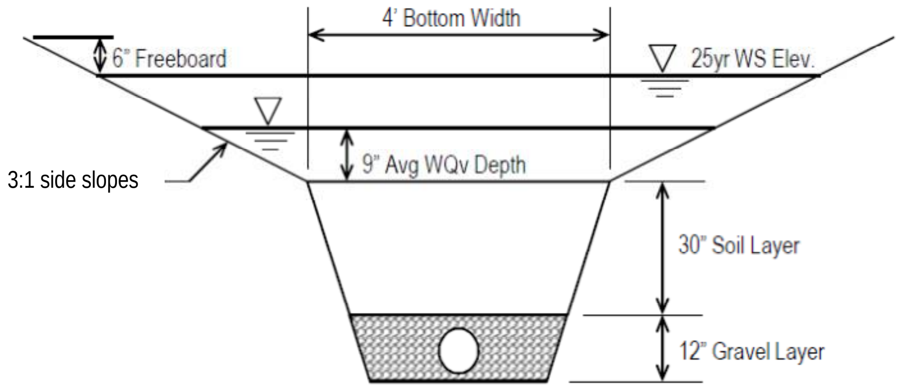
Ø Assume a trapezoidal channel with a maximum WQ_v depth of 18 inches (9 inch average depth).
Ø The dry swale has a length of 475 ft, and a slope of 1.1%.
Ø Assume 4 foot bottom width and 3:1 side slopes.

Cross-sectional area = 0.5 x 0.75 ft x (4 ft + 7 ft) = 4.125 ft^2

Volume of Dry Swale = 4.125 ft^2 x 475 ft = 1959 ft^3 > 2004 ft^3 – 200 ft^3 = 1804 ft^3 ü

The WQ_v is reduced by the volume of the pretreatment forebay.

Example Design



Step 6 – Compute number of check dams (or similar structures) required to detain WQ_v.

Ø The slope of the dry swale is 1.1% and the maximum depth of is 18 inches.

Maximum check dam spacing = 1.5 ft / 1.1% = 136 ft

Ø Place 4 check dams spaced at 118 ft.

Step 7 – Calculate draw-down time.

Check channel geometry to ensure sizing for full drawdown through 8" underdrain.

$$A_f = (WQ_V \times d_f) / [k \times (h_f + d_f) \times t_f]$$

Where:

A_f = surface area of the dry swale system, (ft^2)
WQ_V = available water quality volume, (ft^3)
d_f = filter bed depth, (ft)
k = coefficient of permeability of filter media, (ft/day) (0.5 ft/day is the recommended k for the permeable soil layer. This value is conservative to account for clogging associated with accumulated sediment.)
h_f = average height of water above filter bed, (ft)
t_f = design filter bed drain time, (days)
(24- 48 hours is the required drawdown time, t_f, for dry swales)

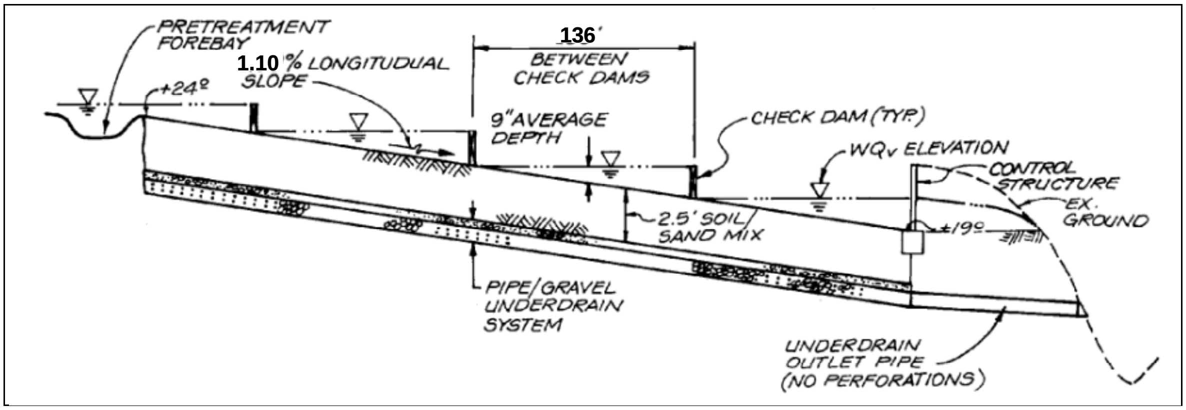
$A_f = (1959ft^3 \times 2.5ft) / [0.5ft/day \times (0.75ft + 2.5ft) \times 2days]$

A_f = **1506.9** ft^2

Surface area available = 475' x 4' = **1900**ft^2 ü

Example Design

Step 8 – Design inlets, sediment forebay(s), and underdrain system (dry swale).



Step 9 – Prepare Vegetation and Landscaping Plan.

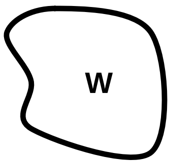
Ø Prepare vegetation and landscaping management plan based on the guidance given in the Landscaping Section.

Step 10 – Complete the Design Summary Table.

Design Parameter	**Required Size**	**Actual Size**
Open Channel Type	Dry Swale	
WQ_v	2004 ft^3	Forebay- 200 ft^3; Swale - 1959 ft^3 = 2159 ft^3
Channel Dimensions (WxL)	1506.9 ft^3	1900 ft^3 (475' x 4')
Slope	1.1%	1.1%
Check Dams or other	4 @ 118ft	4 @ 118ft

3.4 Post Construction Stormwater Control Fact Sheets (PTP)

Post Construction Stormwater Control Practices	PTP-03 Wet Ponds



Symbol

SP

Description

Wet ponds are detention ponds containing a permanent pool (or micropool) that allows the treatment of stormwater runoff, while also contributing to the aesthetic value. Wet ponds enhance water quality through settling and biological uptake, and offer a control for sediment, heavy metals, and floatables. They also may provide benefits in reducing impacts due to nutrients, oxygen demanding substances, oil and grease, and bacteria and viruses.

The different types of wet ponds consist of the following components: a sediment forebay, a permanent pool, runoff control volume storage, and a shallow littoral zone, or aquatic bench, along the edge of the permanent pool. Other design considerations include an emergency spillway, maintenance access and landscaping.

The five types of wet ponds addressed in this fact sheet include the following:

- Wet ponds;
- Wet extended detention ponds;
- Micropool extended detention ponds;
- Pocket ponds; and
- Multiple pond systems.

Applications

Wet ponds are well-suited for several stormwater water quality benefits, including the following items:

- Ø Areas where high particulate control is needed
- Ø Suitable for large, regional tributaries with sufficient drainage area and/or hydrology to support a permanent pool.
    - o Minimum contributing drainage area is 25 acres for wet ponds, wet ED ponds and multiple ponds
    - o Minimum contributing drainage area is 10 acres for a micropool extended detention pond (must check that hydrology is capable of supporting water levels)
    - o Minimum contributing drainage area is 5 acres for pocket ponds (must check that hydrology is capable of supporting water levels).
- Ø Provides multiple benefits for passive recreation such as bird watching, and wildlife habitat
- Ø Capable of controlling both stormwater quantity and quality issues

Wet ponds also have features that limit where this practice may be used.

- Ø Typically, wet ponds are not feasible for dense or urban land uses due to large land requirements and areas with steep or unstable slopes.
- Ø These ponds have the potential for nuisance insects or odor.
- Ø There are possible safety concerns related to the structure and to maintaining a permanent pool of water.
- Ø Wet ponds may cause increased water temperature, including the potential for downstream thermal impact.

Wet Pond Variations

This practice includes five variations of wet ponds. Each of these types is discussed briefly, and design information specific to a type is also included in the fact sheet.

- **Wet Ponds**

Figure PTP-03- 1 Wet Pond.
Source, Stormwater Managers Resource Center, www.stormwatercenter.net

Wet ponds maintain a permanent pool to treat incoming stormwater, and require a contributing drainage area of 25 acres or greater. Treatment occurs through settlement of suspended particles and uptake of dissolved contaminants by aquatic plants between storm events. Wet ponds are constructed with two storage areas: a permanent pool, or "dead," storage area based on the water quality volume calculation; and a temporary, or "live," storage area provided above the permanent pool to accommodate larger flows and control erosion. During storm events, runoff displaces the water existing in the permanent pool.

Wet ponds provide for the controlled release of Q_{P25} and Q_{P100} through the spillway outlets. The WQ_v is maintained within the pond's permanent pool (i.e., there is no spillway opening included to control the release of WQ_v). See Figures PTP-03-3 and PTP-03-4 for schematics of a typical wet pond.

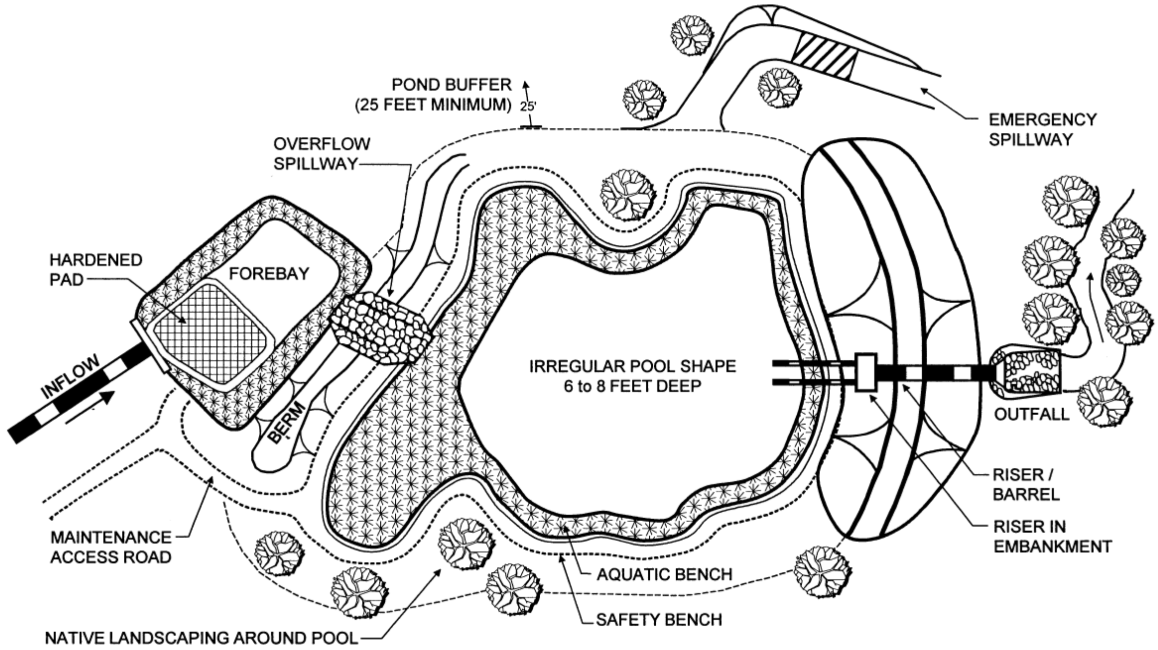


Figure PTP-03- 2 Plan View of Wet Pond
Source, Georgia Stormwater Management Manual

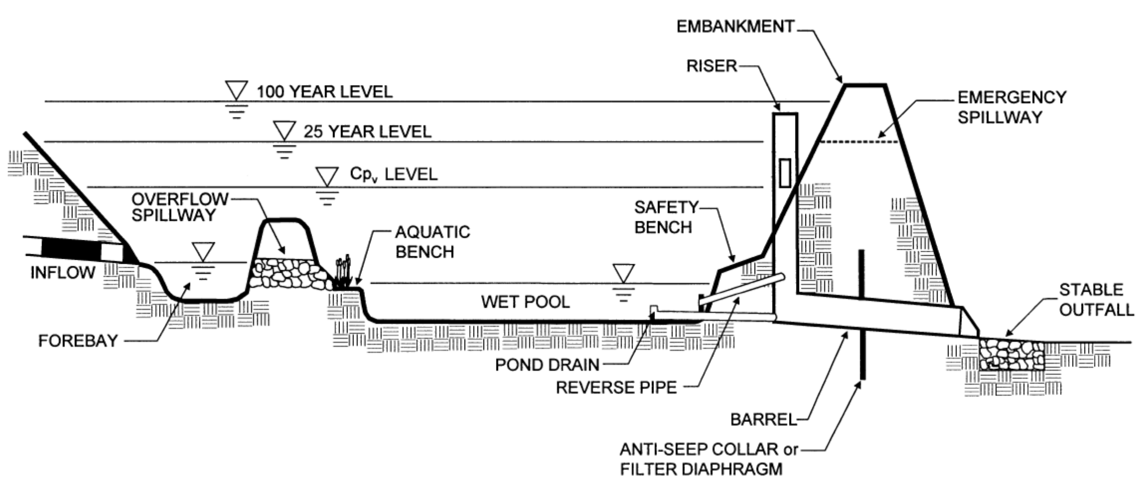


Figure PTP-03- 3 Profile View of Wet Pond.
Source, Georgia Stormwater Management Manual

Wet Pond Variations

Ø **Wet Extended Detention Pond**

Figure PTP-03- 4 Wet Extended Detention Pond.
Source, Stormwater Managers Resource Center, www.stormwatercenter.net

A wet extended detention (ED) pond is a wet pond where the basin is designed to hold the water quality volume divided evenly between the permanent pool and the extended detention area. This wet pond type requires a minimum of 25 acres of contributing drainage area. During a rain event, water is held in the extended detention area and released over a 24 hour period. Wet ED ponds typically have smaller land area requirements compared to wet ponds. See PTP-03-03 and PTP-03-04 for schematics of a typical wet ED pond.

The wet ED pond is similar to the wet pond in that both pond types provide for the controlled release of Q_{P25} and Q_{P100} through the spillway outlets. However, the wet ED pond also includes a spillway outlet at the top of the permanent pool to allow the controlled release of 50% of WQ_v. The permanent pool will be set to hold 50% of WQ_v, with the remainder of WQ_v released through the spillway outlet at the top of the permanent pool. Figures PTP-03-6 and PTP-03-7 show schematics for wet ED ponds.

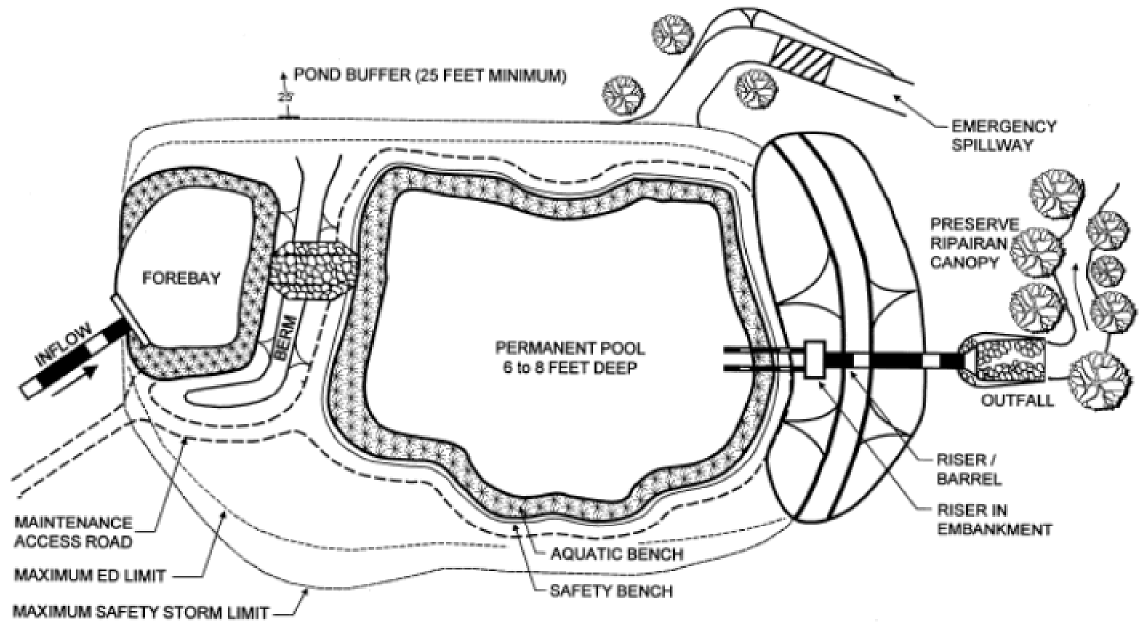


Figure PTP-03- 5 Cross-Section View of Wet Extended Detention Pond.
Source, Minnesota Stormwater Management Manual

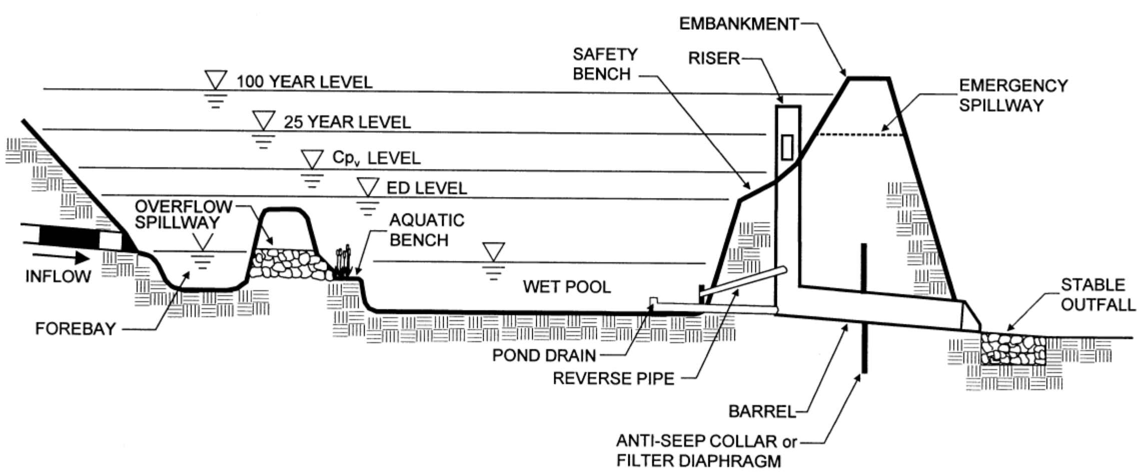


Figure PTP-03- 6 Profile View of Wet Extended Detention Pond.
Source, Georgia Stormwater Management Manual

Micropool Extended Detention Pond

Figure PTP-03- 7 Micropool Extended Detention Pond.
Source, Stormwater Managers Resource Center, www.stormwatercenter.net

A micropool extended detention pond is a basin where a small micropool is permanently maintained at the outlet. The smaller micropool near the pond outlet helps prevent resuspension. The outlet structure is designed to detain the water quality volume for 24 hours and prevents resuspension of sediment particles and clogging of the low flow orifice.

Larger stormwater ponds provide more pollutant removal efficiency than micropool extended detention ponds. However, micropools are ideal for areas where large open stormwater ponds cannot be used or may be undesirable, such as where there are potential thermal impacts to receiving streams, safety concerns in residential areas, or where the contributing drainage area is smaller than what is needed to support a larger wet pond type. See PTP-03-9 and PTP-03-10 for schematics of a micropool ED pond.

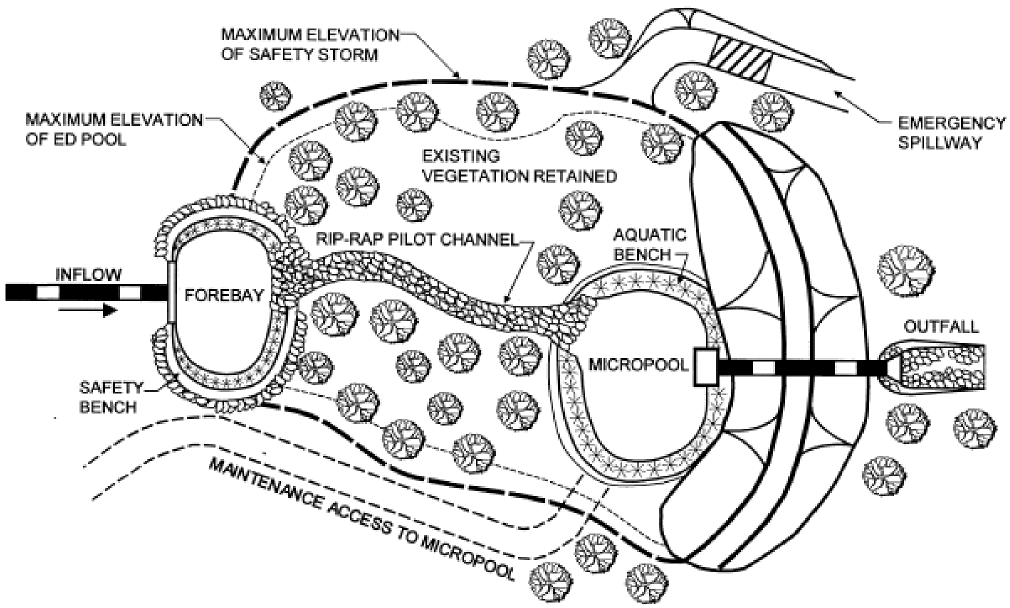


Figure PTP-03- 8 Plan View of Micropool Extended Detention Pond.
Source: Georgia Stormwater Management Manual

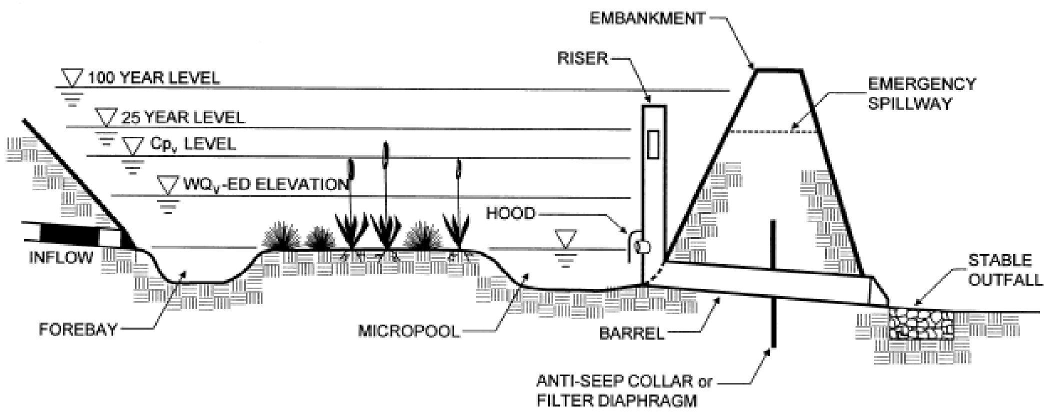


Figure PTP-03- 9 Profile View of Micropool Extended Detention Pond.
Source: Georgia Stormwater Management Manual

Pocket Ponds

Figure PTP-03- 10 Pocket Pond.
Source, Stormwater Managers Resource Center, www.stormwatercenter.net

Pocket ponds are small wet ponds that have smaller contributing drainage areas than other wet pond types. The minimum recommended contributing drainage is 10 acres. These ponds often have little or no baseflow for sustaining water elevations during dry weather, and the permanent pool water elevations rely on a locally high water table or intercepting groundwater. Due to the smaller contributing drainage areas, the pocket pond design should include water balance calculations to assess whether the site's hydrology can sustain a wet pond, including consideration of drought conditions. For land uses where the area draining to the pond may contaminate drinking water supplies, interception of groundwater as a part of stormwater treatment should be avoided (including installation of pocket ponds).

Even though pocket ponds may be well-suited for use for smaller sites where larger wet pond types cannot be used, pocket ponds do have limitations that must be considered in the design. Pocket ponds can be more prone to clogging due to the small size and fluctuating water levels. These fluctuating water levels may also cause other nuisance conditions such as odor and insect habitat when the permanent pool level is diminished.

Pocket ponds should include similar components to those used for other wet pond types even though the pond size will be smaller. The permanent pool for pocket ponds is similar to the micropool for the micropool ED ponds. This permanent pool (micropool) is maintained at the outlet. The outlet structure is designed to detain the water quality volume for 24 hours and prevents resuspension of sediment particles and clogging of the low flow orifice. See Figures PTP-03-12 and PTP-03-13 for pocket pond schematics.

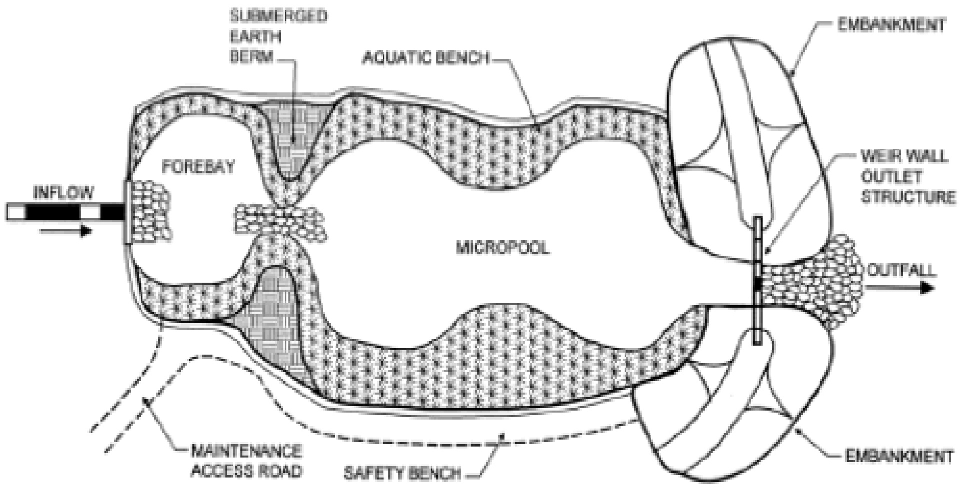


Figure PTP-03- 11 Plan View of Pocket Pond.
Source: Maryland Stormwater Design Manual

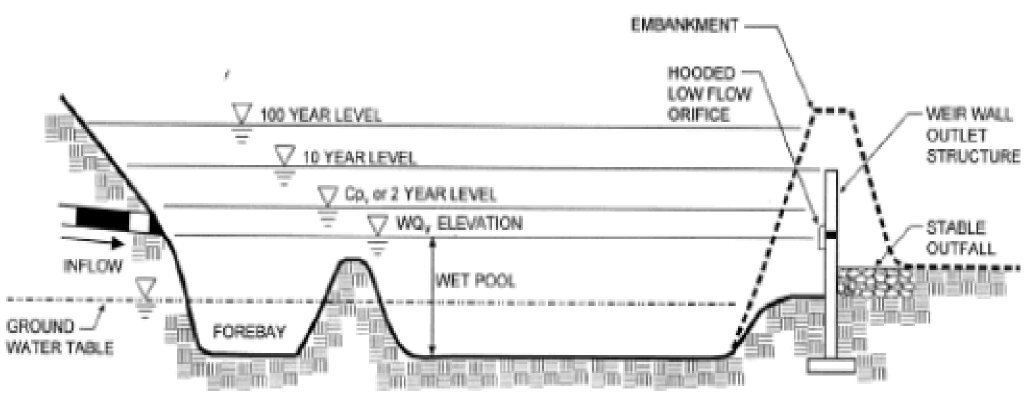


Figure PTP-03- 12 Profile View of Pocket Pond.
Source: Maryland Stormwater Design Manual

Multiple Ponds

Figure PTP-03- 13 Multiple Ponds.
Source, Stormwater Managers Resource Center, www.stormwatercenter.net

A multiple pond system combines one or more wet pond types so that flow passes through the wet ponds in succession. This system increases sediment and pollutant removal from the incoming stormwater. The use of a forebay prior to the first pond can be critical to allowing heavier materials to settle out in the forebay and reducing required maintenance in the wet ponds. Two drawbacks for this multiple pond system would be the required space for multiple ponds and the need to inspect and maintain more than one structure. Using more than one pond must also consider how the permanent pools will be sustained in all wet ponds given the contributing drainage area and water balance. Figures PTP-03-15 and PTP-03-16 show schematics for a two-cell multiple pond system.

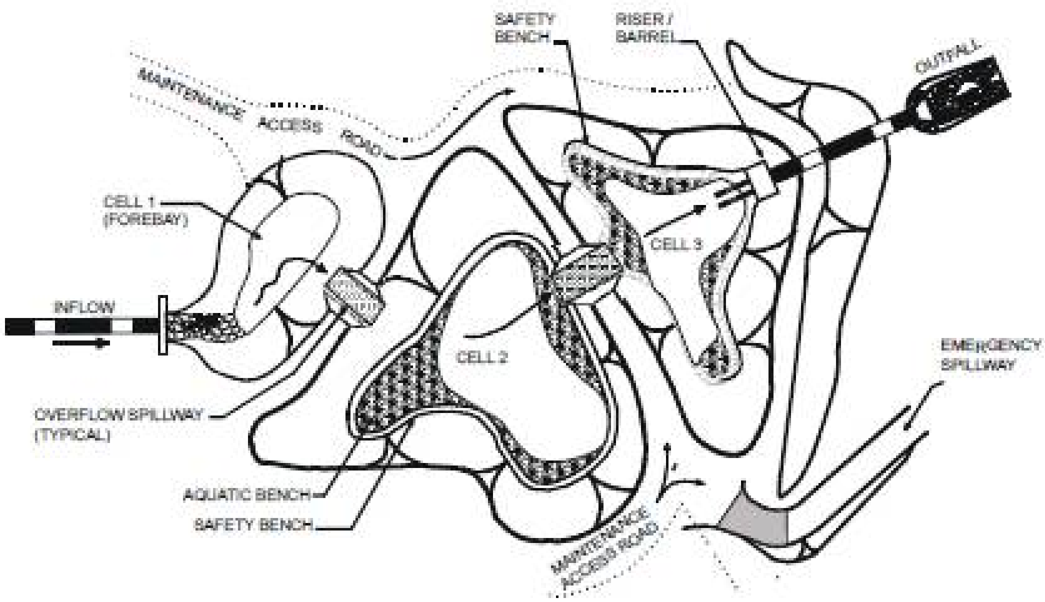


Figure PTP-03- 14 Plan View of Multiple Pond System.
Source: Maryland Stormwater Design Manual

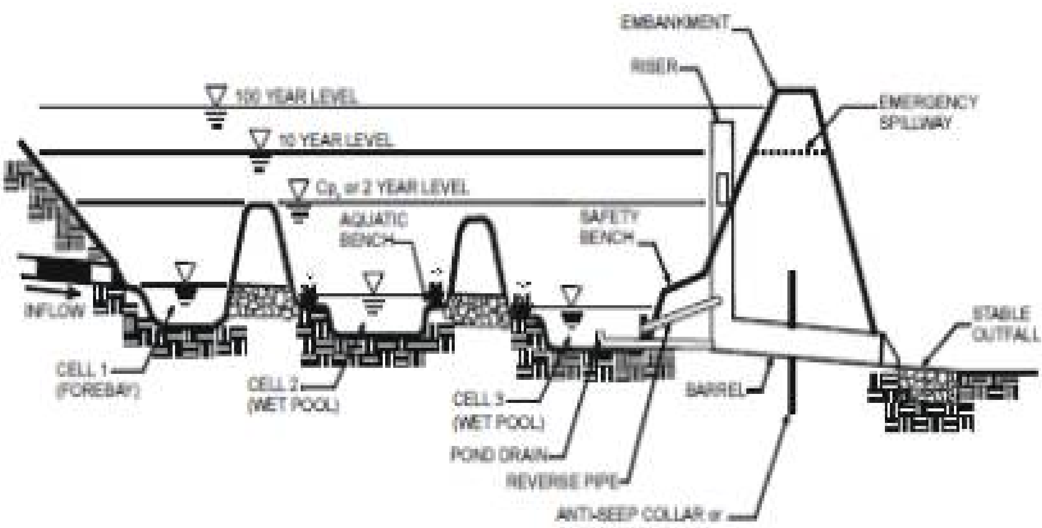


Figure PTP-03- 15 Profile View of Multiple Pond System
Source: Maryland Stormwater Design Manual

Maintenance	**Maintenance Plan**

Maintenance

Maintenance Plan

A site-specific maintenance plan describing maintenance responsibilities should be developed. that addresses the following items:

- Maintenance access for appropriate equipment, vehicles, and personnel
- Vegetation maintenance schedule that includes mowing multiple times per year
- Inspection checklist
- Maintenance agreement between the facility owner and the City with these items:
  - Sediment removal from sedimentation chamber when sediment depth is ½ of the total depth to the outlet, or is greater than 1.5 feet (whichever is less)
  - Clean and/or repair sediment chamber outlet devices if drawdown times exceed 48 hours 36 hours
  - Trash and debris should be removed as necessary
- Properly dispose of any material generated during maintenance activities.

Monthly to Quarterly or After Major Storms (>1")

Check that the maintenance access is free and clear.

- Inspect low flow orifices and all pipes for clogging.
- Check the pond area for debris, bare soil areas and undesirable vegetation.
  - The minimum mowing requirements for mown slopes will be a spring mowing and a fall mowing.
  - Remove debris.
  - Repair undercut, eroded and bare soil areas.
- Look for damaged safety measures or other dangerous items.

Semi-Annual to Annual

- Ensure that the pond's mechanical components (if any) are functional. Repair broken mechanical components if needed.
- Remove invasive vegetation.
- Monitor and record sediment accumulation.
- Pond vegetation needs to be trimmed or harvested as appropriate.

1-3 Years

- Inspect riser, barrel and embankment for damage. Make any needed repairs.
- Inspect all pipes.
- Monitor sediment deposition in the pond and in the forebay. Remove sediment from the forebay and the pond when needed.

Maintenance

5-25 Years

- Use remote television inspection of the reverse slope pipes, underdrains or other hard-to-access piping. If needed, replace or repair pipes.

Embankment

The pond embankment and/or riser will require inspection by a qualified professional (e.g., structural engineer, geotechnical engineer, etc.) who has experience in the construction, inspection and repair of these features.

Inspection Checklist

All appropriate items should be checked on the inspection checklist. If an applicable item does not meet the condition on the checklist

Monthly

- q Maintenance access is free and clear
- q Low flow orifice(s) and pipes are free from clogging.
- q Pond areas are free of debris.
- q Pond areas do not have any bare soil areas.
- q Pond areas do not include any undesirable vegetation (i.e., woody vegetation near the embankment, etc.).
- q Check water depth in pond to see if water level has dropped below the permanent pool (look for a fully visible low flow outlet).
  - o If the pond water depth is below the permanent pool level, inspector should work to determine why water level has dropped below the permanent pool level (drought conditions or problems with pond).
  - o Where low permanent pool levels may produce nuisance insect or odor conditions, the owner should work toward counteracting these conditions until the permanent pool level is restored.
- q There are no damaged safety measures or other dangerous items at the pond.

Semi-Annual to Annual

- q The pond's mechanical components (if any) are functional.
- q The pond's vegetation has been harvested as appropriate.

1-3 Years

- q The riser, barrel and embankment were inspected for damage and do not require repairs.
- q All pipes were inspected and do not require repairs or replacement.
- q The sediment deposition in the pond and in the forebay was checked, and, if needed, sediment was removed from these areas.

5-25 Years

- q Use remote television inspection of the reverse slope pipes, underdrains or other hard-to-access piping. If needed, replace or repair pipes.

Design Criteria

General Design

- A minimum separation distance between the pond and the groundwater table and/or an impervious liner may be required for ponds where source water protection is required or for contributing drainage areas designated as “hot spot” landuses.
- The maximum depth of the pond should not exceed 10 feet.
- For karst areas, it is recommended that ponds use an impermeable liner and include a minimum three foot separation from the barotic rock layer.
- A landscaping plan must address how the pond and the surrounding areas will be stabilized and how vegetation will be established. This plan should include maintenance actions and schedules for the vegetation.

Pre-treatment

- Facilities that receive stormwater from contributing areas with over 50% impervious surface or that are a potential source of oil and grease contamination (hotspots) must include a baffle, skimmer, and grease trap to prevent these substances from being discharged from the facility.
- Require pre-treatment measures such as other water quality BMPs and/or forebay(s). For areas receiving drainage from potential “hot spot” areas, the pre-treatment measures may require an impermeable liner and/or other separation to keep stormwater separated from groundwater.
- The forebay depth should be 4-6 feet deep.
- A sediment forebay sized to 10% of the pond area 0.1 inches per impervious acre of contributing drainage should be provided for all wet ponds
- Direct vehicle/equipment access should be required for forebays to allow for sediment removal and maintenance.
- The forebay may be separated from the remainder of the pond by one of several means: an earthen berm, a concrete weir, gabion baskets, a lateral sill with rooted wetland vegetation, two ponds in series, differential pool depth, rock-filled gabions or retaining wall, or a horizontal rock filter placed laterally across the pond.
- If appropriate, a baffle box or water quality inlet(s) can be used in lieu of a forebay.
- The bottom of the forebay may be hardened using concrete, asphalt or grouted riprap to make sediment removal easier.

Inlet and Outlet Structures

- All extended detention wet ponds and pocket ponds must have a low flow orifice capable of releasing the 50% of WQ_v in the temporary storage area over at least 24 hours. The remaining 50% of WQ_v is in the pond’s permanent pool.
- The water quality protection orifice must meet the following criteria:
    - The minimum diameter for the water quality protection orifice without internal orifice protection is 3 inches.

- The orifice should be protected from clogging by an acceptable external trash rack.
- The orifice diameter may be reduced to 1 inch if internal orifice protection is used (e.g., an overperforated vertical stand pipe with 0.5-inch orifices or slots that are protected by wirecloth and a stone filtering jacket).
- Adjustable gate valves may also be used to achieve this equivalent diameter.

- The minimum diameter for the water quality protection orifice without internal orifice protection is 3 inches. The orifice should be protected from clogging by an acceptable external trash rack. The orifice diameter may be reduced to 1 inch if internal orifice protection is used (e.g., an over perforated vertical stand pipe with 0.5-inch orifices or slots that are protected by wire cloth and a stone filtering jacket). Note that a 3 inch diameter orifice or larger is preferred. Adjustable gate valves may also be used to achieve this equivalent diameter.
- All wet pond types must also include an outlet structure that is sized for Q_{P25} control (based upon hydrologic routing calculations) and can consist of a weir, orifice, outlet pipe, combination outlet, or other acceptable control structure. Small outlets that will be subject to clogging or are difficult to maintain are not acceptable.
- An emergency spillway is to be included in the stormwater pond design to safely pass the extreme flood flow (Q_{P100}). The spillway prevents pond water levels from overtopping the embankment and causing structural damage. The emergency spillway must be designed to State of Kentucky guidelines for dam safety and must be located so that downstream structures will not be impacted by spillway discharges.
- Inflow channels are to be stabilized with flared riprap aprons, or the equivalent.
- Pond outlets must be designed to prevent discharge of floating debris.
- Burying all pipes below the frost line can prevent frost heave and pipe freezing.
- The outflow riser should be located so that short-circuiting between inflow points and riser does not occur.
- Riprap, plunge pools or pads, or other energy dissipators are to be placed at the end of the outlet to prevent scouring and erosion. Large facility outlets may also require an anti-vortex device.

Permanent Pool

- The permanent pool's contours and shape should be irregular to compliment natural landscaping.
- The permanent pool may be excavated into bedrock for a wet pond
- The maximum permanent pool depth is generally less than 8 feet. Deeper depths may allow thermal stratification and anaerobic conditions to occur, causing odor problems if no artificial mixing or aerators are used.

Design Criteria

- Greater depths near the outlet may allow water to cool and minimize thermal impacts to receiving streams.
- Minimum depth of the permanent pool should be 3 to 4 feet.

Embankment

- Vegetated embankments shall be less than 20 feet in height and shall have side slopes no steeper than 2:1 (horizontal to vertical) although 3:1 is preferred. Riprap-protected embankments shall be no steeper than 2:1. Geotechnical slope stability analysis is recommended for embankments greater than 10 feet in height and is mandatory for embankment slopes steeper than those given above. All embankments must be designed to State of Kentucky guidelines for dam safety.
- Seepage control or anti-seep collars should be provided for all outlet pipes.
- A minimum of 1 foot of freeboard must be provided for earthen embankments.
- Earthen embankment slopes should be vegetated to avoid erosion. Drought tolerant groundcover species should be used if irrigation cannot occur during the summer.

Maintenance and Safety

- Adequate maintenance access such as a maintenance access bench must be provided for all wet ponds. The access bench is a shallow slope area adjacent to the pond that will be used for equipment access.
- The forebay of the pond should include a fixed vertical sediment depth marker securely installed in the forebay. This marker will be used as an indicator for when sediment removal is needed in the forebay. Sediment removal should occur for forebay areas every 2-7 years or after 50% of the total forebay storage capacity is filled with sediment.
- The riser should be planned for future maintenance, lessening the clogging potential, planning access for inspections and maintenance, and safety from improper access by children and/or vandals.
- Public safety must be considered in every aspect of the pond design.
- Dam safety regulations must be strictly followed in pond design and maintenance to ensure that downstream property and structures are adequately protected.
- OSHA safety procedures must be followed for maintenance activities in enclosed areas, such as outlet structures.
- All wet ponds must include a drain and written procedures for draining the pond.

Multiple Pond Systems

- Performance is enhanced by using multiple treatment cells, longer flowpaths and high surface area to volume ratios.
- For separating multiple ponds, a berm or simple weir is preferred rather than using pipes because pipes have higher freezing potential.

Design Components

Pre-Treatment

- Wet ponds require pre-treatment measures such as other water quality BMPs and/or forebay(s). For pre-treatment areas receiving drainage from potential “hot spot” areas, the pre-treatment measures may require an impermeable liner and/or other separation to keep stormwater separated from groundwater.
- A sediment forebay sized to 0.1 inches per impervious acre of contributing drainage should be provided for wet ponds that are in a treatment train with off-line water quality treatment structural controls. This forebay may be a small pool separated from the pond area by barriers such as earthen berms, concrete weirs or gabion baskets.
- Direct vehicle/equipment access should be required for forebays to allow for sediment removal and maintenance.
- The bottom of the forebay may be hardened using concrete, asphalt or grouted riprap to make sediment removal easier.
- The forebay outlets should include non-erosive conditions as flows move from the forebay to the pond.
- Channels used to convey runoff to the pond should be stabilized to reduce the sediment loads.
- The forebay of the pond should include a fixed vertical sediment depth marker securely installed in the forebay. This marker will be used as an indicator for when sediment removal is needed in the forebay. Sediment removal should occur for forebay areas every 2-7 years or after 50% of the total forebay storage capacity is filled with sediment.
- Removed sediment from pond areas that do not receive runoff from confirmed hotspots is generally not considered toxic or hazardous material, and can be safely disposed by land application or land filling. For sediment from runoff from hotspot areas, sediment testing may be necessary prior to disposal.

Inlet and Outlet Structures

- For extended detention ponds and pocket ponds, the low flow orifice must be capable of releasing 50% of WQ_v over at least 24 hours.
- For a wet pond, the outlet structure is sized for Q_{P25} control (based upon hydrologic routing calculations) and can consist of a weir, orifice, outlet pipe, combination outlet, or other acceptable control structure that is not easily clogged.
- The water quality protection orifice should have a minimum diameter of 3 inches and should be adequately protected from clogging by an acceptable external trash rack. The orifice diameter may be reduced to 1 inch if internal orifice protection is used (e.g., an overperforated vertical stand pipe with 0.5-inch orifices or slots that are protected by wirecloth and a stone filtering jacket). Adjustable gate valves can also be used to achieve this equivalent diameter.

Design Components

- Ø The two most common outlet problems that occur are: 1) the outlet capacity is too great, resulting in partial filling of the pond, shorter drawdown time, and reduced pollutant removal; and 2) the outlet clogs because it is not adequately protected against trash and debris.

  To avoid these problems, two alternative outlet types are recommended for use: 1) V-notch weir; and 2) perforated riser. The V-notch weir will not clog as easily and should be designed to extend at least 12 inches below the normal pool. The perforated riser allows flow to enter at varying depths, providing internal flow control at varying depths and treatment volumes. The number of perforations per row is a function of the outlet sizing for the pond.
- Ø An emergency spillway may be required in wet pond designs to safely pass the extreme flood flow. The spillway prevents pond water levels from overtopping the embankment and causing structural damage. The emergency spillway must be designed to State of Kentucky guidelines for dam safety and must be located so that downstream structures will not be impacted by spillway discharges.
- Ø Inflow channels are to be stabilized with flared riprap aprons, or the equivalent.
- Ø The principal spillway opening should not permit entry by small children, and endwalls above pipe outfalls greater than 48 inches in diameter should be fenced to prevent a hazard.
- Ø Pond outlets must be designed to prevent discharge of floating debris. The recommended approach is to equip the principal spillway openings with removable trash racks to prevent clogging by large debris and to restrict riser access for safety. U. S. EPA guidance for controlling floatables suggests that openings in the range of 1.5 inches are both cost-efficient and effective in removing floatables and large solids.
- Ø The riser should be planned for future maintenance, lessening the clogging potential, planning access for inspections and maintenance, and safety from improper access by children and/or vandals.
- Ø OSHA safety procedures must be followed for maintenance activities in enclosed areas, such as outlet structures.
- Ø The recommended approach for limiting riser access is to install lockable manhole covers and manhole steps within easy reach of valves and other controls. These measures will allow maintenance access and help prevent unauthorized access.
- Ø For spillway outlets, flared pipe sections that discharge at or near the downslope invert or a step-pool arrangement are recommended rather than headwalls at the spillway outlet.
- Ø Burying all pipes below the frost line can prevent frost heave and pipe freezing.
- Ø A riser or an alternative method may be used for the pond's principal spillway.
  - o For perforated risers, the minimum opening diameter should be ½ inch and the minimum pipe diameter is 8 inches.

Design Components

- o The low flow orifice for the riser must be adequately protected from clogging. This protection may be an acceptable external trash rack (recommended minimum orifice diameter of 3 inches) or a smaller orifice diameter may be used along with internal orifice protection (recommended minimum diameter of 1 inch).
- o One example alternative method would be to use a broad crested, rectangular, V-notch or proportional weir, protected by a half-round CMP.

- Ø The outflow riser should be located so that short-circuiting between inflow points and the riser does not occur.
- Ø Where standard weirs are used, the minimum slot width is 3 inches. This is particularly important for tall slots.
- Ø The pond must include an emergency spillway to pass storm events in excess of the pond's hydraulic design. The emergency spillway must be stabilized to prevent erosion, must comply with state dam safety requirements and must be located so that downstream structures will not be impacted by spillway discharges. If the emergency spillway crosses the maintenance access for the pond, materials meeting the appropriate load requirements must be selected.
- Ø Riprap, plunge pools or pads, or other energy dissipators are to be placed at the end of the outlet to prevent scouring and erosion. If the pond discharges to a channel with dry weather flow, care should be taken to minimize tree clearing along the downstream channel, and to reestablish a forested riparian zone in the shortest possible distance.
- Ø For outlets, it is recommended that a stilling pond or outlet protection be used to reduce outflow velocities to non-erosive velocities (3.5 to 5.0 fps).

Pond

- Ø Wet ponds require a minimum contributing drainage area and may also require water balance calculations to confirm that a wet pond can be supported at the location.
  - o Minimum contributing drainage area is 25 acres for wet ponds, wet ED ponds and multiple ponds
  - o Minimum contributing drainage area is 10 acres for a micropool extended detention pond (must check that hydrology is capable of supporting water levels)
  - o Minimum contributing drainage area is 5 acres for pocket ponds (must check that hydrology is capable of supporting water levels).
- Ø Side slopes should be 6:1 (H:V) or flatter to provide a littoral shelf and safety bench from the side of the facility out to a point 2 to 3 feet below the permanent pool elevation. Side slopes above the littoral zone should be no steeper than 4:1 (H:V). Side slopes below the littoral zone can be 2:1 (H:V) to maximize permanent pool volumes where needed. A short (1.0 ft) drop-off can be constructed at the edge of the pond to control the potential breeding of mosquitoes.

Design Components

- For outlets, it is recommended that a stilling pond or outlet protection be used to reduce outflow velocities to non-erosive velocities (3.5 to 5.0 fps).
- Dam safety regulations must be strictly followed in pond design and maintenance to ensure that downstream property and structures are adequately protected.
- Public safety must be considered in every aspect of the pond design.
- The minimum length to width ratio for the pond is 1.5:1.
- It is recommended that the pond's footprint cover approximately 1-3% of the contributing drainage area.
- Adequate maintenance access must be provided for all wet pond types. One approach for this is to incorporate an access bench (a shallow slope area adjacent to the pond) that will be used for equipment access.
    - The recommended access bench width is 10 feet (minimum 8 feet).
    - The maximum access bench cross-slope should be 0.06:1 (V:H) or 6%.
    - Use a maximum bench slope of 0.15:1 (V:H).
    - The bench should be appropriately stabilized for vehicle and equipment access.
    - This bench may also consider extending to other areas such as forebays, inlet and outlet, and should also consider the need for vehicle turn around space.
    - Access benches are not needed for ponds with side slopes that are 1:4 (V:H) or flatter.
    - The recommended maintenance access will connect with a maintenance right-of-way or easement (if needed) that will extend from the pond to a public or a private road.
- A minimum separation distance between the pond and the groundwater table and/or an impervious liner may be required for ponds where source water protection is required or for contributing drainage areas designated as "hot spots".
- A site-specific geotechnical investigation should be conducted.
- Side slopes should not exceed 1V:3H.
- The slopes immediately adjacent to the pond should be less than 25% but greater than 0.5-1% to maintain positive drainage toward the pond.
- Wet ponds are sized to store all of WQ_v in the permanent pool and to temporarily store the volume of runoff required to provide overbank flood (Q_{P25}) protection (i.e., reduce the post-development peak flow of the 25-year storm event to the pre-development rate), and control the peak flow for the 100-year storm (Q_{P100}) if required.
- Wet ED ponds, micropool ED ponds and pocket ponds are designed to store 50% of WQ_v in the permanent pool and the remainder of WQ_v in temporary storage for at least 24 hours. These ponds can also provide additional storage volume for normal detention (peak flow reduction) for Q_{P25} and Q_{P100}. Routing calculations must be used to demonstrate adequate storage volume.

Design Components

- Ø The maximum depth of the pond should not exceed 10 feet.
- Ø The elevation difference from the site inflow to outflow is recommended to be 6-10 feet. However, lower heads may also work for smaller sites.
- Ø The recommended pond side slopes would be 1:3 (V:H).
- Ø Construction inspections are needed to confirm that the pond is being built by the approved design and specifications. Use a detailed inspection checklist that includes sign-offs by qualified individuals at critical construction stages to check that the contractor's plan interpretation is acceptable to the project's designer.
- Ø Areas above the normal high water elevations of the pond should be sloped toward the pond to allow drainage and to prevent standing water. Carefully finish grading to avoid creation of upland surface depressions that may retain runoff. The pond bottom should be graded toward the outlet to prevent standing water conditions. A low flow or pilot channel across the pond bottom from the inlet to the outlet (often constructed with riprap) helps convey low flows and prevent standing water conditions.
- Ø For karst areas, it is recommended that ponds use an impermeable liner and include a minimum three foot separation from the barotic rock layer. Liner options include a layer of 6-12 inches of clay soil including bentonite (minimum 15% passing the #200 sieve and a maximum permeability of 1X 10^{-5} cm/sec), a 30 mL polyliner or another approved engineering design.
- Ø A landscaping plan should describe how the pond and surrounding areas will be stabilized, how vegetation will be established, how these areas will be maintained and maintenance schedules.
  - o Rooted wetland vegetation should be planted along the pond's perimeter.
  - o Keep in mind that vegetation planted in the extended detention zone should be able to withstand both wet and dry conditions.
- Ø All wet ponds must include a drain and written procedures for draining the pond.

Embankment

- Ø Vegetated embankments shall be less than 20 feet in height and shall have side slopes no steeper than 2:1 (horizontal to vertical) although 3:1 is preferred. Riprap-protected embankments shall be no steeper than 2:1. Geotechnical slope stability analysis is recommended for embankments greater than 10 feet in height and is mandatory for embankment slopes steeper than those given above. All embankments must be designed to State of Kentucky guidelines for dam safety.
- Ø Seepage control or anti-seep collars should be provided for all outlet pipes.
- Ø A minimum of 1 foot of freeboard must be provided, measured from the top of the water surface elevation for the extreme flood, to the lowest point of the dam embankment not counting the emergency spillway.
- Ø For earthen embankments, suitable soils must be used to construct the embankment.
- Ø Woody vegetation should not be planted or allowed to grow within 15 feet of the embankment toe and within 25 feet of the inlet and outlet structures.

Design Components

Multiple Pond Systems

- Performance is enhanced by using multiple treatment cells, longer flowpaths and high surface area to volume ratios.
- For separating multiple ponds, a berm or simple weir is preferred rather than using pipes because pipes have higher freezing potential.

Design Procedure

Step 1 – Make a preliminary judgment as to whether site conditions are appropriate for the use of a type of wet pond, and identify the function of the pond in the overall treatment system. This includes performing an initial suitability screening for the site.

- Consider basic issues for initial suitability screening, including:
  - Site drainage area
  - Site topography and slopes
  - Soil characteristics
  - Depth to water table and bedrock
  - Presence of active karst features and/or wetlands
  - Post-development landuse (Is it a potential "hot spot" landuse?)
- Determine how the type of wet pond will fit into the overall stormwater treatment system.
  - Keep in mind that other water quality BMPs may be used upslope of the pond that may reduce the required pond size.
  - Decide where on the site the pond is most likely to be located.

Step 2 – Confirm design criteria, site constraints and applicability.

- Determine the design criteria that will be used.
  - Local construction and stormwater requirements
  - State stream construction permitting (if in a floodplain area)
  - State dam safety guidance (for ponds with embankments)
  - Any other criteria or restrictions that apply
- Determine any constraints the site will place on the pond such as:
  - Available contributing drainage area
  - Limited amount of space and surface area available for treatment
  - High water table
  - Active karst areas

Design Procedure

Ø Determine the TSS reduction provided, using the equations below for weighted TSS reduction, $TSS_{weighted}$, and TSS treatment train, TSS_{train}. The minimum TSS reduction required for the site is 80% and can be weighted for the site.

$$\%TSS_{\text{weighted}} = \frac{\sum_n^1 (TSS_1 A_1 + TSS_2 A_2 + ... + TSS_n A_n)}{\sum_n^1 (A_1 + A_2 + ... + A_n)}$$

Where runoff is treated by two or more BMPs in series, the TSS reduction provided is calculated with the following equation for a treatment train:

$$TSS_{train} = A + B - \frac{(A \times B)}{100}$$

Where A is the TSS reduction provided by the first BMP and B is the TSS reduction provided by the next BMP.

Step 3 –Confirm site suitability, including field verification of site suitability.

Ø The field verification should be conducted by a qualified geotechnical professional.

Ø The recommended minimum is one soil boring per acre with a minimum of three soil borings or pits dug at the same location as the proposed pond. The borings or pits will be used to verify soil types and to determine the depth to groundwater and bedrock.

Ø The recommended minimum depth of the soil borings or pits is five feet below the bottom elevation of the proposed pond.

Ø Perform water balance calculations, if needed. A water balance is recommended where there is a need to document sufficient inflows to support a wet pond type. The water balance considers the site's ability to maintain a constant permanent pool during prolonged dry weather conditions. Use the following steps to perform water balance calculations:

- Check maximum drawdown during periods of high evaporation and during an extended period of no appreciable rainfall to ensure that wetland vegetation will survive.
- The change in storage within a pond = inflows – outflows.
- Potential inflows: runoff, baseflow and rainfall (ground water and surface water).
- Potential outflows: Infiltration, surface overflow and evapotranspiration.
- For some wet pond types, some assumptions can help simplify the water balance since only the permanent pool volume is being evaluated. . The validity of these assumptions need to be verified for each design and wet pond type.
    - Assume no inflow from baseflow,

Design Procedure

- Assume no outflow losses for infiltration
- Assume no outflow losses for surface overflows

- In equation format, the water balance based on the contributing drainage area is as follows:

  •SP=RO+B+RF-I-SO-ET

  Where:

  •SP = change in pond storage, inches

  RO = runoff, inches

  B = baseflow, inches

  RF = rainfall, inches

  I = infiltration, inches

  SO = surface overflow, inches

  ET = evapotranspiration, inches

- For testing a site's suitability for a wet pond type, the critical issue is maintaining a minimum permanent pool depth to avoid nuisance conditions such as insect conditions or odor. The water balance equation may be modified to calculate the required design depth for the permanent pool by considering 30-day summer drought conditions. In equation format, the 30-day water balance based on the contributing drainage area is as follows:

  •• > ••. + •. + ••• + •.

  Where:

  DP = Average design depth of the permanent pool, inches

  ET_S = Summer evapotranspiration amount, inches

  I_S = Summer infiltration amount, inches

  RES = Pond's water reservoir for a factor of safety (assume 24 inches)

  B_S = Summer baseflow amount, inches

Design Procedure

Step 4 – Compute runoff control volumes, permanent pool volume and peak flows. Refer to Section 2.4.7 for more information on these values.

- Calculate the Permanent Pool Volume (V_{PP}).

$$\bullet_{\bullet\bullet} = 0.5\bullet\bullet\bullet\bullet\bullet\bullet\bullet \bullet \,_{\bullet}\, \bullet \frac{1\bullet\bullet}{12\bullet\bullet}$$

Where:

V_{PP} = Permanent Pool Volume, acre-feet

A_W = total watershed area draining to the pond, acres

- Calculate the Water Quality Volume (WQ_V).

$$\mathbf{WQ_v = [P\ Rv)(A)]/12}$$

Where:

P = is the average rainfall, (inches)

R_V = 0.05 + 0.009(I), where I is the percent impervious cover

A = the area of imperviousness, (acres)

- Calculate the Peak Flow for the 25 year storm (Q_{P25}).
- Calculate the Peak Flow for the 100 year storm (Q_{P100}).

If the pond will be used as the only BMP for rate control for larger storms, the pond should be designed to treat the entirety of each of these runoff control volumes. If other BMPs will be used to control portions of these runoff control volumes, the portion handled by other BMPs may be subtracted from the appropriate volumes to determine the volumes to be controlled in the pond.

Note: Steps 5 – 12 may be iterative to achieve a pond design that meets the required performance and the site constraints.

Step 5 – Determine the pond location and preliminary geometry.

- Use the following steps to develop the preliminary grading plan for the pond.
    - Locate the pond at the site's lowest elevation area that is not in a jurisdictional wetland or active karst area. Provide space around the pond for maintenance access (minimum width of 8 feet, recommended minimum width of 10 feet).
    - Establish a primary outlet elevation (normal water level) and/or a pond bottom elevation.
    - Provide storage for the permanent pool below the primary outlet elevation in the main pond area.

Design Procedure

- The permanent pool should include an aquatic bench extending into the pool and an access bench extending out of the pool.
- Provide storage based on the water quality volume (WQ_V), volume for the Peak Flow (V_{P25}) and volume for the Extreme Flood Peak Flow (V_{P100}). The pond must be able to contain the first two volumes, and must be designed to pass the extreme flood peak flow.
- Considering the desired pond footprint during the WQ_V, V_{P25} and V_{P100} design storms, allocate storage volume above the riser bottom orifice for WQ_V, V_{P25} and V_{P100}, respectively. While developing the grading plan, consider the desired (or required) length to width ratio and side slopes based on the Design Criteria and Design Components information.
- Once the preliminary grading plan has been developed, determining the associated stage-storage relationship for water surface elevations through the maximum expected levels.

Ø Use the average end area method to calculate the approximate storage at a given stage (elevation). The area within each of the closed contour lines on the pond's grading plan is measured. The average area is calculated between two adjacent contours. The average areas are then multiplied by the elevation difference to calculate the approximate volume between the two contours.

$$\bullet_{\dots} = \frac{\bullet_{.} + \bullet_{.}}{\bullet} \times (\bullet_{.}\ \bullet\ \bullet_{.})$$

Where:

V_{1-2} = the volume between contour 1 and contour 2 (acre-feet)

A_1 and A_2 = the areas within closed contours 1 and 2, respectively (acres)

E_1 and E_2 = the elevations of contours 1 and 2, respectively (feet)

The cumulative pond volume above the bottom of the pond can be calculated by adding the incremental volumes. The stages (elevations) and the corresponding storages can be used to develop a stage-storage-discharge table as the outlet structures are designed. This is an iterative process that may require revising the preliminary grading plan and recalculating the stage-storage relationship until all of the items in Design Criteria and Design Components are satisfied.

Design Procedure

STEP 6 – Determine the pre-treatment volume for the sediment forebay.

- Where there are no adequate upstream treatment BMPs, a sediment forebay or a similarly performing treatment system is recommended at each inlet to the pond that conveys 10% or more of the total design inflow.
- The recommended forebay volume is 10% of the WQ_v with a depth of 4-6 feet. More shallow depths increase the potential for sediment resuspension in the forebay.
- Both the storage volume of the forebay and the storage volumes for other water quality BMPs upstream in the treatment train count toward the required water quality volume, and may be subtracted from the total water quality volume required.

STEP 7 – Size and design the outlet structures.

- The pond must include the following outlet stages in the pond design. It is possible to design one device to meet all required stages.
- The assumed water quality volume (low flow) outlet is an orifice at the bottom of the riser designed to release WQ_v with an average detention time of 24 hours. After designing the low flow orifice, the design should be checked to verify that the release rate is no greater than 5.66 cfs/acre of pond surface area.
- The following outlet equations are based on assumptions about the outlet structure type that will be used to control flows at various stages. If a different structure type is selected, the designer must use specific equations for structure type to determine the stage-discharge relationships. However, the general design approach will remain the same even if a different outlet structure type is used for the pond calculations.
- The average release rate of WQ_v (Q_{WQ_avg}) is calculated using the following equation:

• • •_• • • = • • • / • • •

Where:

t_{WQ} = the intended WQ_v detention time (seconds)

WQ_v = water quality volume (cubic feet)

Q_{WQ_avg} = average release rate of WQ_v (cfs)

- From the stage-storage table, find the elevation associated with WQ_v. Calculate the approximate average head (in feet) on the water quality outlet (h_{wq_avg}) using the following equation:

• • •_• • • = • • • • • • • • • • • • • / •

Design Procedure

Where:

E_{WQ} = the WQ_v pool elevation (feet)

$E_{PermPool}$ = the permanent pool elevation (feet) at the invert of the water quality orifice.

Ø Calculate the required orifice cross-sectional area indirectly by using the orifice equation.

• . ._. . . = • • . . • • • • . ._. . .

Where:

C = the orifice coefficient (0.6 is typically used, but not apply for all cases)

A_{WQ} = the orifice area (square feet)

g = gravitational acceleration (32.2 feet/s^2)

Ø Calculate the control for the 25-year, 24-hour runoff peak flow (Q_{P25}). The calculation procedures will be similar to those used for the low flow orifice except that any higher outflow openings (i.e., perforated riser openings, weir, orifices, etc.) would be included as well. The combined outflow from all openings must be such that the post-development Q_{P25} does not exceed the pre-development Q_{P25}.

Ø The combined outflow from the low flow orifice and any higher outflow openings is calculated by adding together the discharges from each structures associated with a given head value and a specified pond water surface elevation.

Ø Calculate the required control for water quantity management. See Section 2.4.7. At minimum, Q_{p100} must be able to be safely passed through the pond with 1-2 feet of freeboard below the top of the embankment. Check with local officials and/or state dam safety personnel to determine whether Q_{p100} may be passed using only a principal spillway, or if a combination of a principal spillway and emergency spillway will be required. If an emergency spillway is required, the spillway type is often a broad-crested weir or similar structure that is not easily obstructed. The combined outflow through all spillway openings is calculated by adding together the discharges for each opening associated with a given head value and a specified water surface elevation.

Ø Using the determined opening and spillway information, incorporate the outlet structures into the pond design. Keep in mind that the spillway design must also consider using measures such as removable trash racks to prevent the discharge of floating debris.

STEP 8 – Design the spillways and embankments.

Ø All spillway and embankment design must meet any applicable state and/or local criteria.

Ø The emergency spillway must be stabilized.

Design Procedure

- The embankments must be overfilled by at least 5% to allow for settling.
- The minimum embankment with is 6 feet. A wider embankment width may be preferred for maintenance access.
- All embankments must be adequately stabilized with appropriate non-woody vegetation or other measures.
- The embankment and spillway side slopes should be no steeper than 1:3 (V:H).
- Using the determined opening and spillway information, incorporate the outet structures into the pond design. Keep in mind that the spillway design must also consider using measures such as removable trash racks to prevent the discharge of floating debris.

STEP 9 – Design the inlets.

- If inflow inlet pipes are used, it is recommended that the pipes be buried below the frost line.
- Inlet design should consider preventing or reducing scour by including riprap or flow diffusion devices such as plunge pools or berms.

STEP 10 – Design the sediment forebay.

- The sediment forebay size was determined in Step 6.
- The bottom of the forebay may be hardened using concrete, asphalt or grouted riprap to make sediment removal easier.
- The forebay outlets should include non-erosive conditions as flows move from the forebay to the pond.
- The forebay of the pond should include a fixed vertical sediment depth marker securely installed in the forebay. This marker will be used as an indicator for when sediment removal is needed in the forebay. Sediment removal should occur for forebay areas every 2-7 years or after 50% of the total forebay storage capacity is filled with sediment.

STEP 11 – Design the maintenance access and safety features.

- Maintenance access and safety features should meet the requirements included in the Design Criteria and Design Component sections.
- Any additional safety features or signage should be added as appropriate.
- Dam safety regulations must be strictly followed in pond design and maintenance to ensure that downstream property and structures are adequately protected.
- OSHA safety procedures must be followed for maintenance activities in enclosed areas, such as outlet structures.

STEP 12 – Check the expected pond performance against regulatory requirements.

- The pond design should be re-checked to confirm that the pond meets the flow control requirements.

Design Procedure

- Ø The average detention time for WQ_v is 12 hours. The release rate for WQ_v should not exceed 5.66 cfs per acre of pond area.
- Ø Post-development Q_{P25} is no more than the pre-development Q_{P25}.
- Ø If required, post-development Q_{p100} is no greater than the pre-development Q_{p100}.
- Ø If required, the post-development Q_{p100} must be able to be safely passed through the pond while maintaining 1-2 feet of freeboard below the top of the embankment.
- Ø Any other requirements for state dam safety.
- Ø The % TSS removal for the treatment train (upstream water quality BMPs and pond) must be 80% or greater.

STEP 13 – Prepare the vegetation and landscaping plan.

The vegetation and landscaping plan should include soil preparation information, vegetation type and vegetation maintenance. The plan should include information about where woody vegetation is not appropriate (i.e., embankment areas, near spillways where access may be affected, etc.). The plan should also include information about reapplying stabilization measures to areas where vegetation growth is sparse.

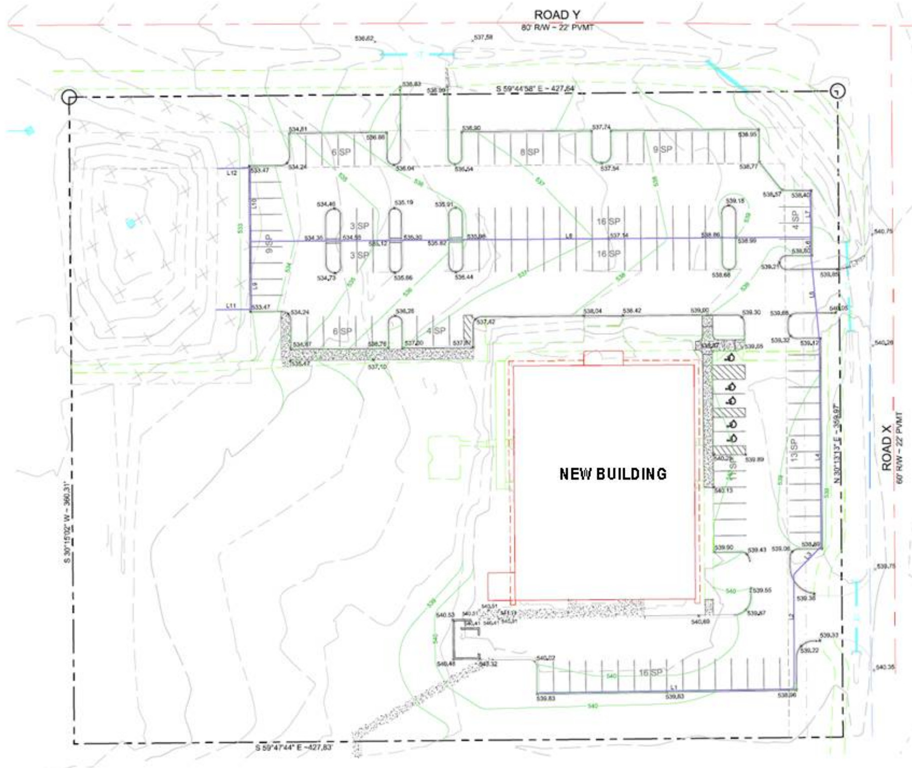
STEP 14 – Prepare the operation and maintenance plan.

The operation and maintenance plan should include maintenance information and inspection checklists similar to those discussed in this practice's fact sheet.

STEP 15 – Complete the Design Summary Table.

Design Parameter	Required Size	Actual Size
Pond Type		
WQv		
WQv Elevation		
Forebay		
Outlet		

Example Design



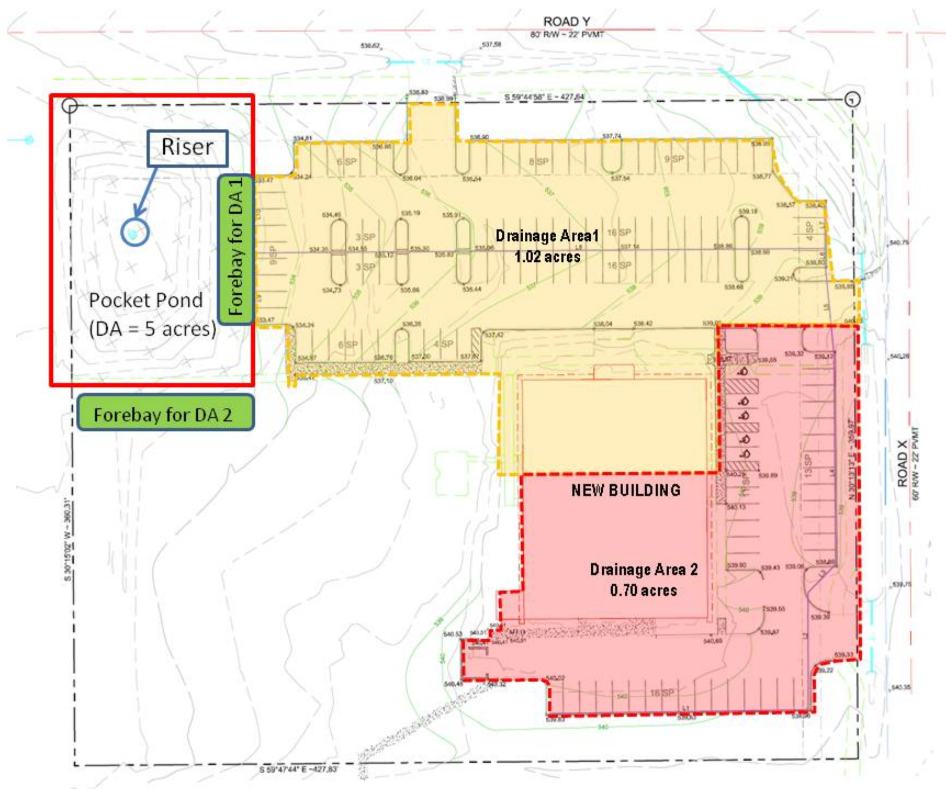
Proposed development of an undeveloped site into an office building and associated parking.

Base Data	**Hydrologic Data**
Site Area = 3.54 ac	Pre Post
Total drainage area = 5.0 ac	CN 71 89
Soils Type "C"	
Pre-Development	**WQ_v Depth** = 1.1 in
Impervious Area = 0 ac; or I = 0%	
Meadow (CN = 71)	**Precipitation**
	I_{WQ} 2.45 in/hr
Post-Development	
Impervious Area = 1.72 ac; or I = 1.72/3.54 = 49%	2yr, 24hr 3.54 in
Open Space, Fair (CN = 79)	25yr, 24hr 5.88 in
Paved parking lots, roofs, driveways, etc. (CN =98)	100yr, 24hr 7.43 in

This example focuses on the design of a pocket pond to meet the water quantity control requirements and to also be a part of the treatment train for the site's water quality treatment requirements. This example design focuses on water quality volume (WQ_v) control only. However, similar design procedures would be used to design for the other water quantity control requirements. The primary functions of the pocket pond are to provide water quality treatment of stormwater and to provide large storm attenuation.

Example Design

Problem: Design a post-construction stormwater water quality and quantity pocket pond for this site. The pocket pond will be constructed to meet the required detention standards and will provide 80% TSS reduction for the site. There are two impervious drainage areas for the site, and stormwater from both areas will drain to the pocket pond. The total watershed drainage area, A_w, to the pond is 5 acres. Try designing the pocket pond for this site.



Step 1 – Make a preliminary judgment as to whether site conditions are appropriate for the use of a pocket pond, and identify the function of the pond in the overall treatment system. This includes performing an initial suitability screening for the site.

Ø Consider basic issues for initial suitability screening, including:

- The total drainage area to the pond is 5 acres (A_w).
- The site's topography and slopes show that the northwest corner of the site is the preferred pond location.
- The site has type "C" soils
- The depth to the water table and bedrock show that the northwest corner of the site is a suitable location for a pocket pond.
- There are active karst areas on the site. The pond will be located away from the active karst areas.
- The proposed development is a commercial office building with associated parking.

Example Design

Ø Determine how the pocket pond will fit into the overall stormwater treatment system.

- The proposed pocket pond will be the primary BMP for TSS removal. No other water quality BMPs will be installed at the site.
- The northwest corner of the site is the best candidate location for the pocket pond.
- The stormwater from the two impervious areas on the site will be conveyed through pipes or other stabilized conveyances into the pocket pond.
- Two separate sediment forebays (one to the east of the pond and a second to the south of the pond) will be used as pre-treatment for the runoff from each impervious area as well as pervious areas draining to the pond. These forebays will reduce maintenance requirements for the pocket pond since other water quality BMPs will not be used upstream of the pond. All pervious site areas as well as all contributing pervious off-site drainage areas will be well-stabilized with vegetative cover.

Step 2 – Confirm design criteria, site constraints and applicability.

Ø The following minimum criteria will be used in the design.

- o The pocket pond must meet the following criteria:
  - § The WQ_v must have an average detention time of 24 hours.
  - § The post-development 25-year peak flow (Q_{P25}) discharged from the pond must be no greater than the pre-development 25-year peak flows (Q_{P25}).
  - § For this location, the City is not requiring that the 100-year peak flow to be controlled by the pocket pond, but is requiring the pond to be able to safely pass the 100-year peak flow through the principal spillway.
  - § The pocket pond is the primary water quality BMP for meeting the City's requirement for % TSS removal.
- o The site is not within a floodplain area, and does not require state permitting for floodplain construction.
- o The pond is bounded on two sides by existing streets, and will not require an embankment (i.e., the pond is excavated). Therefore, no state dam safety approvals are needed.
- o The outlet structure will be an improved sinkhole and will require registration as such.

Ø The following items are the site constraints related to the pond:

- The proposed pond location is bounded on two sides (north and west) by existing streets. The design for high flow conditions must consider street flooding potential.
- The proposed pond's principal spillway discharge will not impact roads or buildings downstream (and also off-site).

Example Design

- Determine the TSS reduction provided, using the equations below for weighted TSS reduction, $TSS_{weighted}$. The pocket pond BMP has an estimated 80% TSS removal. All runoff from impervious surfaces goes to the pocket pond.

$$\%TSS_{weighted} = \frac{(80*1.02\,\text{acres})+(80*0.70\,\text{acres})}{1.72\,\text{acres}} = 80\%$$ ü

Step 3 –Confirm site suitability, including field verification of site suitability.

- The site geotechnical investigation showed that proposed pond location was suitable for installing a pocket pond and that the nearby sinkhole drainage is not expected to adversely affect the ability to maintain a permanent pool here.
- The soil borings indicated that the underlying soils in the vicinity of the proposed pocket pond had limited infiltration capacity and that the high water elevation allowed a minimum 3-foot separation between the bottom of the pond and the high water elevation.
- No impermeable layers/lenses or bedrock was encountered during the geotechnical field evaluation of the site.
- The pond site's water balance will be based on 30-day drought conditions, and will check that the pond site is capable of supporting a wet pond.
    - The site's summer evapotranspiration (ET_S) amount is assumed at 8 inches
    - The summer infiltration (I_S) amount for the site is assumed at 7.2 inches
    - The pond water reservoir (RES) for factor of safety is assumed at 24 inches.
    - The site's summer baseflow (B_S) amount was measured, but the average design depth of the permanent pool did not include baseflow here for a conservative estimate of the average design depth.

• • > • •. + •. + • • • + •.

• • > 8 •••••• + 7.2 •••••• + 24 •••••• + 0 ••••••

• • > 39.2 •••••• = 3.27 ••••

Step 4 – Compute runoff control volumes and peak flows. Refer to Chapter 2 and Appendix B for more information on these values.

- Calculate the Permanent Pool Volume (V_{PP}). Use A_W = 5 acres.

•.. = 0.5 •••••• • 5 ••••• • (1 •• / 12 ••••••) = 0.208 •••• • •••• = 9075 ••

- Calculate the Water Quality Volume (WQ_V).

Total Site WQ_v:

$$WQ_v = [(P\ R_v)(A)]/12$$

Example Design

Where:

P = 1.1 inches

$R_v = 0.05 + 0.009(I)$

I = 49

$R_v = 0.05 + 0.009(49) = 0.491$

A = 1.72 acres

WQ_v = (1.1in x 0.491 x 1.72ac)/12 = 0.077 acre-ft = **<u>3373</u>** ft^3

Ø For the Example Design, the proposed pocket pond will be assumed to be the only rate control for the site (i.e., assumes that no other BMPs reduce the runoff control volumes that are to be handled by the pocket pond).

Note: Steps 5 – 12 may be iterative to achieve a pond design that meets the required performance and the site constraints.

<u>First Iteration</u>

<u>Step 5</u> – Determine the pond location and preliminary geometry.

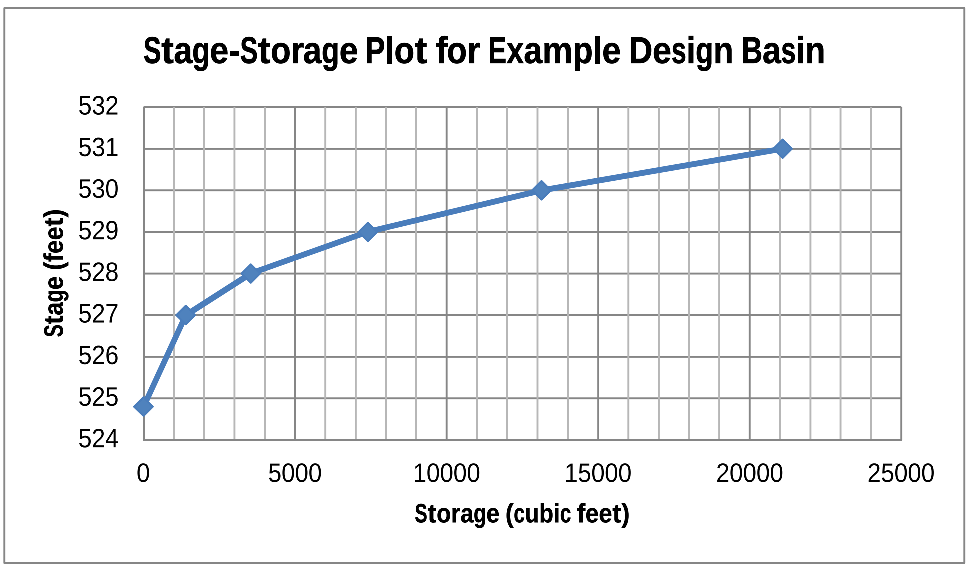
Ø These items were used to develop the preliminary grading plan for the pond.

- The pond's lowest elevation is not in a jurisdictional wetland. The maintenance access for the pond will be on the eastern side of the pond near the parking area. Additionally, the pond side slopes here are approximately 1.4% or 1:7 (V:H).
- The pond bottom elevation is at 524.80 feet. This elevation will also be the invert for the permanent pool.
- The pond is assumed to have sufficient storage for all required controlled discharges.
- The outlet riser is centrally located in the pond, and cannot be moved farther away from the pond inlets due to the existing roadways nearby. The central riser location helps maximize the available length to width ratio.

Example Design

The proposed stage-storage relationships for the pond are summarized in the table and chart shown below:

Elevation E (ft)	Area A (square feet)	Average Area between Elevations	Average Area (ft^2)	Depth (Elevation Difference)	Incremental Volume (ft^3)	Cumulative Volume (ft^3)
524.8	0	NA – pond bottom	NA – pond bottom	NA – pond bottom	0	0
527	1266	524.8 ft & 527 ft	633	2.2	1392.6	1392.6
528	3024	527 ft & 528 ft	2145	1	2145	3537.6
529	4709	528 ft & 529 ft	3866.5	1	3866.5	7404.1
530	6744	529 ft & 530 ft	5726.5	1	5726.5	13130.6
531	9169	530 ft & 531 ft	7956.5	1	7956.5	21087.1



- Ø One assumption for the pocket pond design is that 50% of WQ_v will be stored in the permanent pool. This means the added total storage for the permanent pool and the temporarily detained portion of WQ_v is about 10,762 ft^3 (Vpp + [50%WQ_v]). From the stage-storage plot (or linear interpolation from the table values), this total volume would be at approximate stage of 529.6 feet – about 1.4 feet from the top pond elevation.

- Ø If a design objective is to control peak flows for larger storm events, the pond size will need to be increased to detain the added volume.

Example Design

- For the purposes of this Example Design, the detention storage for the larger storm events will be ignored and the pond footprint will not be enlarged.

Ø The expected permanent pool depth of 4.5 feet is greater than the permanent pool depth based on 30-day drought conditions (3.27 feet) from Step 3.

Ø The primary outlet elevation will be at the top of the permanent pool storage. From the stage-storage information, the primary outlet elevation is at 529.3 ft.

STEP 6 – Determine the pre-treatment volume for the sediment forebay.

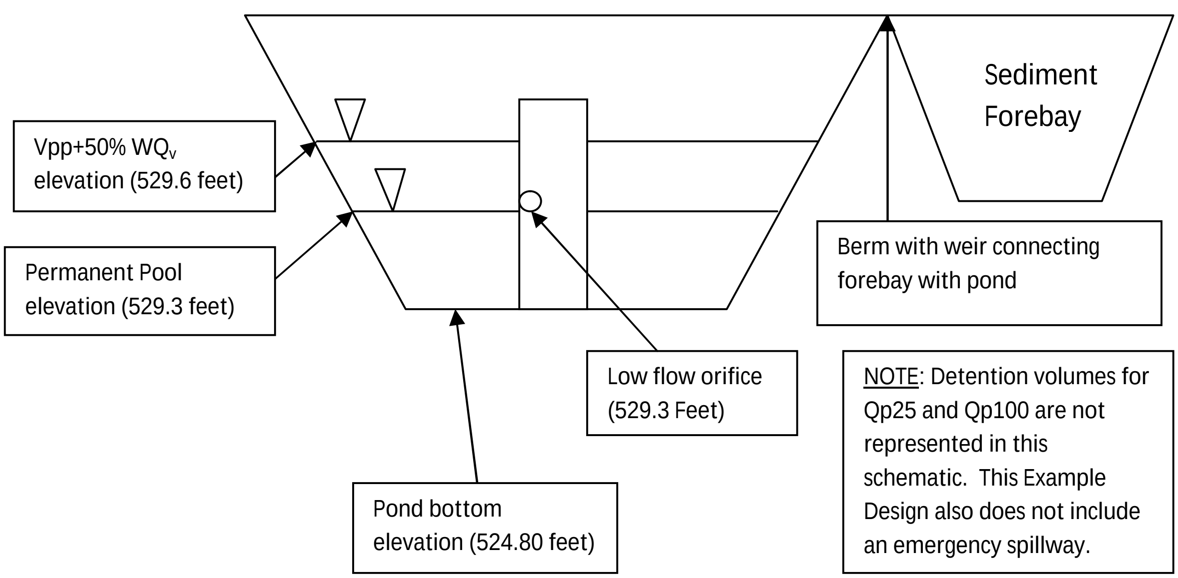
Ø This design example includes two sediment forebays – one for each of the two impervious drainage areas. These forebays do not include any added sediment load for pervious site areas (i.e., pervious areas are well-stabilized).

Ø The site's total sediment forebay storage should hold 10% of WQ_v, or about 338 ft^3.

Ø Forebay 1 receives drainage from Drainage Area 1 (1.02 acres). This forebay must be sized to hold 59% of the total forebay storage, or 200 ft^3 with a depth of 4 feet. The minimum surface area for Forebay 1 is 50 ft^2.

Ø Forebay 2 receives drainage from Drainage Area 2 (0.70 acres). This forebay must be sized to hold 41% of the total forebay storage, or 138 ft^3 with a depth of 4 feet. The minimum surface area for Forebay 2 is about 35 ft^2.

STEP 7 – Size and design the outlet structures.



Ø The assumed outlet structure will be a principal spillway riser that has a low flow orifice at the permanent pool elevation that will control the release of the detained portion of WQ_v. The example design will not include outlet calculations for the higher flow events.

Ø The low flow orifice design will release 50% of WQ_v with an average detention time of 24 hours.

Example Design	

Ø The average release rate of the WQ_v (Q_{WQ_avg}) is calculated using the following equation:

[illegible]

Where:

t_{WQ} = the intended WQ_v detention time = 24 hours = 86,400 seconds

WQ_v = 50% of WQ_v to be released = 1687 ft^3

Q_{WQ_avg} = average release rate of WQ_v (cfs)

[illegible]

Ø From the stage-storage table, the elevation of the detained portion of WQ_v is at 529.6 feet.

Calculate the approximate average head (in feet) on the water quality outlet (h_{wq_avg}) using the following equation:

[illegible]

Where:

E_{WQ} = 529.60 feet

$E_{PermPool}$ = 529.30 feet.

[illegible]

Ø Calculate the required orifice cross-sectional area indirectly by using the orifice equation.

[illegible]

Where:

Q_{WQ} = 0.020 cfs

C = the orifice coefficient (0.6 is typically used, but not apply for all cases)

A_{WQ} = the orifice area (square feet)

g = gravitational acceleration (32.2 $feet/s^2$)

Example Design

First, rearrange the orifice equation to solve for A_{WQ}.

• . . = • . . _ . . . / • • • • • . . _ . . .

• . . = •.••• ••• / •.••••••.•••(•.•• ••••) = •. •••• ••••˙ ü

Ø Calculate the orifice diameter using the following equation:

• . . = • • √(• . . / •)

Where:

d_{WQ} = the orifice diameter (feet)

• . . = • • √(•.••••• ••˙ / •.••) = •. •• ••••ü

• . . = •. •• •••• = •. •••••••• • •••••

For the Example Design, the minimum allowed orifice diameter (1 inch) will be used. This device will require internal orifice protection. An alternate approach is to use an adjustable gate valve to achieve an equivalent orifice diameter.

Ø The rate of discharge for the orifice for any head value at the water quality orifice (h_{WQ}) can be calculated using:

• . . = ••. . √(••••. .)

Where:

Q_{WQ} = the orifice discharge rate at head h_{WQ} (cfs)

h_{WQ} = the head value above the water quality orifice (feet)

Using the range of values for h_{WQ} based on the elevations (E) up to E_{WQ} used in the pond's stage-storage relationship, the Q_{WQ} values are calculated for each corresponding value of h_{WQ}.

Elevation E (ft)	h_{WQ} (feet)	Q_{WQ} (cfs)
529.3	0	0
529.6	0.3	0.0144

Example Design

- Calculate the control for the 25-year, 24-hour runoff peak flow (Q_{P25}). The calculation procedures will be similar to those used for the low flow orifice except that any higher outflow openings (i.e., perforated riser openings, weir, orifices, etc.) would be included as well. The combined outflow from all openings must be such that the post-development Q_{P25} does not exceed the pre-development Q_{P25}.

  This Example Design will not include calculations for control for the 25-year, 24-hour peak flow. However, the pond's ability to meet the requirements for post-development Q_{P25} would need to be checked for an actual design.

- The combined outflow from the low flow orifice and any higher outflow openings is calculated by adding together the discharges from each structures associated with a given head value and a specified pond water surface elevation.

  The combined outflow would be calculated for all of the outflow openings to check that the pond meets the requirements for controlling the post-development Q_{P25}.

- Calculate the required control for the 100-year storm peak flow (Q_{p100}). If required, the post-development Q_{p100} must be no greater than the pre-development Q_{p100}. At minimum, Q_{p100} must be able to be safely passed through the pond with 1-2 feet of freeboard below the top of the embankment. Check with local officials and/or state dam safety personnel to determine whether Q_{p100} may be passed using only a principal spillway, or if an emergency spillway will be required. If an emergency spillway is required, the spillway type is often a broad-crested weir or similar structure that is not susceptible to obstruction. For calculating the combined outflow through all spillway openings, the combined outflow may be calculated by adding together the discharges for each opening associated with a given head value and a specified water surface elevation.

- Using the determined opening and spillway information, incorporate the outlet structures into the pond design. Keep in mind that the spillway design must also consider using measures such as removable trash racks to prevent the discharge of floating debris.

  The outlet openings and spillways are then added into the pond design. Other measures such as removable trash racks are also added to the design.

STEP 8 – Design the spillways and embankments.

- The Example Design pond will target passing all required flows through the principal spillway, and will not be required to include an emergency spillway.

STEP 9 – Design the inlets.

- The Example Design pond uses inflow inlet pipes from the upstream impervious areas to the pond. These inflow inlet pipes are designed to be buried below the frost line. The designer should consider winter freeze conditions and how the inlets would be affected since these discharge to a permanent pool.

Example Design

STEP 10 – Design the sediment forebays.

Ø The two sediment forebay sizes were determined in Step 6.

Ø The forebay bottoms will be hardened to allow for easier sediment removal.

Ø Each forebay will be equipped with a fixed vertical sediment depth marker to gauge when sediment removal is needed.

STEP 11 – Design the maintenance access and safety features.

Ø All maintenance access and safety features are designed in this step. The removable trash racks on the spillway riser will also function to prevent unauthorized access to the riser. The riser's pipe diameter will include bars across the pipe outlet to prevent unauthorized access if the pipe diameter is over 3 feet.

STEP 12 – Check the expected pond performance against regulatory requirements.

Ø The pond design should be re-checked to confirm that the pond meets the flow control requirements.

Ø The release rate for WQ_v should not exceed 5.66 cfs per acre of pond surface area. Calculate the flow rate and pond surface area associated with each available elevation and head value up to E_{WQ}. The maximum release rate for WQ_v will then be calculated using the pond surface area at each given elevation and head value, and the actual release rate will be compared with the maximum release rate.

Elevation E (ft)	**h_{WQ} (feet)**	**Q_{WQ} (cfs)**	**Pond Surface Area at E (sq ft)**	**Pond Surface Area at E (acres)**	**Release rate (based on Q_{WQ} per acre of surface area) (cfs/acre)**
529.3	0	0.000	0	0	0
529.6	0.3	0.014	1266	0.0291	0.49 ü

The release rate in the last column of the table is checked to confirm whether the actual pond release rate exceeds 5.66 cfs per acre of surface area. All values are below the target value of 5.66 cfs per acre.

Ø The expected average detention time for WQ_v is 24 hours. Calculate the average release rate for the pond (Q_{WQ_avg}). Use WQ_v and Q_{WQ_avg} to calculate the actual average detention time for the pond. The required target detention time for WQ_v is 24 hours.

• . . _. . . = ••••.••• / • = 0.007 cfs

•. . = • •. / • . . _. . . = ••••.••• / •.••••• = 240858 seconds = 66.9 hours ü

Example Design

The actual value of t_{WQ} is over two times greater than the required 24 hours. The 1-inch diameter orifice used for the pond design is smaller than the calculated orifice size (diameter of 1.10 inches) from earlier in the Design Procedure. The smaller orifice gives a conservative design with a higher detention time for WQ_v. However, it may not be desirable to have an average detention time for the detained portion of WQv that exceeds 48 hours.

Second Iteration

If the calculated detention time for WQ_v is determined to be too long, a second iteration may be performed to attempt to improve the design. Examples of modifications that could help reduce the detention time for WQ_v include:

- Adjusting the pond configuration to try to get the detention time closer to 24 hours.
- Using an adjustable gate valve to allow the low flow orifice size to be increased above 1 inch.
- Subtracting the portions of WQ_v in the sediment forebays from the pond storage. This subtraction would decrease the required pond volume. It may also be desirable to increase the forebay sizes.

The Example Design will not include the final three design steps (Steps 13-15), but these steps would be incorporated into a full pond design.

STEP 13 – Prepare the vegetation and landscaping plan.

STEP 14 – Prepare the operation and maintenance plan.

STEP 15 – Complete the Design Summary Table.

Design Parameter	Required Size	Actual Size
Pond Type	Pocket Pond	
Vpp	10,762 ft^3 (Vpp + 50%WQ_v)	
Permanent Pool Elevation	529.3 ft	529.3 ft
WQv	3373 ft^3	3373 ft
WQv Elevation	529.6 ft	529.6 ft
Forebay	Forebay 1: 50ft^2 x 4ft Forebay 2: 35ft^2 x 4ft	Forebay 1: 10'x5'x4' Forebay 2: 7'x5'x4'
WQv orifice	1 inch	1 inch with hood

Post Construction Stormwater Control Practices	PTP-05 Infiltration Systems

IS

Symbol

IS

TSS Reduction: 90%

3.4 Post Construction Stormwater Control Fact Sheets (PTP)

Description

Infiltration systems are depressions with no outlet used to detain stormwater for a short period of time until it percolates into the groundwater table. Runoff flows into the system, is stored in the voids between stones and is slowly infiltrated through soil layers. As the stormwater penetrates the underlying soil, chemical, biological, and physical processes remove pollutants. Infiltration systems also provide groundwater recharge and preserve baseflow in nearby streams. Two types of infiltration systems that will be addressed here include: infiltration trenches and infiltration basins.

Applications

Infiltration systems can be used to manage stormwater runoff from urban areas, where they can be used to treat sheet flow from impervious areas. Infiltration systems are typically suitable for the following applications:

- Small drainage areas
- Impervious area runoff
- Offline systems
- Areas where removal of suspended solids, pathogens, metals, and nutrients is needed
- Areas determined appropriate by karst & geotechnical evaluations

Infiltration systems may fail due to improper siting, design, construction and/or maintenance. Infiltration systems are **not** suitable for the following applications:

- As an independent treatment mechanism
- Sites with steep slopes
- Sites where runoff from hot spot landuses that could contribute to groundwater contamination
- Sites that may cause water problems to downgrade properties.
- Sites with high sediment or pollutant loads
- Sites with high pesticide or pathogen levels
- Manufacturing or industrial sites
- Sites with combined sewer overflows are not suitable applications for this BMP

Infiltration systems should only be applied to stabilized drainage areas, as heavy sediment loads from construction areas will clog and disable the infiltration media. Likewise, they should not be used in areas where stormwater has the potential for high silt or clay content. High amounts of organic debris may also cause clogging for infiltration systems.

Infiltration systems should typically be designed for off-line use to capture the first flush of runoff. A diversion structure such as a flow splitter or weir may be necessary to separate and route the first flush to the infiltration system for water quality control, and route the remaining stormwater to a water quantity management device downstream. Infiltration systems are most effective when turbulent flow is minimized and the flow is spread uniformly across the filter media.

Infiltration Systems Variations

Infiltration Trench

Figure PTP-05- 1 Infiltration Trench
Source, Stormwater Managers Resource Center, http://www.stormwatercenter.net

An infiltration trench is a shallow excavated trench that is backfilled with a coarse stone aggregate allowing temporary storage of runoff in the void space of the material. Discharge of this stored runoff occurs through infiltration into the surrounding naturally permeable soil. An infiltration trench is ideal for linear applications, and is most effective when preceded by a pretreatment measure, such as a swale. Since these practices cannot be designed for stormwater quantity control, another measure must be included in the treatment train such as a stormwater pond.

For an infiltration trench, runoff is conveyed from the pretreatment practice into the trench where it is stored in the voids between pea gravel. Treatment occurs as water seeps through the soil. This practice requires verification of soil permeability and contributes to groundwater recharge. If used without proper pretreatment devices, the longevity of this practice may be less than 5 years. Therefore, infiltration trenches should not be constructed as an independent treatment mechanism. This practice is also not appropriate to serve hotspot landuse applications due to the propensity for groundwater contamination.

Infiltration Systems
Variations

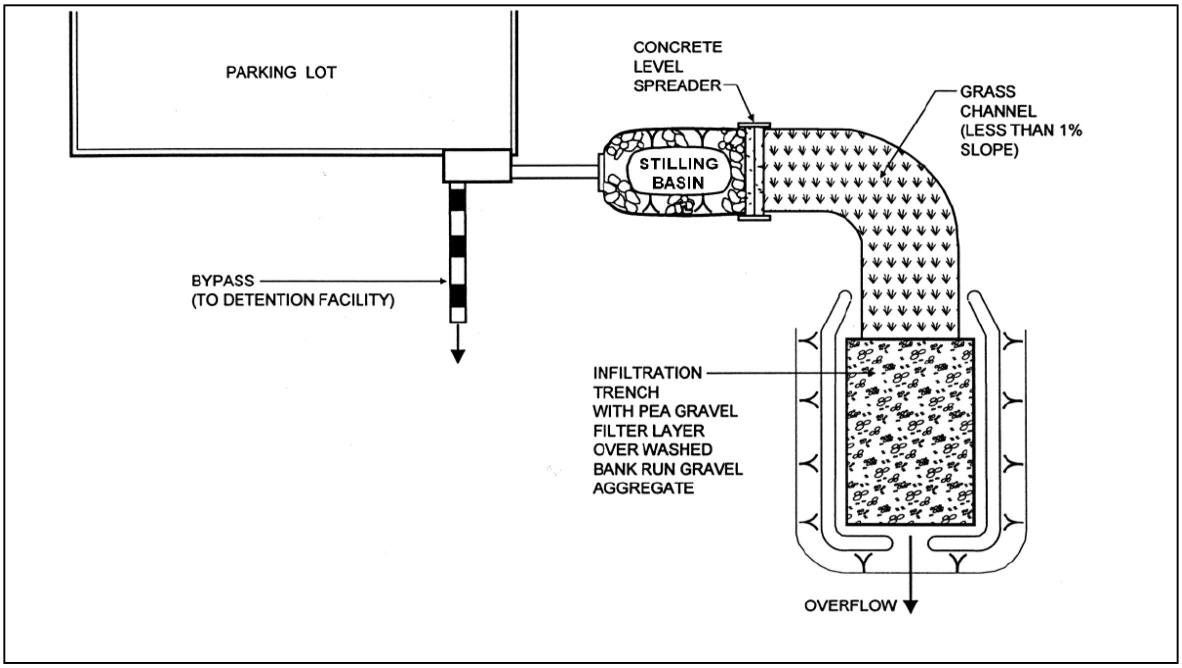


Figure PTP-05- 2 Infiltration Trench
Source: Maryland Stormwater Design Manual

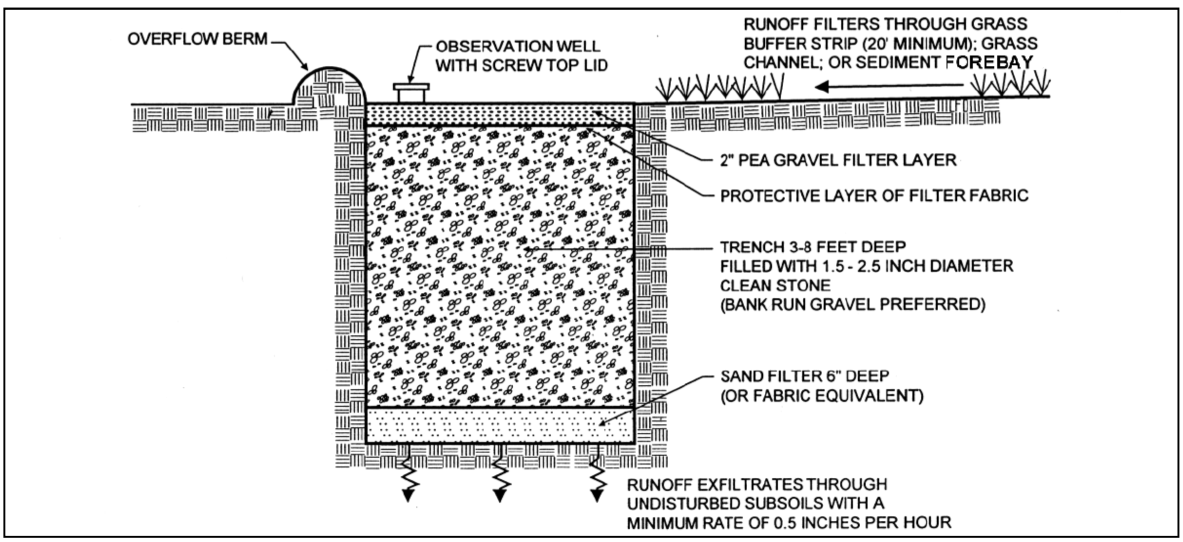


Figure PTP-05- 3 Infiltration Trench
Source: Maryland Stormwater Design Manual

Infiltration Systems Variations

Infiltration Basin

Figure PTP-05- 4 Infiltration Basin
Source, Stormwater Managers Resource Center, http://www.stormwatercenter.net

An infiltration basin is a natural or constructed impoundment that captures, temporarily stores and infiltrates the design volume of water over several days. In the case of a constructed basin, the impoundment is created by excavation or embankment. Like the infiltration trench, this practice is most effective when coupled with pretreatment practices such as grass filter strips or grass channels. This practice requires verification of soil permeability and has high maintenance requirements to prevent clogging. Although this practice does not utilize an outlet, a backup underdrain pipe is incorporated to relieve ponded water that has not infiltrated over long periods of time. Drawbacks to the use of infiltration basins are a high failure rate, and frequent maintenance to maintain soil permeability.

Infiltration Systems
Variations

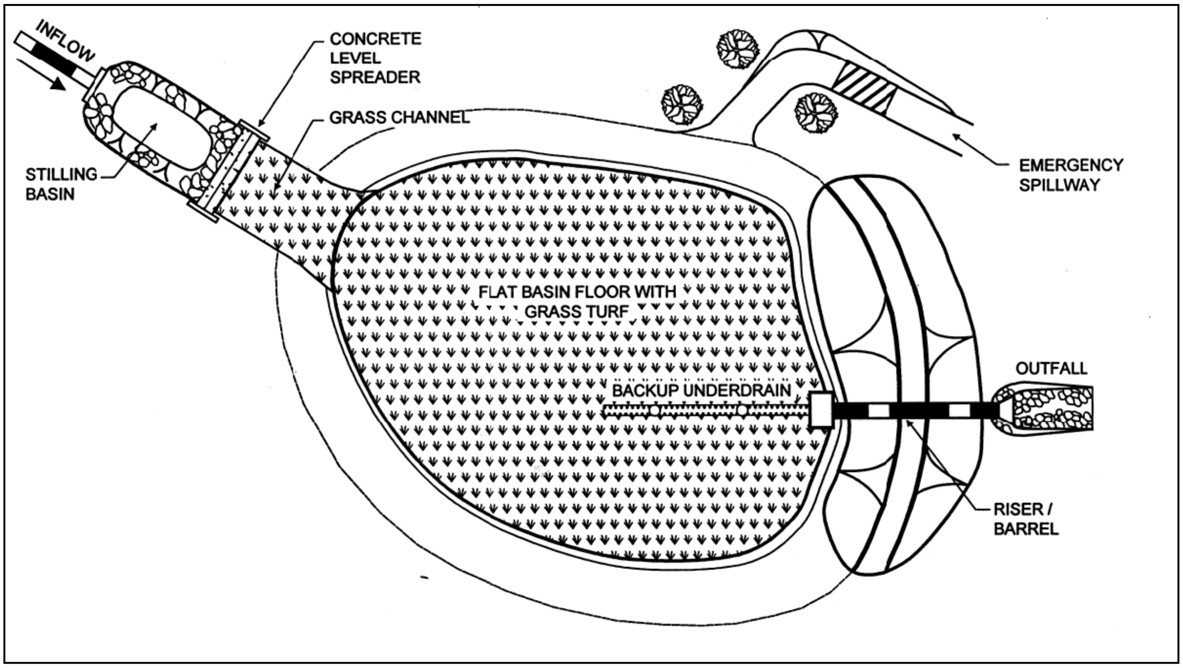


Figure PTP-05- 5 Infiltration Basin
Source: Maryland Stormwater Design Manual

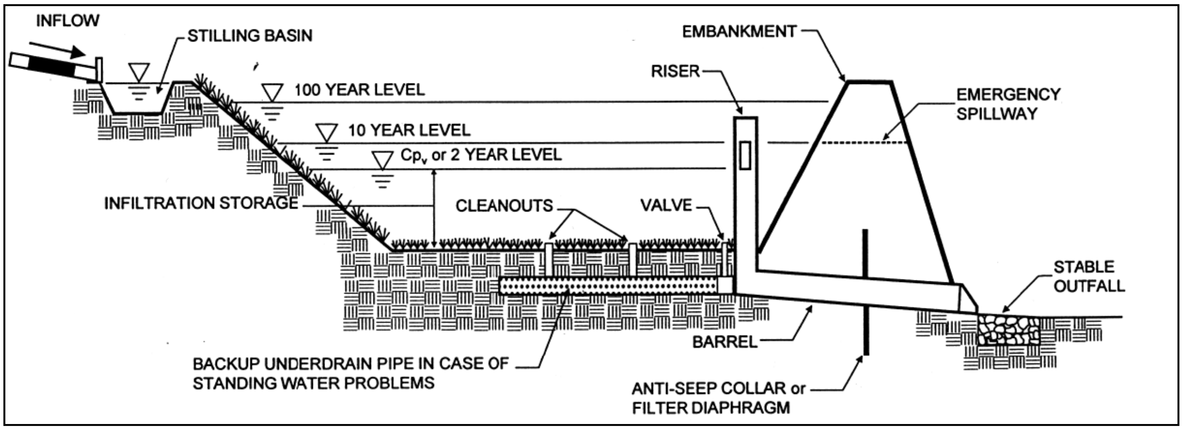


Figure PTP-05- 6 Infiltration Basin
Source: Maryland Stormwater Design Manual

Maintenance

When not properly maintained, infiltration systems have a high failure rate. Maintenance and inspections should be conducted regularly to ensure the long term functionality of the system. An observation well should be installed in trenches to determine how quickly it drains after a storm event and to observe sediment buildup.

As-Needed

- Replace pea gravel/topsoil and top surface filter fabric (when clogged).
- Mow grass filter strips and remove grass clippings.

Monthly

- Ensure that contributing area, practice and inlets are clear of debris.
- Ensure that the contributing area is stabilized.
- Remove sediment and oil/grease from pretreatment devices and outflow structures.
- Repair under cut and eroded areas at inflow and outflow structures.

Semi-Annual

- Check observation wells following 3 days of dry weather (failure to infiltrate within this time indicates clogging).
- Inspect pretreatment devices and diversion structures for sediment buildup and structural damage.
- Remove trees that start to grow in the vicinity of the infiltration system.

Annual

- Disc or aerate basin bottom. De-thatch basin bottom.

Every 5-Years

- Scrape basin bottom and remove sediment. Restore original cross-section and infiltration rate. Seed or sod to restore ground cover.
- If bypass capability is available, utilize to provide an extended dry period. This may allow the system to regain the infiltration rate in the short term.

Upon Failure

- Total rehabilitation of the system to maintain storage capacity.
- Excavate trench walls to expose clean soil.

Design Criteria

- The size of the drainage area typically dictates the type of infiltration system. Infiltration trenches have a maximum drainage area of 5 acres. Infiltration basins can work with drainage areas between 5 and 10 acres.
- Sloped areas immediately adjacent to the bioretention system should be no greater than 15%.
- Both types of infiltration systems provide a 90% TSS reduction.
- Pretreatment by other BMPs is required for infiltration systems.
- The sides of infiltration trenches should be lined with a filter fabric that prevents soil piping but has greater permeability that the underlying soil.
- Sheet flow should enter the infiltration system perpendicular to its main axis, and channel flow should enter parallel to the main axis of the direction of flow.
- Underlying soils must be suitable for infiltration.
- Infiltration systems should be constructed with a minimum of 4 feet distance between its base and the seasonally high water table or bedrock to allow for infiltration to occur.
- If a site overlies karst geology, additional geotechnical investigation must be undertaken. The potential for groundwater contamination and sinkhole collapse must be evaluated.
- A porosity value "n" ($n=V_v/V_t$) of 0.40 should be used in the design of stone reservoirs for infiltration systems.
- Design infiltration systems to fully de-water the entire WQ_v within 48 hours after the storm event.
- A conveyance system shall be included in the design of all infiltration systems in order to ensure that excess flow is discharged at non-erosive velocities.
- A dense and vigorous vegetative cover should be established over the contributing pervious drainage area before runoff can be accepted into an infiltration system. Infiltration systems should not be constructed until the contributing drainage area has been completely stabilized.
- Infiltration systems should not be used for a sediment control device during the construction phase.
- Infiltration systems cannot be covered by an impermeable surface.
- Direct access should be provided to all infiltration practices for maintenance and rehabilitation.

Design Components

- **Site** – Infiltration systems may fail due to improper siting, design, construction and/or maintenance.

  - Soils
    - To be suitable for infiltration, underlying soils should have an infiltration rate of 0.52 inches per hour or greater. Initially, soil infiltration rates can be determined from NRCS soil textural classification and subsequently confirmed by field geotechnical tests.
      - The recommended geotechnical testing is one test hole per 5000 square feet, with a minimum of two borings per facility (taken within the proposed limits of the facility).
    - Soils should have a clay content of less than 20% and a silt/clay content of less than 40%.
    - Infiltration systems should not be located in fill soils.

  - Setbacks
    - 50 feet (horizontally) from 20% or greater slopes
    - 100 feet (horizontally form any water supply well
    - 10 feet down gradient from dry wells
    - 25 feet down gradient from structures

- **Pretreatment** – to ensure the long term effectiveness of infiltration systems, preventative measures should be taken to minimize clogging. Pretreatment is generally most effective when multiple BMPs are placed in series.

  - Before entering an infiltration system, stormwater should first enter a pretreatment practice sized to treat a minimum of 25% of the WQ_v.
    - If the infiltration rate of the underlying soils in the infiltration system treatment area exceeds 2 inches per hour, a pre-treatment practice capable of treating a minimum of 50% of the WQ_v should be used.
    - If the infiltration rate of the underlying soils in the infiltration system treatment area exceeds 5 inches per hour a pre-treatment practice capable of treating 100% of the WQ_v should be used.

  - To prevent cogging and preserve the long term integrity of the infiltration system treatment area infiltration rate, the following pretreatment BMPs/techniques should be used (at least three per trench and two per basin):
    - Grass filter strips/Grass channel
    - Swale
    - Plunge pool
    - Forebay
    - Bottom sand layer
    - Upper sand layer (6" minimum) with filter fabric at the sand/gravel interface
    - Use of washed bank run gravel as aggregate

Design Components

- To protect groundwater from possible contamination, runoff from designated hotspot land uses or activities should not be infiltrated without proper pretreatment to remove hydrocarbons, trace metals, or toxicants.

- Exit velocities from pretreatment systems should be non-erosive and flows should be evenly distributed across the width of the practice.

Treatment

Design infiltration trenches to handle the WQ_v. Stormwater associated with the larger rainfall events should bypass the infiltration trench.

- Conveyance System
  - A flow splitter or diversion structure should be provided to divert the WQ_v to the infiltration system and the larger flows bypass unless the infiltration system is sized for water quality treatment.
  - When a flow splitter or diversion structure is not used the contributing drainage area for the infiltration system should be limited to the appropriate size given the variation, and an overflow should be provided within the system to pass part of the WQ_v to a stabilized watercourse or storm drain.
  - A natural overland flow path may be used for stormwater runoff exceeding the capacity of the infiltration system. However, it should be evaluated for concentrated flow that may cause erosion. If computed flow velocities do not exceed the non-erosive threshold, the overflow may be accommodated by natural topography.

- Infiltration Trenches – range from 2 to 10 feet deep and less than 25 feet wide, with a maximum of 3:1 (H:V) side slopes. The bottom of the infiltration trench should be flat, in order to enable even distribution and infiltration of stormwater. The longitudinal slope may vary from 0% to 1%, while the lateral slopes should be held at 0%. Fill the infiltration trench with a 6" layer of sand and coarse stone aggregate. Install filter fabric to separate the sand layer and coarse aggregate. Infiltration trenches are less conducive to site aesthetics.
  - Observation Well – install an anchored 6 inch diameter perforated PVC pipe with a lockable cap in infiltration trenches to monitor the water level and drawdown time. The pipe should be flush with the bottom of the trench.

- Infiltration Basins – range from 3 to 12 feet deep with a maximum of 3:1 (H:V) side slopes. The bottom of infiltration basin should be flat, in order to enable even distribution and infiltration of stormwater. The longitudinal slope may vary from 0% to 1%, while the lateral slopes should be held at 0%. Infiltration basins should be integrated into the site planning process and aesthetically designed as attractive green space planted with native vegetation.

- Outlet – it is recommended that infiltration systems include dewatering methods in the event of failure. This can be done with an underdrain system that accommodates drawdown. Infiltration basins that are designed for water quality should have a multistage outlet and emergency spillway.

Design Procedures

Compute The following design procedures apply to infiltration trenches and infiltration basins.

Step 1 – Compute runoff control volumes.

- Calculate the Water Quality Volume (WQ_v).

Step 2 – Determine if the development site conditions are appropriate for the use of an infiltration trench.

- Type of development?
- Permeable subsoils?
- Low water table?
- Low sediment load?
- Karst area?

Step 3 – Confirm design criteria and applicability

- Consider any special site-specific design conditions/criteria (Additional Site-Specific Design Criteria and Issues).

Step 4 – Size flow diversion structure, if needed

- A flow regulator (or flow splitter diversion structure) should be supplied to divert the WQ_v to the infiltration trench.
- Size low flow orifice, weir, or other device to pass Q_{wq}.

Step 5 – Size infiltration system.

- The area of the trench can be determined from the following equation:

$$A = (WQ_v) / (nd + kT/12)$$

Where:

A = Surface Area

WQ_v = Water Quality Volume (or total volume to be infiltrated)

n = porosity

d = trench depth (feet)

k = percolation (inches/hour)

T= Fill Time (time for the practice to fill with water), in hours

- A porosity value n = 0.32 should be used. All infiltration systems should be designed to fully dewater the entire WQ_v within 48 hours after the rainfall event. A fill time T=2 hours can be used for most designs.

Design Procedures

- Infiltration Basins should be sized according to the following:
  - Determine the depth of the infiltration basin.

    $D = i \times t$

    Where:

    i = infiltration rate, (in/hr)

    t = maximum drawdown time, (hr)
  - Determine the Effective Infiltration Area of the infiltration basin.

    $A = WQ_v/D$

    Where:

    A = effective infiltration area at the bottom of the practice, (ft^2)

    WQv = Water Quality volume, (ft^3)

    D = maximum depth of practice, (ft)
  - Determine the dimensions of the infiltration basin.

    Design the infiltration basin with a 2:1 length to width ratio at the bottom.
  - Determine the volume of the infiltration basin.

    $V = [(A_1+A_2) / 2] \times D$

    Where:

    A_1 = Area at bottom of infiltration basin, (ft^2)

    A_2 = Area at top of infiltration basin, (ft^2)

    D = Depth of infiltration basin, (ft)

Step 6 –Determine pretreatment volume and design pretreatment measures.

- A pretreatment practice should be sized to treat a minimum of 25% of the WQ_v.
  - If the infiltration rate of the underlying soils exceeds 2 inches per hour a pre-treatment practice capable of treating a minimum of 50% of the WQv should be used.
  - If the infiltration rate of the underlying soils exceeds 5 inches per hour a pre-treatment practice capable of treating 100% of the WQv should be used.

Step 7 – Design underdrains, emergency spillway.

- An underdrain system with a drawdown valve should be provided to dewater an infiltration basin for maintenance.
- Infiltration basins that are designed for water quality should have a multistage outlet and emergency spillway.

STEP 8 – Prepare vegetation and landscaping plan

- A landscaping plan for infiltration system should be prepared to indicate how the infiltration system will be stabilized and established with vegetation. The appropriate grass species and wetland plants should be chosen based on the site location, soil type, and hydric conditions.

Design Procedures

STEP 9 – Complete the Design Summary Table.

Design Parameter	**Required Size**	**Actual Size**
Infiltration System Type		
WQ_v		
Pretreatment Type		
Pretreatment Size, V		
Infiltration Rate		

Example Design

Proposed development of an undeveloped site into an office building and associated parking.

Base Data
Total Drainage area = 5.0 ac
Site Area = 3.54 ac
Soils Type "C"

Pre-Development
Impervious Area = 0 ac; or I = 0%
Meadow (CN = 71)

Post-Development
Impervious Area = 1.72 ac; or I = 1.72/3.54 = 49%
Open Space, Fair (CN = 79)
Paved parking lots, roofs, driveways, etc. (CN =98)

Hydrologic Data

	Pre	Post
CN	71	89

WQ_v Depth = 1.1 in

Precipitation

I_{WQ}	2.45 in/hr
2yr, 24hr	3.54 in
25yr, 24hr	5.88 in
100yr, 24hr	7.43 in

Example Design

This example focuses on the design of an infiltration basin to meet the water quality control requirements. This example design focuses on water quality volume (WQ_v) control only. However, similar design procedures would be used to design for the other water quantity control requirements.

Problem: Design an infiltration basin for this site. Infiltration basins provide 90% TSS reduction. Therefore, not other water quality treatment BMPs will be needed for this site. The total drainage area to the pond is 5 acres, which includes offsite drainage.

Step 1 – Compute runoff control volumes

Total Site WQ_v:

$$WQ_v = [(P\ R_v)(A)]/12$$

Where:

$P = 1.1$ inches

$R_v = 0.05 + 0.009(I)$

$I = 49$

$R_v = 0.05 + 0.009(49) = 0.491$

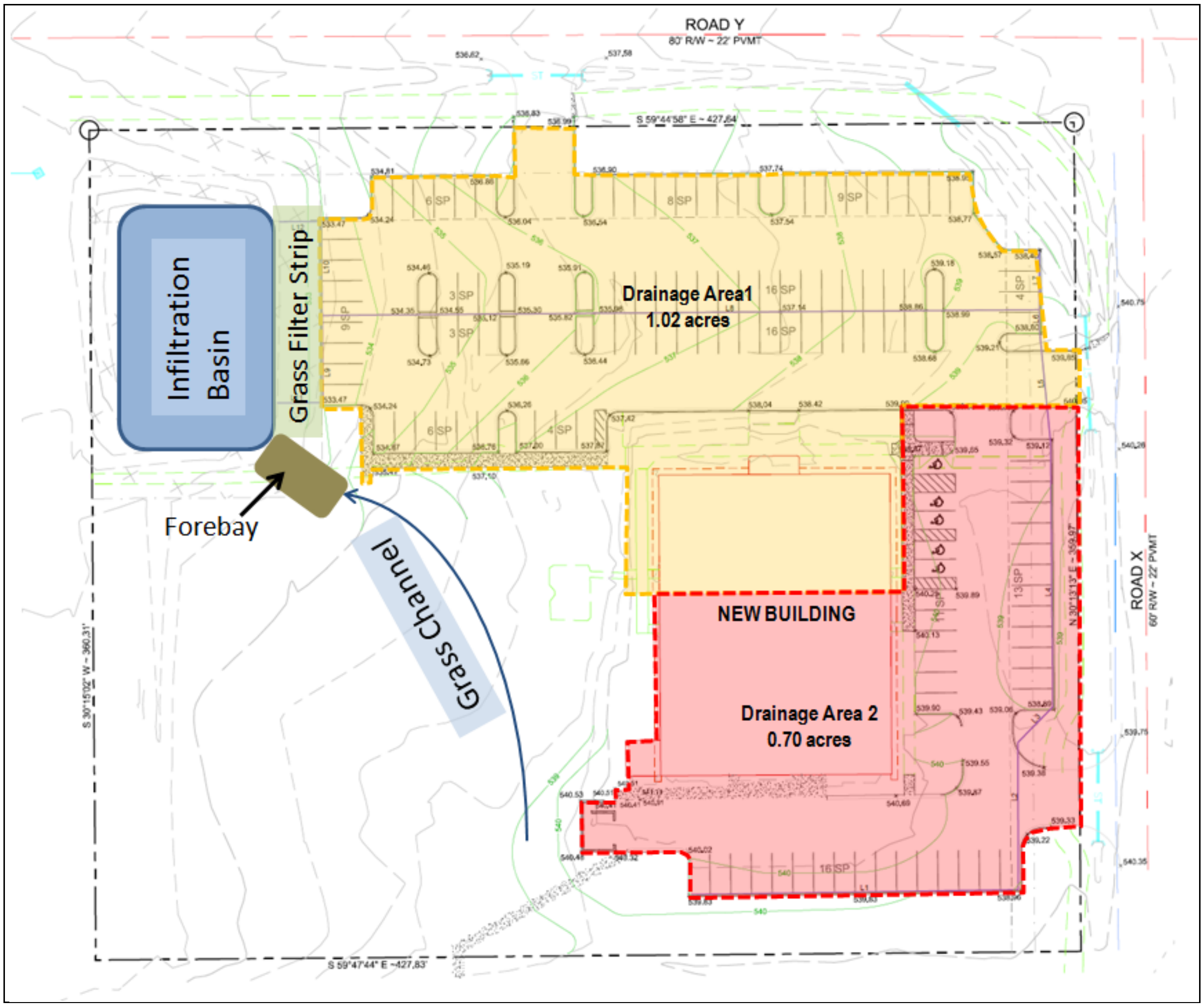
$A = 1.72$ acres

$$WQ_v = (1.1\text{in} \times 0.491 \times 1.72\text{ac})/12 = 0.077 \text{ acre-ft} = 3373 \text{ ft}^3$$

Step 2 – Determine if the development site conditions are appropriate for the use of an infiltration trench.

- Ø The landuse for the development is not considered a hotspot landuse.
- Ø High levels of pesticides, sediment, and other pollutant loads are not anticipated.
- Ø Based upon soil borings, the high water table level is 15 feet below the ground surface, and the clay content is 12%. The silt/clay content is 38%.
- Ø Geotechnical reports found no active karst features on the site.
- Ø There are no water supply or dry wells within 100 ft.

Example Design



Step 3 – Confirm design criteria and applicability

- Underlying soils on this site have an infiltration rate of 0.6 in/hr.
- A sediment forebay will be included and designed for 25% of WQ_v
- A grass lined channel will convey runoff from drainage area 2 to the forebay and infiltration basin. A flow diversion will be incorporated into the channel design to bypass larger storm events. The infiltration basin is only being designed for stormwater quality.
- A grass filter strip will provide pretreatment for drainage area 1.

Step 4 – Size flow diversion structure, if needed

Since the infiltration basin will only treat the water quality volume, a diversion structure will be placed in the grass channel to bypass the flows in excess of WQ_v to the water quality treatment BMP.

Example Design

Step 5 – Size infiltration basin.

- The infiltration basin will have 3H:1 side slopes.
- Determine the depth of the infiltration basin.

  D = i x t

  Where:

  i = infiltration rate, (in/hr)

  t = maximum drawdown time, (hr)

  D = (0.6 in/hr) x (48 hr) = 28.8 in = 2.4 ft

- Determine the Effective Infiltration Area of the infiltration basin.

  A = WQ_v/D

  Where:

  A = effective infiltration area at the bottom of the practice, (ft^2)

  WQ_v = Water Quality volume, (ft^3)

  D = maximum depth of practice, (ft)

  A = (3373 ft^3) / (2.4 ft) = 1406 ft^2

- Determine the dimensions of the infiltration basin.

  Design the infiltration basin with a 2:1 length to width ratio at the bottom. The basin will be 54 ft long and 27 ft wide. The top and bottom dimensions are generally the same.

- Determine the volume of the infiltration basin.

  V = [(A_1+A_2) / 2] x D

  Where:

  A_1 = Area at bottom of infiltration basin, (ft^2)

  A_2 = Area at top of infiltration basin, (ft^2)

  D = Depth of infiltration basin, (ft)

- V = [(1458 ft^2 + 1458 ft^2) / 2] x 2.4 ft = **3499.2 ft^3 > 3373** ft^3 ü

Example Design

Step 6 –Determine pretreatment volume and design pretreatment measures.

- Ø A sediment forebay will be added at the end of the grass channel prior to the WQ_v entering the Infiltration Basin.
- Ø Determine WQ_v conveyed by grass channel.

$WQ_v = [(P\ R_v)(A)]/12$

Where:

P = 1.1 inches

$R_v = 0.05 + 0.009(I)$

I = 49

$R_v = 0.05 + 0.009(49) = 0.491$

A = 0.70 acres for DA2

WQ_v = (1.1in x 0.491 x 0.70ac)/12 = 0.032 acre-ft = 1394 ft^3

- Ø Verify percentage of WQ_v.

%WQ_v pretreated = (1394 ft^3 / 3373 ft^3) x 100 = 41.3% > 25% ü

- Ø Determine Area of the forebay. Set the forebay depth at 3 ft

A = V/D

Where:

A = Area of forebay, (ft^2)

V = Pretreatment Volume, (ft^3)

D = Depth of forebay (ft^3)

A = (1394ft^3) / (3 ft) = 465 ft^2

- Ø Determine the dimensions of the forebay.

Design the forebay with a 2:1 length to width ratio at the bottom. The forebay will be 31 ft long 15 ft wide, and 3ft deep, which is 1395 ft^3 in storage provided.

Step 7 – Design underdrains, emergency spillway.

- Ø An underdrain system with a 6-inch perforated PVC pipe surrounded by a 12-inch thick gravel layer should be used. The 6-in perforated pipe should be connected to a drawdown valve.
- Ø This infiltration basin is designed to treat the water quality volume only with higher flows bypassing the basin. An emergency spillway is not required.

STEP 8 – Prepare vegetation and landscaping plan

- Ø The infiltration basin will have a grass lining.

Example Design

Step 9 –Complete the Design Summary Table.

Design Parameter	**Required Size**	**Actual Size**
Infiltration System Type	Basin	
WQ_v	3373 ft3	
Pretreatment Type	Pretreatment 1: grass filter strip: no design Pretreatment 2: forebay (25% WQv): 1394 ft^3	Pretreatment 1: no design Pretreatment 2: 1395 ft^3
Pretreatment Size, V	3373 ft^3	3499.2 ft^3
Infiltration Rate	0.6 in/hr	0.6 in/hr

3.4 Post Construction Stormwater Control Fact Sheets (PTP)

Post Construction Stormwater Control Practices	PTP-06 Water Quality Units

WQ

Symbol

WQ

TSS Reduction:
Pretreatment: 50%
Full treatment: Varies

Description

Water quality units target pollutants from urban areas or hotspots and provide water quality benefits at stormwater inlets. Units are generally designed as compact below grade systems constructed of precast concrete. Units often employ a swirling motion or baffling that causes sediments and particulates to settle out and a chamber to capture floatable material. Water quality units included here are hydrodynamic separators, filtration units, and continuous deflection separators.

Hydrodynamic separators are flow-through systems with a separation cylinder unit to promote the settlement of sediments and other pollutants. No outside power source is required as the system is designed to utilize the energy of flowing water. Means of separation vary between hydrodynamic separator units, which may employ velocity reduction to allow settling or indirect filtration.

Filtration units are devices inserted into storm drains to filter or absorb sediment, pollutants and oil and grease. Filter media cartridges are commonly used to collect and dispose of pollutants.

Continuous deflection separators treat runoff by screening sediment and debris via a vortex of water that deflects sediment and debris into a sump while water flows through a screen.

Applications

Water quality units work well in areas targeting floatables, grass solids, oils and grease. Water quality units are most suitable for highly impervious sites. Because of their limited removal ability of soluble pollutants and fine particles, these devices should be used as a pretreatment device, and should not act as a stand-alone practice for new development. However, when space is limited, water quality units are ideal for retrofit applications. Site types may include automotive lots, parking lots, roadways, road salt storage facilities, hazardous substance facilities and rooftop runoff.

Water quality units are typically suitable for the following applications:

- Impervious area runoff
- Retrofit applications
- In conjunction with other stormwater BMPs

Target Pollutants

Target pollutants and removal effectiveness may vary widely between the unit type and manufacturer. If available, independent data should be used to consider a water quality unit brand or manufacturer. Independent studies suggest that water quality units primarily target litter and debris with limited pollutant removal capacity, particularly for fine particles and soluble pollutants. Target pollutant information for this fact sheet was based on data from the Environmental Protection Agency's fact sheet, Manufactured Products for Stormwater Inlets, referencing S.S. Greb and R. Waschbusch's study, "Evaluation of Stormceptor® and multi-chamber treatment train as urban retrofit strategies", 1998. This study investigated 45 precipitation events over a 9-month period and calculated percent removal rates to reflect overall efficiency, accounting for pollutants in bypassed flows.

Design Components

- **Hydrodynamic Separators**

Hydrodynamic separators are generally considered flow-through devices that promote settling or separation to remove sediment and other pollutants by a swirling action. These structures do not require outside power sources, and become effective through the energy of flowing stormwater. These units are typically placed beneath parking lots or streets, and are directly connected to impervious areas.

- **Filtration Units**

Filtration units employ some type of filter media that collects stormwater pollutants as water flows through the structure. The filter media must be regularly replaced to allow pollutant removal to continue effectively.

- **Continuous Deflection**

The sizing and design for water quality units should be based on the manufacturer's product specifications. Units are generally designed according to the peak flow rate for a given design storm event at the inlet. Units may have features designed to reduce the velocity of the stormwater flow entering the unit, which increases the capacity of sediment removal of the system.

Design Guidance

Section 2.7 outlines the criteria and approval process for proprietary or manufactured BMPs within the City limits. Where the water quality unit is not rated for full treatment (80% TSS reduction), additional permanent treatment practices are required. Water quality units are not typically designed for stormwater quantity control as well, so a detention structure such as a detention pond will be required.

For water quality units designed based upon a flow rate, the following equation must be used to simulate treatment of the WQ_v:

•• = • • • • •

Where:
Qp = the peak flow through the proprietary BMP in cfs
C = runoff coefficient
I = rainfall intensity, 2.45 in/hr
A = the contributing drainage area for the BMP, in acres

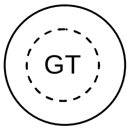
Maintenance

A maintenance and operation plan must be provided for each water quality unit. This information can be provided by the manufacturer and must address the following items:

- Expected clean out frequency
- Unit life expectancy
- Procedures addressing dewatering of the unit, should it get clogged
- A cross sectional view of the unit with all overflow structures, weirs, pipe connections clearly identified
- The bypassing mechanism and any maintenance requirements for that component

3.4 Post Construction Stormwater Control Fact Sheets (PTP)

Post Construction Stormwater Control Practices	PTP-07 Grease Management



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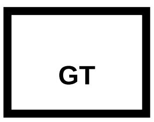


Description

Many businesses such as restaurants and food manufacturing generate grease waste during daily operations. The disposal of grease wastes can become a significant source of pollution in streams if not managed properly. Spills, overflows, and leaks occur due to poor maintenance of storage facilities and lack of proper disposal education. This fact sheet addresses proper disposal technique and storage facilities to hold used fats, oils, and grease. In addition to water quality pollution impacts, poor management practices can cause unpleasant odors, attract rodents, and have negative visual effects.

As grease spills may cause potential health risks, grease practices should be approved by the Health Department, and sites should be maintained according to any special operating requirements for food service establishments or grease collection systems.

Applications

Grease is generated from several different sources, including meat fats, lard, food scraps, sauces, butter or margarine, shortening, and dairy products. Food service industries such as restaurants should implement grease management and staff education to ensure implementation. Grease management implementation is suitable for the following applications:

- Ø Restaurants
- Ø Food Preparation Facilities

Approach

Cover and Contain

In situations where the grease collection dumpster is located outside, overhead cover in the form of a canopy and containment, via a curb system is recommended.

Treat and Discharge

For situations where grease has the potential to be released to the ground, a treat and discharge solution is recommended. This could be accomplished by installing a BMP such as a water quality unit (PTP-06) or another BMP designed to remove oils and greases.

Internal Grease Management

An internal collection system is a closed-loop, grease and oil collection system that utilizes two storage tanks, one each for fresh oil and waste oil. The system directly connects the flow of fresh oil to kitchen oil fryers. Once this oil has been used, the system can directly pump new oil in while the used oil is pumped out. Waste oil and grease is then drained through a filter and to the waste oil storage tank.

Maintenance

A maintenance and operation plan must be submitted for grease management structures that specifically addresses the following items:

- Inspect storage area weekly and following rainfall events
- Repair or replace containment structures, perimeter controls, or storage bin as needed

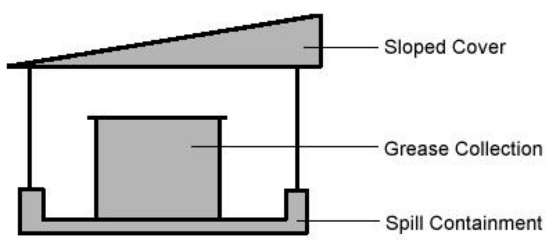


Figure PTP-07- 1 Containment for grease disposal

Management Alternatives

Exterior containment of grease is one management solution, but other management solutions exist. Alternative grease management techniques that are available include internal collection systems (shown in Figure PTP-07-02). These systems, if properly maintained and installed, may be better suited for restaurants or other food preparation facilities that utilize deep fryers or other cooking equipment using large quantities of oil. These systems are often preferred to minimize spills, transfer containers, and related employee injuries.

An internal collection system is a closed-loop, grease and oil collection system that utilizes two storage tanks, one each for fresh oil and waste oil. The system directly connects the flow of fresh oil to kitchen oil fryers. Once this oil has been used, the system can directly pump new oil in while the used oil is pumped out. Waste oil and grease is then drained through a filter and to the waste oil storage tank.

The system is metered by a service provider who monitors need for delivery of new oil and removal of waste oil. This is performed through a pump system and directly transferred to the delivery/removal truck.

Although the City of Bowling Green does not endorse specific brands or products, one example of an internal collection system manufacturer and provider is Restaurant Technologies, Inc. (RTI). More information about RTI products can be found on their website, www.rti-inc.com.

Figure PTP-07- 2 Internal Grease Collection System

3.4 Post Construction Stormwater Control Fact Sheets (PTP)

Post Construction Stormwater Control Practices	PTP-08 Dry Detention/Dry ED Ponds

D

Symbol

DB

TSS Reduction: 60%

Description

KEY CONSIDERATIONS

- Applicable for drainage areas up to 75 acres
- Typically less costly than stormwater (wet) ponds for equivalent flood storage, as less excavation is required
- Often used in conjunction with water quality structural control
- Recreational and other open space opportunities between storm runoff events
- Typical BMP used in residential landuse

Dry detention and dry extended detention (ED) ponds are surface facilities intended to provide for the temporary storage of stormwater runoff to reduce downstream water quantity impacts. These facilities temporarily detain stormwater runoff, releasing the flow over a period of time. They are designed to completely drain following a storm event and are normally dry between rain events. Dry detention ponds are intended to provide overbank flood protection (peak flow reduction of the 25-year storm, Q_{p25}) and can be designed to control the extreme flood (100-year, Q_{p100}) storm event. Dry ED ponds provide Q_{p25} and Q_{p100} control. Both dry detention and dry ED ponds provide limited pollutant removal benefits and are not intended for water quality treatment. Detention-only facilities must be used in a treatment train approach with other structural controls the 80% TSS reduction goal. Compatible multi-objective use of dry detention facilities in strongly encouraged.

Applications

BMP Suitability

- Used for residential, commercial and industrial sites
- Large space requirement
- Not well-suited for sites with
  - Low relief
  - High water table
  - Near-surface bedrock
- Safety concerns should be considered in deciding BMP use
- Extended detention ponds can be sized to treat WQ_V.
- Cannot be used alone to meet the 80% TSS reduction goal. Must be used in a treatment train.
- Suitable for a secondary or end-of-pipe BMP at the downstream end of a treatment train.
- This BMP is prone to sediment re-suspension since the pond does not have a permanent pool
- This BMP's performance may be enhanced by using multiple treatment cells in succession.
- Use of upstream BMPs may also reduce the required detention pond size and outflow regulation requirements.

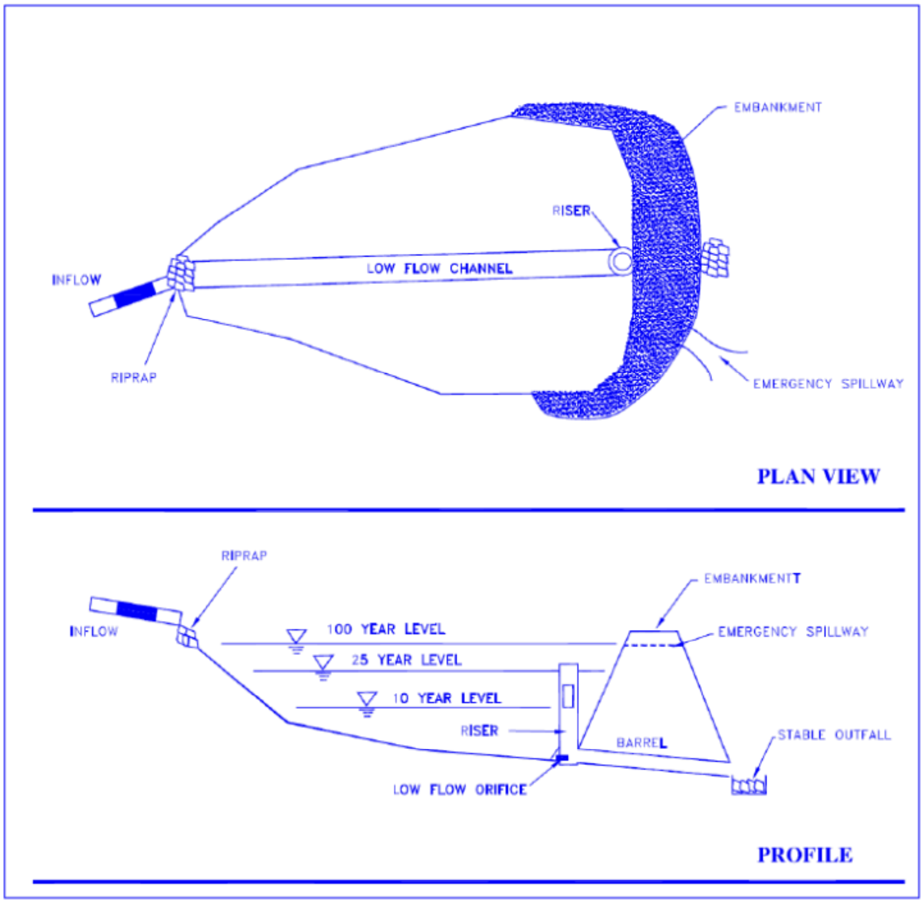


Figure PTP-08- 1 Detention Pond
Source, Center for Watershed Protection

Maintenance

A site-specific maintenance plan describing maintenance responsibilities must be developed. that addresses the following items:

- Ø Maintenance access for appropriate equipment, vehicles, and personnel
- Ø Vegetation maintenance schedule that includes mowing multiple times per year
- Ø Inspection checklist
- Ø Maintenance agreement between the facility owner and the City with these items:
  - Sediment removal from the forebay and/or pond when sediment depth is ½ of the total depth to the outlet, or is greater than 1.5 feet (whichever is less)
  - Clean and/or repair outlet devices if drawdown times exceed 48 hours
  - Trash and debris should be removed as necessary
- Ø Grass cover filters should be mowed as needed (maximum grass height of 12 inches)
- Ø Properly dispose of any material generated during maintenance activities.

Maintenance

Monthly to Quarterly or After Major Storms (>1")

Check that the maintenance access is free and clear.

- Inspect low flow orifices and all pipes for clogging.
- Check the pond area for debris, bare soil areas and undesirable vegetation.
    - The minimum mowing requirements will be a spring mowing and a fall mowing.
    - Remove debris.
    - Repair undercut, eroded and bare soil areas.
- Look for damaged safety measures or other dangerous items.

Semi-Annual to Annual

- Ensure that the pond's mechanical components (if any) are functional. Repair broken mechanical components if needed.

1-3 Years

- Inspect riser, barrel and embankment for damage. Make any needed repairs.
- Inspect all pipes.
- Monitor sediment deposition in the pond and in the forebay. Remove sediment from the forebay and the pond when needed.

5-25 Years

- Use remote television inspection of the reverse slope pipes, underdrains or other hard-to-access piping. If needed, replace or repair pipes.

Embankment

The pond embankment and/or riser will require inspection by a qualified professional (e.g., structural engineer, geotechnical engineer, etc.) who has experience in the construction, inspection and repair of these features.

Inspection Checklist	All appropriate items should be checked on the inspection checklist. If an applicable item does not meet the condition on the checklist, maintenance and/or repair should be planned.

Monthly

- ☐ Maintenance access is free and clear
- ☐ Low flow orifice(s) and pipes are free from clogging.
- ☐ Pond areas are free of debris.
- ☐ Pond area is stabilized with no evidence of erosion.
- ☐ Pond areas do not include any undesirable vegetation (i.e., woody vegetation near the embankment, etc.).
- ☐ Pond vegetation is mown with grass height no greater than 12 inches.
- ☐ There are no damaged safety measures or other dangerous items at the pond.

Semi-Annual to Annual

- ☐ The pond's mechanical components (if any) are functional.

1-3 Years

- ☐ The riser, barrel and embankment were inspected for damage and do not require repairs.
- ☐ All pipes were inspected and do not require repairs or replacement.
- ☐ The sediment deposition in the pond and in the forebay was checked, and, if needed, sediment was removed from these areas.

5-25 Years

- ☐ Use remote television inspection of the reverse slope pipes, underdrains or other hard-to-access piping. If needed, replace or repair pipes.

Design Criteria

Location and Layout

- As dry detention and dry ED ponds provide limited water quality benefits, they are to be located downstream of other structural stormwater controls providing treatment of the water quality volume (WQ_v) to meet the 80% TSS reduction goal.
- The maximum contributing drainage area to be served by a single dry detention or dry ED pond is 75 acres.
- A minimum separation distance between the pond and the groundwater table and/or an impervious liner may be required for ponds where source water protection is required or for contributing drainage areas designated with "hot spot" landuses.

General Design

- Dry detention ponds are sized to temporarily store the volume of runoff required to provide Q_{p25} protection (i.e., reduce the post-development peak flow of the 25-year storm event to the pre-development rate), and control the 100-year storm (Q_{p100}) if required. The dry detention pond should be sized to release the WQ_v over 24 to 36 hours.

  Dry ED ponds are sized to provide extended detention of the water quality volume over 24 hours and can also provide additional storage volume for normal detention (peak flow reduction). Routing calculations must be used to demonstrate that the storage volume is adequate for peak flow attenuation (see Appendix B).
- The dry pond or ED pond must be installed in series with other water quality BMPs to achieve the 80% TSS reduction goal.
- The maximum depth of the pond should not exceed 10 feet.
- Areas above the normal high water elevations of the detention facility should be sloped toward the pond to allow drainage and to prevent standing water. Careful finish grading is required to avoid creation of upland surface depressions that may retain runoff. The bottom area of storage facilities should be graded toward the outlet to prevent standing water conditions. A low flow or pilot channel across the facility bottom from the inlet to the outlet (often constructed with concrete) is recommended to convey low flows and prevent standing water conditions.
- For karst areas, it is recommended that ponds use an impermeable liner and include a minimum three foot separation from the high water table.
- A landscaping plan must address how the pond and the surrounding areas will be stabilized and how vegetation will be established. This plan should include maintenance actions and schedules for the vegetation.
- Pre-treatment measures such as other water quality BMPs and/or forebay(s) are desirable. For areas receiving drainage from potential "hot spot" landuse areas, the pre-treatment measures may need an impermeable liner and/or other separation to keep stormwater separated from groundwater.

Design Criteria

- Direct vehicle/equipment access should be required for forebays to allow for sediment removal and maintenance.
- The bottom of the forebay may be hardened using concrete, asphalt or grouted riprap to make sediment removal easier.

Inlet and Outlet Structures

- Inflow channels are to be stabilized with flared riprap aprons, or the equivalent.
- Pond outlets must be designed to prevent discharge of floating debris.
- Burying all pipes below the frost line can prevent frost heave and pipe freezing.
- A riser or an alternative method may be used for the pond's principal spillway. This riser must include a low flow orifice to allow the pond to fully dewater for a dry pond.
- The outflow riser should be located so that short-circuiting between inflow points and riser does not occur.
- Riprap, plunge pools or pads, or other energy dissipators are to be placed at the end of the outlet to prevent scouring and erosion.

Embankment

- Vegetated embankments shall be less than 20 feet in height and shall have side slopes no steeper than 2:1 (horizontal to vertical) although 3:1 is preferred. Riprap-protected embankments shall be no steeper than 2:1. Geotechnical slope stability analysis is recommended for embankments greater than 10 feet in height and is mandatory for embankment slopes steeper than those given above. All embankments must be designed to State of Kentucky guidelines for dam safety.
- Seepage control or anti-seep collars should be provided for all outlet pipes.
- A minimum of 1 foot of freeboard above the elevation corresponding with the Q_{p100} must be provided for earthen embankments. For dug ponds, the freeboard must be provided and identified in the area of inundation.

Maintenance and Safety

- Adequate maintenance access must be provided for all dry detention and dry ED ponds. One approach for this is to incorporate an access bench (a shallow slope area adjacent to the pond) that will be used for equipment access.
- The forebay of the pond should include a fixed vertical sediment depth marker securely installed in the forebay. This marker will be used as an indicator for when sediment removal is needed in the forebay. Sediment removal should occur for forebay areas when 50% of the total forebay storage capacity is filled with sediment.
- The riser configuration should be planned for future maintenance, lessening the clogging potential, planning access for inspections and maintenance, and safety from improper access by children and/or vandals.

Design Criteria

- Ø Public safety must be considered in every aspect of the pond design.
- Ø Dam safety regulations must be strictly followed in pond design and maintenance to ensure that downstream property and structures are adequately protected.
- Ø OSHA safety procedures must be followed for maintenance activities in enclosed areas, such as outlet structures.

Design Components

Pre-Treatment

- Ø A sediment forebay sized to 0.1 inches per impervious acre of contributing drainage should be provided for dry detention and dry ED ponds that are in a treatment train with off-line water quality treatment structural controls. This forebay may be a small pool separated from the pond area by barriers such as earthen berms, concrete weirs or gabion baskets.

Inlet and Outlet Structures

- Ø Where the outlet structure is connected to an improved sinkhole, zero drawdown through the sinkhole must be assumed.
- Ø For a dry ED pond, a low flow orifice capable of releasing the water quality volume over 24 hours must be provided. The water quality protection orifice should have a minimum diameter of 3 inches and should be adequately protected from clogging by an acceptable external trash rack. The orifice diameter may be reduced to 1 inch if internal orifice protection is used (e.g., an over perforated vertical stand pipe with 0.5-inch orifices or slots that are protected by wire cloth and a stone filtering jacket). Adjustable gate valves can also be used to achieve this equivalent diameter.
- Ø For a dry detention pond, the outlet structure shall be sized according to the detention requirements found in Warren County Government's Subdivision Regulations, Appendix B, and can consist of a weir, orifice, outlet pipe, combination outlet, or other acceptable control structure. Small outlets that will be subject to clogging or are difficult to maintain are not acceptable.
- Ø An emergency spillway is to be included in the stormwater pond design to safely pass the extreme flood flow. The spillway prevents pond water levels from overtopping the embankment and causing structural damage. The emergency spillway must be designed to State of Kentucky guidelines for dam safety and must be located so that downstream structures will not be impacted by spillway discharges.
- Ø A riser or an alternative method may be used for the pond's principal spillway. This riser must include a low flow orifice to allow the pond the fully dewater for a dry pond.
    - o For perforated risers, the minimum opening diameter should be ½ inch and the minimum pipe diameter is 8 inches.
    - o The low flow orifice for the riser must be adequately protected from clogging. This protection may be an acceptable external trash rack (recommended minimum orifice diameter of 3 inches) or a smaller orifice diameter may be used along with internal orifice protection (recommended minimum diameter of 1 inch).
    - o One example alternative method would be to use a broad crested, rectangular, V-notch or proportional weir, protected by a half-round CMP.

Design Components

- The pond must include an emergency spillway to pass storm events in excess of the pond's hydraulic design. The emergency spillway must be stabilized to prevent erosion, must comply with state dam safety requirements and must be located so that downstream structures will not be impacted by spillway discharges. If the emergency spillway crosses the maintenance access for the pond, materials meeting the appropriate load requirements must be selected.
- Riprap, plunge pools or pads, or other energy dissipators are to be placed at the end of the outlet to prevent scouring and erosion. If the pond discharges to a channel with dry weather flow, care should be taken to minimize tree clearing along the downstream channel, and to reestablish a forested riparian zone in the shortest possible distance.
- For outlets, it is recommended that a stilling pond or outlet protection be used to reduce outflow velocities to non-erosive velocities and sheer stresses.

Pond

As dry detention and dry ED ponds provide limited water quality benefits (60% TSS reduction), they are to be located downstream of other structural stormwater controls providing treatment of the water quality volume (WQ_v) to provide the full 80% TSS reduction.

- Adequate maintenance access must be provided for all dry detention and dry ED ponds. One approach for this is to incorporate an access bench (a shallow slope area adjacent to the pond) that will be used for equipment access.
    - The recommended access bench width is 10 feet (minimum 8 feet).
    - The maximum access bench cross-slope should be 0.06:1 (V:H) or 6%.
    - Use a maximum bench slope of 0.15:1 (V:H).
    - The bench should be appropriately stabilized for vehicle and equipment access.
    - This bench may also consider extending to other areas such as forebays, inlet and outlet, and should also consider the need for vehicle turn around space.
    - Access benches are not needed for ponds with side slopes that are 1:4 (V:H) or flatter.
    - The recommended maintenance access will connect with a maintenance right-of-way or easement (if needed) that will extend from the pond to a public or a private road.
- The maximum contributing drainage area to be served by a single dry detention or dry ED pond is 75 acres.
- The minimum length to width ratio for the pond is 1.5:1.
- It is recommended that the pond's footprint cover approximately 1-3% of the contributing drainage area.

Design Components

- A minimum separation distance between the pond and the groundwater table and/or an impervious liner may be required for ponds where source water protection is required or for contributing drainage areas designated as “hot spots”.
- Side slopes should not exceed 1V:3H.
- The slopes immediately adjacent to the pond should be less than 25% but greater than 0.5-1% to maintain positive drainage toward the pond.
- For karst areas, it is recommended that ponds use an impermeable liner and include a minimum three foot separation from the barotic rock layer. Liner options include a layer of 6-12 inches of clay soil including bentonite (minimum 15% passing the #200 sieve and a maximum permeability of 1X 10^{-5} cm/sec), a 30 mL polyliner or another approved engineering design.
- A landscaping plan must address how the pond and the surrounding areas will be stabilized and how vegetation will be established. This plan should include maintenance actions and schedules for the vegetation.
- Inspections during construction are needed to confirm that the pond is being built according to the approved design standards and specifications. A detailed construction inspection checklist should be developed that will include sign-offs by qualified individuals at critical construction stages to ensure that the contractor’s interpretation of the plan is acceptable to the project’s professional designer. As-built inspection documentation is required.

Embankment

- Vegetated embankments shall be less than 20 feet in height and shall have side slopes no steeper than 2:1 (horizontal to vertical) although 3:1 is preferred. Riprap-protected embankments shall be no steeper than 2:1. Geotechnical slope stability analysis is recommended for embankments greater than 10 feet in height and is mandatory for embankment slopes steeper than those given above. All embankments must be designed to State of Kentucky guidelines for dam safety.
- Seepage control or anti-seep collars should be provided for all outlet pipes.
- A minimum of 1 foot of freeboard must be provided, measured from the top of the water surface elevation for the extreme flood, to the lowest point of the dam embankment not counting the emergency spillway.
- For earthen embankments, suitable soils must be used to construct the embankment.
- Woody vegetation should not be planted or allowed to grow within 15 feet of the embankment toe and within 25 feet of the inlet and outlet structures.

Design Procedure

Step 1 – Make a preliminary judgment as to whether site conditions are appropriate for the use of a dry pond or dry ED pond, and identify the function of the pond in the overall treatment system. This includes performing an initial suitability screening for the site.

- Consider basic issues for initial suitability screening, including:
  - Site drainage area
  - Site topography and slopes
  - Soil characteristics
  - Depth to water table and bedrock
  - Presence of active karst features and/or wetlands
  - Post-development landuse (Is it a potential "hot spot" landuse?)
- Determine how the dry pond or dry ED pond will fit into the overall stormwater treatment system.
  - Keep in mind that other water quality BMPs are needed upslope of the pond for impervious area drainage, and that the pond cannot be a primary water quality BMP.
  - Decide where on the site the pond is most likely to be located.
- Determine how the dry pond or dry ED pond will fit into the overall stormwater treatment system.

Step 2 – Confirm design criteria, site constraints and applicability.

- Determine the design criteria that will be used.
  - Local construction and stormwater requirements
  - State stream construction permitting (if in a floodplain area)
  - State dam safety guidance (for ponds with embankments)
  - Any other criteria or restrictions that apply
- Determine any constraints the site will place on the pond such as:
  - Limited amount of space and surface area available for treatment
  - High water table
  - Active karst areas
- Determine the TSS reduction provided, using the equations below for weighted TSS reduction, $TSS_{weighted}$, and TSS treatment train, TSS_{train}. The minimum TSS reduction required for the site is 80% and can be weighted for the site.

$$\%TSS_{\text{weighted}} = \frac{\sum_{n}^{1}(TSS_1 A_1 + TSS_2 A_2 + \ldots + TSS_n A_n)}{\sum_{n}^{1}(A_1 + A_2 + \ldots + A_n)}$$

Where runoff is treated by two or more BMPs in series, the TSS reduction provided is calculated with the following equation for a treatment train:

Design Procedure

$$TSS_{train} = A + B - \frac{(A \times B)}{100}$$

Where A is the TSS reduction provided by the first BMP and B is the TSS reduction provided by the next BMP.

$\boxed{\textbf{Step 3}}$ –Confirm site suitability, including field verification of site suitability.

- The field verification should be conducted by a qualified geotechnical professional.
- The recommended minimum is one soil boring per acre with a minimum of three soil borings or pits dug at the same location as the proposed pond. The borings or pits will be used to verify soil types and to determine the depth to groundwater and bedrock.
- The recommended minimum depth of the soil borings or pits is five feet below the bottom elevation of the proposed pond.

$\boxed{\textbf{Step 4}}$ – Compute runoff control volumes and peak flows. Refer to Chapter 2 and Appendix B for more information on these values. Note that this design is only for water quality treatment, not quantity control. Therefore, only TSS reduction and WQ_v design is included.

- Calculate the Water Quality Volume (WQ_V).

  WQ_v = [P Rv)(A)]/12

  Where:

  P = is the average rainfall, (inches)

  R_V = 0.05 + 0.009(I), where I is the percent impervious cover

  A = the area of imperviousness, (acres)

- Calculate the peak flow for the Water Quality Volume (Q_{wq}).

  $Q_{wq} = C \times I_{WQ} \times A$

  Where:

  Q_{wq} = the water quality volume peak flow, (cfs)

  C = the runoff coefficient

  I_{WQ} = the rainfall intensity, (in/hr)

  A = the area of imperviousness, (acres)

- Calculate the volume for the Peak Flow attenuation. See appendix B for more information on detention requirements.

  If the pond will be used as the only BMP for rate control for larger storms, the pond should be designed to treat the entirety of each of these runoff control volumes. If other BMPs will be used to control portions of these runoff control volumes, the portion handled by other BMPs may be subtracted from the appropriate volumes to determine the volumes to be controlled in the pond.

Design Procedure

Note: Steps 5 – 12 may be iterative to achieve a pond design that meets the required performance and the site constraints.

Step 5 – Determine the pond location and preliminary geometry.

Ø Use the following steps to develop the preliminary grading plan for the pond.

- o Locate the pond at the site's lowest elevation area that is not in a jurisdictional wetland or active karst area. Provide space around the pond for maintenance access (minimum width of 8 feet, recommended minimum width of 10 feet).
- o Provide storage based on the water quality volume (WQ_V), volume for the Q_{p25} and Q_{p100}. .
- o Considering the desired pond footprint during the WQ_V, allocate storage volume above the riser bottom orifice for WQ_V. Flow attenuation must be provided for the Q_{p25} and Q_{p100}. While developing the grading plan, consider the desired (or required) length to width ratio and side slopes based on the Design Criteria and Design Components information.
- o Once the preliminary grading plan has been developed, determine the associated stage-storage relationship for water surface elevations through the maximum expected levels.

Ø Use the average end area method (or other equivalent method) to calculate the approximate storage at a given stage (elevation). The area within each of the closed contour lines on the pond's grading plan is measured. The average area is calculated between two adjacent contours. The average areas are then multiplied by the elevation difference to calculate the approximate volume between the two contours.

$$\bullet... = \frac{\bullet. + \bullet.}{\bullet} \times (\bullet.\ \bullet\ \bullet.)$$

Where:

V_{1-2} = the volume between contour 1 and contour 2 (acre-feet)

A_1 and A_2 = the areas within closed contours 1 and 2, respectively (acres)

E_1 and E_2 = the elevations of contours 1 and 2, respectively (feet)

The cumulative pond volume above the bottom of the pond can be calculated by adding the incremental volumes. The stages (elevations) and the corresponding storages can be used to develop a stage-storage-discharge table as the outlet structures are designed. This is an iterative process that may require revising the preliminary grading plan and recalculating the stage-storage relationship until all of the items in Design Criteria and Design Components are satisfied.

STEP 6 – Determine the pre-treatment volume for the sediment forebay.

Ø Where there are no adequate upstream treatment BMPs, a sediment forebay or a similarly performing treatment system is recommended at each inlet to the pond that conveys 10% or more of the total design inflow.

Design Procedure

- The recommended forebay volume is 10% of the WQ_v with a depth of 4-6 feet. More shallow depths increase the potential for sediment re-suspension in the forebay.
- Both the storage volume of the forebay and the storage volumes for other water quality BMPs upstream in the treatment train count toward the required water quality volume, and may be subtracted from the total water quality volume required.

STEP 7 – Size and design the outlet structures.

- The pond must include the following outlet stages in the pond design. It is possible to design one device to meet all required stages.
- The assumed water quality volume (low flow) outlet is an orifice at the bottom of the riser designed to release WQ_v with an average detention time of 24 hours. After designing the low flow orifice, the design should be checked to verify that the release rate is no greater than 5.66 cfs/acre of pond surface area.
- The pond must also be designed to meet the requirements of Warren County Government's Subdivision Regulations, Appendix B.
- The following outlet equations are based on assumptions about the outlet structure type that will be used to control flows at various stages. If a different structure type is selected, the designer must use specific equations for structure type to determine the stage-discharge relationships. However, the general design approach will remain the same even if a different outlet structure type is used for the pond calculations.
- The average release rate of WQ_v (Q_{WQ_avg}) is calculated using the following equation: Hydrologic software can be used for determining the release rate and stage-storage table.

$$\bullet\,.\,.\_\ldots = \frac{\bullet\,\bullet\,.}{\bullet\,.\,.}$$

Where:

Q_{WQ_avg} = average release rate of WQ_v (cfs)

t_{WQ} = the intended WQ_v detention time (seconds)

WQ_v = water quality volume (cubic feet)

- From the stage-storage table, find the elevation associated with WQ_v. Calculate the approximate average head (in feet) on the water quality outlet (h_{wq_avg}) using the following equation:

$$\bullet\,.\,.\_\ldots = \frac{\bullet\,.\,.\ \bullet\ \bullet\ldots\ldots\ldots}{2}$$

Where:

h_{wq_avg} = average head on the water quality outlet (feet)

E_{WQ} = the WQ_v pool elevation (feet)

$E_{PermPool}$ = the permanent pool elevation (feet) at the invert of the water quality orifice. For a dry pond, this elevation is at the bottom of the pond.

Design Procedure

- Using the determined opening and spillway information, incorporate the outlet structures into the pond design. Keep in mind that the spillway design must also consider using measures such as removable trash racks to prevent the discharge of floating debris.

STEP 8 – Design the spillways and embankments.

- All spillway and embankment design must meet any applicable state and/or local criteria.
- The emergency spillway must be stabilized.
- The embankments must be overfilled by at least 5% to allow for settling.
- The minimum embankment with is 6 feet. A wider embankment width may be preferred for maintenance access.
- All embankments must be adequately stabilized with appropriate non-woody vegetation or other measures.
- The embankment and spillway side slopes should be no steeper than 1:3 (V:H).
- Using the determined opening and spillway information, incorporate the outlet structures into the pond design. Keep in mind that the spillway design must also consider using measures such as removable trash racks to prevent the discharge of floating debris.

STEP 9 – Design the inlets.

- If inflow inlet pipes are used, it is recommended that the pipes be buried below the frost line.
- Inlet design should consider preventing or reducing scour by including riprap or flow diffusion devices such as plunge pools or berms.

STEP 10 – Design the sediment forebay.

- The sediment forebay size was determined in Step 6.
- The bottom of the forebay may be hardened using concrete, asphalt or grouted riprap to make sediment removal easier.
- The forebay outlets should include non-erosive conditions as flows move from the forebay to the pond.
- The forebay of the pond should include a fixed vertical sediment depth marker securely installed in the forebay. This marker will be used as an indicator for when sediment removal is needed in the forebay. Sediment removal should occur for forebay areas when 50% of the total forebay storage capacity is filled with sediment.

STEP 11 – Design the maintenance access and safety features.

- Maintenance access and safety features should meet the requirements included in the Design Criteria and Design Component sections.
- Any additional safety features or signage should be added as appropriate.

Design Procedure

- Calculate the required orifice cross-sectional area indirectly by using the orifice equation.

$$Q_{WQ} = C A_{WQ} \sqrt{2 g h_{WQ}}$$

Where:

C = the orifice coefficient (0.6 is typically used, but not apply for all cases)

A_{WQ} = the orifice area (square feet)

g = gravitational acceleration (32.2 feet/s^2)

- Calculate the orifice diameter using the following equation:

$$d_{WQ} = 2\sqrt{\frac{A_{WQ}}{\pi}}$$

Where:

d_{WQ} = the orifice diameter (feet)

- The rate of discharge for the orifice for any head value at the water quality orifice (h_{WQ}) can be calculated using:

$$Q_{WQ} = C A_{WQ} \sqrt{2 g h_{WQ}}$$

Where:

Q_{WQ} = the orifice discharge rate at head h_{WQ} (cfs)

h_{WQ} = the head value above the water quality orifice (feet)

- Calculate the control for the 25-year, 24-hour runoff peak flow (Q_{P25}). The calculation procedures will be similar to those used for the low flow orifice except that any higher outflow openings (i.e., perforated riser openings, weir, orifices, etc.) would be included as well. The combined outflow from all openings must be such that the post-development Q_{P25} does not exceed the pre-development Q_{P25}.
- The combined outflow from the low flow orifice and any higher outflow openings is calculated by adding together the discharges from each structures associated with a given head value and a specified pond water surface elevation.
- Calculate the required control for the 100-year storm peak flow (Q_{p100}). If required, the post-development Q_{p100} must be no greater than the pre-development Q_{p100}. At minimum, Q_{p100} must be able to be safely passed through the pond with 1-2 feet of freeboard below the top of the embankment. Check with local officials and/or state dam safety personnel to determine whether Q_{p100} may be passed using only a principal spillway, or if a combination of a principal spillway and emergency spillway will be required. If an emergency spillway is required, the spillway type is often a broad-crested weir or similar structure that is not easily obstructed. The combined outflow through all spillway openings is calculated by adding together the discharges for each opening associated with a given head value and a specified water surface elevation.

Design Procedure

- Dam safety regulations must be strictly followed in pond design and maintenance to ensure that downstream property and structures are adequately protected.
- OSHA safety procedures must be followed for maintenance activities in enclosed areas, such as outlet structures.

STEP 12 – Check the expected pond performance against regulatory requirements.

- The pond design should be re-checked to confirm that the pond meets the flow control requirements.
- The average detention time for WQ_v is 12 hours. The release rate for WQ_v should not exceed 5.66 cfs per acre of pond area.
- Post-development Q_{P25} is no more than the pre-development Q_{P25}.
- If required, post-development Q_{p100} is no greater than the pre-development Q_{p100}.
- If required, the post-development Q_{p100} must be able to be safely passed through the pond while maintaining 1-2 feet of freeboard below the top of the embankment.
- The % TSS removal for the treatment train (upstream water quality BMPs and pond) must be 80% or greater.

STEP 13 – Prepare the vegetation and landscaping plan.

The vegetation and landscaping plan should include soil preparation information, vegetation type and vegetation maintenance. The plan should include information about where woody vegetation is not appropriate (i.e., embankment areas, near spillways where access may be affected, etc.). The plan should also include information about reapplying stabilization measures to areas where vegetation growth is sparse.

STEP 14 – Prepare the operation and maintenance plan.

The operation and maintenance plan should include maintenance information and inspection checklists similar to those discussed in this practice's fact sheet.

Example Design

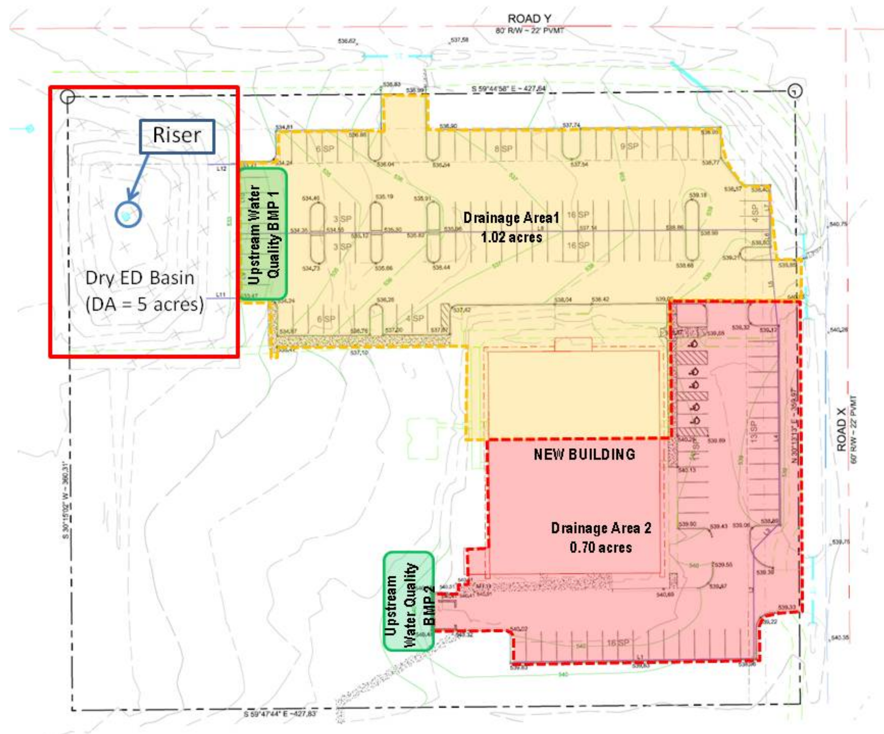
Proposed development of an undeveloped site into an office building and associated parking.

Base Data Total drainage area = 5 ac Site Area = 3.54 ac Soils Type “C” **Pre-Development** Impervious Area = 0 ac; or I = 0% Meadow (CN = 71) **Post-Development** Impervious Area = 1.72 ac; or I = 1.72/3.54 = 49% Open Space, Fair (CN = 79) Paved parking lots, roofs, driveways, etc. (CN =98)	**Hydrologic Data** Pre Post CN 71 89 **WQ_v Depth** = 1.1 in **Precipitation** I_{WQ} 2.45 in/hr 2yr, 24hr 3.54 in 25yr, 24hr 5.88 in 100yr, 24hr 7.43 in

This example focuses on the design of dry extended detention (ED) pond to meet the water quantity control requirements and to also be a part of the treatment train for the site’s water quality treatment requirements. This example design focuses on water quality volume (WQ_v) control only. However, similar design procedures would be used to design for the other water quantity control requirements. In general, the primary function of the dry ED pond is to provide large storm attenuation rather than to provide water quality treatment.

Example Design

Problem: Design a post-construction stormwater water quantity dry extended detention (ED) pond for this site. The dry ED pond will be constructed to meet the required detention standards and will provide 60% TSS reduction for the site. Sand filters are to be installed upstream of the dry ED pond so that the % TSS removed by the treatment train is over 80%. The total drainage area to the pond is 5 acres. Try designing the dry ED pond for this site.



Step 1 – Make a preliminary judgment as to whether site conditions are appropriate for the use of a dry pond or dry ED pond, and identify the function of the pond in the overall treatment system. This includes performing an initial suitability screening for the site.

- Consider basic issues for initial suitability screening, including:
  - The total drainage area to the pond is 5 acres.
  - The site's topography and slopes show that the northwest corner of the site is the preferred pond location.
  - The site has type "C" soils
  - The depth to the water table and bedrock show that the northwest corner of the site is a suitable location for a dry ED pond.
  - There are active karst areas on the site.
  - The proposed development is a commercial office building with associated parking.

Example Design

- Determine how the dry pond or dry ED pond will fit into the overall stormwater treatment system.
    - The proposed dry ED pond will be a downstream component of a treatment train for TSS removal. Two separate sand filters will be designed and installed upgradient (identified as Upstream Water Quality BMP 1 and 2).
    - The northwest corner of the site is the best candidate location for the dry ED pond.
    - The treated WQ_v from the two sand filters will be conveyed through pipes or other stabilized conveyances into the dry ED pond. All pervious site areas as well as all contributing pervious off-site drainage areas will be well-stabilized with vegetative cover. Therefore, the dry ED pond design will not require a separate sediment forebay at the dry ED pond. If a forebay were to be used for the design, one could be located at the south end of the pond.

Step 2 – Confirm design criteria, site constraints and applicability.

- The following minimum criteria will be used in the design.
    - The dry ED pond must meet the following criteria:
        - The WQ_v must have an average detention time of 12 hours.
        - The post-development 25-year peak flow (Q_{P25}) discharged from the pond must be no greater than the pre-development 25-year peak flows (Q_{P25}).
        - For this location, the City is not requiring that the 100-year peak flow to be controlled by the dry ED pond, but is requiring the pond to be able to safely pass the 100-year peak flow through the principal spillway.
        - The dry ED pond is a part of a water quality treatment train that will meet the City's requirement for % TSS removal.
    - The site is not within a floodplain area.
    - The pond is bounded on two sides by existing streets, and will not require an embankment (i.e., the pond is excavated). Therefore, no state dam safety approvals are needed.
    - The outlet structure will be an improved sinkhole. Improved sinkholes must be inventoried, with specific information provided to US EPS. The inventory form can be found at www.bgky.org under the Stormwater Section page.
- The following items are the site constraints related to the pond:
    - The proposed pond location is bounded on two sides (north and west) by existing streets. The design for high flow conditions must consider street flooding potential.
    - The proposed pond's principal spillway discharge will not impact roads or buildings downstream (and also off-site).

Example Design

- Determine the TSS reduction provided, using the equations below for weighted TSS reduction, $TSS_{weighted}$, and TSS treatment train, TSS_{train}. The two upstream water quality BMPs are sand filters with 80% TSS removal. The dry ED pond has 60% TSS removal. All runoff from impervious surfaces goes to the sand filters and dry ED pond.

$$\%TSS_{train} = 80 + 60 - \frac{80 * 60}{100} = 92\%$$

Step 3 –Confirm site suitability, including field verification of site suitability.

- The site geotechnical investigation showed that proposed pond location was suitable for installing a dry ED pond and that the sinkhole can be improved to serve as the primary spillway.
- The soil borings indicated that the underlying soils in the vicinity of the proposed dry ED pond had limited infiltration capacity and that the high water elevation allowed a minimum 3-foot separation between the bottom of the pond and the high water elevation.
- No impermeable layers/lenses or bedrock was encountered during the geotechnical field evaluation of the site.

Step 4 – Compute runoff control volumes and peak flows. Refer to Appendix B for more information on peak flow attenuation for Q_{p25} and Q_{p100}.

- Calculate the Water Quality Volume (WQ_V).

Total Site WQ_v:

$$WQ_v = [(P\ R_v)(A)]/12$$

Where:

P = 1.1 inches

$R_v = 0.05 + 0.009(I)$

I = 49

$R_v = 0.05 + 0.009(49) = 0.491$

A = 1.72 acres

$$WQ_v = (1.1in \times 0.491 \times 1.72ac)/12 = 0.077 \text{ acre-ft} = 3373 \text{ ft}^3$$

Example Design

- Calculate the peak flow for the Water Quality Volume (Q_{wq}). The equation below is based on the Rational Method. The Rational Method equation is an empirical equation, and the input units do not match up with the output units.

$$Q_{wq} = C \times I_{WQ} \times A$$

Where:

Q_{wq} = the water quality volume peak flow, (cfs)

C = the runoff coefficient (0.90 for impervious areas)

I_{WQ} = 2.45 in/hr

A = 1.72 acres

$$Q_{wq} = 0.90 \times 2.45 \times 1.72 = 3.79 \text{ cfs}$$

- Calculate the Q_{p25} and Q_{p100}. The NRCS hydrograph method is recommended for these calculations.

For the Example Design, the focus will be on sizing the pond based on WQ_v. Therefore, higher flow event calculations are not included.

Note: Steps 5 – 12 may be iterative to achieve a pond design that meets the required performance and the site constraints.

First Iteration

Step 5 – Determine the pond location and preliminary geometry.

- These items were used to develop the preliminary grading plan for the pond.
  - The pond's lowest elevation is not in a jurisdictional wetland. The maintenance access for the pond will be on the eastern side of the pond near the parking area. Additionally, the pond side slopes here are approximately 1.4% or 7:1 (H:V)
  - The pond bottom elevation is at 524.80 feet. This elevation will also be the invert for the low flow orifice control WQ_v.
  - The pond is assumed to have sufficient storage for all required controlled discharges.
  - The outlet riser is centrally located in the pond, and cannot be moved farther away from the pond inlets due to the existing roadways nearby. The central riser location helps maximize the available length to width ratio.

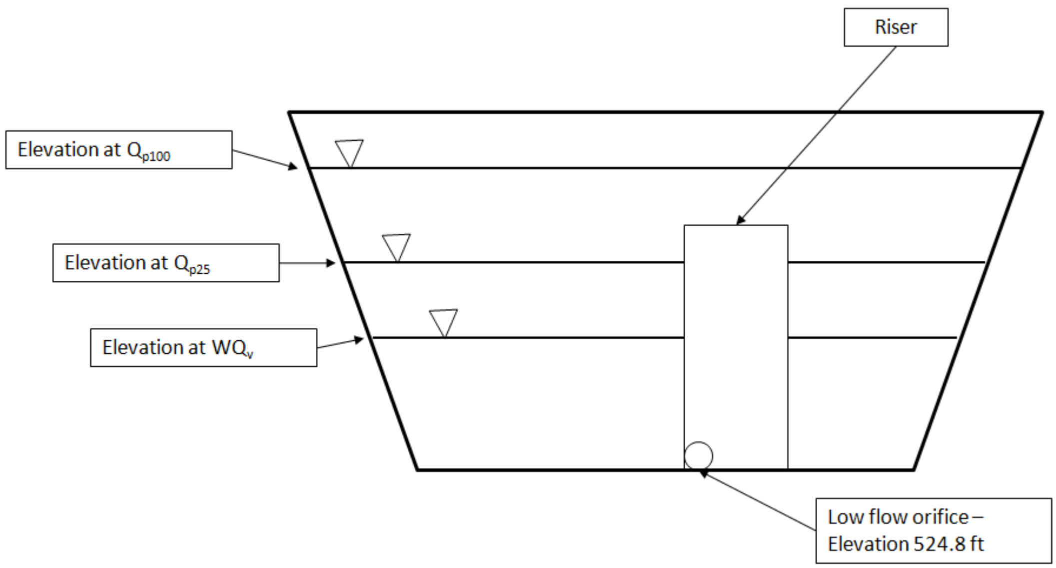
Example Design

STEP 6 – Determine the pre-treatment volume for the sediment forebay.

Ø This design example does not include a sediment forebay as discussed earlier.

Ø If a forebay were used, it would be designed to hold 10% of WQ_v, or about 338 ft^3.

STEP 7 – Size and design the outlet structures.



Ø The assumed outlet structure will be an improved sinkhole throat with a principal spillway riser that has a low flow orifice for controlling WQ_v, perforations in the riser for controlling Q_{P25}, and a top riser opening for passing Q_{p100}. The example design will not include outlet calculations for the higher flow events.

Ø The assumed water quality volume (low flow) outlet is an orifice at the bottom of the riser designed to release WQ_v with an average detention time of 24 hours.

Ø The average release rate of the WQ_v (Q_{WQ_avg}) is calculated using the following equation:

• . ._. . . = • •. / •. .

Where:

t_{WQ} = the intended WQ_v detention time = 24 hours = 86,400 seconds

WQ_v = 3373 ft^3

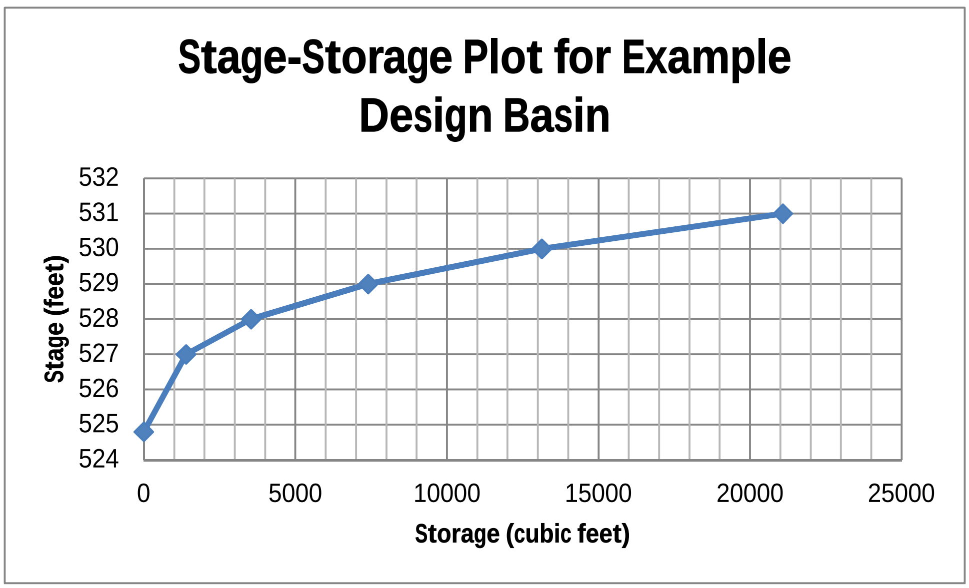
Q_{WQ_avg} = average release rate of WQ_v (cfs)

• . ._. . . = ...˙ / . . . . = 0.039 • • •

Example Design

- The proposed stage-storage relationships for the pond are summarized in the table and chart shown below:

Elevation E (ft)	Area A (square feet)	Average Area between Elevations	Average Area (ft^2)	Depth (Elevation Difference)	Incremental Volume (ft^3)	Cumulative Volume (ft^3)
524.8	0	NA – pond bottom	NA – pond bottom	NA – pond bottom	0	0
527	1266	524.8 ft & 527 ft	633	2.2	1392.6	1392.6
528	3024	527 ft & 528 ft	2145	1	2145	3537.6
529	4709	528 ft & 529 ft	3866.5	1	3866.5	7404.1
530	6744	529 ft & 530 ft	5726.5	1	5726.5	13130.6
531	9169	530 ft & 531 ft	7956.5	1	7956.5	21087.1



- The proposed pond's storage volume is sufficient to hold the WQ_v, and is assumed to be sufficient for the other required peak flow controls.

STEP 7 – Determine the pre-treatment volume for the sediment forebay.

- This design example does not include a sediment forebay as discussed earlier.
- If a forebay were used, it would be designed to hold 10% of WQ_v, or about 338 ft^3.

Example Design

- Ø From the stage-storage table, find the elevation associated with WQ_v. The table indicates that WQ_v = 3373 ft^3 is between elevations 527 ft and 528 ft. The stage-storage relationship plot may be used to estimate the elevation associated with WQ_v, or the elevation may be obtained by linear interpolation between the table values. The elevation associated with WQ_v is estimated at 527.92 feet.

- Ø Calculate the approximate average head (in feet) on the water quality outlet (h_{wq_avg}) using the following equation:

$$\bullet\,.\,._{-}\bullet\bullet\bullet = \frac{\bullet\,.\,.\;\bullet\;\bullet\bullet\bullet\bullet\,.\,\bullet\bullet\bullet\bullet}{2}$$

Where:

E_{WQ} = 527.92 feet

$E_{PermPool}$ = bottom elevation of the pond = 524.80 feet.

$$\bullet\,.\,._{-}\bullet\bullet\bullet = \frac{3.12\ \bullet\bullet\bullet\bullet}{2} = 1.56\ \bullet\bullet\bullet\bullet$$

- Ø Calculate the required orifice cross-sectional area indirectly by using the orifice equation.

$$\bullet\,.\,._{-}\bullet\bullet\bullet = \bullet\bullet\,.\,.\ \bullet\sqrt{2\bullet\bullet\,.\,._{-}\bullet\bullet\bullet}$$

Where:

Q_{WQ} = 0.039 cfs

C = the orifice coefficient (0.6 is typically used, but not apply for all cases)

A_{WQ} = the orifice area (square feet)

g = gravitational acceleration (32.2 feet/s^2)

First, rearrange the orifice equation to solve for A_{WQ}.

$$\bullet\,.\,. = \frac{\bullet\,.\,._{-}\bullet\bullet\bullet}{\bullet\,\bullet\sqrt{2\bullet\bullet\,.\,._{-}\bullet\bullet\bullet}}$$

$$\bullet\,.\,. = \frac{0.039\ \bullet\bullet\bullet}{0.6\bullet\sqrt{2\bullet 32.2\frac{\bullet\bullet}{\bullet^{\bullet}}\bullet(1.56\ \bullet\bullet\bullet\bullet)}} = 0.0065\ \bullet\bullet\bullet\bullet^{\bullet}$$

$$\bullet\,.\,. = 0.0065\ \bullet\bullet\bullet\bullet^{\bullet}$$

Example Design

- Calculate the orifice diameter using the following equation:

• . . = 2 • • . . / •

Where:

d_{WQ} = the orifice diameter (feet)

• . . = 2 • 0.0065•••• / 3.14 = 0.09 ••••

• . . = 0.09 •••• = 1.10 •••••• • 1 ••••

For the Example Design, the minimum allowed orifice diameter (1 inch) will be used. This device will require internal orifice protection.

- The rate of discharge for the orifice for any head value at the water quality orifice (h_{WQ}) can be calculated using:

• . . = • • . . • 2 • • . .

Where:

Q_{WQ} = the orifice discharge rate at head h_{WQ} (cfs)

h_{WQ} = the head value above the water quality orifice (feet)

Using the range of values for h_{WQ} based on the elevations (E) up to E_{WQ} used in the pond's stage-storage relationship, the Q_{WQ} values are calculated for each corresponding value of h_{WQ}.

Elevation E (ft)	h_{WQ} (feet)	Q_{WQ} (cfs)
524.8	0	0
527	2.2	0.0390
527.92	3.12	0.0464

Example Design

- The combined outflow from the low flow orifice and any higher outflow openings is calculated by adding together the discharges from each structures associated with a given head value and a specified pond water surface elevation.

  The combined outflow would be calculated for all of the outflow openings to check that the pond meets the requirements for controlling the post-development Q_{P25}.

- Calculate the required control for the 100-year storm peak flow (Q_{p100}). If required, the post-development Q_{p100} must be no greater than the pre-development Q_{p100}. At minimum, Q_{p100} must be able to be safely passed through the pond with 1-2 feet of freeboard below the top of the embankment. Check with local officials and/or state dam safety personnel to determine whether Q_{p100} may be passed using only a principal spillway, or if an emergency spillway will be required. If an emergency spillway is required, the spillway type is often a broad-crested weir or similar structure that is not susceptible to obstruction. For calculating the combined outflow through all spillway openings, the combined outflow may be calculated by adding together the discharges for each opening associated with a given head value and a specified water surface elevation.

  For this Example Design, the pond's ability to control Q_{p100} will not be calculated. The Example Design pond is an excavated pond that does not include an embankment other than the two existing roadbeds north and west of the site. However, the pond would still need to be checked to determine if the pond could safely pass Q_{p100} while maintaining the required freeboard of 1-2 feet above the elevation associated with the Q_{p100}.

- Using the determined opening and spillway information, incorporate the outlet structures into the pond design. Keep in mind that the spillway design must also consider using measures such as removable trash racks to prevent the discharge of floating debris.

  The outlet openings and spillways are then added into the pond design. Other measures such as removable trash racks are also added to the design.

STEP 8 – Design the spillways and embankments.

- The Example Design pond will target passing all required flows through the principal spillway, and will not be required to include an emergency spillway.

STEP 9 – Design the inlets.

- The Example Design pond uses inflow inlet pipes from the upstream water quality BMPs to the pond. These inflow inlet pipes are designed to be buried below the frost line. Additionally, this pond is a dry pond (no permanent pool). This means that the inlet pipes should be sloped to fully drain as the water levels in the pond drop.

STEP 10 – Design the sediment forebay.

- The sediment forebay size was determined in Step 6. For the Example Design pond, a sediment forebay will not be used because (1) the upstream water quality BMPs will reduce the sediment load to the pond and (2) all pervious areas draining to the pond will be well-stabilized to not provide significant sediment load to the dry ED pond.

Example Design

STEP 11 – Design the maintenance access and safety features.

- All maintenance access and safety features are designed in this step. The removable trash racks on the spillway riser will also function to prevent unauthorized access to the riser. The riser's pipe diameter will include bars across the pipe outlet to prevent unauthorized access if the pipe diameter is over 3 feet.

STEP 12 – Check the expected pond performance against regulatory requirements.

- The pond design should be re-checked to confirm that the pond meets the flow control requirements.

- The release rate for WQ_v should not exceed 5.66 cfs per acre of pond surface area. Calculate the flow rate and pond surface area associated with each available elevation and head value up to E_{WQ}. The maximum release rate for WQ_v will then be calculated using the pond surface area at each given elevation and head value, and the actual release rate will be compared with the maximum release rate.

Elevation E (ft)	h_{WQ} (feet)	Q_{WQ} (cfs)	Pond Surface Area at E (sq ft)	Pond Surface Area at E (acres)	Release rate (based on Q_{WQ} per acre of surface area) (cfs/acre)
524.8	0	0.000	0	0	0
527	2.2	0.039	1266	0.0291	1.34
527.92	3.12	0.046	3373	0.0774	0.60

See last column in above table. All values are below the target value of 5.66 cfs per acre.

- The expected average detention time for WQ_v is 24 hours. Calculate the average release rate for the pond (Q_{WQ_avg}). Use WQ_v and Q_{WQ_avg} to calculate the actual average detention time for the pond. The required target detention time for WQ_v is 24 hours.

$$Q_{WQ\_avg} = \frac{[illegible]}{[illegible]} = 0.028 \text{ cfs}$$

$$t_{WQ} = \frac{[illegible]}{Q_{WQ\_avg}} = \frac{[illegible]}{[illegible]} = 118574 \text{ seconds} = 32.9 \text{ hours}$$

The actual value of t_{WQ} is greater than the required 24 hours. The 1-inch diameter orifice used for the pond design is smaller than the calculated orifice size (diameter of 1.10 inches) from earlier in the Design Procedure. The smaller orifice gives a conservative design with a higher detention time for WQ_v.

Example Design

Second Iteration

If required or desired, a second iteration may be performed to attempt to adjust the pond configuration to try to get the detention time closer to 24 hours or to fit other site constraints. Another modification that could affect the pond's detention time would be to include a forebay that would store a portion of WQ_V.

The Example Design will not include the final three design steps (Steps 13-15), but these steps would be incorporated into a full pond design.

STEP 13 – Prepare the vegetation and landscaping plan.

STEP 14 – Prepare the operation and maintenance plan.

3.4 POST CONSTRUCTION STORMWATER CONTROL FACT SHEETS (PTP)

Post Construction Stormwater Control Practices	PTP-09 Oil and Grease/Water Separator

Symbol

O/W

TSS Reduction: 40%

Description

REASONS FOR LIMITED USE

- Ø Cannot alone achieve the 80% TSS removal target
- Ø Intended for hotspot, space-limited or pretreatment applications
- Ø Limited performance data

KEY CONSIDERATIONS

- Ø Intended for the removal of settleable solids (grit and sediment) and floatable matter, including oil and grease
- Ø Dissolved pollutants are not effectively removed
- Ø Frequent maintenance required
- Ø Performance dependent on design and frequency of inspection and cleanout of unit.
- Ø Must have adequate capacity to accommodate spills

Applications

Gravity separators (also known as oil/water separators) are hydrodynamic separation devices that are designed to remove grit and heavy sediments, oil and grease, debris and floatable matter from stormwater runoff through gravitational settling and trapping. Gravity separator units contain a permanent pool of water and typically consist of an inlet chamber, separation/storage chamber, a bypass chamber, and an access port for maintenance purposes. Runoff enters the inlet chamber where heavy sediments and solids drop out.

Applications

The flow moves into the main gravity separation chamber, where further settling of suspended solids takes place. Oil and grease are skimmed and stored in a waste oil storage compartment for future removal. After moving into the outlet chamber, the clarified runoff is then discharged. The performance of these systems is based primarily on the relatively low solubility of petroleum products in water and the difference between the Gravity separators are not designed to separate other products such as solvents, detergents, or dissolved pollutants. The typical gravity separator unit may be enhanced with a pretreatment swirl concentrator chamber, oil draw-off devices that continuously remove the accumulated light liquids, and flow control valves regulating the flow rate into the unit.

Gravity separators are best used in commercial, industrial and transportation land uses and are intended primarily as a pretreatment measure for high-density or ultra urban sites, or for use in hydrocarbon hotspots, such as gas stations and areas with high vehicular traffic. However, gravity separators cannot be used for the removal of dissolved or emulsified oils and pollutants such as coolants, soluble lubricants, glycols and alcohols. Since resuspension of accumulated sediments is possible during heavy storm events, gravity separator units should be installed off-line. Gravity separators are available as prefabricated proprietary systems from a number of different commercial vendors.

Design

Section 2.7 outlines the criteria and approval process for proprietary or manufactured BMPs within the City limits. Where the water quality unit is not rated for full treatment (80% TSS reduction), additional permanent treatment practices are required. Water quality units are not typically designed for stormwater quantity control as well, so a detention structure such as a detention pond will be required.

For water quality units designed based upon a flow rate, the following equation must be used to simulate treatment of the WQv:

• • = • • • • •

Where:
Qp = the peak flow through the proprietary BMP in cfs
C = runoff coefficient
I = rainfall intensity, 2.45 in/hr
A = the contributing drainage area for the BMP, in acres

The use of gravity (oil/water) separators should be limited to the following applications:

- Pretreatment for other structural stormwater controls
- High-density, ultra urban or other space-limited development sites
- Hotspot landuse areas where the control of grit, floatables, and/or oil and grease are required

Gravity separators are typically used for areas less than 5 acres. It is recommended that the contributing area to any individual gravity separator be limited to 1 acre or less of impervious cover.

Design

Gravity separator systems can be installed in almost any soil or terrain. Since these devices are underground, appearance is not an issue and public safety risks are low.

Gravity separators are rate-based devices. This contrasts with most other stormwater structural controls, which are sized based on capturing and treating a specific water quality volume.

Gravity separator units are typically designed to bypass runoff flows in excess of the design flow rate. Some designs have built-in high flow bypass mechanisms. Other designs require a diversion structure or flow splitter ahead of the device in the drainage system. An adequate outfall must be provided.

The separation chamber should provide for three separate storage volumes:

1. A volume for separated oil storage at the top of the chamber
2. A volume for settleable solids accumulation at the bottom of the chamber
3. A volume required to give adequate flow-through detention time for separation of oil and sediment from the stormwater flow

- The total wet storage of the gravity separator unit should be at least 400 cubic feet per contributing impervious acre.
- Horizontal velocity through the separation chamber should be 1 to 3 $^{ft}/_{min}$ or less. No velocities in the device should exceed the entrance velocity.
- The minimum depth of the permanent pools should be 4 feet.
- A trash rack should be included in the design to capture floating debris, preferably near the inlet chamber to prevent debris from becoming oil impregnated.
- Ideally, a gravity separator design will provide an oil draw-off mechanism to a separate chamber or storage area.
- Adequate maintenance access to each chamber must be provided for inspection and cleanout of a gravity separator unit.
- Gravity separator units should be watertight to prevent possible groundwater contamination.
- The design criteria and specifications of a proprietary gravity separator unit should be obtained from the manufacturer.

Maintenance

A maintenance and operation plan must be provided for each water quality unit. This information can be provided by the manufacturer and must address the following items:

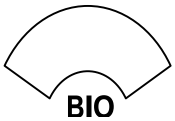
- Expected clean out frequency
- Unit life expectancy
- Procedures addressing dewatering of the unit, should it get clogged
- A cross sectional view of the unit with all overflow structures, weirs, pipe connections clearly identified
- The bypassing mechanism and any maintenance requirements for that component

Additional maintenance requirements for a proprietary system should be obtained from the manufacturer.

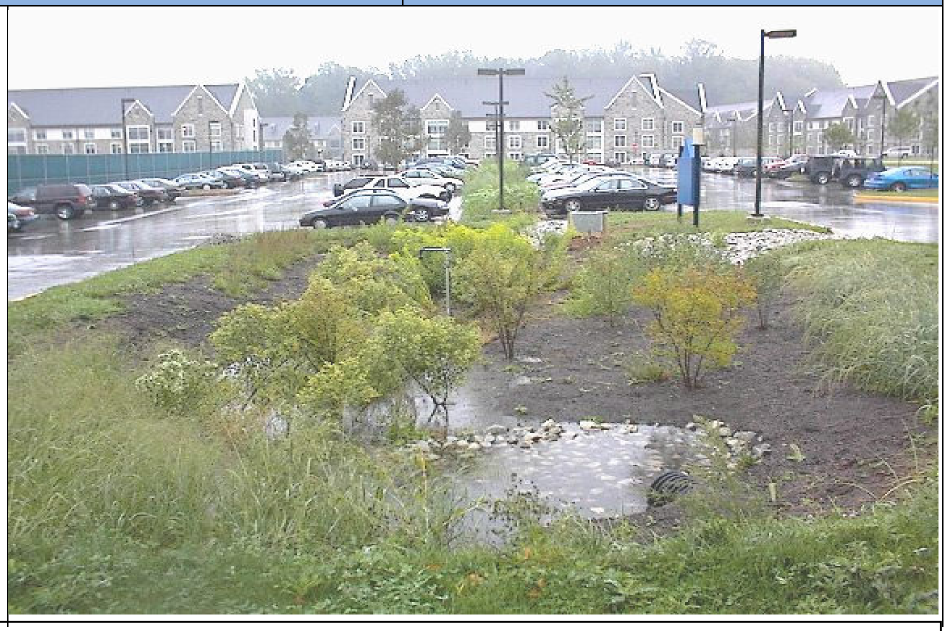
Failure to provide adequate inspection and maintenance can result in the resuspension of accumulated solids. Frequency of inspection and maintenance is dependent on land use, climatological conditions, and the design of gravity separator.

Proper disposal of oil, solids and floatables removed from the gravity separator must be ensured.

Post Construction Stormwater Control Practices	**PTP-10 Bioretention Systems**



Symbol



BIO

TSS Reduction: 80%

3.4 Post Construction Stormwater Control Fact Sheets (PTP)

Description

Bioretention systems are structural water quality control devices that capture and temporarily store, treat, and release stormwater runoff. A properly designed area will replicate a small, dense forest floor. Bioretention systems consist of two main components: a pretreatment area and filtration chamber. The pretreatment area removes floatable materials and heavy sediments, and helps reduce flow velocities. The filtration chamber traps and strains pollutants, and allows the microbial removal of pollutants. Target pollutants for bioretention systems include suspended solids, suspended particulates, biochemical oxygen demand (BOD), fecal coliform bacteria, and others. Bioretention systems employ organic materials such as peat or compost combined with sand, and plantings and mulch on the surface layer. This allows additional pollutant removal via bacterial decomposition and vegetation uptake of nutrients. The two main structures of bioretention systems (the pretreatment area and filtration area) may include or be enhanced by the following components:

- Grass filter strip
- Sand bed
- Ponding area or pretreatment basin
- Organic layer
- Planting soil layer
- Plant material
- Underdrain/collection system

Applications

Bioretention systems are often used to manage stormwater runoff from urban areas where space is limited, and can be applied to areas where retrofit is needed, and are typically suitable in the following applications:

- Small stabilized drainage areas
- Drainage areas with high impervious cover
- Off-line facilities adjacent to parking lots
- Along road drainage swales
- Within larger landscaped pervious areas
- Landscaped islands in impervious or high-density environments (i.e. parking lots)
- Retrofitting exiting parking lot islands/off-line facilities

Bioretention systems are **not** suitable in the following applications:

- Within drainage areas that have not been stabilized
- Areas with mature trees
- Adjacent to areas with slopes greater than 5:1 (H:V)
- Areas that experience continuous flow from surface water, groundwater, sump pumps, or other sources

Bioretention systems should only be applied to stabilized drainage areas, as heavy sediment loads from construction areas will clog and disable it. Likewise, they should not be used in areas where stormwater has potential for high silt or clay content, and areas with a high water table. As a guide, sites implementing bioretention systems should have over 50% impervious cover in the drainage area.

Bioretention systems should typically be designed for off-line use to capture the first flush of runoff. A diversion structure such as a flow splitter or weir may be necessary to separate and route the first flush to the bioretention system for water quality control, and route the remaining stormwater to a water quantity control device downstream. Other options include an overflow structure than carries flows larger than the water quality treatment requirement. Bioretention systems are most effective when turbulent flow is minimized and the flow is spread uniformly across the surface area.

Bioretention is best employed close to the source of runoff generation and is often located in the upstream portion of the stormwater treatment train, with additional stormwater BMPs following downstream. Strong consideration should be given to multiple smaller bioretention system rather than one large bioretention system.

Bioretention System Variations

FILTRATION/PARTIAL RECHARGE FACILITY

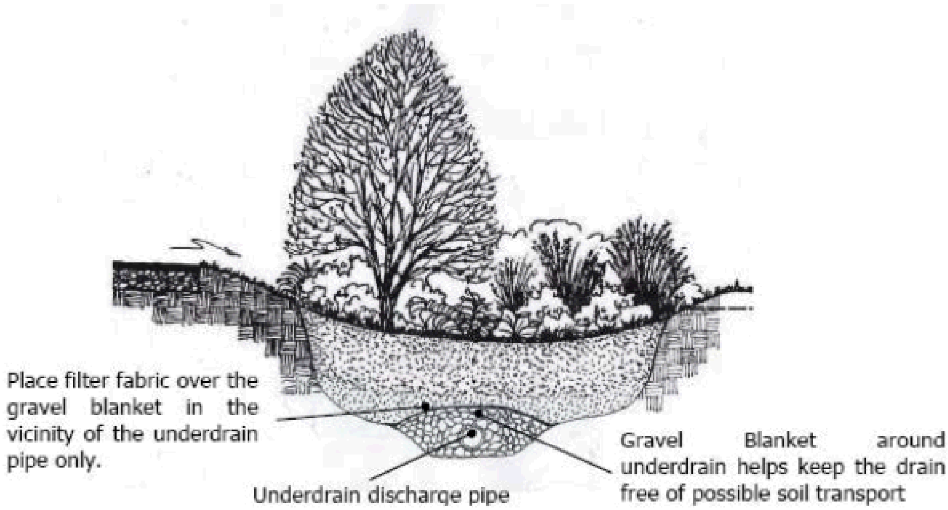


Figure PTP-10- 1 Filtration/Partial Recharge Facility
Source, Minnesota Stormwater Manual

This type of facility is suitable for areas where high filtration and partial recharge of runoff would be beneficial. This facility is designed with an under-drain at the invert of the planting soil mix to ensure that the facility drains at a desired rate. The facility allows for partial recharge, as an impervious liner is not used. The depth is also shallow (2.5') to allow the facility to handle high capacity flows if necessary. Siting of this performance type is suitable for visually prominent or gateway locations in a community. The facility type is suitable for areas and land uses that are expected to generate nutrient and metals loadings (residential, business campus, or parking lots). Attention to mulch type and amount will ensure the adequate treatment of the anticipated loadings. The facility shown above incorporates a filter material between the gravel blanket around the under-drain and the planting soil above. The filter fabric does not need to extend to the side walls. The filter fabric may be installed horizontally above the gravel blanket- extending just 1-2 feet on either side of the under-drain pipe below. Do **not** wrap the under-drain with filter fabric. Instead of using a filter fabric, the designer may opt to utilize a pea gravel diaphragm over the under-drain gravel blanket. This type of facility is also recommended for tight impermeable soils where infiltration is limited. Some volume reduction will be seen from evapotranspiration.

Bioretention System Variations

INFILTRATION/FILTRATION/RECHARGE FACILITY

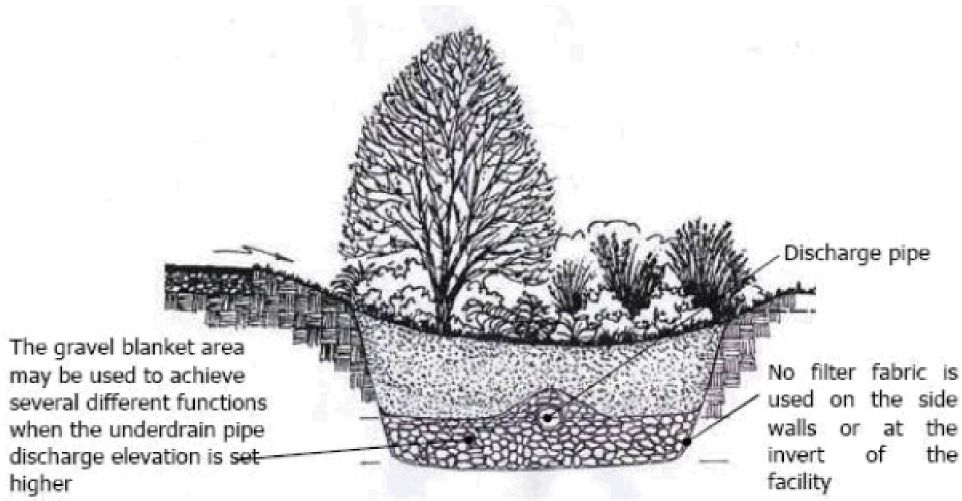


Figure PTP-10- 2 Infiltration/Filtration/Recharge Facility
Source, Minnesota Stormwater Manual

This type of facility is recommended for areas where higher nutrient loadings (particularly nitrates) are anticipated. The facility is designed to incorporate a fluctuating aerobic/anaerobic zone below the raised under-drain discharge pipe. This fluctuation created by saturation and infiltration into the surrounding soils will achieve de-nitrification. With a combination of a fresh mulch covering, nitrates will be mitigated through the enhancement of natural denitrification processes. This type of facility would be suitable for areas where nitrate loadings are typically a problem (residential communities). The raised under-drain has the effect of providing a storage area below the invert of the under-drain discharge pipe. This area provides a recharge zone and quantity control can also be augmented with this storage area. The storage area is equal the void space of the material used.

Bioretention System Variations

FILTRATION ONLY FACILITY

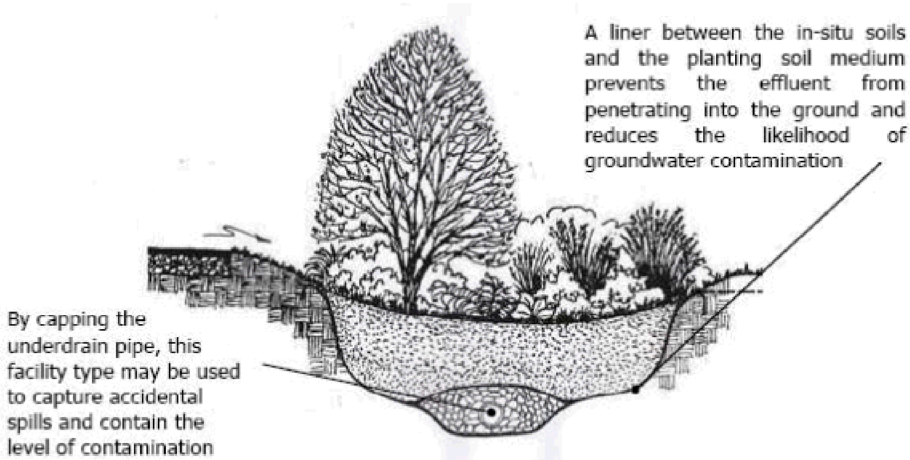


Figure PTP-10- 3 Filtration Only Facility
Source, Minnesota Stormwater Manual

This type of facility is recommended for areas that are known as potential stormwater "hot-spots" (gas stations, transfer sites, and transportation depots). An important feature of this type of facility is the impervious liner designed to reduce or eliminate the possibility of ground water contamination. The facility provides a level of treatment strictly through filtration processes that occur when the runoff moves through the soil material to the underdrain discharge point. In the event of an accidental spill, the under-drain can be blocked and the objectionable materials siphoned through the observation well and safely contained.

Maintenance

Maintenance access should be provided for appropriate equipment, vehicles, and personnel.

Monthly

- Remove trash or debris
- Inspect the bioretention system for clogging
- Pruning and weeding to maintain appearance.
- Mulch replacement when erosion is evident.

Semi-annually

- The planting soils should be tested for pH to establish acidic levels. If the pH is below 5.2, limestone should be applied. If the pH is above 7.0 to 8.0, then iron sulfate plus sulfur can be added to reduce the pH.

Annually

- Remove sediment as necessary
- Repair or replace any damaged structural parts
- Stabilize any eroded areas
- Replace mulch over the entire area.
- Replace gravel diaphragm if warranted every 2 to 3 years.

As Needed

- Inspect inflow points for clogging (off-line systems). Remove any sediment.
- Inspect grass filter strip/grass channel for erosion or gullying. Re-seed or sod as necessary.
- Trees and shrubs should be inspected to evaluate their health and remove any dead or severely diseased vegetation.
- Ponding of water on the surface for more than 48 hours indicates that the filtering capacity is substantially diminished. Replace mulch layer by removing the top few inches that contain sediment. Core aeration or cultivating of unvegetated areas may also be required to ensure adequate filtration. The removed sediment should be disposed of properly, such as in a landfill.
- Silt or sediment should be removed from the bioretention system at the accumulation of approximately 2 inches.
- Properly dispose of any material generated during maintenance activities.

Inspection Checklist

Monthly

- q Contributing area, facility, inlets, and outlets are clear of debris
- q Contributing area is stabilized and mowed, with clippings bagged or removed
- q Treatment area is not clogging – also inspect after moderate/major storm events
- q Activities in the drainage area minimize oil/grease and sediment entering the system
- q Standing water is not present
- q No erosion is present in the bioretention system
- q Pretreatment area shows no evidence or erosion
- q Deposition of sediment should be no more than 2 inches before it is cleaned out

Annually

- q Treatment area contains no more than 2 inches of sediment
- q No evidence of deterioration, spalling, or cracking is present on concrete, if present
- q Inspect grates, where applicable
- q Inlets, outlets, and overflow spillways or diversion structures show no evidence of erosion or deterioration
- q Flow is not bypassing the bioretention system
- q Wetland vegetation is not present in the bioretention area (signifies poor drainage)

Figure PTP-10- 4 Bioretention System
Source, Maryland Department of Natural Resources, www.dnr.state.md.us

Design Criteria

- The size of the drainage area typically dictates the size of the bioretention practice. These areas should be limited to a maximum contributing drainage area of five (5) acres. One-half (0.5) to two (2) acre drainage areas are preferred. Multiple bioretention areas may be required for larger drainage areas. No more than 50 percent of the drainage area can be pervious.
- Sloped areas immediately adjacent to the bioretention system should be no greater than 5:1 (H:V) nor less than 1% to promote positive flow toward the system.
- Bioretention systems should be sized based on the principles of Darcy's Law, as shown in the Design Procedures section. However, the minimum size of a bioretention system is 200 square feet (equivalent to 10-feet wide and 20 feet long).
- The bioretention system surface slope should not exceed 1%, to promote even distribution of flow throughout the system.
- The maximum side slopes for a bioretention system is 3:1 (H:V).
- Planting soils should contain less than 5% clay by volume. Additional specifications for soils are outlined in the Design Components section.
- Where feasible ponding depths should be no greater than 6 inches. The maximum allowable pooling depth is 18 inches.
- The bioretention system should be designed such that it is drained within 48 hours from the peak water level in the system.
- Bioretention systems require pre-treatment and as many pretreatment components as feasible should be incorporated. Pretreatment components are described below.
    - For applications where runoff enters the bioretention system through sheet flow, such as from parking lots, or residential back yards, a grass filter strip with a gravel diaphragm is the preferred method of pretreatment.
    - For applications where concentrated (or channelized) runoff enters the bioretention system, such as through a slotted curb opening, a grassed channel with a gravel diaphragm is the preferred method of pretreatment.
- Underdrains are required in bioretention systems to carry flow to another conveyance element. The underdrains should be equipped with a minimum 8-inch perforated PVC pipe surrounded by a 12-inch thick gravel layer. The underdrain can be installed at the bottom of the storage area or at an elevation above the bottom of the storage area, depending on the treatment goals for the system.
- When designing the underdrain, infiltration of the in situ soils should not be considered. Zero drawdown through the in situ soils should be assumed. The underdrain system must be sized to drain the entire water quality volume (WQ_v) within 48hrs
- The elevation difference from the inflow to the outflow must be 4-6 feet.
- A minimum of 3 feet (5 feet recommended) of separation must be provided between the bottom of the bioretention system and seasonally saturated soils.
- Potential for erosion of stabilized areas and the bioretention system should be evaluated.
- Bioretention systems must have a detailed landscaping plan.

Design Components

- **Pre-treatment** – Pre-treatment areas capture and remove coarse sediment particles from runoff prior to discharging into the bioretention area. Incorporation of pretreatment components helps to reduce the maintenance burden of bioretention, and reduces the likelihood that the planting soil layer will clog over time.
  - **Gravel Diaphragm** – Located at the beginning of the grass buffer strip to reduce velocity of runoff, filter particles in the stormwater, and spread flow across the grass buffer strip.
  - **Grass Buffer Strip/Grass Channel** – Reduces velocity of runoff and filters particles in the stormwater. The length of the grass buffer strip depends on the drainage area, imperviousness, and the buffer strip slope. When bioretention is used to treat runoff from parking lots or roadways that are frequently sanded during snow events, grass buffer strips should be a minimum of 10 feet long and grass channels a minimum of 20 feet long.
  - **Concrete Forebay or Curb** – Often bioretention areas are incorporated into parking lots and other highly impervious areas. Curbs and/or concrete forebays can be constructed to slow runoff and allow larger solids to settle before reaching the bioretention area. Curbs can simply have a lip set 1-2 inches above the parking lot elevation and effectively settle large particles. A concrete forebay can also be installed to aid maintenance and cleaning.
  - **Ponding Area or Pretreatment Basin** – Runoff is detained to settle particulates suspended in stormwater.
- **Treatment** –
  - **Surface/Ponding Area** –The surface area of all infiltration based bioretention systems is a function of the infiltration capacity of the underlying soils. The surface area of all filtration based bioretention practices is a function of the filtration capacity of the soil medium and underdrain. Ponding depths should be kept to a minimum to reduce hydraulic overload of in-situ/planting soils and to maximize the surface area to system depth ratio, where space allows. It is recommended that approximately 5-10% of the tributary impervious area be dedicated to the bioretention system footprint.
  - **Organic Layer** – A layer of mulch filters pollutants out of the stormwater and protects soil from eroding. The layer can also sustain a nutrient rich environment with microbes that can break down petroleum-based contaminants. The layer should contain approximately 2 to 3 inches fresh shredded bark mulch, when possible, to maximize nitrogen retention. If aged mulch is used, use the shredded type instead of the “chip” variety to minimize floating action. Too much mulch can restrict oxygen flow to roots.

Design Components

- **Planting Soil Layer** – This layer is used to provide nutrients and store water for the area's plantings.
  - The planting soil should be a well blended, homogenous mixture of 50-60% construction sand, 20-30% top soil, and 20-30% organic leaf compost. This blend is necessary to provide a planting soil layer with a high infiltration/filtration capacity.
  - Field experiments show that pollutant removal is accomplished within the top 30" of soil depth with minimal additional removal beyond that depth (Prince George's County, 2002). Therefore, the recommended depth of the prepared soil is 30 inches. However, if large trees are preferred in the design, a soil depth of 48"-52" should be utilized. The soil depth generally depends upon the root depth of the prescribed vegetation and content of underlying soils.
  - Clay material can absorb heavy metals, hydrocarbons and other pollutants. However, clay should be mixed with sand or topsoil such that the planting soil layer has a clay content of less than 5%.
  - Additionally, the design permeability rate through the planting soil bed should be high enough to fully drain the stormwater quality design storm runoff within 48hrs. It is recommended that this permeability rate be determined by field testing.
  - The planting soil should have a pH ranging from 5.5 to 6.5.
- **Plant Material** – Consider surrounding environment, climate, maintenance requirements and types of pollutants that the plants must withstand and treat, while maintaining a positive aesthetic enhancement.
- **Underdrain/Collection System** – Necessary to collect and send flows to a stormwater conveyance system. This system should contain a minimum 8-inch perforated PVC pipe surrounded by a 12-inch thick gravel layer. The gravel shall be washed and 1-1/2" in size. Increasing the diameter of the underdrain makes freezing less likely, and provides a greater capacity to drain standing water from the system. Pipe perforations should be sized approximately 3/8 inch in diameter spaced at 6-inch intervals on center. At a minimum, 4 holes per row should be used, and pipe grade placement should be at least 0.5%. Pipes should be spaced no more than 10 feet on center. The porous gravel layer prevents standing water in the system by promoting drainage. Gravel is also less susceptible to frost heaving than finer grain media. A pea gravel diaphragm and/or permeable filter fabric should be placed between the gravel layer and the planting soil layer.

Landscaping

- Impervious area construction must be completed and a dense and vigorous vegetative cover should be established over the contributing pervious drainage areas **BEFORE** runoff can be accepted into the bioretention system.
- Consult with a landscaping professional to select vegetation which fits into the landscape, is appropriate for the hardiness zone, and can tolerate conditions found in bioretention areas (short durations of 6 inch ponding water). Vegetation should be selected based on specified zone of hydric tolerance.
- The bioretention area should be vegetated to resemble a terrestrial forest ecosystem, with a mature tree canopy, sub canopy of under story trees, shrub layer, and herbaceous ground cover. Three species each of both trees and shrubs are recommended to be planted. Many bioretention systems feature wild flowers and grasses in addition to trees and shrubs. Other typical landscape plants can be used, such as day lilies, landscape grasses, or other native plantings.
- The tree-to-shrub ratio should be 2:1 to 3:1. On average, the trees should be spaced 8 feet apart. Plants should be placed at regular intervals to replicate a natural forest.
    - Woody vegetation should not be specified at inflow locations.
    - Trees should not be planted directly over top of underdrains and may be best located along the perimeter of the system.
- After the trees and shrubs are established, the ground cover and mulch should be established. Mulch should not be mounded around the base of plants since this encourages damage from pests and diseases.
- Salt resistant vegetation should be used in locations with probable adjacent salt applications, i.e. roadside, parking lot, etc.
- Choose plants based on factors such as resistance to drought and inundation, cost, aesthetics, maintenance, etc. Native plant species should be specified over non-native species.
- Fluctuating water levels following seeding (prior to germination) can cause seed to float and be transported. Seed is also difficult to establish through mulch, a common surface component of bioretention systems. It may take up to two growing seasons to establish the function and desired aesthetic of mature vegetation via seeding. Therefore mature plantings are recommended over seed.
- If a minimum coverage of 50% is not achieved after the first growing season, a reinforcement planting is required.
- Bioretention system locations should be integrated into the site planning process, and aesthetic considerations should be taken into account in the siting and design.

Design Procedure

Step 1 – Make a preliminary judgment as to whether site conditions are appropriate for the use of a bioretention system, and identify the function of bioretention in the overall treatment system.

- Consider basic issues for initial suitability screening, including:
  - Site drainage area
  - Site topography and slopes
  - Soil infiltration capacity
  - Site location/minimum setbacks
  - Presence of active karst features
- Determine how the bioretention system will fit into the overall stormwater treatment system.
  - Decide whether the bioretention system is the only BMP to be employed, or if there are other BMPs addressing some of the treatment requirements.
  - Decide where on the site the bioretention system is most likely to be located.

Step 2 – Confirm design criteria, site constraints, and applicability.

- Determine the design criteria that will be used.
- Determine any constraints the site will place on the bioretention system such as:
  - High pervious area in the drainage area
  - Limited amount of surface area available for treatment
  - High water table
  - Water surface elevation in any downstream treatment practices or conveyance
- Ensure that stormwater runoff from impervious surfaces is being treated to the 80% TSS reduction standard.
  - The equation for determining the weighted TSS reduction for a site with multiple outlet points is below.

$$\%TSS = \frac{\sum_n^1 (TSS_1 A_1 + TSS_2 A_2 + ... + TSS_n A_n)}{\sum_n^1 (A_1 + A_2 + ... + A_n)}$$

Where:

TSS_1 = TSS reduction by BMP providing treatment for A_1
A_1 = area 1, (acres)
TSS_2 = TSS reduction by BMP providing treatment for A_2
A_2 = area 2, (acres)

  - Where one BMP discharges into another, the treatment train TSS reduction can be found by the following equation:

$$TSS_{train} = A + B - \frac{(A \times B)}{100}$$

Design Procedure

Where:

TSS_{train} = total TSS reduction through successive BMPs
A = TSS reduction through first BMP
B = TSS reduction through second BMP

Step 3 – Perform field verification of site suitability.

- Determine the depth to groundwater. A minimum of 3 feet of separation between the bottom of the bioretention system and seasonally saturated soils (or from bedrock) is required (5 feet recommended).
- The field verification should be conducted by a qualified geotechnical professional.
- If the initial evaluation indicates that a bioretention practice would be a good BMP for the site, it is recommenced that soil borings or pits be dug (in the same location as the proposed bioretention practice) to verify soil types and infiltration capacity characteristics and to determine toe depth to ground water and bedrock. The number of soil borings should be selected as needed to determine local soil conditions.

It is recommended that the minimum depth of the soil borings or pits be five feet below the bottom elevation of the proposed bioretention system.

Step 4 – Compute runoff control volumes and peak flows.

- Calculate the Water Quality Volume (WQ_V), peak runoff for the 25 year storm (Q_{P25}), and the peak runoff for the 100 year storm (Q_{P100}). Refer to Section 2 for more information stormwater quantity design.
  - The required water quality treatment volume is 1.1 inches of runoff from the new impervious surfaces created from the project.
  - Determine Water Quality Volume (WQ_V).

    $$WQ_v = [P\ R_v)(A)]/12$$

    Where:

    P = is the average rainfall, (inches)
    R_V = 0.05 + 0.009(I), where I is the percent impervious cover
    A = the area of imperviousness, (acres)

- Calculate the peak flows for Q_{P25} and Q_{P100} to meet detention requirements.

Design Procedure

Note: Steps 5-8 are iterative

Step 5 – Determine bioretention type and size.

- Select type of bioretention basin – after completion of the previous steps the designer should know the depth to the water table, bedrock or other impermeable layers, and the contributing drainage area.
  - Determine Water Quality Volume (WQ_V) for bioretention system.
    - If part of the overall WQ_V is to be treated by other BMPs, subtract that portion from the WQ_V to determine the part of the WQ_V to be treated by the bioretention system.
    - If the bioretention system has an underdrain the volume of voids in the underdrain system should be subtracted from the WQ_v. The volume of voids should be estimated at 35% of the total volume of the underdrain system.
  - Based on the known WQ_V, infiltration rates of the underlying soils and the known existing potential pollutant loading from proposed/existing landuse select the appropriate bioretention type (see Section 2.6).
- Size Bioretention System With An Underdrain
  - The bioretention surface area is computed using the following equation, for those systems that are designed with an underdrain:

$$A_f = (WQ_V \times d_f) / [k \times (h_f + d_f) \times t_f]$$

Where:

A_f = surface area of bioretention system, (ft^2)
WQ_V = water quality volume, (ft^3)
d_f = filter bed depth, (ft)
k = coefficient of permeability of filter media, (ft/day) (0.5 ft/day is the recommended k for planting medium / filter media soil. This value is conservative to account for clogging associated with accumulated sediment.)
h_f = average height of water above filter bed, (ft)
t_f = design filter bed drain time, (days) (48 hours is the required maximum t_f for bioretention)

STEP 6 – Size outlet structure and/or flow diversion structure, if needed.

- It is required that a secondary outlet be incorporated into the design of a bioretention system to safely convey excess stormwater. Stormwater quantity requirements can be found in Section 2.4.7.
- Potential for erosion to stabilized areas and bioretention system should be evaluated and the design should incorporate ways to mitigate erosive flows.

Design Procedure

STEP 7 – Determine pre-treatment volume and design pre-treatment measures.

Ø Some form of pre-treatment is required prior to the discharge of stormwater into the bioretention system, to remove any sediment and fines that may result in clogging of the soils in the treatment area.

Ø Grass filter strips should be sized based on the following table.

Table PTP-10- 1 Grass Filter Strip Sizing (Minnesota Stormwater Manual)

Parameter	Impervious Parking Lots				Residential Lawns			
Maximum Inflow Approach Length (ft)	35		75		75		150	
Filter Strip Slope	•2%	>2%	•2%	>2	•2%	>2%	•2%	>2%
Filter Strip Minimum Length	10’	15’	20’	25’	10’	12 ’	15’	18’

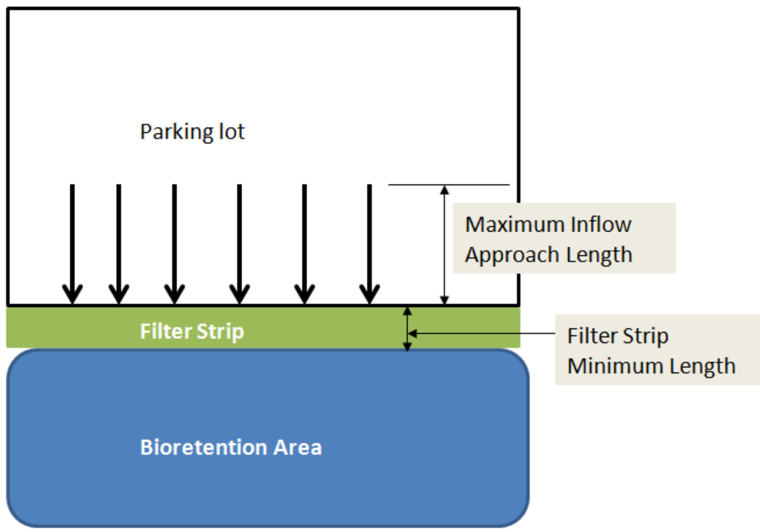


Figure PTP-10- 1. Filter Strip Design Parameters

Ø Grass channels should be a minimum of 20 feet in length and designed according to the following.

- o Parabolic or trapezoidal cross-section with bottom widths between 2 and 8 feet.
- o Channel side slopes no steeper than 3:1 (H:V)
- o Flow velocities limited to 1 foot per second or less for peak flow associated with the water quality event storm.

Flow depth of 4 inches or less for peak flow associated with the water quality event storm.

STEP 9 – Prepare vegetation and landscaping plan

Ø Prepare vegetation and landscaping management plan based on the guidance given in the Landscaping Section.

STEP 10 – Prepare operations and maintenance plan

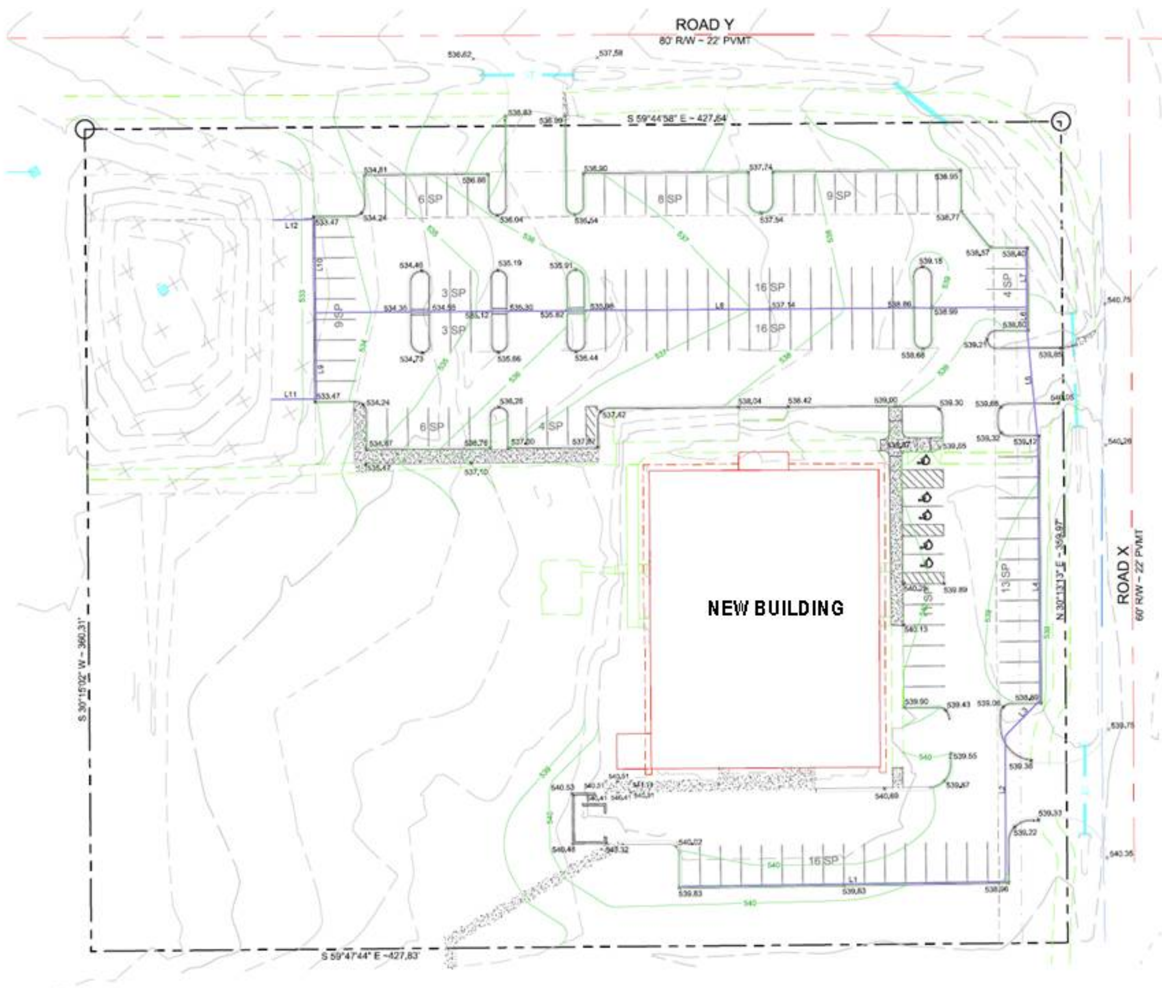
Prepare operations and maintenance plan based on the guidance given in the Maintenance Section.

Design Procedure

STEP 11 – Complete the Design Summary Table.

Design Parameter	**Required Size**	**Actual Size**
WQ_v		
Underdrain storage, Su		
Treatment area, Af		
Ponding depth		
Treatment area (LxW)		

Example Design



Proposed development of an undeveloped site into an office building and associated parking.

Base Data
Total Drainage Area = 5 ac
Site Area = 3.54 ac
Soils Type “C”

Pre-Development
Impervious Area = 0 ac; or I = 0%
Meadow (CN = 71)

Post-Development
Impervious Area = 1.72 ac; or I = 1.72/3.54 = 49%
Open Space, Fair (CN = 79)
Paved parking lots, roofs, driveways, etc. (CN =98)

Hydrologic Data

	Pre	Post
CN	71	89

WQ_v Depth = 1.1 in

Precipitation

2yr, 24hr	3.54 in
25yr, 24hr	5.88 in
100yr, 24hr	7.43 in

Example Design

This example focuses on the design of a bioretention facility to meet the water quality treatment requirements of the site. In general, the primary function of bioretention is to provide water quality treatment and not large storm attenuation. As such, flows in excess of the water quality volume are typically routed to bypass the facility or non-erosively pass through the facility. Where quantity control is required, the bypassed flows can be routed to conventional detention basins (or some other facility such as underground storage vaults).

Problem: Design a water quality treatment plan for this site. A dry detention pond will be constructed to meet the required detention standards and will provide 60% TSS reduction for the site. The total drainage area to the pond is 5 ac. Include multiple bioretention systems in the landscape islands in the parking area to meet the water quality goal of 80% TSS reduction.

Step 1 – Make a preliminary judgment as to whether site conditions are appropriate for the use of a bioretention system, and identify the function of bioretention in the overall treatment system.

- Consider basic issues for initial suitability screening, including:
  - The site has type “C” soils
  - There are no minimum setbacks
  - There are active karst areas on the site. Bioretention systems will not be located close to the sinkhole.
- Determine how bioretention system will fit into the overall stormwater treatment system.
  - Bioretention systems will be constructed in combination with a dry detention pond for water quality and quantity control on the site. Design of the dry detention pond can be found in Section 4.8.
  - Landscaping islands in the parking lot are likely spaces for bioretention systems.
  - The treated water quality volume will be collected by an underdrain and routed to the dry pond located in the northwest corner of the site for water quantity control. Flows greater than the water quality volume will bypass the bioretention systems and be routed to the dry pond for water quantity control and treatment prior to discharging.

Step 2 – Confirm design criteria, site constraints, and applicability.

- The following minimum criteria will be used in the design.
  - Minimum 200 sq ft of surface area
  - Maximum 6 in ponding depth
  - Maximum 48hr drain time from peak water level
  - Minimum 8 in underdrain enveloped in a 12 in gravel layer
  - Minimum 3 ft separation from bottom to seasonally saturated soils
- Determine any constraints the site will place on the bioretention system:
  - Do not place bioretention near sinkhole

Example Design

- Ensure that stormwater runoff from impervious surfaces is being treated to the 80% TSS reduction standard.
  - Determining the weighted TSS reduction.

    Bioretention Systems have an 80% TSS reduction, and all stormwater runoff from impervious surfaces flow through one of three bioretention facilities. Therefore, a weighted TSS calculation is not necessary.
  - Determine the treatment train TSS reduction.

    After the water quality volume is treated by bioretention, it is then treated in the dry pond before leaving the site. Bioretention Systems have an 80% TSS reduction. Dry ponds have a 60% TSS reduction.

$$TSS_{train} = A + B - \frac{(A \times B)}{100}$$

Where:

A = 80%

B = 60%

$$TSS_{train} = 80 + 60 - \frac{(80 \times 60)}{100}$$

$$TSS_{train} = 92\%$$

Step 3 – Perform field verification of site suitability.

- The bioretention systems will be designed as filtration BMPs, with the full WQv discharging within 48 hrs through the underdrain. Therefore, the only field testing required is to determine the high water elevation under the BMP locations.

Field soil tests show the high water elevation to be 8 feet or more below the parking lot.

Step 4 – Compute runoff control volumes and peak flows.

- Calculate the Water Quality Volume (WQ_V), Peak Flow Volume (V_{P25}), and the Extreme Flood Volume (V_{P100}).

Total Water Quality Volume:

WQv = [P Rv)(A)]/12

Where:

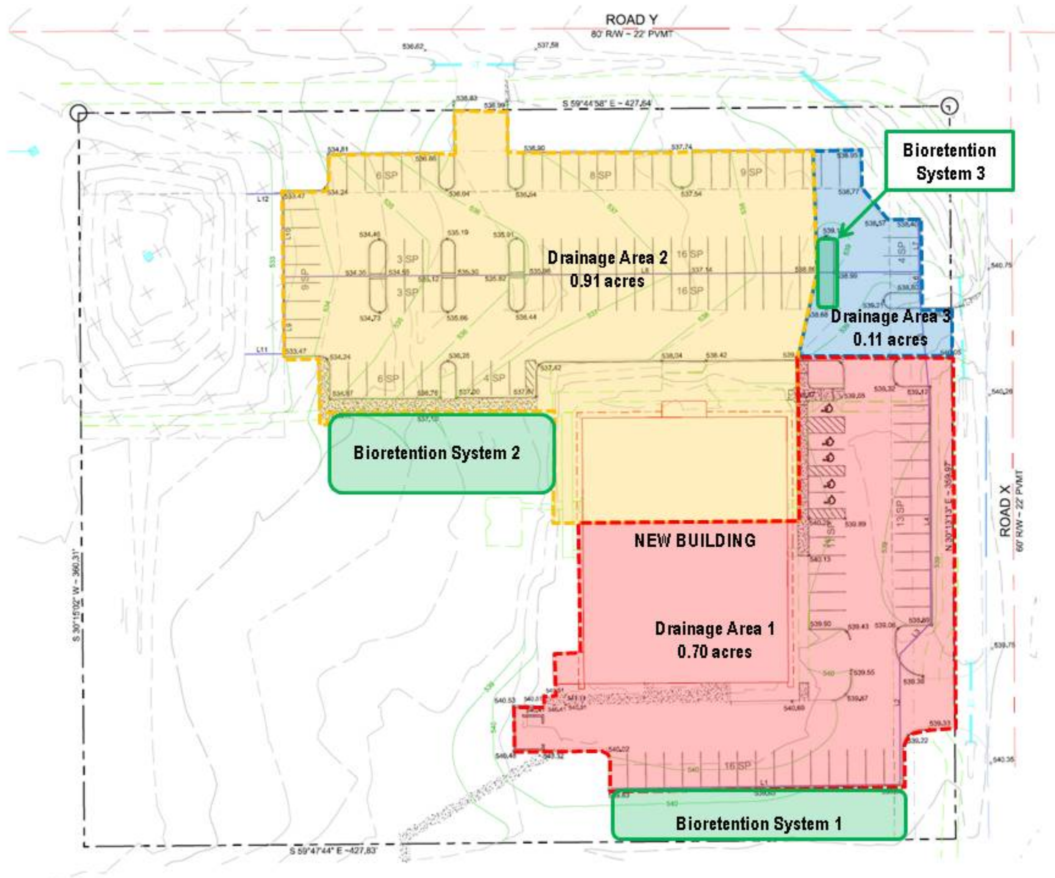
P = 1.1 inches
Rv = 0.05 + 0.009(I)
I = 49
Rv = 0.05 + 0.009(49) = 0.491
A = 1.72 acres

WQv = (1.1in x 0.491 x 1.72ac)/12 = 0.077 acre-ft = 3372 ft^3

Example Design

The pre- and post development volumes for both 25-yr and 100-yr 24-hour return frequency storms should be calculated to determine the required water quantity controls. See Appendix B for more information regarding detention and quantity design.

Ø Calculate the pre- and post-development peak flows for 25 yr (Q_{p25}) and 100 yr (Q_{p100}) storms for the design of flow diversions, outlet structures, and overflow structures.



Example Design

Note: Steps 5-8 are iterative

Step 5 – Determine bioretention type and size.

- Select type of bioretention basin
  - The bioretention system will treat the entire water quality volume.
  - The bioretention system will include an underdrain/collection system.
- Determine Water Quality Volume (WQ_V) for bioretention system.
  - Bioretention System 1
    - A_1 = 0.70 ac; I = 100; WQ_v = 3655 ft^3
  - Bioretention System 2
    - A_2 = 0.91 ac; I=100; WQ_v = 3452 ft^3
  - Bioretention System 3
    - A_3 = 0.11 ac; I=100; WQ_v = 417 ft^3
- Size Bioretention System With An Underdrain
  - Set ponding depth at 6 inches (h_f)
  - Set depth of the filter bed at 5 ft (d_f)
  - Design to drain in 48 hours (t_f)
  - Assume 35% storage (S_u) of WQ_v in underdrain gravel layer
  - Computed surface area
    - Bioretention System 1

      Assume Underdrain 70 ft long

      S_u = 0.35 x 70 ft x [0.5 x 1 ft x (8 ft +2 ft)] = 122.5 ft^3

      A_f = [(WQ_V - S_u) x d_f] / [k x (h_f + d_f) x t_f]

      = [(3655 ft^3 – 122.5 ft^3)x 5 ft] / [0.5 ft/day x (0.5 ft + 5 ft) x 2 days)

      = 3211 ft^2
    - Bioretention System 2

      Assume Underdrain 75 ft long

      S_u = 0.35 x 75ft x [0.5 x 1 ft x (8ft +2 ft)] = 131.25 ft^3

      A_f = [(WQ_V - S_u) x d_f] / [k x (h_f + d_f) x t_f]

      = [(3452 ft^3 – 131.25 ft^3)x 5 ft] / [0.5 ft/day x (0.5 ft + 5 ft) x 2 days)

      = 3019 ft^2

Example Design

§ Bioretention System 3

Assume Underdrain 25 ft long

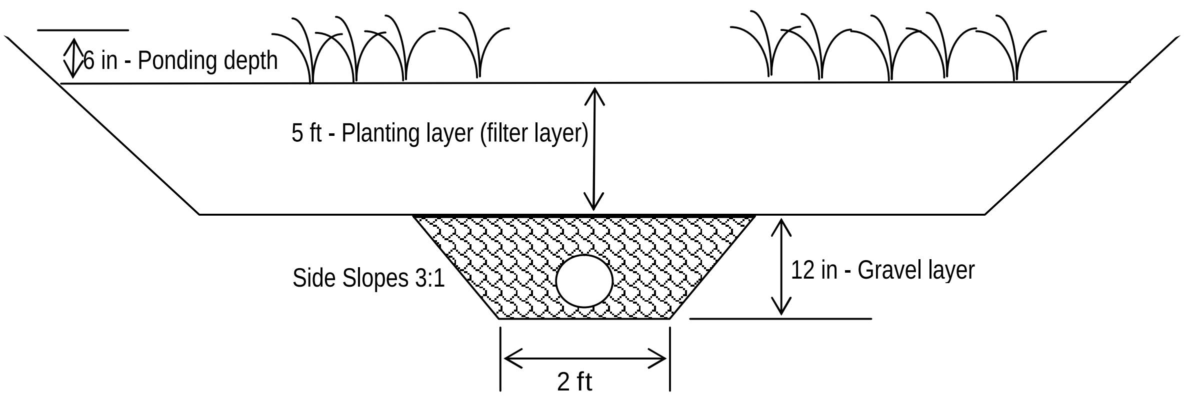
S_u = 0.35 x 25 ft x [0.5 x 1 ft x (8 ft +2 ft)] = 43.75 ft^3

A_f = [(WQ_V - S_u) x d_f] / [k x (h_f + d_f) x t_f]

= [(417 ft^3 – 43.75 ft^3)x 5 ft] / [0.5 ft/day x (0.5 ft + 5 ft) x 2 days)

= 339 ft^2

Bioretention System Cross Sectional View



- Determine Dimensions of Bioretention System
  - § Bioretention System 1

    A_f = 3211 ft^2

    Length = 120 ft; Width = 27 ft
  - § Bioretention System 2

    A_f = 3019 ft^2

    Length = 80 ft; Width = 40 ft
  - § Bioretention System 3

    A_f = 339 ft^2

    Length = 30 ft; Width = 12 ft

STEP 7 – Size outlet structure and/or flow diversion structure, if needed.

Ø A secondary outlet should be designed for the bioretention systems to safely convey excess stormwater.

Ø Potential for erosion to stabilized areas and bioretention system should be evaluated and the design should incorporate ways to mitigate erosive flows.

Example Design

STEP 8 – Determine pre-treatment volume and design pre-treatment measures.

- Some form of pre-treatment is required prior to the discharge of stormwater into the bioretention system, to remove any sediment and fines that may result in clogging of the soils in the filtration area.
- Bioretention System 1 will use curb cuts with lips raised 2 inches above the pavement elevation.
- Bioretention System 2 will use a Grass Filter Strip that is sized based on the Table PTP10-1. The maximum inflow length of 205 feet and the filter strip slope is less than 2%. The grass filter strip should be 25 feet long. There will also be a gravel diaphragm prior to the grass filter strip as an additional pretreatment measure.
- Bioretention System 3 will use curb cuts with lips raised 2 inches above the pavement elevation.

STEP 9 – Prepare vegetation and landscaping plan

- Prepare vegetation and landscaping management plan based on the guidance given in the Landscaping Section.

STEP 10 – Prepare operations and maintenance plan

- Prepare operations and maintenance plan based on the guidance given in the Maintenance Section.

STEP 11 – Complete the Design Summary Table

Bioretention Area 1

Design Parameter	Required Size	Actual Size
WQ_v	3655 ft^3	
Underdrain storage, Su	122.5 ft^3	
Treatment area, Af	3211 ft^2	3240 ft^2
Ponding depth	6 inches	
Treatment area (LxW)	120’ x 27’	

Example Design

Bioretention Area 2

Design Parameter	Required Size	Actual Size
WQ_v	3452 ft^3	
Underdrain storage, Su	131.5 ft^3	
Treatment area, Af	3019 ft^2	3200 ft^2
Ponding depth	6 inches	
Treatment area (LxW)	80'x40'	

Bioretention Area 3

Design Parameter	Required Size	Actual Size
WQ_v	417 ft^3	
Underdrain storage, Su	43.75 ft^3	
Treatment area, Af	339 ft^2	360 ft^2
Ponding depth	6 inches	
Treatment area (LxW)	30'x12''	

Residential Pollution Prevention	RHP-01 Non-Stormwater Discharges to Storm Drains

No Symbol

Symbol

Description

Citizens, residents and property owners of Glasgow and Barren County have the largest impact on the local streams and creeks. Most of the creeks, drainage channels and stormwater drains are located on private property. By eliminating pollution and protecting stormwater quality runoff, our streams and creeks will again support fish and other wildlife. It is important to protect stormwater quality since most city parks and recreation areas are located adjacent to streams, creeks, or karst features.

The City of Glasgow is required by the Kentucky Division of Water (KDOW) to reduce various types of pollution. KDOW issued a NPDES Phase II permit to the City of Glasgow in 2003. Stormwater quality data is reported to KDOW annually. Illicit discharge detection and elimination (non-stormwater discharges) is a control measure regulated by the city.

Design

The principal goal of this BMP is to eliminate all substances (liquid or solid) that do not belong in stormwater. Severe penalties and fines can be assessed for each incident. Consult with the City of Glasgow's Stormwater Ordinance for information regarding allowable and prohibited discharges.

For more information on illicit discharges to stormwater drainage systems contact the Glasgow Public Works Department.

Design (cont'd)

Illegal Discharges

Discharges into the Municipal Separate Sewer System (MS4) of an unapproved substance shall be considered an illicit discharge. This activity is regulated by City Ordinance 21-2.03. Contaminants include, but are not limited to the following:

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 materials
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, either from domestic animals or from feeder lot operations
20. Leaking sanitary sewers and connections which have remained uncorrected for more than seven (7) days
21. Recreational vehicle waste
22. Animal carcasses
23. Food wastes
24. Medical wastes
25. Bark and other fibrous materials
26. Collected lawn clippings leaves, or branches
27. Silt, sediment, or gravel
28. Dyes expect with permission from the [Director]
29. Chemicals, not normally found in uncontaminated water
30. Washing of fresh concrete for cleaning and/or finishing, or to expose aggregates
31. Junk motor vehicles
32. Leading solid waste disposal containers
33. Sewage dumping or dumping of sewage sludge
34. Discharge of any polluted household wastewater, such as but not limited to laundry wash water and dishwater, except to a sanitary sewer or septic system
35. Leaking water lines which have remained uncorrected for seven days or more
36. Commercial, industrial or public vehicle wash discharge
37. Garbage or sanitary waste disposal
38. Dead animals or animal fecal waste
39. Dredged or spoil material

Design (cont'd)

40. Wrecked or discarded vehicles or equipment
41. Wash waters to the storm drain system from the cleaning of gas stations, auto repair garages, or other types of auto repair facilities
42. Wastewater to the storm drain system from mobile auto washing, steam cleaning, mobile carpet cleaning, and other such mobile commercial and industrial operations
43. Waters from areas where repair of machinery and equipment, including motor vehicles, which are visibly leaking oil, fluids or coolants is undertaken
44. Waters from storage areas for materials containing grease, oil, or hazardous materials, or uncovered receptacles containing hazardous materials, grease, or oil
45. Washing of toxic materials from paved or unpaved areas to the storm drain system
46. Discharge from the washing or rinsing of restaurant mats, roof vents, grease traps, equipment or garbage bins or cans in such a manner that causes non-storm water to enter the storm drain system
47. Sewage, industrial wastes, or other wastes into a well or a location that is likely that the discharged substance will move into a well, or the underground placement of fluids and other substances which do or may affect the waters of the state
48. Any hazardous material or waste, not listed above

<u>The following non-stormwater discharges are explicitly prohibited by the Bowling Green Stormwater Ordinance</u>. The list of prohibited discharges is not all-inclusive, as any type of discharge not specifically exempted (see list of items above) is prohibited. In other words, these are only the more commonly observed violations.

- Raw sewage discharges or overflows, including sanitary sewer overflows (SSOs).
- Discharges of wash water from the hosing or cleaning of gasoline stations, auto repair garages, or other types of automotive service facilities.
- Discharges resulting from the cleaning, repair, or maintenance of any type of equipment, machinery, or facility (includes motor vehicles, cement-related construction equipment, portable toilet servicing, etc.)
- Discharges of wash water from mobile operations such as steam cleaning, power washing, pressure washing, carpet cleaning, and mobile carwash facilities.
- Discharges of wash water from the cleaning or hosing of impervious surfaces in industrial and commercial areas including parking lots, streets, sidewalks, driveways, patios, plazas, work yards, and outdoor eating or drinking areas.
- Discharges of runoff from material storage areas containing chemicals, fuels, grease, oil or hazardous materials.
- Discharges of pool or fountain water containing chlorine, biocides or other chemicals, and also discharges of pool or fountain filter backwash water.
- Discharges of water containing sediment or construction-related wastes.
- Discharges of food-related wastes such as grease, oil, fish processing water, kitchen mat wash water, trash bin wash water, pouring liquids into dumpsters, etc. This includes disposing unwanted food or liquid into ditches, creeks or streams.

Residential Pollution Prevention	RHP-02 Vehicle Washing

No Symbol

Symbol

Description

Pollutants, such as detergents and dirty washwater, must always be prevented from directly discharging to streams, creeks, ditches and storm drains. Business and property owners can reduce pollutants from cars, trucks and other personal vehicles in order to protect natural streams and creeks. Every effort should be made to prevent pollutants from running off the land and impervious surfaces due to precipitation and stormwater.

Design

Washing personal vehicles (cars, trucks, vans, motorcycles, etc.) has a 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). The waste products from these vehicles include:

- Fluids that leak slowly from the engine, or may escape from a rupture, or spill during a vehicle collision, 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 toxic to plants and wildlife.
- The moving parts of vehicles that typically wear down, such as pieces of worn tire, brakes and brake pads that erode and grind in a way to minimize vehicle maintenance, and especially those that containing asbestos and metals.

Detergents and cleaning substances are toxic to aquatic life. Reduce or eliminate the use of detergents and cleaners while washing vehicles. Wash vehicles on lawns or grassy areas to reduce direct discharge of washwater to curbs, inlets, ditches and other waterways.

Prohibition to Discharge

Due to federal mandates, the City of Bowling Green has adopted a Stormwater and Street Ordinance to prohibit discharge of chemicals and manmade materials into creeks, streams, ditches, swales, pipes, storm drains, and parts of the city drainage system. See the BMP entitled RHP-01, Non-Stormwater 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 Bowling Green, the state government Kentucky Division of Water (KDOW) can also assess penalties for polluting waters of the state (defined as any blue-line stream on a USGS 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 RHP-01 (Non-Stormwater Discharges to Storm Drains) and in the Bowling Green Stormwater and Street Ordinance. 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 fundraising, or similar noncommercial purpose. However, it is illegal to discharge washwater or rinsewater that adversely affects the water quality of a creek or stream, even if otherwise allowable according to ordinance.

Residents should attempt to minimize the amount of detergents that are used in wash-water. Extremely dirty or grimy vehicles should generally be cleaned at a commercial carwash, which is required to treat all washwater and rinsewater to certain standards.

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.

City and County residents may want to wash vehicles on lawns or other pervious ground surfaces, or at least direct the discharge of washwater and rinsewater 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 washwater in a manner that does not pollute Bowling Green 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:

- Ø GHP-11 Vehicle and Equipment Washing
- Ø RHP-01 Non-Stormwater Discharges to Storm Drains
- Ø RHP-03 Vehicle Maintenance and Repair

Residential Pollution Prevention	RHP-03 Vehicle Maintenance and Repairs

No Symbol

Symbol

Description Pollutants and automotive fluids should be prevented from accumulating on impervious surfaces in order to improve stormwater quality and protect natural streams and creeks.

Design Personal vehicles (cars, trucks, vans, motorcycles) have a high potential for polluting streets, grassy areas, streams, creeks, and the air that we breathe.

- Ø 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.
- Ø 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 throughout the country. Please keep personal vehicles in good condition to reduce air pollution. The Commonwealth of Kentucky currently does not require statewide vehicle inspections or emission 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.

Installation Procedures

- Due to federal mandates, the City of Bowling Green has adopted a Stormwater and Street Ordinance to prohibit discharge of chemicals and manmade materials into creeks, streams, ditches, swales, pipes, storm drains, and any surface which drains into these waterways. See the BMP entitled RHP-01 (Non-Stormwater Discharges to Storm Drains) for a list of allowable discharges; anything else is strictly prohibited.
- One category of prohibited discharges included all 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 stormwater runoff at a later time. In addition to fines and legal action from the City of Bowling Green, the Kentucky Division of Water (KDOW) can also assess severe penalties for polluting waters of the state (defined as any blue-line stream on a USGS 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 the KDOW, the City of Bowling Green and Warren County will assess penalties and take legal actions.

Disposal Options

- Automotive parts stores and repair shops will typically accept engine oil and other fluids for recycling. Ask about recycling when you purchase automotive parts and 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 homeowner/resident has adequate knowledge of 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. 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 stormwater drainage system or to natural creeks and streams. Sweep or mop any spills or leaks promptly. Keep spill containment materials nearby.
- Use non-toxic 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 non-chlorinated solvents such as kerosene or mineral spirits.

Maintenance

The following GHP (Good Housekeeping Practices) BMPs are applicable to everyone who operates or maintains a vehicle such as businesses, industries, homeowners, automotive dealers, repair shops and garages, etc. They contain many specific requirements and guidelines for care and maintenance of vehicles.

- GHP-05 Spill Prevention and Control
- GHP-12 Vehicle and Equipment Fueling
- GHP-13 Vehicle and Equipment Maintenance

Residential Pollution Prevention	RHP-04 Landscape Irrigation and Lawn Watering

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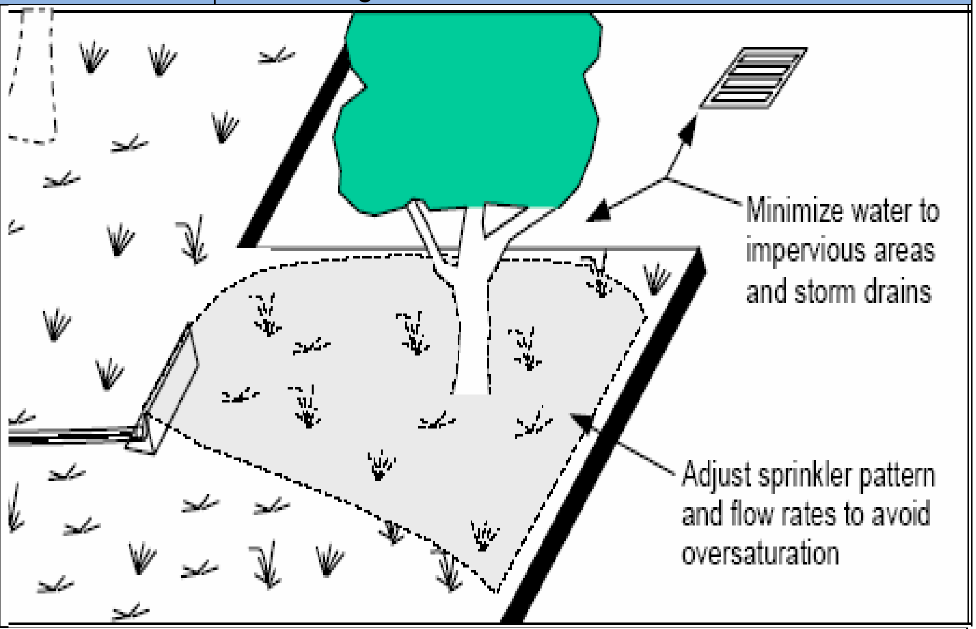

Description Prevent or reduce the discharge of pollutants from sprinklers and landscaping water in order to protect natural streams and creeks. Runoff is reduced by decreasing the flow rate, applying water in a more controlled manner, and by closely monitoring sprinklers.

Design During dry summer months in the Bowling Green 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, pet/animal waste and mulch. In addition, most watering is done with chlorinated utility water. Chlorinated water must not be discharged to Bowling Green's natural creeks, streams, because it kills aquatic life. Runoff from several over watered lawns will kill fish and other aquatic organisms in a small creek. Over watering 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, the City of Bowling Green adopted the Stormwater Ordinance to prohibit all discharges of chemicals, manmade materials and soils (see RHP-01, Non-Stormwater 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

- Ø 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.
- Ø Lower the flow rate and increase watering time as necessary to avoid discharging water to the stormwater drainage system. Excess water damages the lawn or landscaped area by washing away the nutrients and soil.
- Ø Monitor watering activities and correct as necessary. Stop watering as soon as runoff leaves the landscaped area, which indicates saturated conditions.
- Ø Do not leave watering sprinkling activities unattended. Watering will be effective for a few hours, but the ground usually becomes saturated by nightfall. Afterwards, the sprinklers become ineffective and most of the chlorinated water goes directly to the stormwater drainage system.
- Ø Use herbicides, pesticides and fertilizers in accordance with manufacturer's instructions. Excessive use of these hazardous materials can be toxic to vegetation and wildlife in and near 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.
- Ø Construct a small berm, depression area or curb on the lower side of landscaped areas. Minor grading modifications will 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.
- Ø If possible, avoid using chlorinated water for landscaping. Use rain barrels, cisterns, ponds or other methods for capturing stormwater. 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

- Ø 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

- Ø 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 excessive watering.
- Ø 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:

- Ø GHP-14 Employee / Subcontractor Training
- Ø GHP-15 Pesticides, Herbicides, and Fertilizer Use
- Ø EPP-10 Mulching
- Ø RHP-01 Non-Stormwater Discharges to Storm Drains

Residential Pollution Prevention	RHP-05 Pesticides and Fertilizers

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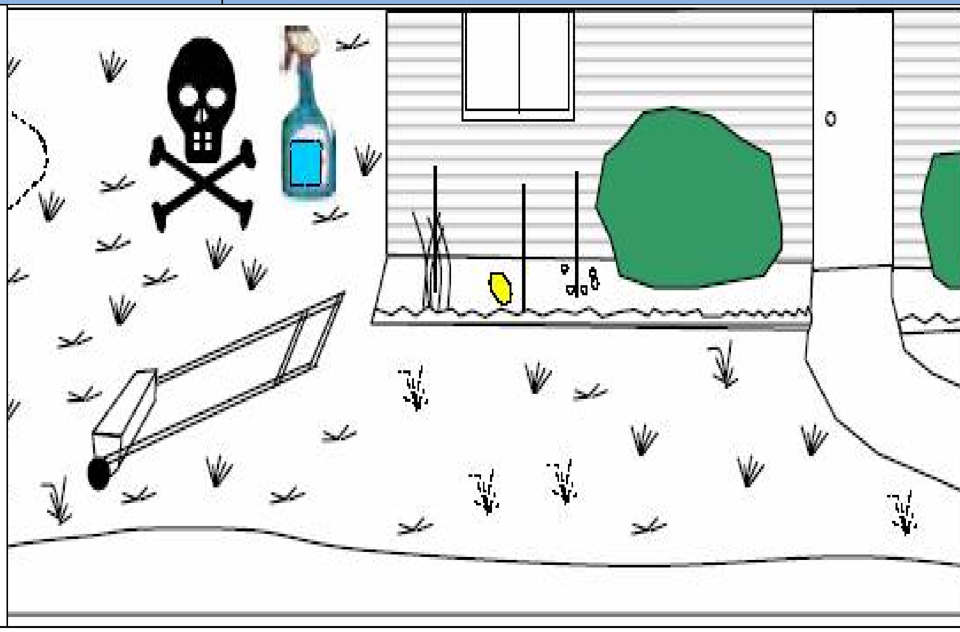

Description

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 stormwater pollution, poisons, and toxic substances in Bowling Green and Warren County creeks and streams. Only use fertilizers and pesticides when necessary, and consider alternative methods and treatments if available.

Design

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 stormwater runoff. The use of fertilizers, herbicides, and pesticides contribute to pollution of stormwater 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 GHP-15 (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 Kentucky's Cooperative Extension Service has many brochures and pamphlets concerning fertilizers and pesticides, including various environment-friendly alternatives. These pamphlets are available online at: http://ces.ca.uky.edu/ces/

More information on pesticides is available from the USEPA Office of Prevention, Pesticides & Toxic Substances: http://www.epa.gov/opptsmnt/

Design (cont'd)

Fertilizers

- 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

- Excessive application and misuse of pesticides and herbicides results in heavily polluted stormwater 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.
- 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 stormwater runoff pollutants. Use pesticides and herbicides with low water solubility. Granular formulations are generally preferable to liquids because application losses are lower.
- 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° – 80° F.

Pesticide and Herbicide Types

- 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.
- 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 non-target 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.
- 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.

Design (cont'd)

- 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.
- Pre-plant 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 much 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 stormwater and away from children, pets, and sources of heat, sparks, and flames. Store products in their original containers and keep well-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

- Warren County sponsors an annual event for residents to disposal of chemicals and poisons used in their homes for free. Contact the Warren County Solid Waste Coordinator for more information.
- In general, use the entire product before disposing the container. However, do not overapply the product if it is not needed. 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

Maintenance

These related BMPs also provide guidance on the correct use and disposal of fertilizers and pesticides:

- GHP-06 Waste Management
- GHP-15 Pesticides, Herbicides, and Fertilizer Use

Residential Pollution Prevention	**RHP-06 Household Hazardous Wastes**

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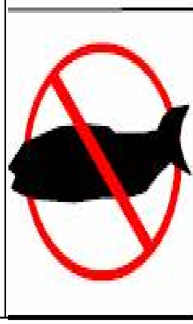


Description

Hazardous wastes exhibit one or more characteristics of ignitability, corrosivity, reactivity or toxicity which make it dangerous. When disposed of in the municipal solid waste stream or otherwise improperly managed, these materials have the potential of contaminating the ground water.

Design

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

Due to poisons and toxic substances, household hazardous waste should not be included in the ordinary weekly garbage collection that is collected curbside. Contact the Warren County Solid Waste Coordinator for more information.

Prohibition to Discharge

Due to federal mandates, the City of Bowling Green has adopted a Stormwater and Street Ordinance to prohibit discharge of all chemicals and manmade materials into creeks, streams, ditches, swales, pipes, storm drains, and any surface that drains into these waterways. See BMP RHP-01 (Non-Stormwater 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 Bowling Green, the state government Kentucky Division of Water (KDOW) can also assess severe penalties for polluting waters of the state (defined as any blue-line stream on a United States Geological Survey (USGS) quadrangle topographic map), which also includes sinkholes and known areas of groundwater recharge.

Disposal Options

A household hazardous waste is any substance that is toxic, poisonous, corrosive, chemically reactive, flammable or combustible. The typical home contains many hazardous chemicals commonly used for cleaning, repairs, construction, automobile maintenance, lawn care, or hobbies. Oftentimes, household hazardous waste will accumulate on shelves in the garage or basement. The following items are not accepted at the Household Hazardous Waste Collection Center:

- Ammunition and explosives
- Medical waste
- Radioactive waste
- Unidentified materials

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.

Recycling

Southern Recycling provides curbside recycling pickup in most areas. Participation in the recycling program is encouraged. Nearly 80% of all households participate in curbside recycling at least once per month. To receive more information about recycling check with the Warren County Solid Waste Coordinator.

Related BMPs

These BMPs have additional information about waste disposal and alternatives:

- GHP-05 Spill Prevention and Control
- RHP-01 Non-Stormwater Discharges to Storm Drains

References

- www.bgky.org
- The Bowling Green Stormwater Ordinance can be found at the following website: www.bgky.org/publicworks/planningdesign/stormwater.htm

Residential Pollution Prevention	RHP-07 Sanitary Sewer Laterals & Septic Tanks
No Symbol Symbol	

Description

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. Those property owners on septic tank systems are responsible for maintenance and repairs to septic tank systems and associated drainfields.

Design

The definition of sanitary and septic waste includes, but is not limited to, the following items as listed in the Bowling Green Stormwater and Street Ordinance:

- 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 community health system but are seldom appreciated, noticed or maintained.

Within the City of Bowling Green, most waste flows are discharged into sanitary sewers leading to wastewater treatment plants operated by the Bowling Green Municipal Utilities (BGMU), a publicly owned utility company. BGMU is independent from the City of Bowling Green and the Warren County governments. In addition to wastewater collection and treatment, BGMU also operates the water and electricity distribution network systems. See

Design (cont'd)

the BGMU website www.bgmu.com or call (270) 782-1200 for additional information on wastewater services, fee structures, request for service, etc. Other wastewater system contacts in the area includeBGMU Automated Customer Service: (270) 782-4301

- BGMU Power Outage Reporting System: (270) 782-4302
- BGMU Fax Number: (270) 782-4590
- BGMU Email Address: customerinquiry@bgmu.com

BGMU is located at 801 Center Street (P.O. Box 10300) Bowling Green, KY, 42102-7300. Their office hours are: 8:00 a.m. – 4:30 p.m. Monday – Friday.

Warren County Water District also operated a sanitary sewer system outside of the BGMU district. For questions in the jurisdiction call 842-0052.

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 to sanitary sewer laterals. Large tree roots can infiltrate and eventually break a sanitary sewer lateral so that it will not function.

Inspection and Investigation

- 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 Bowling Green 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.
- 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 Bowling Green Municipal Utilities to report illicit discharges, spills, leaks, or suspicious sanitary sewer discharges that need to be investigated. Anonymous calls are also handled.

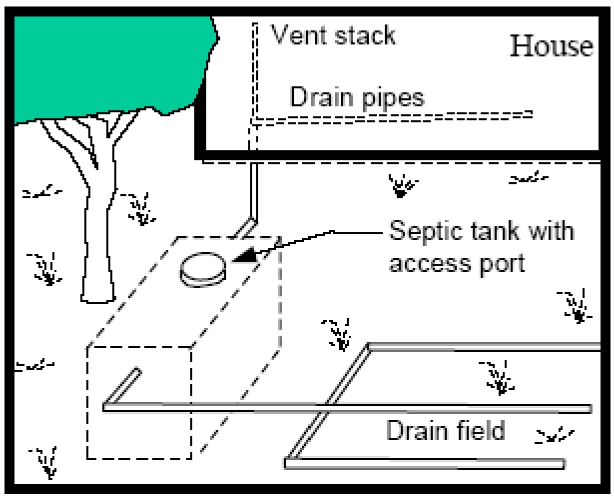
Other Considerations

- All temporary and permanent connections to the municipal sanitary sewer system must be inspected and approved by the BGMU plumbing inspector prior to installation. Contact the Inspections Office for construction procedures and testing requirements. Only use licensed plumbing contractors with adequate experience and equipment for each project.
- Older houses throughout the City of Bowling Green may have illicit connections, where a sanitary sewer line discharges into a storm drain. There are many reasons that this may have occurred, including:
  - Standard practice 50 to 100 years ago, where sanitary sewers did not exist.
  - A building contractor may have misidentified the connection pipe honestly.

Sanitary Laterals (cont'd)

- § A building contractor may have taken a shortcut to save time & money.
- § The storm drain contractor may have misidentified the sanitary sewer pipe.

- Ø When found, cross connections must be replaced and repaired to function correctly. See RHP-01 (Non-Stormwater Discharges to Storm Drains) for additional information on locating illicit discharges and cross connections. Smoke testing and dye testing are two common methods for BGMU to locate leaks in the main sanitary sewer system.
- Ø Roof drains for older houses typically are connected to the sanitary sewer system (standard practice 50 years ago). Current standard procedures for roof drainage call for roof drains and gutters to be disconnected from the sanitary sewer system. Roof drainage is relatively clean water that is discharged directly onto the ground.



Septic Tank Systems

- Ø 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 their cost. Typically a septic tank needs to be inspected every year and pumped out every three years.
- Ø 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.
- Ø 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.
- Ø Inspect the septic tank and septic drainfield 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 RHP-01 for methods to detect illicit discharges and leaks. Look for unusual odors, wet ground, discolored soil, subsidence or unusual settlement.

Safety Concerns

- 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 manhole 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

- GHP-10 Sanitary and Septic Waste Management
- RHP-01 Non-Stormwater Discharges to Storm Drains

Residential Pollution Prevention	RHP-08 Pet and Animal Wastes

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Description

Property owners should strive to prevent animal and pet wastes in or near natural streams and creeks, storm drains, sinkholes, ditches, swales or other types of stormwater conveyance systems. This will reduce the amount of bacteria (particularly fecal coliforms), which has been cited as concern for several creeks within the City of Bowling Green.

Design

Sources of fecal coliforms include animals (such as pets, cattle, wild birds) and humans (failing sewers, straight pipes, improper disposal of food products). This BMP addresses animal wastes (domestic and wild) which are a significant source of water pollution. 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 Bowling Green adopted the Stormwater Ordinance in 2004 to prohibit and reduce pollution (see RHP-01, Non-Stormwater Discharge to Storm Drains) into streets, ditches, storm drains, and natural streams. This prohibition specifically includes animal wastes; see the following sections of the Stormwater 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 MD 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).
- Provide a buffer zone and/or a fence to prevent animals from urinating or defecating into a creek, stream, or other stormwater drainage feature. Do not keep pets immediately adjacent to ditches, swales, storm drains, pipes or culverts.
- 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 in the ground is also an acceptable option, away from ditches or stormwater channels.
- Cat litter can be sent to the sanitary landfill as part of the regular weekly garbage pickup. Burying cat litter in the ground is also an acceptable option, away from ditches or stormwater channels. Dumping used cat litter in piles on the ground surface is not an environmentally approved practice.
- 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.

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 stormwater 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 stormwater channels as possible. Burying animal waste in the ground 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.

Residential Pollution Prevention	RHP-09 Slope and Streambank Stabilization

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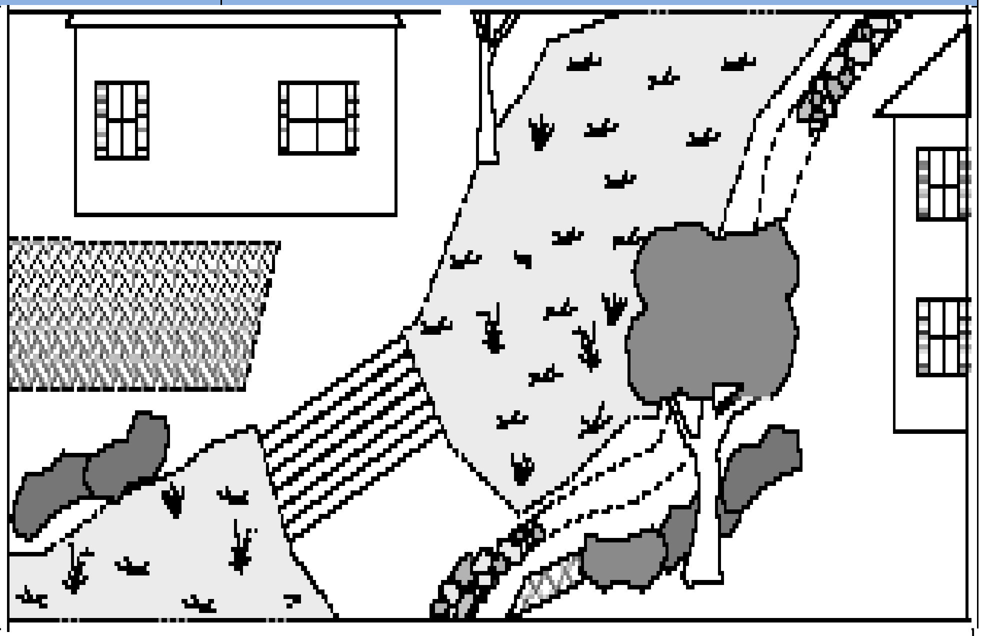

Description

Property owners who stabilize eroding slopes and streambanks in order to protect ditches, swales, storm drains, creeks, lakes and natural waterways will not only improve the appearance of private property but will also substantially reduce sedimentation and flood damage. Streambank stabilization may require a permit from the Kentucky Division of Water (KDOW) prior to grading.

See the KDOW website for more information at www.water.ky.gov.

Design

Homeowners 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 Bowling Green 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, then the soil itself is unstable and typically needs a permanent solution. Possible remedies may include:

- Planting hardier and more durable types of vegetation (native trees and vines)
- Regrading the slope so that it is less steep.
- Constructing a retaining wall, crib wall or other structural feature.
- Divert surface water (and possibly groundwater) that tends to saturate soils and makes them heavier.

If a slope tends to erode or washout in certain spots then the problem may be a combination of inadequate ground cover, poor drainage, no topsoil, wrong plant or some other problem.

- Divert surface water around the slope if possible.
- Improve ground surface by adding topsoil, lime, fertilizer, or mulch.
- Plant 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 non-green solutions. A common misconception is that 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:

- EPP-13 Terracing
- EPP-08 Surface Roughening
- SMP-06 Bank Stabilization
- SMP-07 Riprap
- EPP-09 Topsoil
- EPP-10 Mulching
- EPP-05 Temporary Seeding

Retaining walls, crib walls and prefabricated structural walls must be designed by a professional or other qualified expert for specific site conditions. Walls which have a maximum height of at least 4 feet must be reviewed as part of a site development permit issued by either the City County Planning Commission or City of Bowling Green.

Overview of Streambank Stabilization

KDOW will require a property owner to obtain a Water Quality Certificate and/or a Floodplain Construction Permit for any grading in or near waters of the State. Here are two quick definitions used to specify waters of the State:

- Bowling Green Engineering Department defines this as a blue-line stream on a USGS quadrangle map, or any point downstream from where a blue-line stream begins.
- The KDOW typically defines a channel as carrying water for longer than one week after a heavy rainfall. The local KDOW office can send a field inspector to make difficult judgments when requested.

Overview of Streambank Stabilization (cont'd)

The KDOW 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 channel) are usually necessary to anchor and protect streambanks. To complete this type of construction a property owner may be required to get a Floodplain Construction Permit and a Water Quality Certificate to ensure that Kentucky's water quality standards will not be violated. See the KDOW website for further information on permits, channelization, streambank protection, and allowable activities.

It is important not to alter the hydraulic stream cross sections. Changing the channel hydraulics at one location (flow width, flow depth, velocity, channel roughness) will affect the channel hydraulics elsewhere. Specific aspects of streambank stabilization are addressed in these related BMPs:

- SMP-06 Bank Stabilization
- SMP-08 Channel Linings

Residential Pollution Prevention	RHP-10 Swimming Pools and Spas

No Symbol

Symbol

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.

Design

Due to federal mandates, the City of Bowling Green adopted a Stormwater and Street Ordinance to prohibit discharge of non-stormwater materials (see RHP-01, Non-Stormwater Discharges to Storm Drains) such as chlorine, Baquacil, and other treatment chemicals into streets, ditches, storm drains, and natural streams. Since a wide variety of pool and spa treatment chemicals exist, it would be impossible to address proper disposal methods for every available chemical used in the treatment of pool and spa water.

The most common pool treatment is chlorine, which dissolves in water, then 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 which are frequently used to reduce algae growth, adjust pH, remove hardness or metals, remove stains, etc. Bowling Green 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.

Design (cont'd)

Reducing or Eliminating Discharges

- Before buying chemicals, select a method of pool treatment that has been successfully used in the Bowling Green 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.

Recommended Disposal Alternatives

- Any swimming pool or spa water that has been treated by chlorine only and dechlorinated may be discharged to grassy yards, streets or stormwater systems at a controlled rate. Before discharging dechlorinated pool or spa water, check the water with pool test kit to verify that it is completely dechlorinated. Dechlorinated discharges to streets and driveways should occur in dry weather when it will not contribute to flooding 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. Discharge 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. Construct an infiltration well or trench to allow water to soak into ground.
- The connection to sanitary sewer system must be approved by Bowling Green Municipal Utilities (BGMU) or Warren County Water District (WCWD) prior to discharging. Do not discharge water onto or through neighbor's yard or property. Infiltration rates in some soils can be slow. 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 stormwater 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.
- Note that any connections to sanitary system must be approved by BGMU or WCWD prior to installation. Call the BGMU or WCWD offices for more information.

Limitations Disposal methods that comply with the City of Bowling Green Stormwater Ordinance may not necessarily comply with federal, state, and county regulations. Resolve compliance issues prior to discharging water from swimming pool or spa.

Residential Pollution Prevention	RHP-11 Boating

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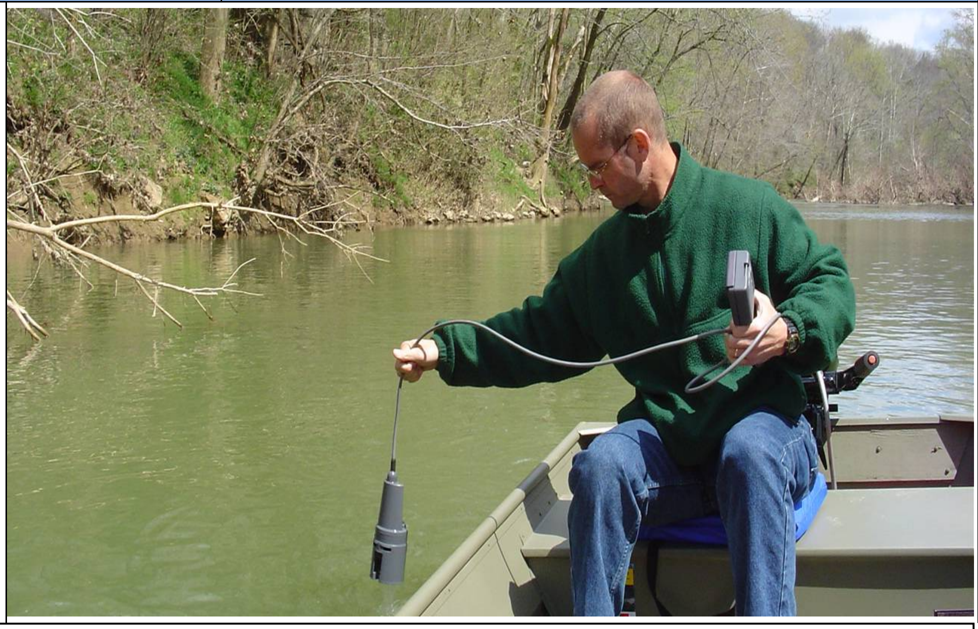

Description

Prevent or reduce the discharge of pollutants to rivers, lakes and streams by proper disposal of wastes, minimizing repairs and maintenance, cleaning up spills and wastes immediately, and improved boating equipment and methods. Protect our natural resources and environment by following guidelines from the National Clean Boating Campaign. Use common sense to protect water quality of Bowling Green lakes and rivers.

Design

Federal, state and municipal regulations prohibit the discharge of any waste or litter into Barren River, Drakes Creek, Jennings Creek or any of the various tributaries. 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. Brochures and fact sheets from the National Clean Boating Campaign for sewage pumpout, fueling, bilge water, litter and boat maintenance are available at www.cleanboating.com/research/boatingpublic.html.

Boating Activities

Boat Sewage and Pumpouts

- 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. 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 website (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	< 1000 / 100 ml	No visible floating solids
Type II	< 200 / 100 ml	Suspended solids < 150 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 Kentucky. 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.

Boating Activities (cont'd)

- Fuel, fluids and oil should be kept in secure containers. Recycle used fuels in properly labeled containers. Inspect and repair engine valves, pipes, hoses as necessary. Use drip pans when conducting maintenance and repair.
- Keep engine and other equipment in good operating condition. Inspect engine prior to each use. Follow manufacturer's recommendations for maintenance and tuneups. Use drip pans and funnels when performing minor engine repairs.
- 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.
- Notify KDOW and the City of Bowling Green or Warren County in the event of major leaks and spills (as described in GHP-05, 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 does not actually remove the pollution from the water.

Litter and Fish Waste

- Do not discharge anything into the water, including excess food. Place all litter and waste into trash bags for disposal onshore. Retrieve any trash which falls overboard.
- 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).
- Do not throw cigarettes (or other smoking materials) overboard. Use an ashtray when smoking. Do not spit chewing tobacco overboard.
- 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.
- People participating in fishing tournaments and other authorized events should follow guidelines presented by the sponsors. Follow all rules and regulations issued by the Kentucky Department of Fish and Wildlife.

Boat Cleaning and Maintenance

- 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.

Boating Activities (cont'd)

- 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.
- 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.
- Painting should be limited to spot work. 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.
- 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 GHP-05 (Spill Prevention and Control) for emergency telephone numbers.

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.

Links

- National Clean Boating Campaign http://www.cleanboating.com/research/boatingpublic.html
- National Clean Boating Campaign http://cleanboating.org/bibliography/index.html

Residential Pollution Prevention	RHP-12 Tips for Wet Basements and Crawlspaces

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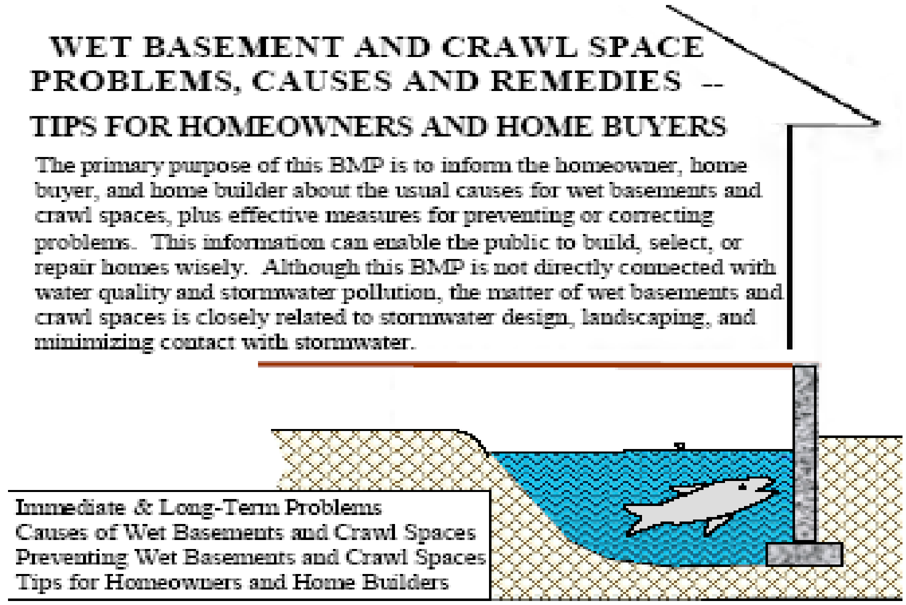

Immediate and Long Term Problems

Standing water or seepage inside residential crawl spaces and basements can cause frustrating problems for the homeowner. 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 sinkhole collapse. 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. Homeowners 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:

- 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 stormwater infiltration.
- 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 2000 square foot roof can produce almost 1250 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.
- 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.
- Rainwater runoff from the adjacent lawn, walks, or driveway areas if the landscaping slopes water to drain 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:

- Subsurface or groundwater may be intercepted or dammed up by a basement or foundation wall. Houses which 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.
- Nearby springs may have been filled in or covered up by others. 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.
- 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. Homeowners 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.

Cause of Wet Basements and Crawl Spaces (cont'd)

- 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 to seep into the basement or crawl space.

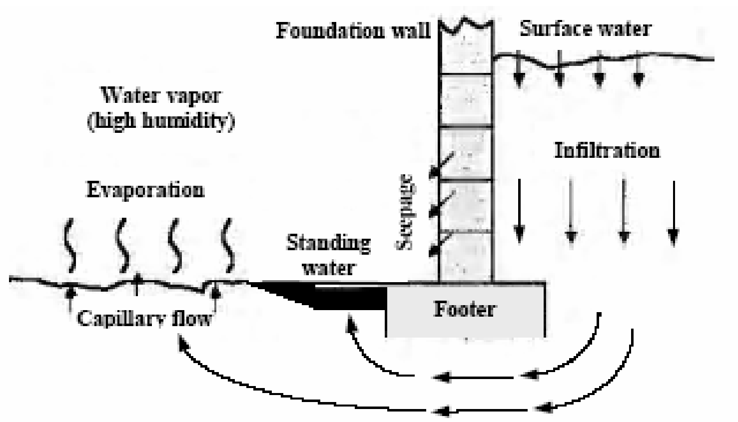

Figure 1. Typical paths of water and moisture entering into a crawl space area.

- 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 1 illustrates how surface water and moisture can enter a crawl space area.
- 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.

Cause of Wet Basements and Crawl Spaces (cont'd)

- 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 Bowling Green requires that new construction or alteration of houses must 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:

- Minimize possibility of dampness in basements and crawl spaces.
- Prevent standing or ponding water on the site.
- Prevent soil erosion.
- 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.

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 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.

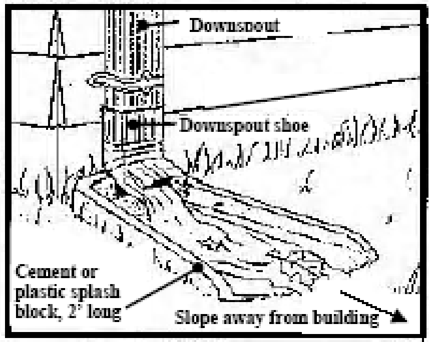

Figure 2. Correct installation of downspout shoe and splash block at foundation wall.
(Note that the ground surface slopes away from house.)

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.

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.

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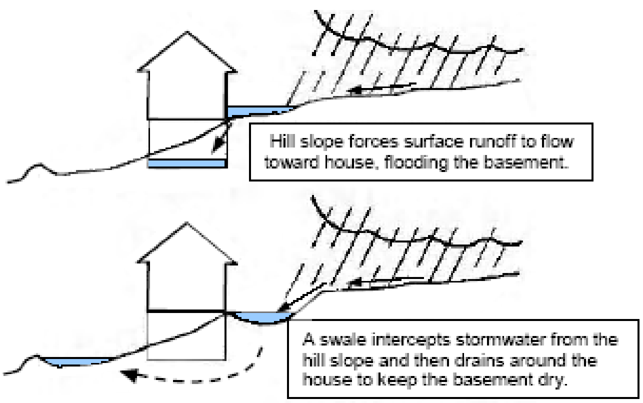


Figure 3. Correction of typical slope drainage problem using swale or ditch.

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.

Preventing Wet Basements and Crawl Spaces (cont'd)

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 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 which 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.

Tips for Homeowners and Homebuilders

"A teaspoon of prevention is worth a gallon of cure" certainly applies to new homebuilders – 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!"

Work with a professional to help locate the new house on the lot and at an elevation which 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 where that may be affected by nuisance flooding.

Tips for buying or building a new house

The following tips are suggested to avoid water problems when building or buying a new house:

Work with a reputable homebuilder that can supply reference names and projects for houses that he 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 dam-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.

Tips for Homeowners and Homebuilders (cont'd)	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) back sloping lawns and landscaping toward foundation walls; (2) back sloping driveways toward garage, stoops, walks or patios which 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 which 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.

Appendix A
Ordinance
2424
2727
2728
2809

Appendix B
List of Definitions, Abbreviations and Acronyms

1. Definitions

"As soon as practicable" shall mean when site at the earliest possible time when external factors such as inclement weather would not prevent completion of the task

"Authorized Enforcement Agency" shall mean the City of Glasgow Public Works Department, City Engineer (or designated subordinates).

"Best Management Practice (BMP)" shall mean a measure that is implemented to protect water quality and reduce the potential for pollution associated with storm water runoff. These could include schedules of activities, prohibitions of practices, general good housekeeping practices, pollution prevention and educational practices, maintenance procedures and other management practices to prevent or reduce the discharge of pollutants directly or indirectly to storm water, receiving waters, any natural drainage crevice, karst feature, ditch, known subterranean water channel, closed systems or catch basins, conveyance or the MS4. BMPs also include treatment practices, operating procedures and practices to control site runoff, spillage or leaks, sludge or water disposal, or drainage from raw materials storage.

"Blue Line Streams" shall mean streams that are represented on the most recent version of the United States Department of the Interior Geological Survey 1:24,000 USGS quadrangle maps.

"Channel" shall mean a natural or constructed/manmade watercourse with definite bed and banks to confine and conduct continuously or periodically flowing water. Channel flow is that water which is flowing within the limits of the defined channel.

"Clean Water Act (CWA)" shall mean those Federal regulations (33 U.S.C - 1251 et seq. and any subsequent amendments thereto) that prohibit the discharge of pollutants to waters of the United States unless such discharge is in accordance with an approved National Pollutant Discharge Elimination System (NPDES) permit.

"Clearing" shall mean any activity that removes vegetative surface cover.

"Construction Activity" shall mean any activities subject to NPDES construction permits issued by the United States Environmental Protection Agency (USEPA) or the Kentucky Division of Water (KDOW). Currently these include construction projects resulting in land disturbance of one (1) acre or more. Such activities include, but are not limited to, clearing and grubbing, grading, excavating and demolition.

"Conveyance" shall include, but not be limited to, any of the following: blue line streams, channel, drainage basin, drainage way, drainage/dry well, ephemeral stream, flood plain, karst feature, public storm drain, storm drainage system, waterbody, watercourse or waterway.

"Critical Area" shall mean a site difficult to stabilize due to exposed subsoil, steep slope, extent of exposure or other conditions.

"Critical Flood Area" shall mean a watershed that has a FEMA Zone "A," or "AE" within the site or a location of historical flooding of roads or structures.

"Detention" shall mean the temporary delay of storm runoff prior to discharge into receiving waters.

"Developer" shall mean any individual, firm, corporation, limited liability company, association, partnership, trust or other business entity involved in commencing proceedings to affect development of land for developers or others.

"Drainage Basin" shall mean a storage area to collect storm water.

"Drainage Way" shall mean any channel that conveys surface runoff throughout the site.

"Drainage/Dry Well" shall mean a bored, drilled, driven, dug, or naturally occurring shaft or hole with a depth greater than the largest surface dimension; used to drain surface fluid, primarily storm water runoff, into a subsurface formation.

"Ephemeral Stream" shall mean a stream or part of a stream that flows only in direct response to precipitation or snowmelt. Its channel is above the water table at all times.

"Erosion" shall mean the wearing away of land surface by the action of wind, water, gravity, ice, or any combination of those forces.

"Erosion Prevention Sediment Control Plan (EPSC)" shall mean a set of plans prepared by or under the direction of a licensed professional engineer detailing the specific measures and sequencing to be used to control sediment and erosion on a development site during and after construction.

"Excavation" shall mean any portion of land surface or area from which earth has been removed or will be removed; the depth below original ground surface to remaining surface.

"Existing Grade" shall mean the slope or elevation of existing ground surface prior to cutting or filling.

"Fill" shall mean the portion of land surface to area to which soil, rock, or other materials have been or will be added; height above original ground surface after the material has been or will be added.

"Finished Grade" shall mean the final slope or elevation of the ground surface after cutting or filling.

"Flood Plain" shall mean the relatively flat or lowland area adjoining a river, stream, watercourse, lake, or other body of standing water, which has been or may be covered temporarily by floodwater. For purposes of this ordinance, the flood plain is defined as the area encompassed by a 100-year storm having a one percent chance of being equaled or exceeded in any given year.

"Grading" shall mean any stripping, cutting, filling, or stockpiling of earth or land, including the land in its cut or filled condition, to create new grades.

"Hazardous Materials" shall mean any material, including any substance, waste or combination thereof which because of its quantity, concentration, physical, chemical or infectious characteristics may cause or significantly contribute to a potential hazard to human health or safety, property, or the environment when improperly treated, stored, transported, disposed of or otherwise managed.

"Illegal Discharge" shall mean any direct or indirect non-storm water discharge to the MS4, or conveyance, except as exempted in paragraph number 5 of Section 21-2.04 hereinbelow.

"Illicit Connections" shall mean any of the following:

(a) Any drain or conveyance, whether on the surface or subsurface, which allows an illegal discharge to enter the MS4 or conveyance. This includes, but is not limited to, any conveyances which allow any non-storm water discharge, including sewage, process wastewater and wash water to enter the MS4 or conveyance.

(b) Any connections to the MS4 or conveyance, regardless of whether said connection had been previously allowed, permitted or approved by the City of Glasgow or any drain or connection from a commercial or industrial land use to the MS4 or conveyance which has not been documented in plans, maps or equivalent records and approved by the authorized enforcement agency.

"Impervious Surface" shall mean a term applied to any ground or structural surface that water cannot penetrate or through which water penetrates with great difficulty.

"Industrial Activity" shall mean activities subject to NPDES Industrial Permits as defined in 40 CFR, Section 122.26 (b)(14).

"Karst Feature" shall mean any cave, sinkhole, sinking stream, bluehole, crevice, spring, lost river, karst window or any other geologic feature associated with karst terrain.

"Kentucky Division of Water (KYDOW) General Permit (KGP)" shall mean an agreement between the regulating authority and the Permittee, which specifies conservation practices that shall be implemented in the construction of activities specified in the terms and conditions of the general permit.

"Land Disturbance" shall mean the purposeful act of clearing, grubbing, excavating, or grading; disrupting ground surface by or for construction activities, including construction access/road, staging, and storage sites producing significant areas of exposed soil and soil piles.

"MS4" (Municipal Separate Storm Sewer System) shall mean any physical inlet, natural or manmade, conveyance, storage basins or outfalls in which storm water is induced, conveyed, stored or discharged.

"National Pollutant Discharge Elimination Systems (NPDES)" shall mean EPA's program to control the discharge of pollutants to waters of the United States. NPDES is a part of the Federal CWA, which requires point and non-point source dischargers to obtain permits. These permits are referred to as NPDES permits.

"Non-Storm Water Discharge" shall mean any discharge to the MS4 or any conveyance that is not composed entirely of naturally occurring storm water.

"Notice of Intent (NOI)" shall mean a formal notice to the EPA or a state agency having delegated NPDES authority that a construction project seeking coverage under a General Permit is about to begin.

"Notice of Termination (NOT)" shall mean a formal notice to the KYDOW having delegated NPDES authority that a construction project is complete and seeking release for the EPSC and the State General Permit.

"Overland Flow" shall mean surface runoff flowing over the land surface towards the MS4 or a conveyance.

"Perimeter Control" shall mean a barrier that prevents sediment from leaving a site by filtering sediment-laden runoff or diverting it to a sediment trap or basin.

"Permit Phasing" shall mean clearing a parcel of land in distinct phases, with the stabilization of each phase completed before the clearing of the next commences.

"Permittee" shall mean the "Person Responsible for the Land Disturbing Activity."

"Person" shall mean any individual, association, organization, partnership, firm, corporation or other entity recognized by law.

"Pollutant" shall mean anything that causes or contributes to a violation of applicable water quality standards. Pollutants may include, but are not limited to, paints, varnishes, solvents, oil or other automotive fluids, non-hazardous liquid and solid wastes, yard wastes, refuse, rubbish, garbage, litter or other discarded or abandoned objects and accumulations, sediment and detergents so that same may cause or contribute to pollution. Pollutants may also include, but are not limited to, floatables, pesticides, herbicides, and fertilizers, hazardous substances and wastes, sewage, fecal coliform and pathogens, dissolved and particulate metals, animal wastes, wastes and residues that result from constructing a building or structure, and noxious or offensive matter of any kind.

"Premises" shall mean any building, lot, parcel of land, easement or portion of land, whether improved or unimproved, including adjacent sidewalks and parking strips.

"Public Storm Drain" shall mean the drain system provided by and maintained by the City of Glasgow that is designed to help convey naturally occurring storm water runoff. It also provides inlets for water to travel to holding areas attempting to remove excessive water from streets and other areas.

"Sediment" shall mean solid material, both mineral and organic, that in suspension is being transported or has been moved from its site of origin by air, water, or gravity as a product of erosion.

"Sediment Control" shall mean measures that prevent eroded soil or other material from leaving the site.

"Site" shall mean a parcel of land or a contiguous combination thereof, where grading work is performed as a single unified operation subject to erosion of sedimentation as a result of cutting, filling, grading, or other disturbance of the soil.

"Land Disturbance Permit" shall mean a permit issued by the City of Glasgow for the construction or alteration of ground improvements and structures for the control of erosion, runoff, and grading.

"Stabilization" shall mean the use of practices that prevent exposed soil from eroding or establishment of vegetative cover (80% coverage or better).

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

"Storm Drainage System" shall mean drainage facilities by which storm water is collected and/or conveyed, including but not limited to, any roads with drainage systems, municipal streets, gutters, curbs, inlets, piped storm drains, pumping facilities, retention and detention basins, natural and human-made or altered drainage channels, reservoirs, drain wells, karst feature or other conveyance.

"Storm Water" shall mean any surface flow, runoff, ponding or drainage from any form of precipitation.

"Storm Water Management Plan (SWMP)" shall mean a plan that is based on hydrologic and hydraulic calculations to determine flood stage and required improvement to minimize impacts by development.

"Storm Water Pollution Prevention Plan (SWPPP)" shall mean a plan required by storm water regulations or permits that includes site map(s), an identification of construction/contractor activities that could cause pollutants in the storm water, and a description of measures or practices to control these pollutants. This is synonymous with the term "BMP Plan" used in the KYDOW General Permit.

"Temporary Protection" shall mean short-term stabilization of erosive sediment producing areas.

"Utility General Permit" shall mean the agreement between the MS4 Municipality and the local municipal separate storm sewer system utilities stating that Phase II regulations shall be applied and implemented.

"Vegetative Protection" shall mean stabilization of erosive or sediment producing areas by covering the soil with any of the following materials: permanent seeding for long-term vegetative cover, short-term seeding for temporary vegetative cover, sodding, producing areas covered with a turf of perennial sod-forming grass, tree planting, or other planting.

"Wastewater" shall mean any water or other liquid, other than naturally occurring storm water discharged from premises.

"Watercourse" shall mean any body of water or conveyance, including but not limited to lakes, ponds, rivers, creeks, streams, karst features, drainage basins or bodies of water delineated by the City of Glasgow.

"Waterway" shall mean a channel that directs surface runoff to a watercourse or conveyance.

"Watershed" shall mean the land area from which surface runoff drains into a stream channel, system of stream channels or karst feature.

2. Abbreviations and Acronyms

ADT	Average Daily Traffic
ARAP	Aquatic Resource Alteration Permit
BFM	Bonded Fiber Matrix
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
BS	Bank Stabilization
BZ	Buffer Zones
CB	Continuous Berms
CD	Check Dams
CL	Channel Lining
COS	Chemical Oxygen Demand
CRS	Construction Road Stabilization
DB	Detention Basin
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
EPP	Erosion Prevention Practices
EPSC	Erosion Prevention and Sediment Control
G	Geotextiles
GHP	Good Housekeeping Practices
HAZWOPER	Hazardous Waste Operations and Emergency Response
KDOW	Kentucky Division of Water
KDWM	Kentucky Division of Waste Management
KUB	Kentucky Utilities Board
M	Mulching
MS4	Municipal Separate Storm Sewer System
MSD	Marine Sanitation Device
MSDS	Material Safety Data Sheet
N and M	Nets and Mats
NPDES	National Pollution Discharge Elimination System
OSDS	On-Site Disposal System

OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated Biphenyl
PE	Professional Engineer
PPE	Personal Protective Equipment
PS	Permenant Seeding
RH	Residential Homeowners
RR	Rip-rap
SBCCI	Southern Building Code Congress International, Inc.
SCE	Stabilized Construction Entrance
SEDCAD	Software for Design of Stormwater, Erosion, and Sediment Control Systems
SF	Silt Fence
SF-LD	Light Duty Silt Fence
SF-HD	Heavy Duty Silt Fence
SMP	Sediment Management Practices
SO	Sodding
SPCC	Spill Prevention Control and Countermeasure
SPD	Site Planning and Design Practices
SR	Surface Roughening
ST	Sediment Traps
SWPPP	Stormwater Pollution Prevention Plan
T	Terracing
TIP	Temporary Inlet Protection
TMDL	Total Maximum Daily Load
TOP	Temporary Outlet Protection
TS	Temporary Seeding
TS	Top Soiling
TW	Tire Washing
USACE	United States Army Corps of Engineers

Appendix C
Standard EPSC Plan for Plot Plans

STANDARD EPSC PLAN FOR PLOT PLAN

(For disturbances <1 acre)

This form can be used if the following conditions are met:
- **Disturbs less than 1 acre,**
- **Adds less than 3400 ft2 of new impervious surfaces, and**
- **Contains no critical slope or flood hazard areas.**

Otherwise, a detailed EPSC plan will be required.

Permit #__________

Please read and complete the bottom of this form before completing this section.

For plot plans, choose one of the following options:
□ The most appropriate, from below, is option ___ or a combination of options ___ & ___.
□ The sedimentation control devices will be installed and maintained as drawn in Option G below.

Does the site have a sinkhole, drainage inlet, drainage easement, or stream? □ Yes □ No If yes, indicate additional measures on appropriate Option below.

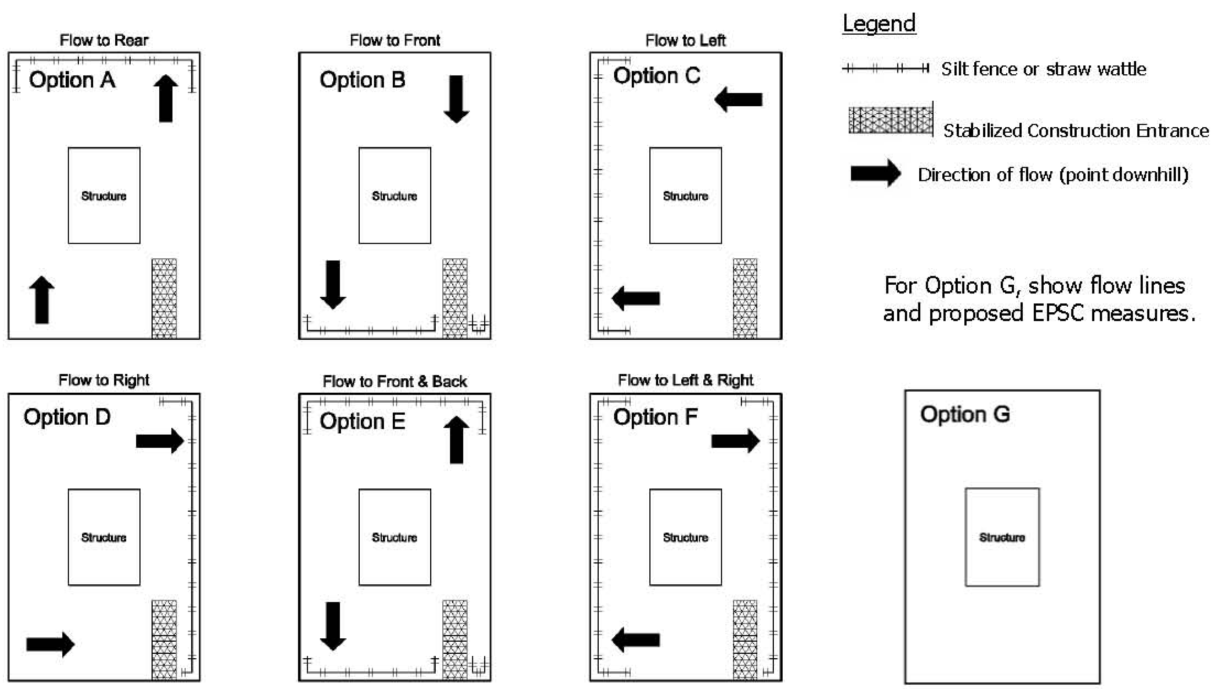
Will excavated materials be stockpiled or used as fill on site? □ Yes □ No If yes, show the location of the stockpiling or filling on the schematic below, with additional measures to protect adjacent properties.

ANTICIPATED START DATE OF CONSTRUCTION:__________________________

Certified Contractor: ________________________ No. __________

EPSC OPTIONS

INSTRUCTIONS: Identify one or any combination of letters for the EPSC schematic that best describes the measures that will be used on this property during construction.



STANDARD CONDITIONS

The applicant will comply with the following conditions:

1. EPSC must be installed to prevent off-site sedimentation.
2. Perimeter controls shall be in place prior to beginning construction.
3. All EPSC measures shall be installed and maintained as specified in the City of Bowling Green's BMP Manual.
4. The contractor shall be responsible for keeping streets, drainage structures, streams and other properties free of sediment and other construction materials generated by this project.
5. Areas at final grade must be seeded and stabilized within 14 days. Disturbed areas not at final grade must be stabilized within 21 days.
6. Upon final stabilization (with at least 80% coverage), EPSC measures must be removed.

The undersigned hereby certifies that he/she will follow the Plot Plan EPSC Plan as described above and will protect all storm drainage structures on this lot. Furthermore, the undersigned will fully comply with the specifications in the City of Bowling Green's *BMP Manual* and Storm Water Management Ordinance. The undersigned will take all necessary actions to prevent off-site sedimentation from occurring. Once the building permit is issued, this document becomes an enforceable EPSC plan for the project site.

____

Applicant's Signature | Applicant's Printed Name | Date

Glasgow, Kentucky
Stormwater Best Management Practices

October 2011

Appendix D
Inspection Report
(EPP, SMP, GHP and PTP)

Glasgow, Kentucky
Stormwater Best Management Practices

October 2011

INSPECTION AND MAINTENANCE REPORT FORM

TO BE COMPLETED EVERY 7 DAYS

INSPECTOR:___________________DATE:___________________

INSPECTOR'S QUALIFICATIONS:
____
____

DAYS SINCE LAST RAINFALL:_____AMOUNT OF LAST RAINFALL ___INCHES

STABILIZATION MEASURES

AREA
____
____

DATE SINCE LAST DISTURBED____________________________

DATE OF NEXT DISTURBANCE____________________________

STABILIZED? (YES/NO)__________________________________

STABILIZED WITH
____
____

CONDITION
____
____

STABLIZATION REQUIRED:
____
____
____
____

TO BE PERFORMED BY:____________ON OR BEFORE:________

Glasgow, Kentucky
Stormwater Best Management Practices

October 2011

INSPECTION AND MAINTENANCE REPORT FORM

SEDIMENT BASIN

DEPTH OF SEDIMENT IN BASIN___________________________

CONDITION OF BASIN SIDE SLOPES
____
____
____

MAINTENANCE REQUIRED FOR SEDIMENT BASIN:
____
____

TO BE PREFORMED BY:_________ON OR BEFORE____________

OTHER CONTROLS
STABILIZED CONSTRUCTION ENTRANCE

DOES MUCH SEDIMENT GET TRACKED ON TO ROAD?__________

IS GRAVEL CLEAN OR IS IT FILLED WITH SEDIMENT?__________

DOES ALL TRAFFIC USE THE STABILIZED ENTRANCE TO LEAVE SITE?__________

MAINTENANCE REQUIRED FOR STABILIZED CONSTRUCTION ENTRANCE:
____
____
____

TO BE PREFORMED BY:_____________ON OR BEFORE________

October 2011

INSPECTION AND MAINTENANCE REPORT FORM

CHANGES REQUIRED TO THE POLLUTION PREVENTION PLAN:
____
____
____
____

REASONS FOR CHANGES:
____
____
____

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Signature:____________________________Date:_______________________

CONTRACTOR'S CERTIFICATION

I certify under penalty of law that I understand the terms and conditions of the general National Pollutant Discharge Elimination System (NPDES) permit that authorizes the storm water discharges associated with industrial activity from the construction site identified as part of this certification.

Name:

Title:

Responsible for:

Company Name:

Address:

Phone:

Appendix E
Water Quality Management Statement

Glasgow, Kentucky
Stormwater Best Management Practices

March 2012

Water Quality Management Statement Checklist

Every subdivision, as defined in the Warren County Subdivision, disturbing more than one acre that adds 10,000 ft2 of new impervious surfaces shall submit a Water Quality Management Statement. The Statement shall be a narrative with supporting documentation addressing and including the following information:

- Development name and location
- Developer/Owner and Consultant contact information
- Site description
- Description of proposed development
- Total project acreage
- Impervious Area Calculation
  - § Square feet or acreage in roadway pavement and sidewalks
  - § Estimated square feet or acreage covered by rooftops for houses and accessory structures to be initially constructed
  - § Estimated square feet or acreage in driveways and sidewalks
  - § Estimated square feet or acreage in parking lot(s)
- A description of the proposed storm water quality and quantity management BMPs to be installed on the project
- A vicinity map, USGS topographic map and Warren County Soil Survey with the development area indicated thereon

Preliminary subdivision plats that do not include a Water Quality Management Statement will not be considered complete and may not be included on the Planning Commission's agenda.

Appendix F: Water Quality Management Plan Checklists

This appendix includes checklists for the following types of development:

- Building permits. Note that the Water Quality Management Plan checklist has been incorporated into the overall Level II Building Permit Review Checklist
- Subdivision. A separate checklist for subdivisions in included (Subdivision Water Quality Plan Review Checklist)

City of Glasgow

Level II Building Permit Review Checklist
(For sites requiring a grading and drainage plan and water quality management plan)

Project Name:

Location:

General Requirements:

		Y	N	N/A	Are the following included?
1.					Accurate vicinity map at an appropriate scale
2.					North arrow and scale
3.					Bench mark (note datum)
4.					Title block containing:
	A.				Name, address, and phone number of Builder/Applicant
	B.				Name, address, and phone number of person or firm preparing plot plan
	C.				Subdivision name, lot number, block, section, Plat Book and Page Number, etc. If not a subdivision of record, supply deed book and page number.
	D.				Street address of site. Include house number obtained by owner from Planning Commission or insert a "blank" in front of the street name. House number will be assigned and inserted on the title block.
5.					Plans stamped by Professional Engineer, Surveyor, or other professional
6.					Revision block denoting dates and revision descriptions

Property Requirements:

		Y	N	N/A	Are the following included?
1.					Property lines labeled with distances and bearings
2.					Total site/lot acreage (acreage and square feet)
3.					Building set back lines
4.					Easements (size, location, type)
5.					Location and size of public utilities and drainage system
6.					Street names and right-of-way width
7.					Frontage on an approved street accepted for public/private maintenance or given preliminary approval by the Planning Commission as a Public/Private Road and currently under construction
8.					Locations of existing buildings, roadways, parking lots or other hardened surfaces including graveled driveways and parking surfaces within the project boundaries. Existing structure location within 0.1 foot (dimensions, disposition, and description) – if any
9.					Existing Contours (1 foot interval)
10.					Property corner elevations (if less than two percent (2%) slope on lot)
11.					PVA map code

Glasgow, Kentucky
Stormwater Best Management Practices

March 2012

Grading:					
		Y	N	N/A	Are the following included?
1.					Total site acreage to be disturbed
2.					All graded slopes at 3:1 or flatter (unless approved by City Engineer)
3.					Proposed contours (1 foot interval)
4.					Note stating, "6 inch fall in 10 feet minimum from building"
Buildings/Structures:					
		Y	N	N/A	Are the following included or been considered?
1.					Proposed finished floor elevations
2.					Existing and proposed ground elevations at corners of proposed structures
3.					Proposed structure or pavement locations (dimensions, description and relation to easements and property lines)
4.					All finished floor elevations, including basement, must be minimum 1.5 feet above the 100-year floodplain elevation for the site.
5.					Structures without basements shall have a minimum finish floor elevation 1.5 feet above the highest finished grade if crawl space is used, or 0.67 feet above for slab foundation.
Streets and Sidewalks:					
		Y	N	N/A	Are the following included or been considered?
1.					Proposed driveway AND sidewalk (location and dimensions) including handicap ramps, if necessary
	A.				Driveways within the City of Bowling Green must conform to City's Access Management Standards; found at www.bgky.org.
	B.				Street sidewalk or curb cuts within the City of Bowling Green require a Right of Way Excavation permit.
	C.				Note stating that sidewalks and drive entrances shall be constructed to meet ADA and City standards
2.					KYTC right-of-way access permit (if on state route)
3.					All markings within public right-of-way must be thermoplastic and signage must meet MUTCD standards
Traffic:					
		Y	N	N/A	Are the following included or been considered?
1.					Traffic Impact Study, requirements found at www.bgky.org
Drainage:					
		Y	N	N/A	Are the following included or been considered?
1.					Certification by licensed surveyor or engineer regarding flood hazard
2.					Summary of impervious cover within project boundaries, including building footprint, driveways, roadways, parking lots, etc.
3.					Existing drainage features, type and invert elevations.
4.					Locations of drainage system features, streams, known sinkholes, drywells, springs, wetlands and/or ponds, floodways and flood zones adjacent to the project boundaries or within 50' of project site.
5.					Note that environmental message for storm water manhole covers, curb inlets, etc is required.
6.					Note that entrances pipes, when needed, shall be minimum of 24 foot – 15 inch pipe with 6 inch minimum cover
7.					Dimensions, location, description, and elevation of proposed drainage structures. If using a drainage swale in lieu of pipe, it shall not impede the flow of water through the ditch and must be graded to follow the ditch side slopes and flow line. If using pipe must have headwall (excluding entrance pipes)
8.					Drainage flow arrows and spot grading elevations as required
9.					Drainage basins that encompass all or a portion of the project, with acreages for each drainage basin identified on the plans or in the calculations submittal. Recorded 100yr. flood elevation for basin included.

Glasgow, Kentucky
Stormwater Best Management Practices

March 2012

Storm Water Detention/Retention:

		Y	N	N/A	Are the following included or been considered?
1.					Plans correspond to drainage calculations
2.					Drainage study stamped by a professional engineer
3.					Calculations verifying that the detention/retention requirements for the site have been met, assuming zero drawdown for any sinkhole within the project boundaries. Submit copies of software program output, if a software program is used to size the detention/retention facility. Calculations must also be provided to show that the detention/retention facility will not cause downstream flooding. Consideration must be given to peak flow timing for sites that discharge into streams or rivers.
4.					Detailed construction drawings with invert elevations, trash racks, anti-flotation blocks, emergency and primary spillways, and, for large detention/retention facilities, an emergency drain that can drain the facility in 24 hrs.
5.					Detention/retention facility located in a permanent easement
6.					Access easement for maintenance of the detention/retention with grading at 10 ft. wide and 5:1 or flatter slope.
7.					Detention/retention basins have a positive slope towards the outlet control structure (2% recommended)
8.					Detention/retention basin smoothly graded with adequate berms (if applicable) and 3:1 maximum slopes

Water Quality Management Plan

		Y	N	N/A	Are the following included or been considered?
1.					Will the residential development have <15% total impervious cover? If yes, then answer A-F below
	A				Provide estimate of impervious cover for site
	B				Provide copy of restrictive covenant for site
	C				Are disturbed areas clearly marked on plans and in field?
	D				Are lots 1 ac or more?
	E				Are roof drains disconnected from storm drains and allowed to sheet flow away from footings?
	F				Are existing trees in the sinkhole basin (if present) being protected?
2.					Nonresidential developments: Maintenance and Operation Plan including all BMPs finalized
3.					Design calculations demonstrating 80% TSS reduction and WQv treatment
4.					Are manufactured BMPs included? If so, answer A-B below
	A				Verifiy that the treatment unit meets required performance standards
	B				Manufacturer's specifications included in calculation package for maintenance and installation
5.					BMPs located in permanent drainage easment with access from public ROW
6.					Infiltration BMPs: Answer A-C below
	A				Infiltration rates for soils
	B				Planting plan for treatment area
	C				Observation wells in treatment area to verify infiltration rate after construction

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Erosion Prevention and Sediment Control:	Y	N	N/A	
	Y	N	N/A	Are the following erosion prevention and sediment control items included or been considered?
1.				Areas to be disturbed and identified and square feet or acreage shown on plans.
2.				Area disturbed equal an acre or more. (if yes you will need a SWPPP and NOI)
3.				A legend identifying measures, structures, storm water components etc. for each plan sheet.
4.				Location of each structural and non-structural BMP.
5.				Pre-grading plans showing erosion prevention and sediment control for site during the beginning phases of construction.
6.				Final grading plans showing erosion prevention and sediment control for site during the final phase of construction.
7.				Surface waters, drainage systems, and wetlands within a half-mile of the project labeled that can receive storm water runoff from this project.
8.				Locations that are not to be disturbed.
9.				Details shown for all structural and non-structural BMP's shown on the plans with dimensions, specifications, and amount of material needed.
10.				Designated areas for stockpiled soil.
11.				Protection at discharge points where water is leaving the site.
12.				If dewatering is to occur, location of dewatering activity, and dimensions of dewatering basin or structure.
13.				Note directing the construction detention/retention and drainage ditches as first item of construction after perimeter sediment control measures.
	Y	N	N/A	Are the following BMP items included or been considered?
1.				Silt Fence, Straw Waddles, or Fiber Rolls
2.				Stabilized Construction Entrance
3.				Temporary Sediment Traps
4.				Temporary Diversions
5.				Channels and Ditches
6.				Pipes and Swales Inlet and Outlet Protection
7.				Retention Basin with Slope Protection
8.				Check Dams with Spacing and Dimensions
9.				Temporary Seeding
10.				Permanent Seeding
11.				Channel Lining
12.				Slope Stabilization
13.				Dust Control Measures
14.				Straw Mulching, Hydro-seeding, or Erosion Control Blankets

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Miscellaneous:				
	Y	N	N/A	
1.				Has a bond (performance and indemnity agreement) been posted?
2.				Does the property have a recorded plat?
3.				Have all variances and zoning regulations been incorporated?
4.				Dumpster location and associated site improvements
5.				Parking requirements for commercial use
6.				Has a note been provided prohibiting changes without prior approval of reviewing agency
Landscaping:				
	Y	N	N/A	
1.				Is the project a single family residence? (If yes, no plan required unless required in the water quality management plan BMPs)
2.				Is the project a duplex residence? (If yes, buffering and screening required)
3.				Is the project non- single family or duplex residence? (If yes, plan required per Section ______)
4.				Has the Plot plan preparer discussed the landscape plan with the CCPC Landscape Architect?
5.				Has a bond (performance and indemnity agreement) been posted?
6.				Has a landscaping surety contract been signed?
7.				Exterior site lighting needs to be shown on landscape plan to avoid conflicts
Zoning Related Issues:				
	Y	N	N/A	
1.				If the property has Binding Elements, have they been checked and compiled with?
Subdivision Platting Related Issues:				
1.	Y	N	N/A	
2.				Is there a change in property boundary? If yes, plat recordation needed prior to permit request.
3.				Is there a change or addition of a drainage easement? If yes, plat recordation needed prior to permit request.
4.				Is there a change or addition of other easements, ie utilities? If yes, plat recordation needed prior to permit request.
5.				Plat recorded?
6.				Surety bond in place for drainage improvements?
7.				Construction contract signed for drainage improvements?
8.				Drainage and access easements for Water Quality Management BMPs?
				Non-residential development: recorded Operation and Maintenance Plan?
Note: This checklist is intended to serve as a guideline for plan preparation. Additional items may be required depending on unique conditions.				

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City of Glasgow
Water Quality Management Plan Review Checklist

In addition to the P&Z Subdivision Checklist, the following items must be addressed for the Water Quality Management Plan submitted to the City:

¨ For residential conservation subdivision design:
   - Total impervious surface must be less than 15%
   - Roof drains must be disconnected from other storm water system components and allowed to sheet flow over vegetation
   - Lots must be 1 acre or more in size

¨ Break down of estimated impervious surfaces as follows:
   - Estimated square footage covered by roof top (note that square footage of a multi-level building may not be the same as the square footage covered by roof top); For residential developments, this estimate should be based upon the typical size of house to be built.
   - Estimated square footage in roadway
   - Estimated square footage in driveways, patios (not decks) and sidewalks

¨ Method of restricting the maximum impervious cover on each lot
   - Restrictive covenant
   - Deed restrictions

¨ Locations of structural and non-structural water quality treatment BMPs
   - Supporting calculations for each BMP
   - Site-specific construction details for each BMP
   - All structural BMPs must be located in dedicated drainage easements with access from a public right-of-way

¨ Non-residential subdivisions
   - Draft final Operation and Maintenance Plan addressing the long term operation and maintenance of any BMPs on the property
   - Considered water quantity and quality management on a regional basis?
   - Subdivision restrictive covenants to limit imperviousness?

Appendix G: As-Built Inspection Certification

Includes the following:

- § Certification checklist
- § As-built BMP data collection sheets for PTPs

Glasgow, Kentucky
Stormwater Best Management Practices

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City of Glasgow
Water Quality
As-Built Certification Checklist

Date:____________________________________ Property Owner:____

Certifying Engineer: ____

Certifying Surveyor: ____

Project Name:____

Address: ____

This Water Quality As-Built Certification process is necessary in order for a construction or performance bond to be released or for a Certificate of Occupancy to be issued, as described in the Warren County Subdivision Regulations.

CERTIFICATION REQUIREMENTS:

Ü **Date**

________ A. Submit as-built drawings that meet the minimum requirements of this checklist. Complete the appropriate as-built BMP data sheet (see Appendix H of the SOP).

________ B. Ensure that the BMPs on the project site meet the design requirements established and approved in the Water Quality Management Plan.

________ C. Ensure that all drainage system components, permanent BMPs, and structure access easements are properly delineated on a plat or through deed restrictions.

________ D. Ensure that the Operations and Maintenance Plan for all water quality devices has finalized and recorded at the Warren County Register of Deeds and denoted on the recorded plat or in deed restrictions.

________ E. For Conservation Subdivisions: Ensure that the impervious area estimates in the plans are still accurate to the best of you knowledge. Provide a breakdown of the existing impervious surfaces.

________ F. For Subdivisions: Ensure that the impervious cover restrictions are properly denoted on the recorded plat or in deed restrictions.

General Information

Ü **Date / NA**

________ 1. Are seal and signature for the certifying engineer and surveyor shown on the as-built drawings?

________ 2. Does the as-built drawing(s) have survey benchmarks or other reference points?

________ 3. Does each as-built plan contain standard plan contents, such as a north arrow, scale, and legend?

________ 4. Is construction complete and have all disturbed areas been stabilized?

________ 5. Are the footprints of all impervious surfaces constructed consistent with the approved Water Quality Management Plan?

________ 6. Was the O&M plan updated to reflect the findings of the as-built? It must also be recorded prior to being submitted with the as-built certification.

________ 6. Do the as-built drawings contain the following statement along with the Registered Land Surveyor’s stamp, signature and license number:

I hereby certify that I have surveyed the land boundaries and easements shown hereon in accordance with accuracy requirements for a Category I survey and that the ratio for precision of the unadjusted survey is not less than 1:10,000. I further certify that I have located all natural and manmade features shown hereon in accordance with the current Standards of Practice as adopted by the Kentucky State Board of Licensure for Land Surveyors. I certify the location, elevation and description of these features.

________ 7. Do the as-built drawings contain the following statement along with the Registered Engineer's stamp, signature and license number:

Based upon site observations and/or information provided by a registered Land Surveyor, I hereby certify that all grading, drainage, structures, and/or systems including facilities and vegetative measures have been completed in substantial conformance with the approved plans and specifications.

As-Built Drawings - Storm Water Quality BMPs

I hereby certify that the stormwater management facility (facilities) shown on the plans and individually identified below has (have) been constructed in accordance with the plans approved by the City of Glasgow, Public Works, except as noted in red on the "AS BUILT" drawings. Furthermore, the red-noted exceptions do not adversely affect the intended performance of the facility (facilities).

______________________________ ______________________________

______________________________ ______________________________

______________________________ ______________________________

Facility Identification (Identify Each Facility Individually)

______________________________ ______________________________

Name (Printed) Signature

______________________________ ______________________________

Engineers license number Date

"Certify" means to state or declare a professional opinion based on sufficient and appropriate onsite inspections and material tests conducted during construction

Project name:	BMP ID:

AS-BUILT DATA FOR FILTERS (SAND FILTERS AND BIORETENTION – PTP-01)

***TO BE COMPLETED BY THE CERTIFYING ENGINEER**

Facility Type:	**Design**	***As-Built**
Filter Bed Area (L x W)		
Filter Bed Surface Elevation		
Filter Inlet Pipe Size/Elevation		
Outlet Pipe (Underdrain) Size/Elevation		
Filter Bed/Planting Media Depth		
Infiltration Rate		
Composition of filter media or planting media		

Additional Considerations:
Forebay/pretreatment area and volume ______________________________

Bioretention planting composition/number/health ______________________________

____

Geotextile placement location(s) ______________________________

Date accepted by Glasgow Public Works: ______________________

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Project name:	BMP ID:

AS-BUILT DATA FOR OPEN CHANNEL SYSTEMS (WET/DRY SWALES PTP-02)

*TO BE COMPLETED BY THE CERTIFYING ENGINEER

Type of Facility: (circle) Dry Wet	**Design**	***As-Built**
Bottom Width		
Total Length		
WQ Volume		
Number/Type of Check Dams/Weirs		
Longitudinal Slope		
Infiltration Rate (dry swale)		
Underdrain Pipe Size		

Any other data appropriate to the specific BMP: ________________________________

____

____

Date accepted by Glasgow Public Works:______________________

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Project name:	BMP ID:

AS-BUILT DATA FOR INFILTRATION TRENCHES/BASINS (PTP-05)

***TO BE COMPLETED BY THE CERTIFYING ENGINEER**

Facility Type	**Design**	***As-Built**
Bottom elevation		
Surface elevation		
Bottom dimensions		
Storage Volume		
Infiltration rate		
Basins: Depth of Stone/Filter Material		
Basins: Stone Size		

Any other data appropriate to the specific BMP: ______________________________

____

____

Date accepted by Glasgow Public Works:____________________

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Stormwater Best Management Practices

March 2012

Project name:	BMP ID:

AS-BUILT DATA FOR PONDS/WETLANDS (PTP-03, PTP-04, PTP-08)
*TO BE COMPLETED BY THE CERTIFYING ENGINEER

Facility Type:	**Design**	***As-Built**
WQv Storage Volume		
Detention: for 2.95 in (1 hr, 100 yr storm)		
Retention: for 4.0 in (3 hr, 100 yr storm)		
Principal Spillway Type/Diameter		
Principal Spillway Outlet Elevation		
Emergency Spillway Type		
Emergency Spillway Dimensions		
Emergency Spillway Elevation		
Outlet Protection: Length/Width/Stone Size		

Additional Considerations:
Forebay/pretreatment area and volume ____________________

Planting composition/number/health ____________________

____

Geotextile placement information ____________________

Drywell protection type ____________________

Date accepted by Glasgow Public Works:______________________

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March 2012

Project name:	BMP ID:

AS-BUILT DATA FOR WATER QUALITY UNITS AND OIL WATER SEPARATORS (PTP-06, PTP-09)

*TO BE COMPLETED BY THE CERTIFYING ENGINEER

Facility Type/Name:	**Design**	***As-Built**
Drainage Area		
Flow		
Treatment Area		
Bypass structure/pipe		

Additional Considerations:

Cleaning access noted on plans correctly________________________________

Access to each chamber provided ________________________________

Other BMP specific information________________________________

____

Date accepted by Glasgow Public Works:________________________

Appendix F
PTP Operation and Maintenance Plans

Includes the following:

- BMP Maintenance Agreement
- BMP location map (example)
- BMP schematics (example)
- BMP maintenance and inspection templates
- Annual BMP report template

Operation and Maintenance Plan

Procedure

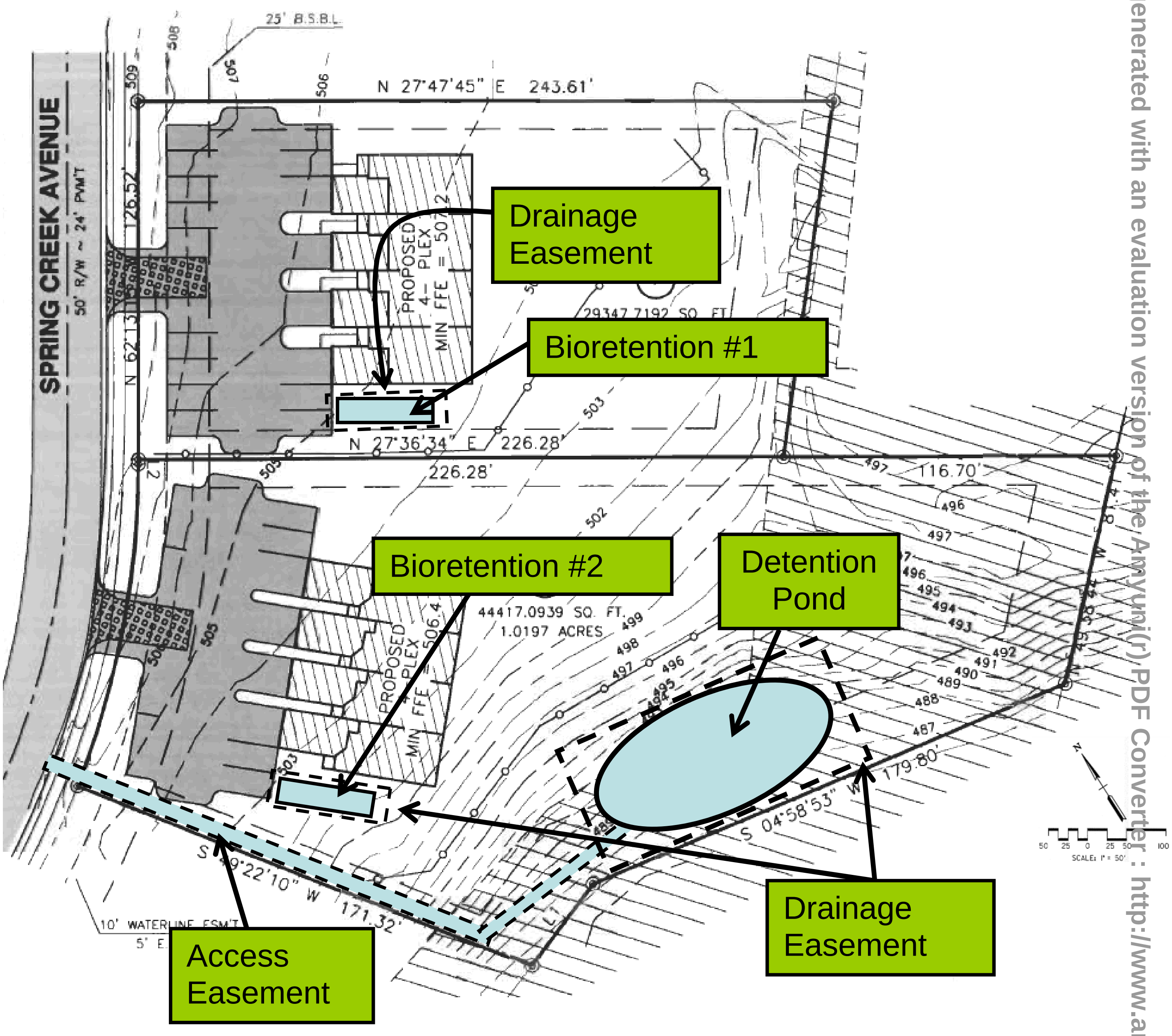
The Operation and Maintenance (O&M) Plan for each site must be finalized prior to final SWMP approval. It is recommended that the designer/developer submit the O&M plan once the City has completed their review of the SWMP to prevent multiple submittals the O&M Plan. It is likely that the SWMP will be modified or revised during the City's review process. Note that the O&M Plan must be recorded with the deed to ensure the information about the PTPs and maintenance requirements is transferred along with the property.

Contents

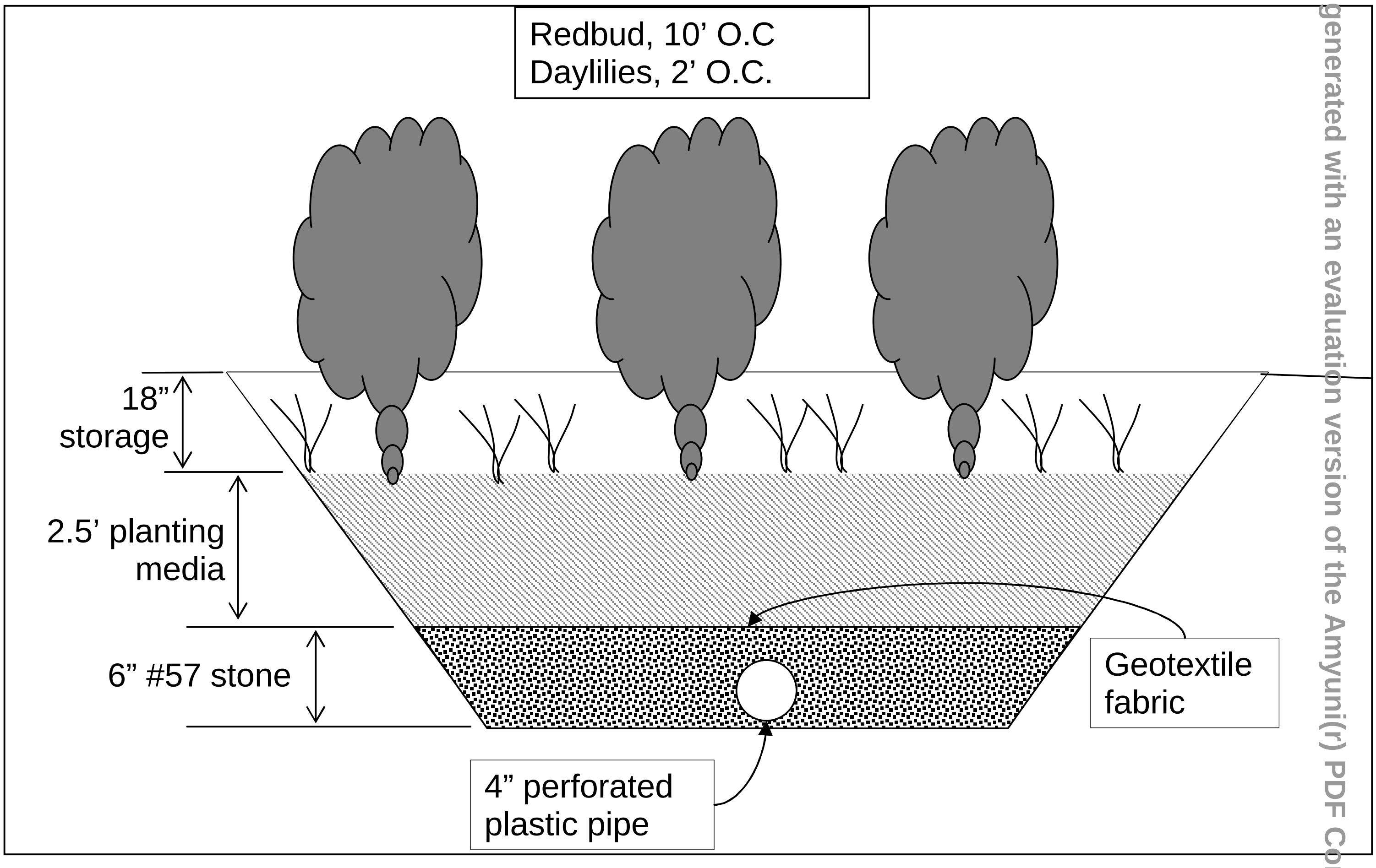
All permanent treatment practices must be maintained perpetually. To facilitate the long term maintenance and functionality of the practices, Bowling Green requires the developer to prepare an Operation and Maintenance (O&M) Plan for each site and requires that the landowner perform an annual inspection of the facility. A template for the inspection is included with the O&M Plan, and the O&M Plan must be recorded with the deed.

1. **Completed Operation and Maintenance Agreement**
2. **Location map.** The location map should show the locations of all permanent stormwater management treatment practices and easements. This map should be specific and clear enough for a landowner to identify the practice on the property.
3. **Schematics for the PTP.** These schematics must show the general BMP depth, length, inlets and outlets. For bioretention areas, the schematics should note that the mulch, planting media and vegetation are all components of the PTP. Underdrains must be clearly noted as well. For measures with observation wells, locations of the observation wells must be identified. Pretreatment components must also be identified on the schematics. Note that the schematic is not required to be surveyed.
4. **Template inspection reports**. Each PTP has a template inspection report. The template inspection report must be included in the O&M plan. If the PTP is a proprietary or non-standard practice, the developer/designer is required to provide an inspection report that covers basic maintenance needs with maintenance frequency. The manufacturer of the practice can provide this information. An inspection report for each type of PTP on the project must be included.
5. **Annual inspection report**

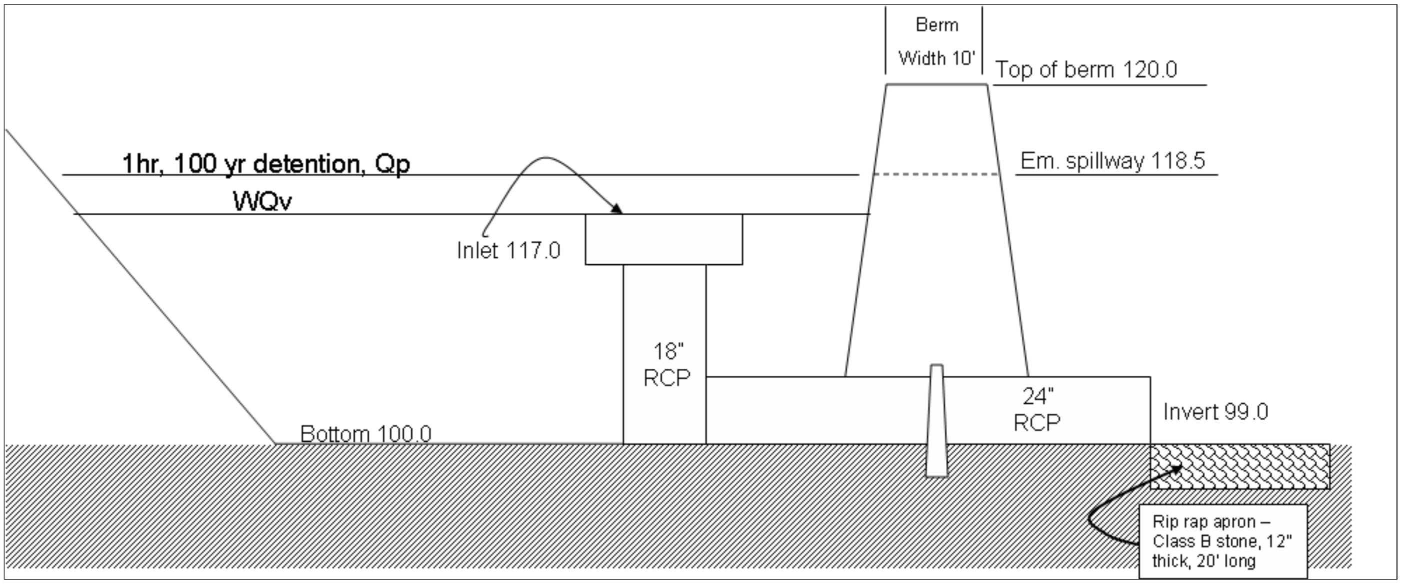
BMP Location Plan (Example)



Bioretention Area 1 (Example)



Detention Pond (Example)



Storm Water Pond

Inspection Checklist for BMP Owners

Site name: ______________________________

BMP Number: ______________________________

Owner Change since last inspection? Y N

Owner Name ______________________________

Address ______________________________

Phone Number ______________________________

Location: ______________________________

Inspection Date: ______________________ Time: ______________

Inspector: ______________________________

Weather Conditions: ______________________________

Was flow observed: If so, what was the appearance of the water (i.e. color, sheen, estimated flow rate, etc.)?

____

Maintenance Item	Inspected? (Yes/No)	Maintenance needed? (Yes/No)	Comments
Embankment and Emergency Spillway (Inspect annually and after major storms)			
Circle Type: Reinforced concrete, corrugated pipe, masonry, other ______________			
1. Vegetation			
2. Erosion on embankment			
3. Animal burrows			
4. Cracking, bulging or sliding of dam			
A. Location:			
B. Describe			
5. Drains clear and functioning			
6. Leaks or seeps on embankment			
A. Location			
B. Describe			
7. Slope protection failure			
8. Emergency spillway clear of obstructions			
9. Other (describe)			
Riser and Principal spillway (Inspect annually)			
Circle Type: Reinforced concrete, corrugated pipe, masonry, other ______________			
1. Low flow orifice blocked			
2. Trash rack			
A. debris removal needed			
B. corrosion noted			
3. Excessive sediment buildup in riser			
4. Concrete/Masonry condition			
A. cracks or displacement			

Maintenance Item	Inspected? (Yes/No)	Maintenance needed? (Yes/No)	Comments
B. spalling			
5. Metal pipe condition			
6. Control Valve operational			
7. Pond drain valve operational			
8. Outfall channels functioning			
9. Other (describe)			
Permanent Pool (Inspect monthly)			
1. Undesirable vegetative growth			
2. Floatable debris removal needed			
3. Visible pollution			
4. Shoreline erosion			
5. Other (describe)			
Sediment Forebays			
1. Sediment deposition noted			
2. Sediment cleanout needed (over 50% full)			
Other (Inspect monthly)			
1. Erosion at outfalls into pond			
2. Headwalls and endwalls			
3. Encroachment into pond or easement area			
4. Complaints from residents			
5. Public hazards (describe)			
6. Needs to be mowed			
7. Other vegetation needs to be removed			

Note: If any inspection items were checked "yes" for maintenance needed, list maintenance actions and dates completed below.

Maintenance Action Needed	**Date Due**	**Com-pleted? Y/N**

Inspector signature: ______________________________

Storm Water Constructed Wetland
Inspection Checklist for BMP Owners

Site name: ______________________________
BMP Number: ______________________________
Owner Change since last inspection? Y N
Owner Name ______________________________
Address ______________________________
Phone Number ____________________ Location: ____________________
Inspection Date: ____________________ Time: ____________________
Inspector: ______________________________
Weather Conditions: ______________________________
Was flow observed: If so, what was the appearance of the water (i.e. color, sheen, estimated flow rate, etc.)?
____

Maintenance Item	Inspected? (Yes/No)	Maintenance needed? (Yes/No)	Comments
Embankment and Emergency Spillway (Inspect annually and after major storms)			
Circle Type: Reinforced concrete, corrugated pipe, masonry, other ____________________			
1. Vegetation			
2. Erosion on embankment			
3. Animal burrows			
4. Cracking, bulging or sliding of dam			
A. Location:			
B. Describe			
5. Drains clear and functioning			
6. Leaks or seeps on embankment			
A. Location			
B. Describe			
7. Slope protection failure			
8. Emergency spillway clear of obstructions			
9. Other (describe)			
Riser and Principal spillway (Inspect annually)			
Circle Type: Reinforced concrete, corrugated pipe, masonry, other ____________________			
1. Low flow orifice blocked			
2. Trash rack			
A. debris removal needed			
B. corrosion noted			
3. Excessive sediment buildup in riser			
4. Concrete/Masonry condition			
A. cracks or displacement			
B. spalling			
5. Metal pipe condition			
6. Control Valve operational			
7. Pond drain valve operational			

Maintenance Item	Inspected? (Yes/No)	Maintenance needed? (Yes/No)	Comments
8. Outfall channels functioning			
9. Other (describe)			
Permanent Pool (Inspect monthly)			
1. Undesirable vegetative growth			
2. Floatable debris removal needed			
3. Visible pollution			
4. Shoreline erosion			
5. Sediment deposits noted			
6. Other (describe)			
Sediment Forebays			
1. Sediment deposition noted			
2. Sediment cleanout needed (over 50% full)			
Other (Inspect monthly)			
1. Erosion at outfalls			
2. Headwalls and endwalls			
3. Encroachment into pond or easement area			
4. Complaints from residents	N/A		
5. Public hazards (describe)	N/A		
6. Needs to be mowed			
7. Other vegetation needs to be removed			
Constructed Wetland Area (inspect annually)			
1. Vegetation healthy			
2. Evidence of invasive species			
3. Sediment deposits noted in wetland area (clean out when 50% full or when vegetation damage noted)			

Note: If any inspection items were checked “yes” for maintenance needed, list maintenance actions and dates completed below.

Maintenance Action Needed	**Date Due**	**Com-pleted? Y/N**

Inspector signature: ______________________________

Storm Water Bioretention Area

Inspection Checklist for BMP Owners

Site name: ____________________

BMP Number: ____________________

Owner Change since last inspection? Y N

Owner Name ____________________

Address ____________________

Phone Number ____________________ Location: ____________________

Inspection Date: ____________________ Time: ____________________

Inspector: ____________________

Weather Conditions: ____________________

Was flow observed: If so, what was the appearance of the water (i.e. color, sheen, estimated flow rate, etc.)?

____

Maintenance Item	Inspected? (Yes/No)	Maintenance needed? (Yes/No)	Comments
Treatment area (Inspect after major storm events)			
1. Evidence of drainage (Is water ponding less than 24 hrs after rain event?)			
2. Signs of erosion noted (in contributing watershed or in bioretention area?)			
3. Mulch condition – thin or decomposing?			
4. Sediment deposits noted in treatment area?			
5. Vegetation condition			
6. Overflow spillway in good condition?			
7. Other (describe)			

Note: If any inspection items were checked "yes" for maintenance needed, list maintenance actions and dates completed below.

Maintenance Action Needed	**Date Due**	**Com-pleted? Y/N**

Inspector signature: ____________________

Storm Water Open Channel Systems

Wet and Dry
Inspection Checklist for BMP Owners

Site name: ____________________
BMP Number: ________ Channel Type: (circle) Wet Dry
Owner Change since last inspection? Y N
Owner Name ____________________
Address ____________________
Phone Number ____________ Location: ____________
Inspection Date: ____________ Time: ____________
Inspector: ____________________
Weather Conditions: ____________________
Was flow observed: If so, what was the appearance of the water (i.e. color, sheen, estimated flow rate, etc.)?
____

Maintenance Item	Inspected? (Yes/No)	Maintenance needed? (Yes/No)	Comments
Channel treatment area (Inspect after major storm events)			
1. Evidence of trash/debris build up?			
2. Signs of erosion noted in channel			
3. Evidence of ponding			
A. In dry swale, more than 12 hrs			
B. In wet swale, more than 48 hrs			
4. Vegetation in good condition?			
Spillway systems (Inspect annually)			
1. Dry Swale – outlet of underdrain stabilized?			
2. Wet Swale - Check dam(s) in good condition?			
3. Other (specify)			

Note: If any inspection items were checked "yes" for maintenance needed, list maintenance actions and dates completed below.

Maintenance Action Needed	**Date Due**	**Com-pleted? Y/N**

Inspector signature: ____________________

Storm Water Infiltration Trench/Basin

Inspection Checklist for BMP Owners

Site name: ______________________________
BMP Number: ______________________________
Owner Change since last inspection? Y N
Owner Name ______________________________
Address ______________________________
Phone Number ______________ Location: ______________
Inspection Date: ______________ Time: ______________
Inspector: ______________________________
Weather Conditions: ______________________________
Was flow observed: If so, what was the appearance of the water (i.e. color, sheen, estimated flow rate, etc.)?
____

Maintenance Item	Inspected? (Yes/No)	Maintenance needed? (Yes/No)	Comments
Treatment area (Inspect after major storm events)			
1. Treatment area – free of debris/trash?			
2. Treatment area – free of erosion?			
3. Contributing watershed – stabilized?			
4. Treatment area – water ponding more than 24 hrs?			
5. Observation well(s) – water within 1 foot of bottom of trench/basin?			
6. Signs of subsurface collapse in treatment area?			
7. Other (describe)			

Note: If any inspection items were checked “yes” for maintenance needed, list maintenance actions and dates completed below.

Maintenance Action Needed	**Date Due**	**Com-pleted? Y/N**

Inspector signature: ______________________________

Storm Water Manufactured BMP

Inspection Checklist for BMP Owners

Site name: ____________________
BMP Product Name: ____________________
BMP Number: ____________________
Owner Change since last inspection? Y N
Owner Name ____________________
Address ____________________
Phone Number ____________________ Location: ____________________
Inspection Date: ____________________ Time: ____________________
Inspector: ____________________
Weather Conditions: ____________________
Was flow observed: If so, what was the appearance of the water (i.e. color, sheen, estimated flow rate, etc.)?

____

Note: The following maintenance plan items must be filled in based upon the manufacturer's recommendations and submitted to the City of Glasgow for approval with the maintenance agreement.

Maintenance Item/Maintenance Frequency	Inspected? (Yes/No)	Maintenance needed? (Yes/No)	Comments

Note: If any inspection items were checked "yes" for maintenance needed, list maintenance actions and dates completed below.

Maintenance Action Needed	**Date Due**	**Com-pleted? Y/N**

Inspector signature: ____________________